CIGRE GOTF
IEC 61850 Lab Tour

IEC 61850 Overview
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Introductions

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01

IEC 61850 Standard

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International Electrotechnical Commission (IEC)

- One of three leading international standards organizations made up of ~20,000 experts from industry, commerce, academia, research laboratories, and other related fields
  - Divided into national committees – each nation is represented equally
- Founded in 1906 – globally based in each continent
- Works closely with IEEE and other standards development organizations
- Prepares/publishes consensus-based standards
- Manages conformity assessments for electrical products, systems, and services

IEC 61850 Standard

Objectives

- A single communication protocol designed to model the entire station
- A secure & reliable communication protocol that can be made future proof
- Promotion of high inter-operability between systems from different vendors
- Common method/format to store complete data
- Defined testing required to ensure equipment conforms to the standard

02

The Digital Substation

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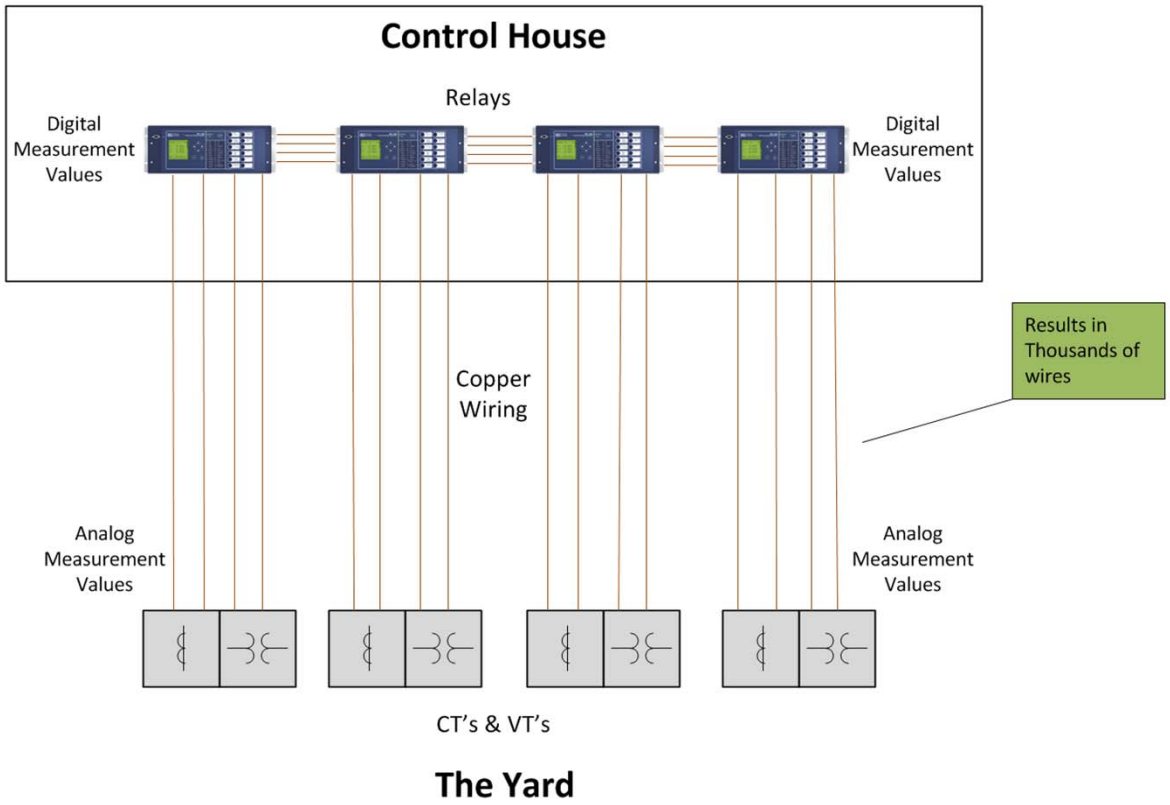
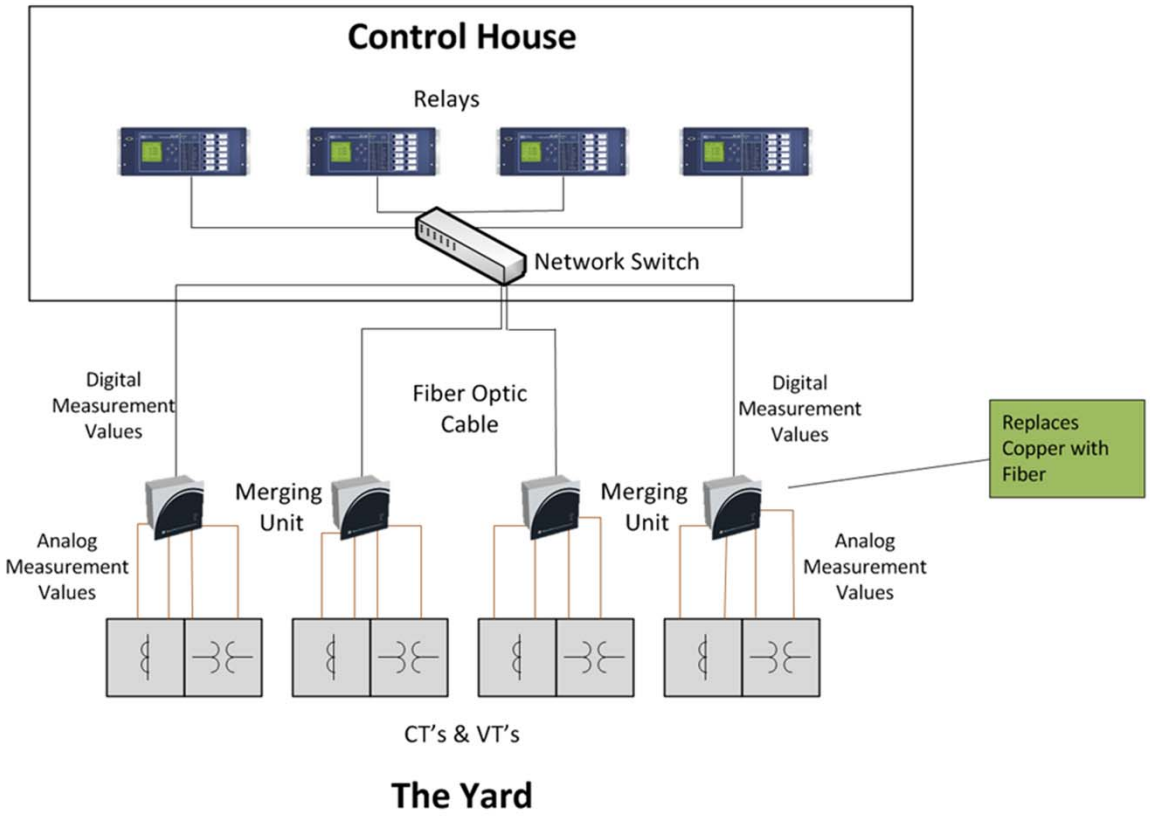
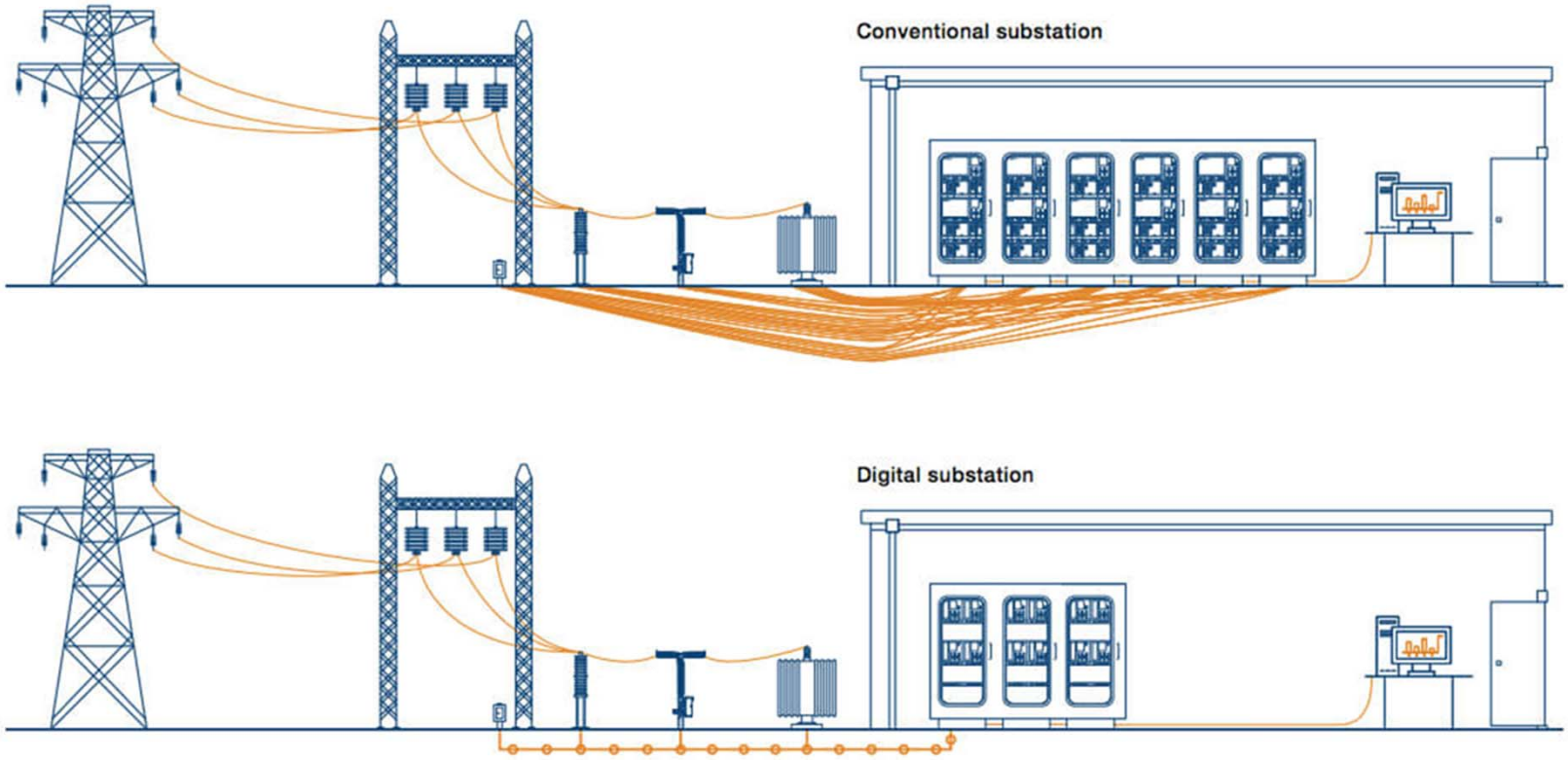
Conventional Substation



Digital Substation



Conventional Substation vs. Digital Substation



Source: 1 [https://www.windpowerengineering.com/going-digital-look-modern-substation/]

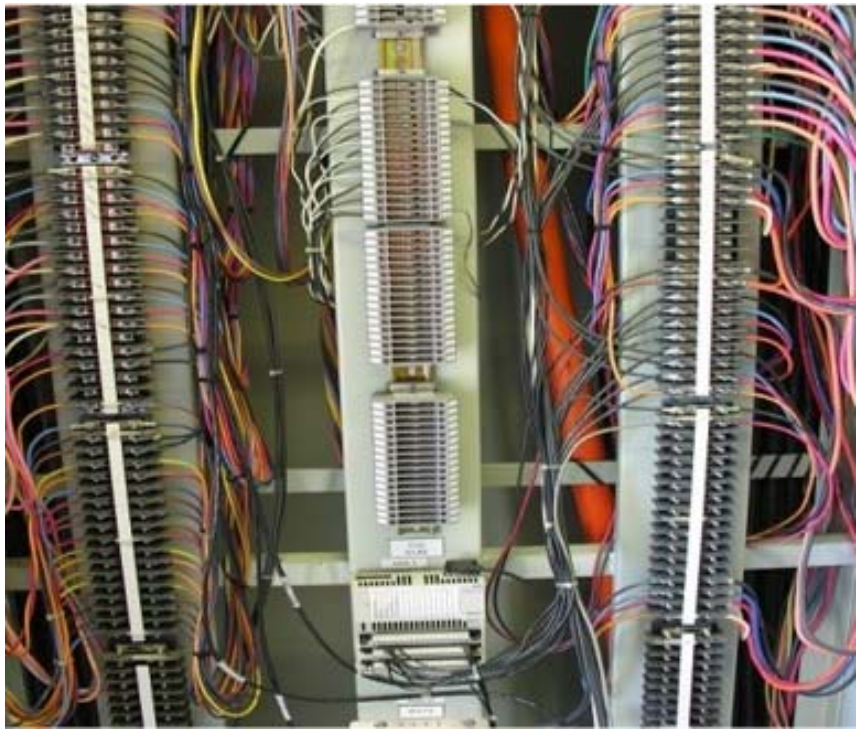
Benefits of IEC 61850

	Description
Interoperability	• Non-propriety common communication language • Common platform for protection, control, asset management systems
Design Standardization	• Shorter construction window as system can be designed, modeled, and tested in advance • Designs are easily reproducible
Flexibility	• Data is available over the network, modifications can be done via settings rather than physical changes • System can be easily expanded
Digital Control System	• Reduced panel space • Reduced physical wiring
Increased System Visibility	• Optimizing on-site maintenance • Easier access to more asset data
Safety	• Electrical hazards are remote from operator terminals • Enhanced tagging control

Benefits of IEC 61850 - Wiring

Conventional

- Time-consuming, space-intensive, and expensive wiring & installation
- Limited performance and data transmission capabilities



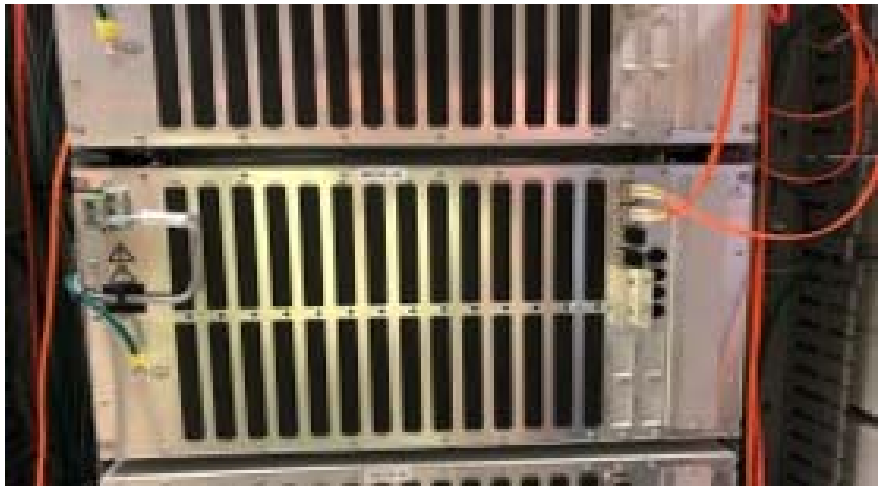
Benefits of IEC 61850 - Wiring

Conventional

Benefits of IEC 61850 - Wiring

IEC 61850

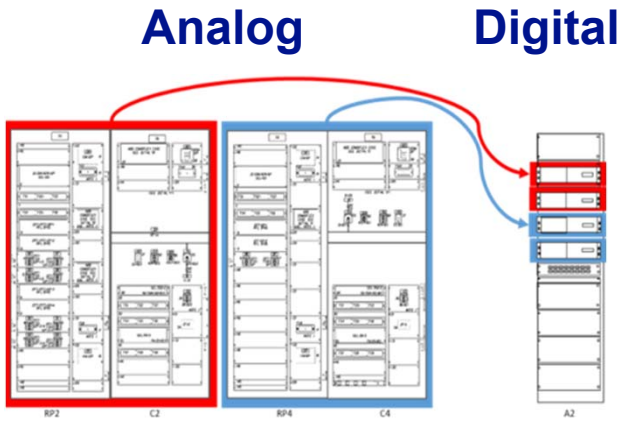
- Simplified, cost-effective, and easy to install & maintain
- Enhanced performance and data transmission capabilities



Benefits of IEC 61850 – Digitization of Information

Digital Protection & Control System

- Control performed over the network through digital devices
  - No LORs, control handles, panel meters, test switches, mimic buses, etc.
- Panel reduction



Analog

Digital

IEC 61850 Model Levels

Station Level Devices

- Station Controller, Human-Machine Interface (HMI), Engineering Computer, and other interfaces for remote communication

Bay Level Devices

- Protection, Control, and Monitoring Units per Bay

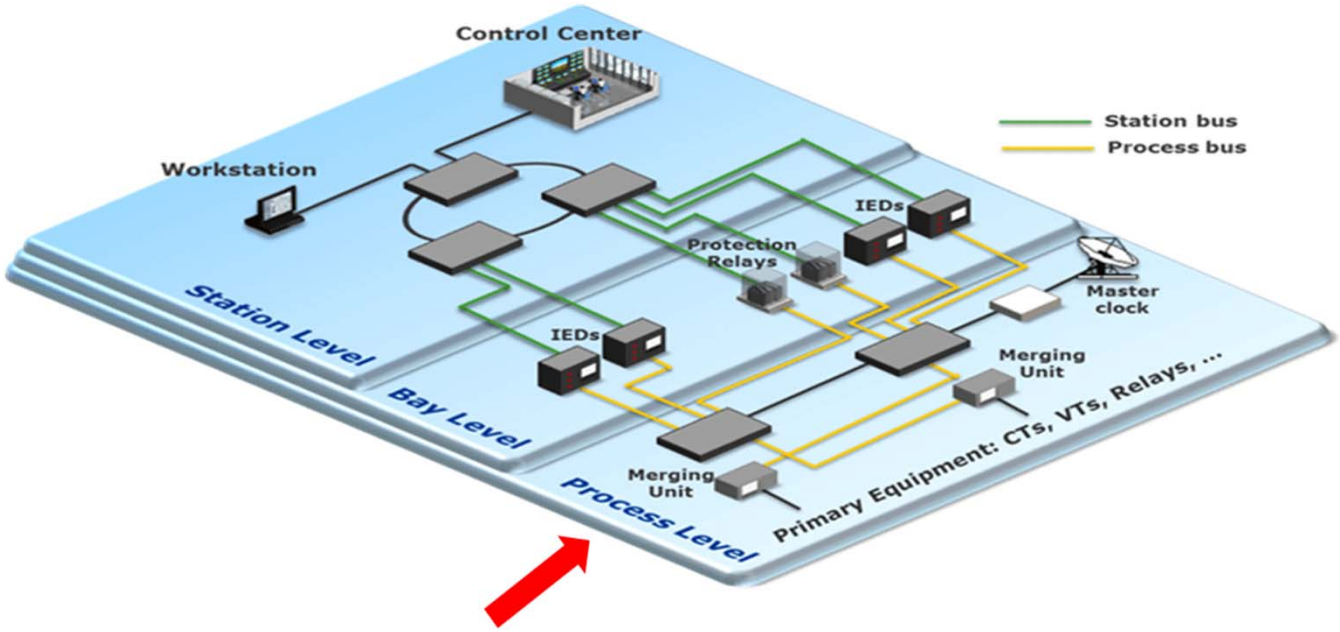
Process Level Devices

- Devices interfacing with primary equipment, such as remote I/O and A/D merging units

Substation Architecture

Process Level

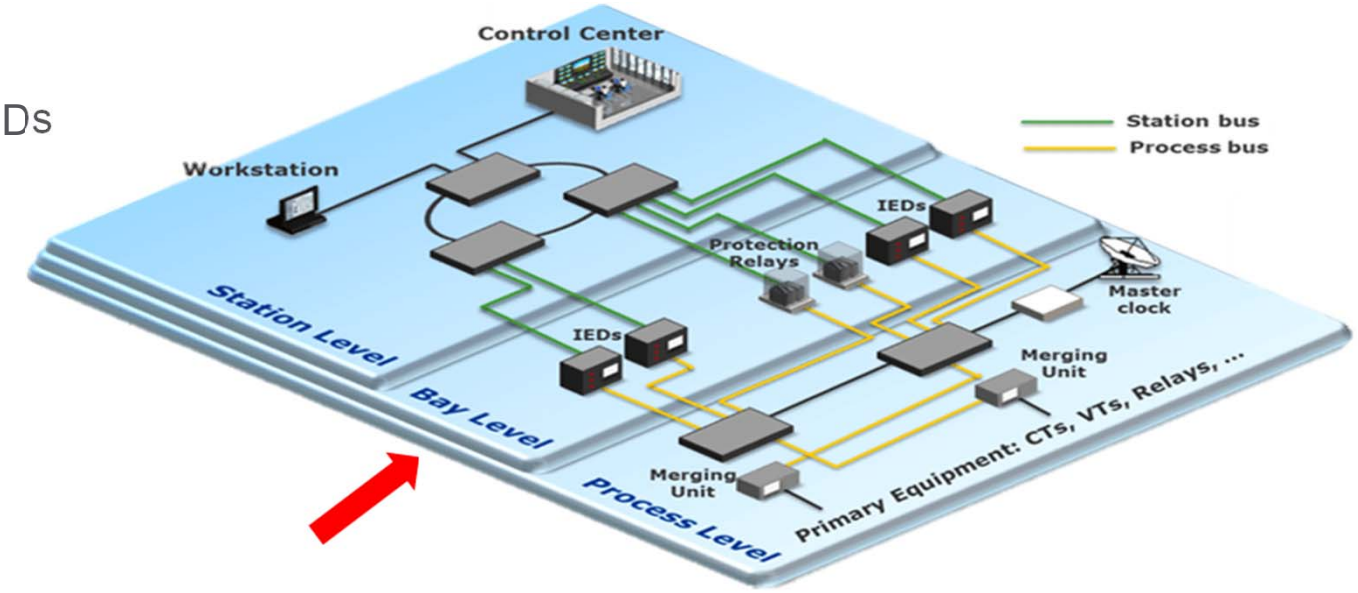
- Circuit Breakers
- Disconnect Switches
- Transformers
- PTs / CTs
- Merging Units



Substation Architecture

Bay Level

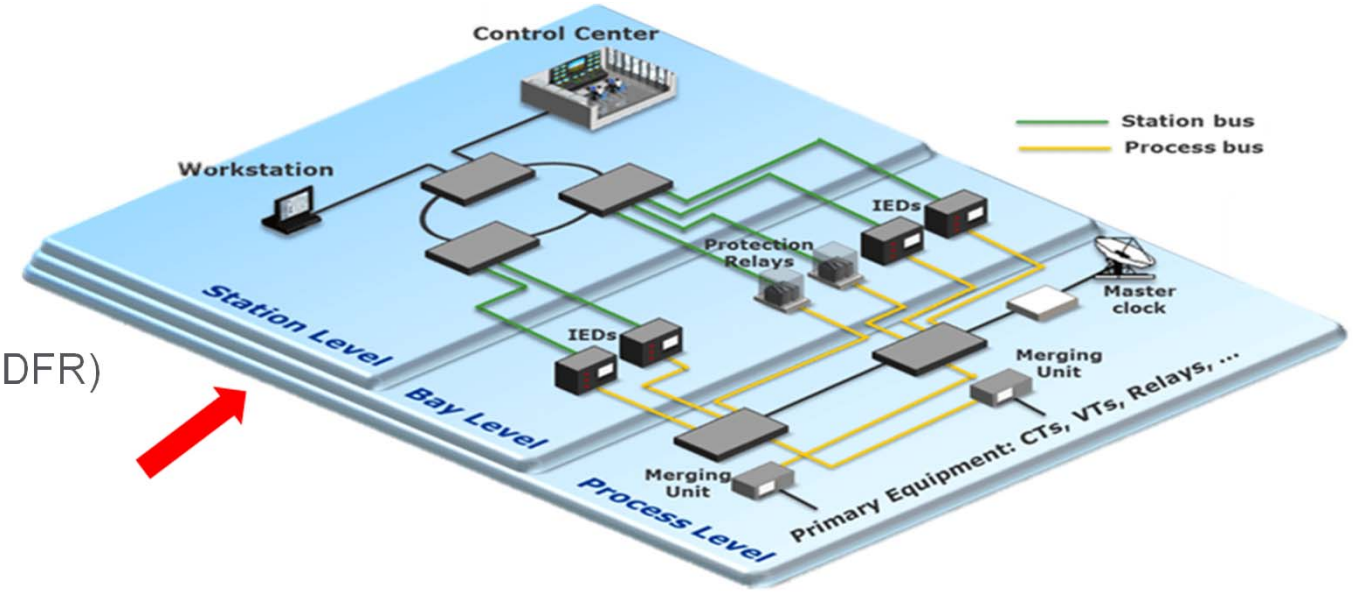
- Protection & Control IEDs
  - Relays
  - Bay Controllers



Substation Architecture

Station Level

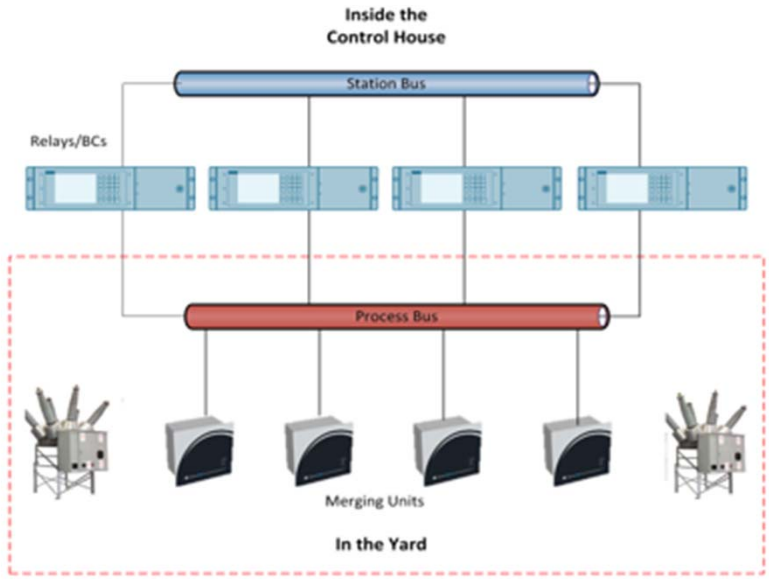
- Station Controllers
- EMS / SCADA
- HMI
- Digital Fault Recorder (DFR)



Process Bus

Shared IT-based network which bridges process and bay levels

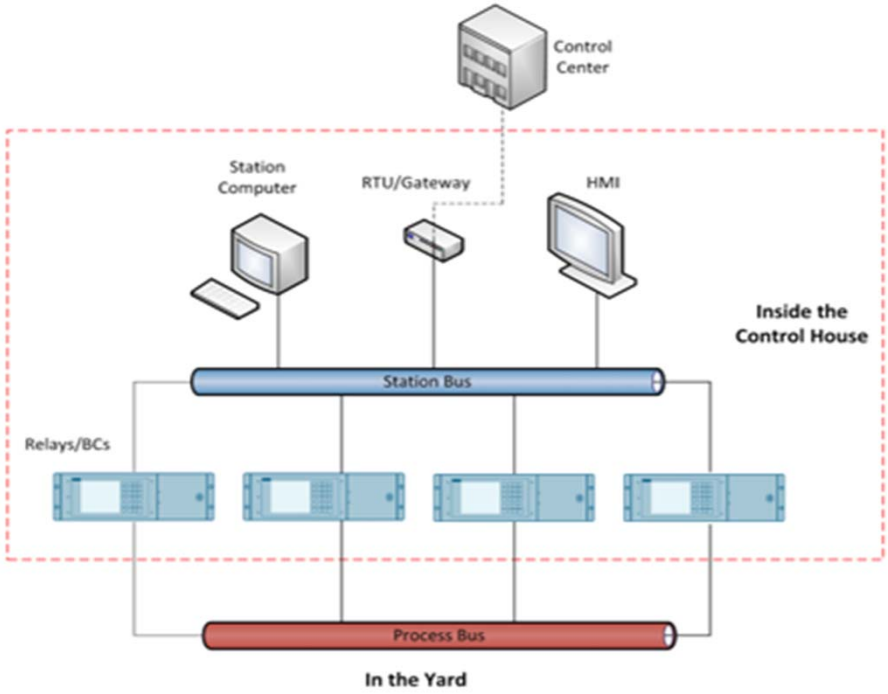
- Unprocessed signals sent from switchyard devices to IEDs
- Source data is processed and converted into digitalized measurements or decisions
- Data is broadcast to the network



Station Bus

Network which connects bay level and station level

- Transmits data from control enclosure to outside the substation



03

Intelligent Electronic Devices

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Intelligent Electronic Device (IED)

Microprocessor-based devices that host the substation protection, control, and automation functionalities

- Protective Relays
- Bay Controllers
- Merging Units
- Remote IO

Bay Controller

Bay Controllers host the breaker protection and control functionality

- Open / Close circuit breakers and associated motor operated switches
- Breaker Failure protection functionality
- Reclose and Synch Check functionality
- Serves as gateway between station bus and process bus for HMI and SCADA control

Protective Relay

Protective Relays host protection functionality for protected electrical elements

- Line Protection
- Bus Protection
- Transformer Protection

Station Controller

Ruggedized PC (Hardware) which runs specialized software for

- HMI Operation
- Interfacing with IEC 61850 protocols
- Communication to SCADA server

Human-Machine Interface (HMI)

Provides ability to monitor and control status and function within the substation

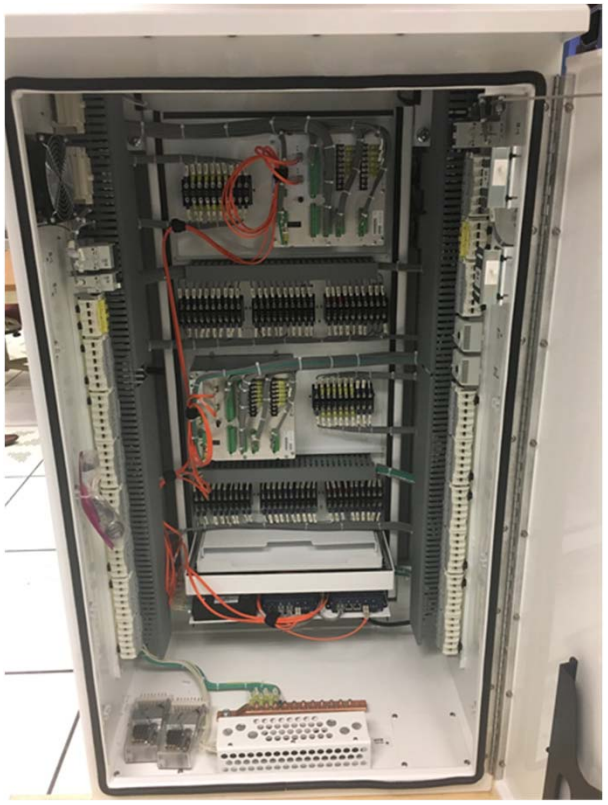
- Integral part of Station Controller
- Digitally replaces physical controls
- Communicates with network connected devices
- Used for placing devices in Test or Simulation modes

Merging Unit

Units installed at the breaker which convert the analog signals to digital sampled values

- “Back-half of the relay” – communication bridge between processing and I/O
- Remote I/O devices interface discrete physical I/O points with network communications
- Merging Unit and Remote I/O functionality may reside in same box or separate boxes

Merging Unit Cabinet



Merging Unit Cabinet

Merging Unit Cabinet

04

Networking

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Network Importance

Physical contacts are replacement with digital data points:

- Trip & Close
- CT/VT information
- Lockout
- Breaker failure initiate
- Alarm points

The network must be resilient, reliable, fast, and secure.

Network Benefits

Reduced wiring and CT/VT loading

Increased availability of information by:

- Networked devices
- Point-to-multipoint communication
- Consolidated wiring
- Breaker failure initiate
- Alarm points

Faster “wiring” changes

Resiliency & Reliability

Separate Networks

- Process Bus: Protection related information and controls
- Station Bus: Lower priority device control and monitoring information
- Separation provides access restriction and traffic management

Redundancy

- Redundant process networks

Traffic Management & Messaging

Network Segmentation

- Use of VLANs to isolate traffic

Traffic Management

- Use of priority for critical messages

Multicast Messaging

- Single message provided to group of devices

04

Time Synchronization

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Time Synchronization in Digital Substations

Protection functions rely on time-sensitive digital communication

System accuracy depends on precise time synchronization between devices

Precision Time Protocol (PTP)

- Used to synchronize equipment clocks
- Combines data and timing networks
- Inherent flexibility via hierarchical approach of Best Master Clock Algorithm (BMCA)
- Sub-microsecond accuracy

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