FROM COPPER TO DIGITAL: THE EVOLUTION OF SUBSTATIONS

IEC 61850: ENABLING MODERN DIGITAL SUBSTATIONS AND GRID AUTOMATION

IEC 61850 enables standardized, high-speed digital substations—reducing complexity, improving reliability, and accelerating deployment through real-time validation and testing.

IEC 61850: THE BACKBONE OF MODERN SUBSTATIONS

1 LEGACY PROTOCOL LIMITATIONS

- Proprietary protocols to exchange binary status and digitized voltage and current inputs
- No digital peer-to-peer communication
- Large, hardwired systems requiring labor-intensive installation and maintenance with limited visibility and monitoring

2 HOW IEC 61850 HELPS

- Standardizes substation design
- Shortens substation energization timeline
- Reduces on-site testing and commissioning requirements
- Reduces copper wiring required
- Improves testing process and quality
- Best suited for standardized, high-volume substation construction

3 IEC 61850 TERMINOLOGY

- **MMS (Manufacturing Message Specification)/station bus:** HMI, SCADA, remote control
- **GOOSE:** Event-driven messaging for protection and control
- **Merging unit (MU):** Digitizes analog voltage and current signals from CTs/PTs into Sampled Values (SV)
- **HMI:** Replaces physical control handles with virtualized functions

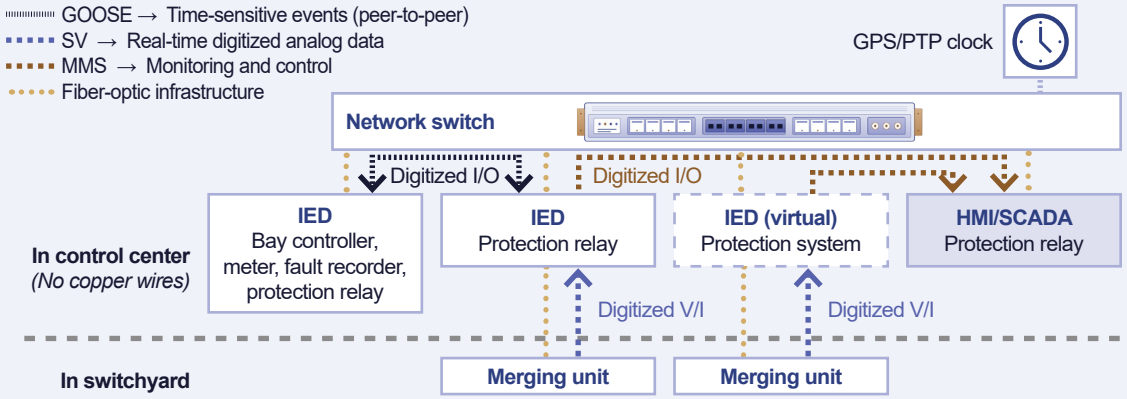
4 IEC 61850 BUILDING BLOCKS

- Merging units (MU): Replace copper wiring from CTs/PTs with digital signals
- Ethernet switches
- Intelligent electronic devices (IEDs)
- Supporting components: gateways, PTP clock

5 KEY IEC 61850 COMPONENTS

- **MMS:** Data exchange for HMI, SCADA, and control systems
  - Latency: milliseconds
- **GOOSE (Generic Object-Oriented Substation Event):** High-speed protection and control signals
  - Latency: sub-milliseconds
- **Process bus (IEC 61850-9-2 SV)** Streams digitized voltage and current data across the network
  - Latency: sub-milliseconds

6 DIGITAL SUBSTATION (DSS) BASIC ARCHITECTURE



7 HOW IT WORKS FOR A FAULT

1. **Fault occurs** — Disturbance appears on the line
2. **IED detects fault** — Based on SV data from MU
3. **IED makes decision** — Protection logic issues trip command
4. **IED triggers action** — IED receives GOOSE message and energizes the trip coil to open the circuit breaker
5. **Information is shared** — To other IEDs or upstream circuit breakers via GOOSE for breaker failure, MMS for SCADA
6. **System resets** — System returns to normal operation

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IEC 61850: USE CASES, BENEFITS, ROLE OF RTDS

8 PRACTICAL USE CASES

- **Digital substations** (merging units and sampled values)
- **Centralized protection and control (CPC) and virtual protection** (MUs, GOOSE, and SV)
- **SCADA/EMS integration** (MMS)
- **High-speed peer-to-peer interlocking** (GOOSE)
- **Wide-area monitoring and protection** (synchrophasor data with PTP time synchronization)
- **Enhanced equipment monitoring and self-diagnostics** (IED- and system-level)
- **Support analytics** for:
  - Condition-based maintenance
  - Oscillation detection
  - Fault location
  - Event analysis
  - Compliance.

9 HOW IEC 61850 COMPARES

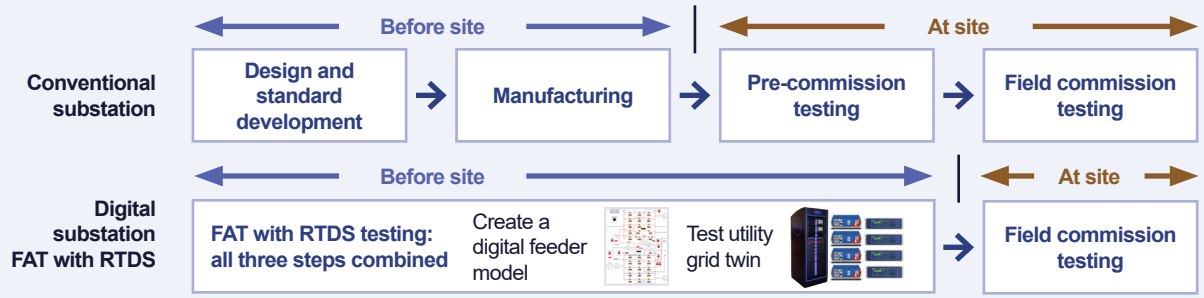
TYPE	FUNCTION	USE CASES	LATENCY
MMS/ station bus	Data exchange for SCADA	Substation, HMI, SCADA, remote control	ms
GOOSE	Event-driven messaging for protection and control	High-speed protection and control signals such as trips, interlocks, etc.	ms
Process bus/9-2	Streams digitized voltage and current samples	Streams voltage and current samples from merging units	sub ms
Merging unit	Digitize voltage and current samples from the PTs and CTs	Replaces copper wires from PTs and CTs with streaming digital data	sub ms
HMI	Field operations and control, local monitoring	Replaces physical control panels with virtual interfaces	s

10 KEY BENEFITS

- **Reduced site testing requirements**
  More than 90% field configuration issues identified before field commissioning during factory acceptance testing (FAT)
- **Standardized substation design**
  Reduces project timelines through standard designs
- **Remote troubleshooting and training**
  Laboratory training and troubleshooting with RTDS
- **Reduced control house footprint**
  Savings in real-estate and infrastructure requirements
- **Simplified engineering and configuration**
  Supports scalable, repeatable large substation volume
- **Enhanced data analytics, monitoring, and diagnostics**
  Real-time visibility enabled by SV and GOOSE

11 ROLE OF FAT USING REAL-TIME DIGITAL SIMULATOR (RTDS)

Ability to validate protection, communication, and control systems prior to field commissioning, reducing the overall timeline



12 STEPS TO ADOPT A DIGITAL SUBSTATION PROGRAM

1. **Recognize need:** Define DSS objectives and business drivers
2. **Business case:** Align use case with organizational goals
3. **Conceptual design:** Evaluate technical architecture options
4. **Design validation:** Execute type and functional testing
5. **Data and analytics:** Leverage DSS data for insights
6. **Deployment planning:** Define manufacturing, procurement, and testing approach
7. **Project delivery:** Utilize factory-tested, pre-integrated systems
8. **Standardization:** Maintain consistent, scalable design frameworks
9. **Organizational readiness:** Define processes, roles, and tools

Contact us to define your IEC 61850 roadmap and validate your digital substation design through RTDS-based testing—reducing risk, cost, and commissioning timelines.

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