Deploying Digital Substations

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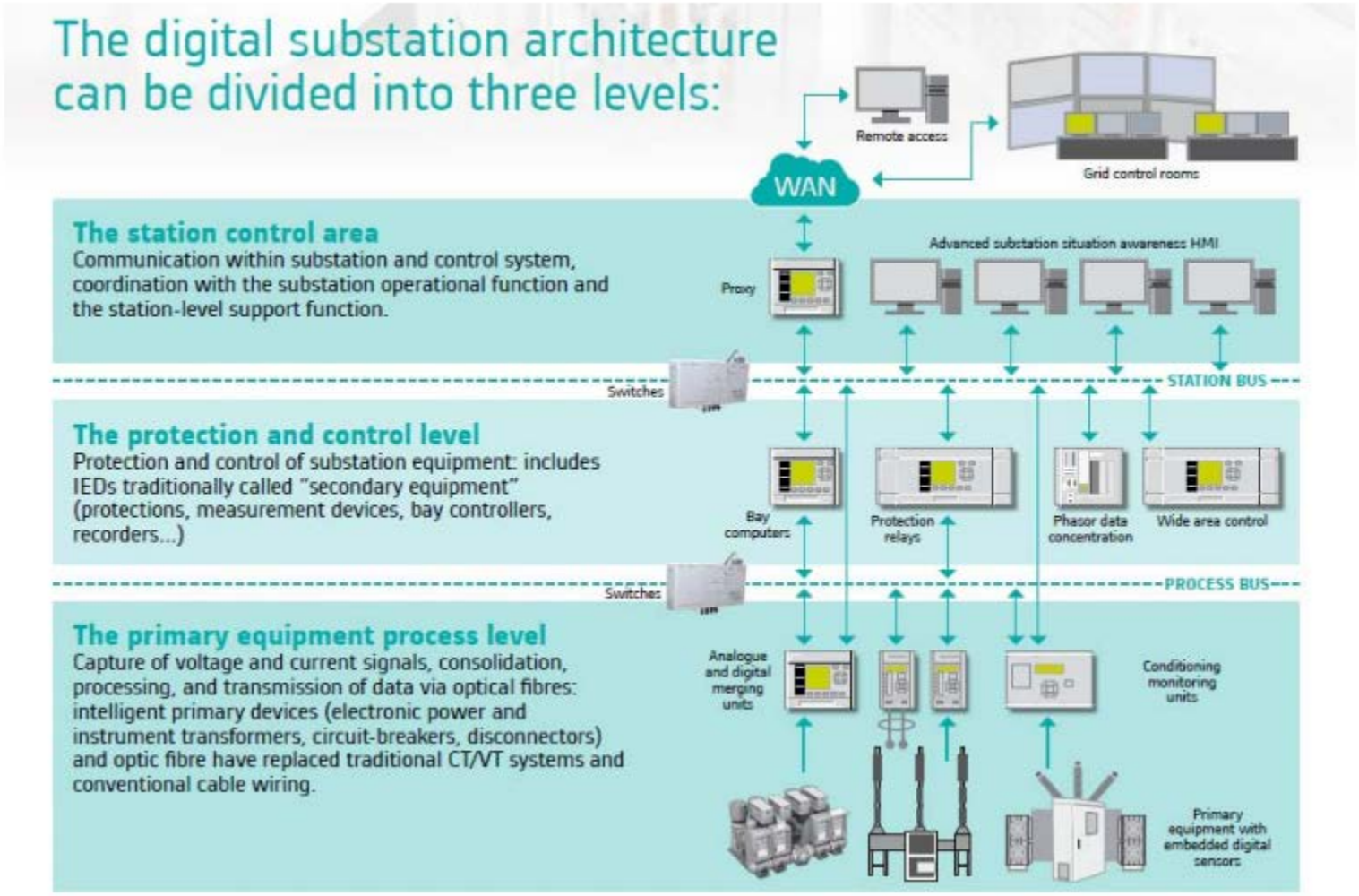
Imagination at work

IEC 61850 Digital Substation



Process Bus Introduction

The standard: IEC 61850-9-2 (Ed.1)

- Standard for communication networks and systems in substations – Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3
- The standard was very broad, leaving wide room for interpretation which complicates interoperability

Implementation Guideline for digital interface to Instrument transformers using IEC 61850-9-2

- To facilitate implementation and enable interoperability, the UCA International Users Group created a guideline that defines an application profile of IEC 61850-9-2
- Commonly referred to as IEC 61850-9-2 LE (Light Edition)

The standard: IEC 61869-9 DIGITAL INTERFACE FOR INSTRUMENT TRANSFORMERS

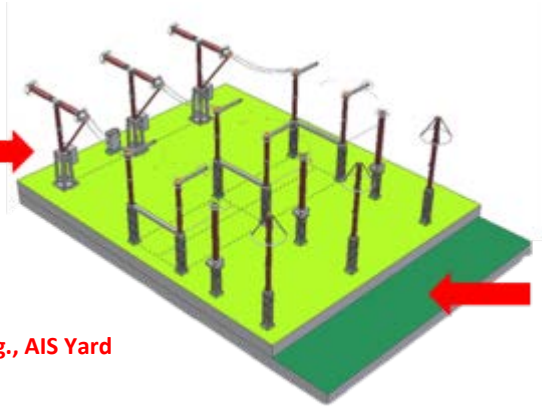
- Replaces IEC 60044-8 digital solution
- Provides a product standard for instrument transformers with a digital interface according to 61850 Includes backward compatibility for IEC 61850-9-2
- Uses IEC 61588 for time synchronization

Digital Substation Drivers

1. Footprint Reduction/ Copper Reduction

- **Primary equipment, AIS:** Sharing of steelwork and foundations
- **Primary equipment, GIS:** CT chamber size reduction with DIT, VT integration in bus-duct
- **Secondary equipment:** Panel size reduction: compact IEDs
- **Copper hardwiring replaced by fibre**

CB + CT



e.g., AIS Yard

Panels

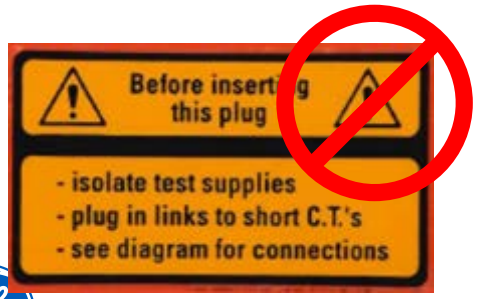
= Footprint reduction

up to 30%

2. Safety

- **Primary equipment:** Oil-free instrument transformers

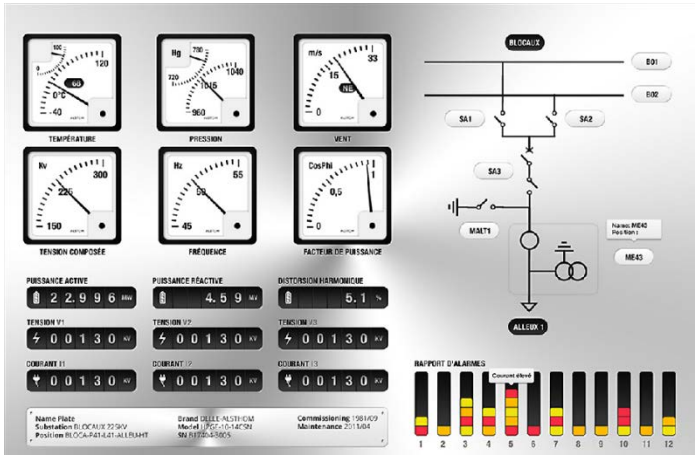
- **Secondary equipment:** Removal of CT secondary circuit, removal of need to change ratio taps



Care for employees and the public: No fatality risk

3. Situational Awareness Applications

- Integrated condition monitoring, asset management and wide area control



Clear alerts and dashboards

PECO Digital Substation Pilot
POST Substation

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PECO POST Substation Pilot

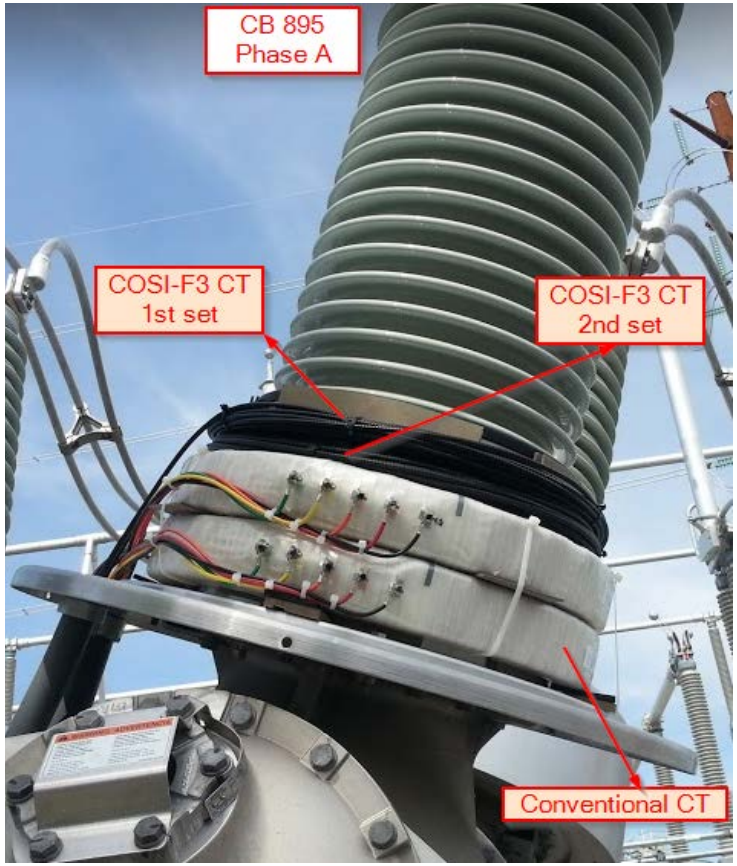
Purpose - To implement the digital substation technology in the substation as a "**proof of concept**", learn and understand different components of a digital substation and compare it with the existing conventional technology.

Scope - The scope of the project involves supplying a complete digital solution for the protection & control of a 230kV Line consisting two Circuit Breakers.

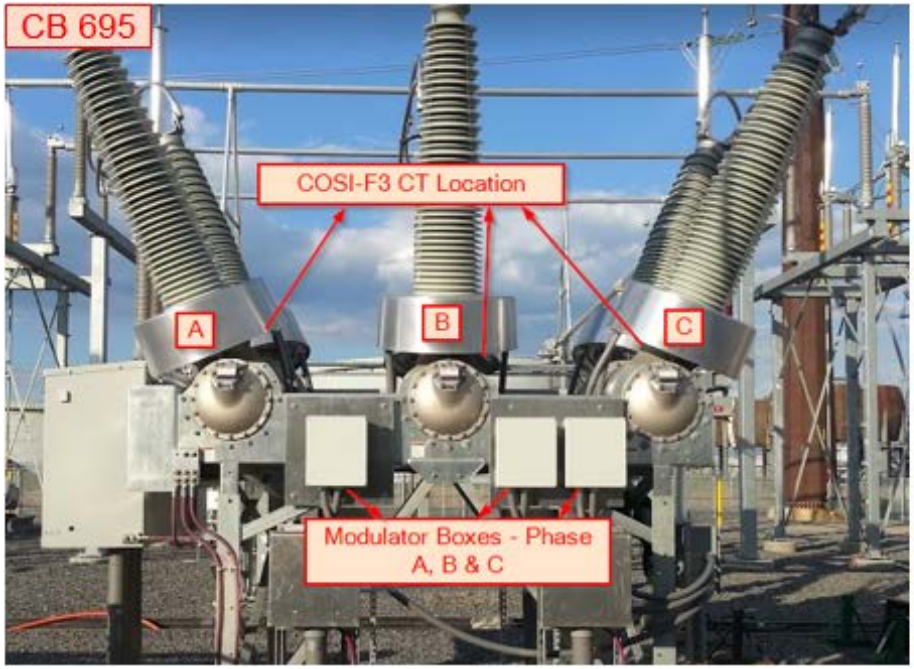
Name of the substation: POST Substation
Location: Philadelphia, PA
Total Number of Bays: 12
Digital Substation Pilot Bays: 2
Commissioning Date: May, 2017

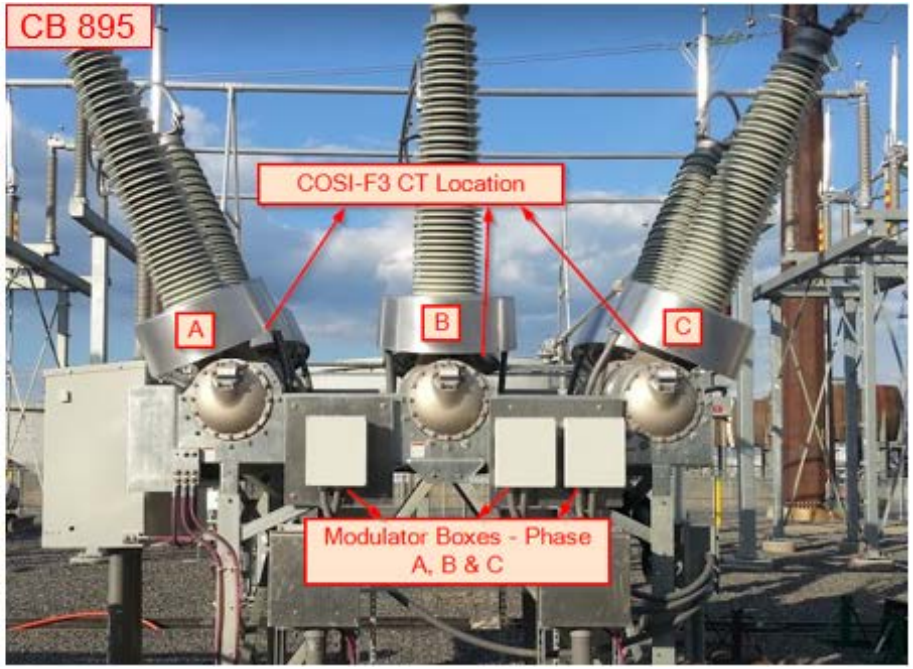
Selection of Equipment

Primary Equipment – Optical CT



POST Substation – Optical CT Installation





Primary Interface Devices - Merging Units, Switchgear Control Unit

Merging Units

- Merging Units are used to merge the output signal from COSI-F3 Optical current transformers and conventional VTs to produce the 9-2LE Sampled value streams
- 80 Samples/ Cycle

Switchgear Control Units

- SCU is used to interface with the Circuit Breakers, Isolators, earth switches etc.. The Circuit breaker status inputs (52a and 52b contacts) are hard wired to the SCU. SCU then communicates these signals to the protection and control devices on the station bus.
- Protection Trips, CB control commands are sent via SCU

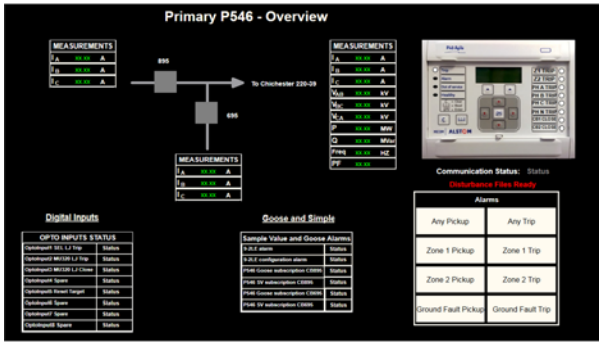
9-2LE Protection Relay

- A Line distance protection relay supporting IEC 61850 9-2LE is selected. The relay can subscribe to multiple streams of 9-2LE sampled values.
- Each primary and backup system has one such relay.
- The primary protection relay subscribes to the sampled values coming from the primary Merging units, MU-CB895 and MU-CB695
- Backup protection relay subscribes to the sampled values coming from the backup Merging units, MU-CB895 and MU-CB695
- Relays have self monitoring & Diagnostic features

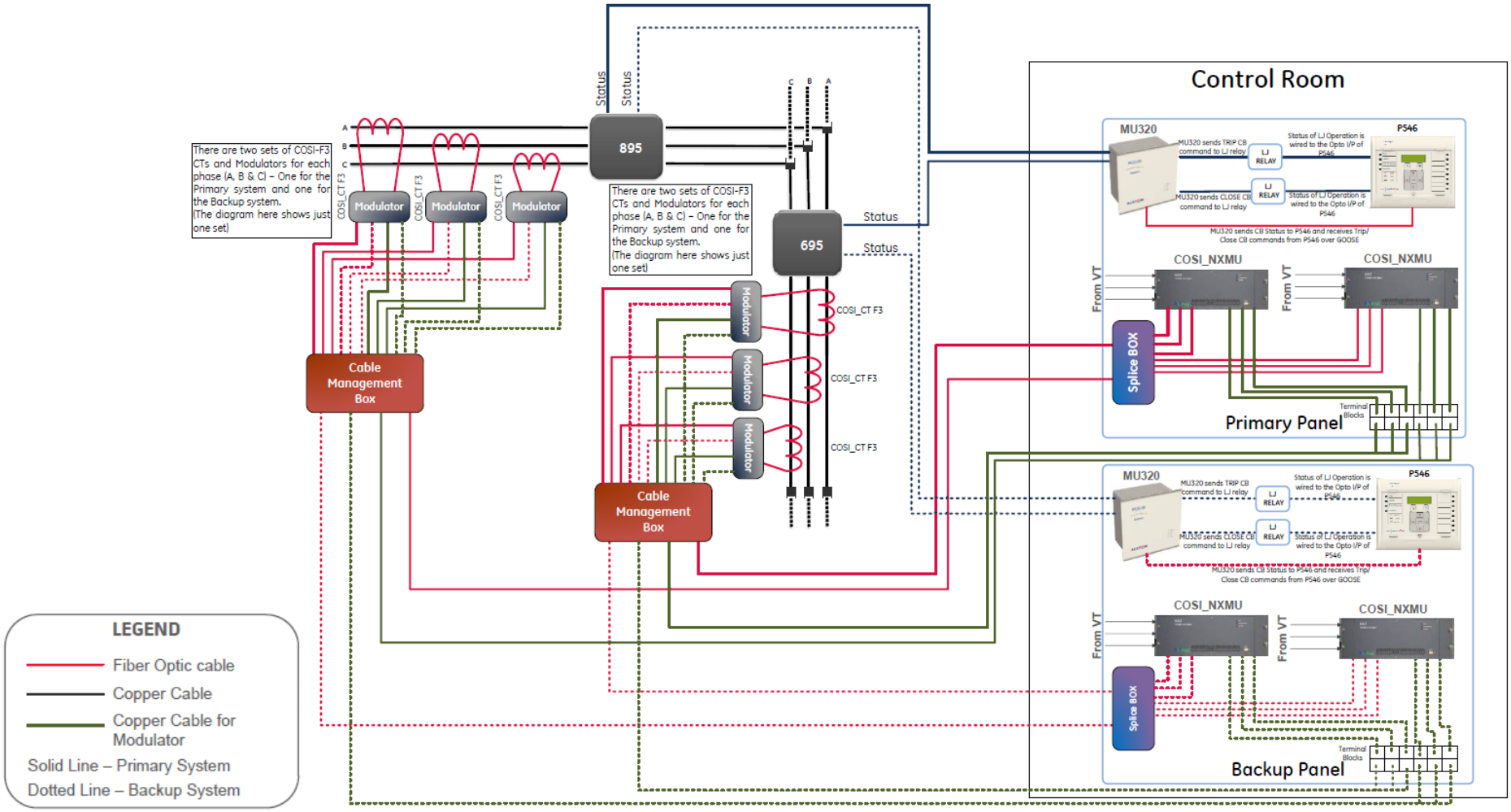
Ethernet Switch, Substation Server

Ethernet switches are required to make the necessary Ethernet network for process bus and station bus. Ethernet switches selected in the project also supports the functionality of PTP Transparent clocks for the time distribution using PTP.

A substation server (with HMI) supporting IEC61850 Client functionality is also provided for local monitoring & engineering of the system. All the Equipment (Protection relays, Merging units, GPS clock etc.) could be accessed via the HMI PC



POST Substation Logical Wiring Diagram



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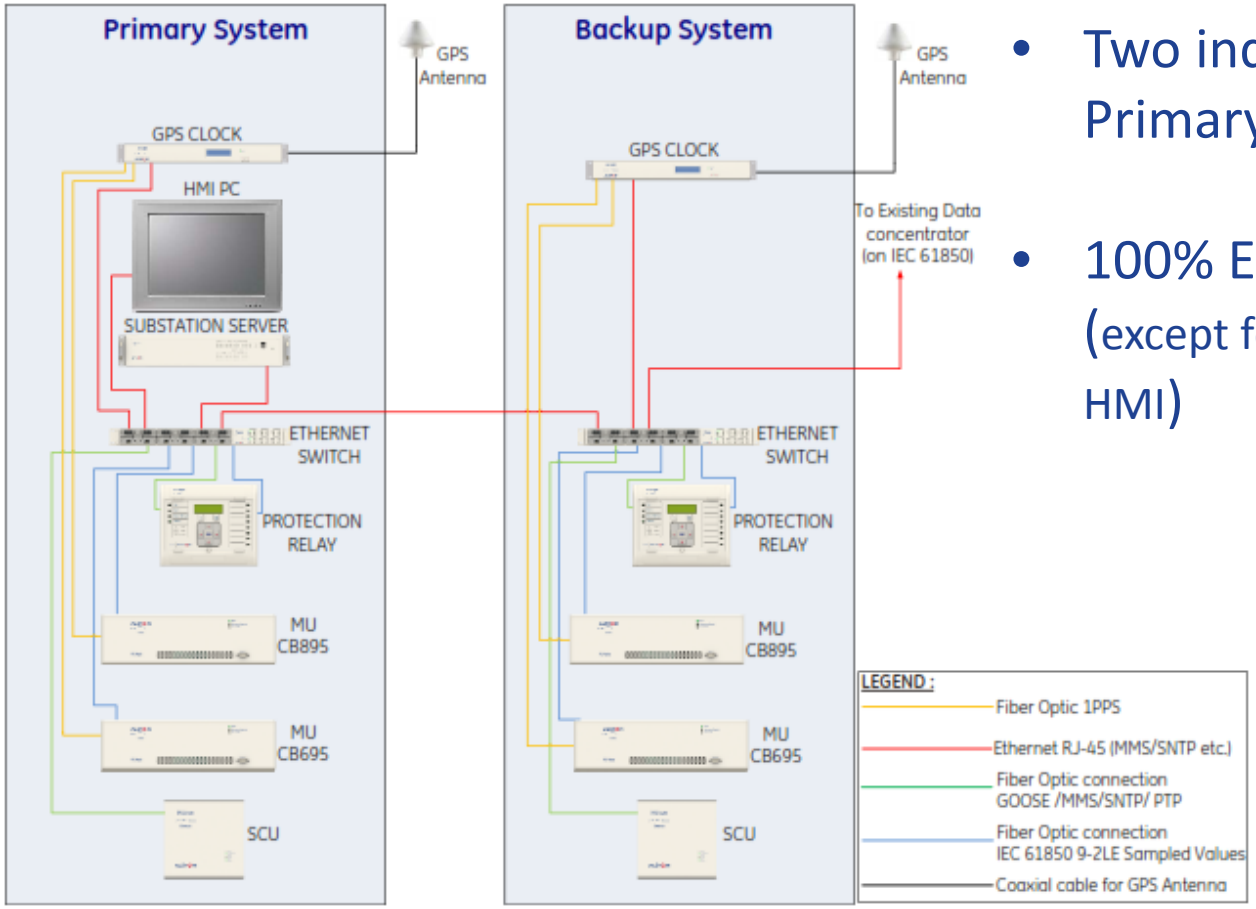
GPS Clock – Time Synchronization

Redundant GPS Clocks

GPS Clock Antenna

Equipment	Time synchronization Method
Protection Relay	PTP (Precision Time Protocol)
SCU	PTP (Precision Time Protocol)
Merging Units	PPS (Pulse Per Second) over Fiber
Substation Server	SNTP (Simple Network Time Protocol)
HMI PC	SNTP (Simple Network Time Protocol)

POST Substation Architecture



- Two independent Systems – Primary System and Backup
- 100% Equipment Redundancy (except for substation server and HMI)

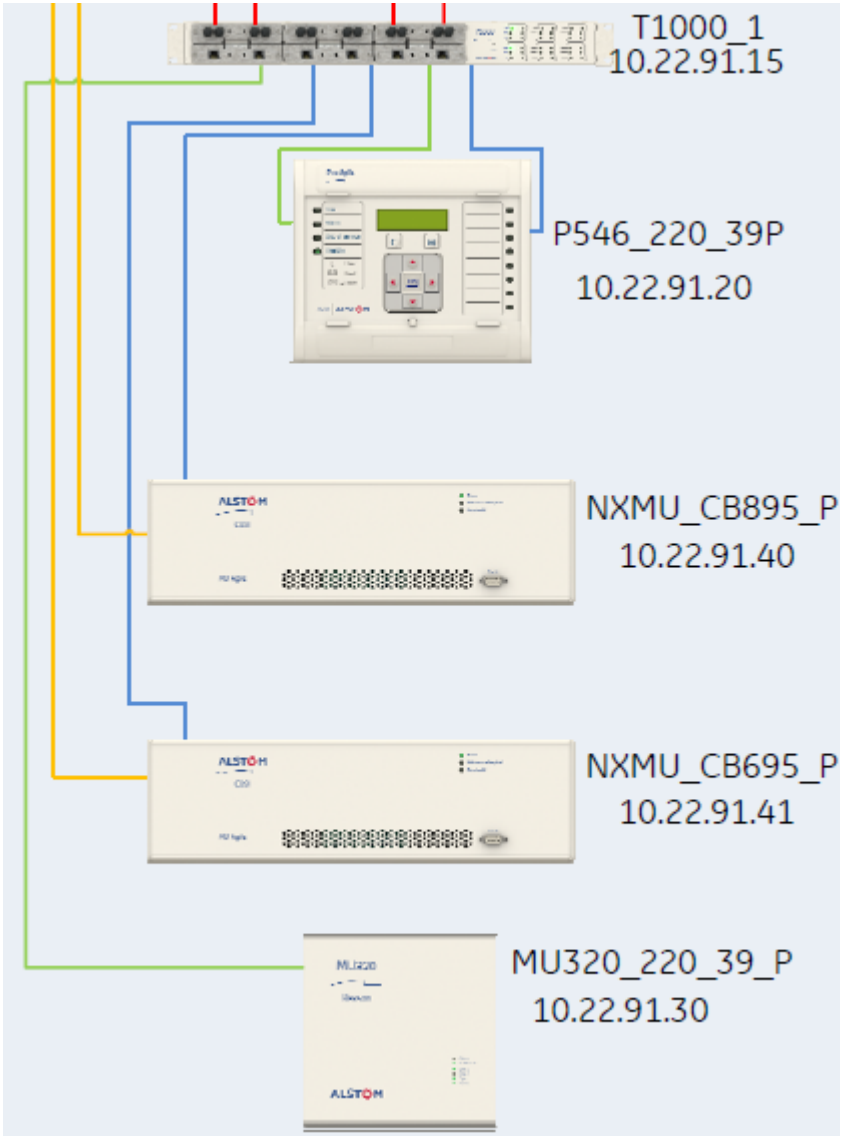
POST Substation – Communication Optimization (Segregating Process bus and Station Bus)

Optimization of the Ethernet Traffic:

- V-LAN Filtering

OR

- **MAC address Filtering**



LEGEND :

- Fiber Optic IRIG-B
- Ethernet RJ-45 (MMS/SNTP etc.)
- Fiber Optic connection GOOSE / MMS/SNTP/ PTP
- Fiber Optic connection IEC 61850 9-2LE Sampled Values
- Coaxial cable for GPS Antenna

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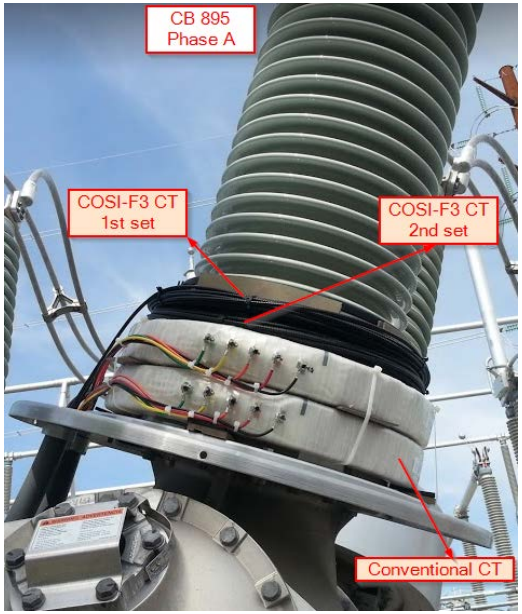
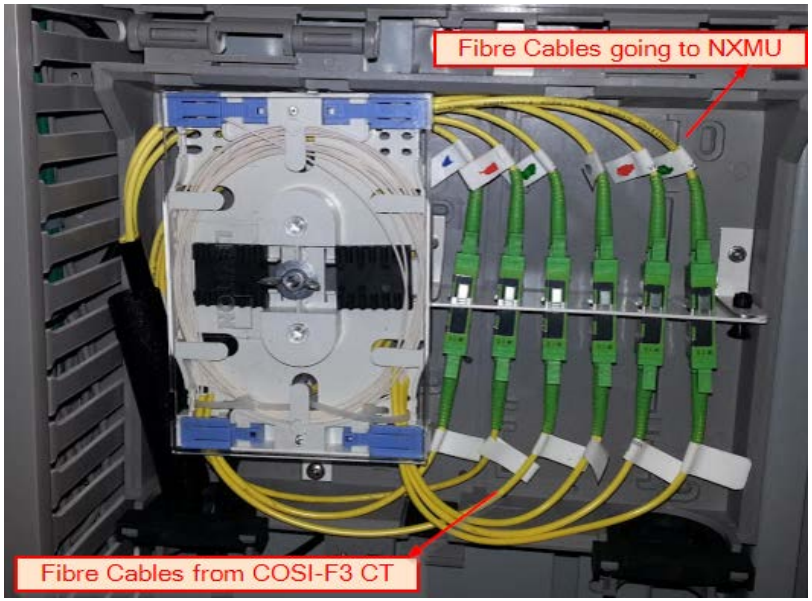
Installation, Testing & Commissioning

Optical CTs – Installation, Testing & Commissioning

- Each Circuit Breaker has two sets of COSI-F3 CTs on each phase (A, B & C)
- CTs are pre-calibrated at the factory for a stated accuracy for a given range of primary current
- No need to worry about the CT ratios and CT polarities.





Secondary Equipment – Installation, Testing & Commissioning

- All the secondary equipment is mounted in the panels
- All equipment are pre-tested during FAT

- Configuration tool for Process Bus Relays is same as for conventional Relays
- Settings for Process Bus Relays is same as for conventional Relays with some additional settings such as SvId, time sync etc.
- Secondary Injection kit supporting 9-2LE is used to test the relays

Self-Diagnostic & Monitoring System

- All the devices in the system have self-diagnostic capabilities so the end user does not have to spend much time troubleshooting the system.
- If there is any failure in receiving the digital signal from the optical CTs mounted in the field, the merging unit will generate an alarm for this. Moreover, the merging unit will also raise the corresponding quality flag for this in the sampled value frames so that the subscribing protection relay would know about this failure and would act accordingly.
- If the protection relay fail to subscribe to any of the two merging units or if the samples coming from any of the merging units are not time synchronized, the relay will generate an alarm for this. Another example, If the SCU fails to subscribe the GOOSE signals from the protection relay, the SCU will generate an alarm for this and send it to the SCADA.

POST Substation – Panels at Site

GPS Clock – RT430

DAP Server – DAP AT

Ethernet Switch – T1000

Touchscreen HMI PC

Protection Relay MiCOM P546

Keyboard for HMI PC

COSI NXMU – CB 895

COSI NXMU – CB 695

Digital I/O Merging Unit – MU320

Auxiliary Relays - LJ

Test Blocks

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Conclusion

This project is a first step beyond studies to understanding and realizing the practical benefits from the design process to implementation and maintenance.

Implementing a digital system in parallel with a conventional protection and control system was necessary to evaluate and compare the performance between the systems

This project will be an invaluable vehicle and model to proving that digital substations can be a practical reality.

Thank You