This webinar brought to you by the Relion® product family Advanced protection and control IEDs from ABB

Relion. Thinking beyond the box.

Designed to seamlessly consolidate functions, Relion relays are smarter, more flexible and more adaptable. Easy to integrate and with an extensive function library, the Relion family of protection and control delivers advanced functionality and improved performance.
ABB is pleased to provide you with technical information regarding protective relays. The material included is not intended to be a complete presentation of all potential problems and solutions related to this topic. The content is generic and may not be applicable for circumstances or equipment at any specific facility. By participating in ABB's web-based Protective Relay School, you agree that ABB is providing this information to you on an informational basis only and makes no warranties, representations or guarantees as to the efficacy or commercial utility of the information for any specific application or purpose, and ABB is not responsible for any action taken in reliance on the information contained herein. ABB consultants and service representatives are available to study specific operations and make recommendations on improving safety, efficiency and profitability. Contact an ABB sales representative for further information.
Benefits of Digital Substation

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Steve Kunsman is ABB Vice President of Business Development where he leads ABB’s Substation Automation businesses in North America for the complete solution and product portfolio within the industrial and utility customer base.

Steve’s ABB career began in 1984 when he joined protective relay group as an Electrical Designer. Steve has held various engineering, technology and product management positions within the North American and global substation automation organizations.

He is also recognized as a Substation Automation specialist with his areas of expertise including: over 30 years in substation automation, protection and control applications, communications technologies (IEC 61850 and DNP), cyber security for substation automation, and Relion product family of protection and control relays.

He is an active senior member in the IEEE PES Power System Relaying and Substations Committee including a PSRC main committee member, past working group chairs for substation cyber security and relay quality processes, past IEC TC57 US delegate in the development of the IEC61850 communication standard and resides on the UCA International Users Group Executive Committee as co-chairperson since the organization’s founding.

Steve holds a BS in Electrical Engineering from the Lafayette College in Easton, Pennsylvania and an MBA in management of technology from Lehigh University in Bethlehem, Pennsylvania.
Market movement

Trends
- Focus on reliability, availability, power network stability
- Increased pressure from regulators on reliability and security
- Growing interest in the digital substation to lower overall cost and improve performance, reliability and safety

Factors constraining market adoption
- Utility resource constraint leads to inability to evaluate and approve new technology
- Protection engineers are conservative and reluctant to change
- IEC 61850 has been viewed as a European standard
  - Benefits of the “digital” substation are enabled by IEC 61850
  - Positive market perception of GOOSE messaging for wire reduction
  - Greatest interest in Process bus (IEC 61850-9-2)
Communication
The new kind of communications

Home / Office Network
Plug and Play Technology – Phones, Printers, computers, mobile phones, network devices, Laptops, and many more devices

Digital Substation deploys similar Ethernet networking technology to Substations
All the devices are connected in the substation
Local area network that includes devices from multiple vendors.
Applications

Digital substation

Station Level
- Station automation
- Monitoring
- Fault evaluation
- Event and alarm viewing and acknowledgement
- Remote communication for telecontrol and supervision

Bay Level
- Protection
- Control
- Monitoring
- Interlocking
- Data acquisition

Process Level
- GIS or AIS switchgear
- Instrument transformers
- Power transformers
- Surge arresters
- Non-conventional transformers

FUNCTIONS
What is so special about the digital substation?
Footprint, copper wires, safety, reliability and cost
Basics - A breakthrough for Substation Automation

Goal of the Standard

- **Interoperability**
  - Exchange information between IED’s (Intelligent Electronic Device) from several manufacturers
  - IEDs use this information for their own function

- **Free Configuration**
  - Free allocation of functions to devices
  - Support any philosophy of customer – centralized or decentralized systems

- **Long Term Stability**
  - Future proof
  - Follow progress in mainstream communication technology
  - Follow evolving system requirements needed by customers
Basics – Standardized Data Models

Primary equipment

Secondary functionality

XCBR
XSWI
XSWI
SIMG
PTOC
CSWI
PDIS
CILO
RREC
Digitize copper (GOOSE + SMV)

- Thanks to Ethernet technology and previously mentioned data model we are able to digitize copper:
  - Binary signals (GOOSE)
  - Analog signals (GOOSE)
  - Analog signals as input to protection and metering functions (SMV in the Process Bus)
Basics - What is GOOSE message?

- GOOSE messages are based on change event
- GOOSE messages include diagnostic functions (a “heart beat” to all devices subscribed is sent periodically)
- GOOSE messages are managed by GCBs (GOOSE control block) inside IEDs
- GOOSE messages send “Data Sets” upon changes of state
Basics - Process Bus

What is Process Bus

Station level

IEC 61850 station bus

Bay level

Process level

conventional connections to CT/VT and drives

IEC 61850 process bus

Process bus to merging units for current and voltage sensors

Process bus to merging units for current, voltage and binary signals
Why Care? - Lower Total Cost of Ownership
An efficient, flexible, cost effective & powerful solution

- Do more with less - functional consolidation and flexibility
  - Fewer devices = fewer panels = less space required for the control building and supporting infrastructure
- Process bus ready – the next step in your evolution of protection and control
- Advanced self monitoring and diagnostics reduce maintenance and periodic testing
- Ease of repair and restoration with fewer spare parts minimizes support and increases system-wide availability
- Streamlined repeatability of protection schemes shortens engineering and commissioning times
  - One engineering tool for the entire product family
  - Advanced network forensics and protection and control diagnostic tools
  - Learn one product, know them all

Significant reduction in TCO with Relion
Leveraging utility experience to provide transformative digital solutions that deliver significant improvements over traditional approaches

**Enhanced safety....**
Reduce risk of fire and safety hazards for your personnel

**Functional consolidation....**
Next generation multi-function capabilities significantly reduce footprint

**Improved reliability and efficiency through simplicity....**
Reduced complexity improves reliability and efficiency
WARNING!!! The secondary circuit of CTs should never be opened or left open when current is flowing in the primary. If the secondary circuit is open, the primary current will drive the core to saturation, inducing abnormally high and possibly lethal PEAK voltages.
Proofs - Enhanced safety
Reducing open CT risks in the control house

- Reduce risk of injury when conventional instrument transformers, voltage and current signals are connected to a digital interface at the primary equipment safely away from field personnel
- Safely replace relays without taking the substation out of service

Increased safety and reduced risk of personnel injury in the control house
Proofs - Enhanced safety
Reducing the risks in the control house

Digital substation reduces wiring complexity and resulting risks for operations & maintenance personnel

Before

After

No cable tray

Single conduit to carry fibers
Proofs - The Digital Substation
Solutions for utilities' critical needs

Leveraging utility experience to provide transformative digital solutions that deliver significant improvements over traditional approaches

Enhanced safety....
Reduce risk of fire and safety hazards for your personnel

Functional consolidation....
Next generation multi-function capabilities significantly reduce footprint

Improved reliability and efficiency through simplicity....
Reduced complexity improves reliability and efficiency

Lower total cost of ownership
Proofs – Analogy of functional consolidation
The evolution of technology

- Technology drives consolidation of functions in all industries
- Reduces amount of inventory
- Improves the work process
- Requires new skill sets
Proofs – Free allocation of function/logical nodes
Enables functional consolidation

Function Library

Hardware Platform

PAC Application

Communication
Proofs – Example of Functional consolidation
Reduced footprint, hardware and infrastructure

Reduction in panels from 3 to 1

Conventional

Digital

14 protection & control devices (Electro-Mechanical system could add 3 devices per function)

2 protection & control devices including busbar protection/backup

Advanced solution
From 3 panels to 1 panel
Proofs – Example of functional consolidation
Reduced footprint, hardware and infrastructure

Comparison of digital vs. traditional solution for static VAr compensator (SVC) project example

- 4 ABB Relion relays vs. 14 traditional relays
- 50% reduction in number of panels – 4 to 2

Main protection - traditional relays

Main protection - digital substation
Proofs - The Digital Substation
Solutions for utilities’ critical needs

Leveraging utility experience to provide transformative digital solutions that deliver significant improvements over traditional approaches

- Enhanced safety....
  Reduce risk of fire and safety hazards for your personnel

- Functional consolidation....
  Next generation multi-function capabilities significantly reduce footprint

- Improved reliability and efficiency through simplicity....
  Reduced complexity improves reliability and efficiency

Lower total cost of ownership
Proofs - Simplicity improves reliability
Reduces complexity and number of points of failure

Example – Hybrid digital substation implementation

**Traditional Copper Wires**

- **Conventional cabling**
  - No of cables: 768
  - Conductors: 4500
  - Terminations: 9000

- **Test/Debug** – Labor intensive
- **Maintenance** – Drawings up to date?
- **Reliability** – Many connections

**Digital Communications**

- **Partly Digital Communications**
  - No. cables: 256
  - No. conductors: 1500
  - No. terminations: 3000

- **Test/Debug** – Easier to test/debug using digital tools
- **Maintenance** – Digital record of connections and much simpler wiring improves maintenance
- **Reliability** – Less connections and units to fail improves reliability (receive digital notification of an issue)

67% reduction wires
Conventional design

- Control IED
- Protection IED
- Protection IED
- Switchgear
- CTs/VTs

Circuit diagrams
Connection tables
Cable lists
Proofs - Simplicity improves reliability
Reduces complexity and number of points of failure

Example – Complete digital substation implementation

**Traditional Copper Wires**

**Conventional cabling**
- No of cables: 768
- Conductors: 4500
- Terminations: 9000

**Test/Debug** – Labor intensive
**Maintenance** – Drawings up to date?
**Reliability** – Many connections

**Digital Communications**

**Full Communications**
- No. of Fiber optic cables: 4
- Continuous self supervision

**Test/Debug** – Easier to test/debug using digital tools
**Maintenance** – Digital record of connections and much simpler wiring improves maintenance
**Reliability** – No conventional cables and self supervision
Proofs - Simplicity improves efficiency
Tools simplify substation analysis and testing

Visualization of logic within the substation

Faster troubleshooting of substation logic

Simple Testing of Relay Sources

Easy review of voltage and current source connections for relaying (polarity of inputs)
Parallel Redundancy Protocol (PRP)

Principle

- **Operation Mode**
  - 2 Ports active
    - Messages are sent / received simultaneously on both ports
    - Switch over time 0ms

- **Advantages**
  - No recovery time
  - No messages are lost
  - Network redundancy (Network A and B)
  - IEDs are not active part of the network
  - Standard according IEC 61850-8-1/9-2 Edition 2
How it works

PRP Operation in normal condition
Demonstration
PRP Operation with “faulty” condition

network A

network B

Redundancy Manager

application

device interface

Redbox

IED
Proofs – Digital Substation Benefits
Assessment of cost impact

| Project Management |  
|-------------------|---
| Base/Concept Design |  
| SA Engineering |  
| Panel and cable engineering |  
| Protection, control devices |  
| SAM600 devices |  
| Panel mfg + testing |  
| Kiosk mfg + testing |  
| Fiber mat., laying, connecting |  
| Copper mat., laying, connecting |  
| Signal test |  
| Commissioning |  
| Retrofit outage time |  
| Maintenance |  
| Total costs |  

- Overall reduced time to engineer, install and commission substations
- Up to 50% reduction in real estate requirements
- >70% reduction in copper wiring – installation, maintenance, and debug
- Reduced operational costs using tools to improve installation and troubleshooting needs
Proofs – Digital Substation Benefits
Assessment of operations impact

- Improved safety for personnel
- Improved documentation
- Improved reliability
- Improved maintenance and diagnostics
- Increased flexibility for future expansion
- Reduced outage time for retrofits
- Safeguards investment with a future-ready solution that provides migration to the digital substation
  - DNP 3.0 today, 670 delivered with IEC 61850 for tomorrow usage
Summary - Why the Digital Substation is so special!

- Reduce amount of cables by using fiber instead of copper
- Optimize drive and interface boxes with direct process bus connection
- Lower requirements on CTs/VTs by reducing burden from cabling and minimizing No of circuits
- Simplify P&C panels and increase safety by full isolation from process
- Include NCITs in P&C system and by that further increase safety & availability
- Reduce maintenance through increased supervised area
The Digital Substation - part of the future Smart Grid
Communication, interoperability & cyber security!

ABB has designed the building blocks to meet these requirements for the Digital Substation – ready for the future Smart Grid
Communication is the game changer and interoperability throughout systems of systems is the main challenge.

Change from old box-and-wire blue print to a system approach with functional specification allowing more efficient solutions with lower total cost.

Bring together Control & Protection with standardized Communication to ensure future proof interoperability and supports Cyber Security compliance.

Implement Reliability Centric Design of the complete system with self supervision and redundancy to guarantee availability and maintainability.

Plan, structure and empower involved work force in engineering, operation and maintenance.

Pilot with Proof of Concept and FAT/SAT to ensure total system performance.

Build a technology sandbox (test bed) to demonstrate the Digital Substation capabilities to your organization.
Enabling advanced protection, control and automation
Extending to Asset health and Wide Area solutions

Wireless communications
- Provide a redundant communication path for critical asset health applications
- Mesh network allow communication reconfiguration
- Reliable, high capacity, low latency, secure and adaptable

Asset Health systems
- Control of the recovery allows for efficient decision making
- Transmission applications focused on grid resiliency in development
- Systems allow for managing congestion, balancing the load and maintaining reserve capacity

Proactive control systems
- Collect and analyze real-time data throughout the power grid
- Early warning system for blackouts
- Safety and stability margins analyzed
- Aids operators in making correct live decisions
- Dynamic monitoring system
Digital substation product portfolio

Substation interface and HMI (Station level)
- RTU560 & MicroSCADA SYS600C

Protection and Control (Bay level)
- Relion family control and protection IEDs
  - 670 series & 650 series
  - REB500 for distributed busbar applications
  - IEC 61850 system engineering: IET600
  - IEC 61850 testing: ITT600 SA Explorer

Interface to Switchgear (Process level – NCIT)
- ABB NCITs for GIS, CP-MU merging unit for ELK-CP14 and ELK-CP3 (current and voltage)
- ABB LTB with integrated Fiber Optic Current Sensor FOCS-MU (current only)

Process level – stand-alone merging units
- SAM600 modular process bus IO system
# Digital Substation process bus products

## Process level equipment - Sensor technology

<table>
<thead>
<tr>
<th></th>
<th>AIS / GIS</th>
<th>Voltage level</th>
<th>Current/ voltage</th>
<th>Application</th>
<th>Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABB NCITs with IEC 61850-9-2 merging units</td>
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</tr>
<tr>
<td>FOCS LTB</td>
<td>AIS</td>
<td>420kV</td>
<td>Current</td>
<td>Protection, control</td>
<td>Redundant optical CT integrated in disconnecting circuit breaker</td>
<td>Pilot installation since 2010</td>
</tr>
<tr>
<td>FOCS FS</td>
<td>AIS</td>
<td>72 – 800kV</td>
<td>Current</td>
<td>Protection, control, revenue metering</td>
<td>Redundant optical CT, free-standing</td>
<td>Commercialized 2014</td>
</tr>
</tbody>
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|                  |           |               |                  |                                      |                                                                                                                                                 |                                  |
| ABB stand-alone merging units for conventional instrument transformers |           |               |                  |                                      |                                                                                                                                                 |                                  |
| SAM600           | GIS & AIS | any           | Current & voltage| Protection, control, operational metering| Modular IEC 61850 process bus I/O system with modules per primary object                                                                   | Ready for pilot installations    |
| SAM600           | GIS & AIS | any           | Current & voltage & breakers, disconnectors… | Protection, control, revenue metering | Modular IEC 61850 process bus I/O system with modules per primary object                                                                   | Under development                |
ABB’s experience with NCITs and process bus
Some project highlights

- **Pilot installation**
  - Braemar, AU
  - GIS NCIT, 670series

- **Pilot installation**
  - Laufenburg, CH
  - GIS NCIT, 670series, REB500

- **Pilot installation**
  - Bäsna, SE
  - FOCS NCIT, 670series

- **Real installation**
  - Loganlea, AU
  - GIS NCIT, 670series, REB500

- **Pilot installation**
  - Nehden, DE
  - 3rd party NCIT, REB500

- **Pilot installation**
  - Bickigen, CH
  - GIS NCIT, 670series, 3rd party

- **Pilot installation**
  - Bodelwyd., UK
  - GIS NCIT, 670 series

- **Real installation**
  - 5 more inst., AU
  - GIS NCIT, 670series, REB500

[Timeline with project highlights for 2009 to 2013]
Experience in demanding applications
> 100,000 Relion 670s, > 2,000 substations with IEC61850

Examples of Relion deliveries worldwide

Your strategic partner
Questions?

WE ARE THINKING OUTSIDE THE BOX
This webinar brought to you by:
ABB Power Systems Automation and Communication

- **Relion Series Relays** – Advanced flexible platform for protection and control
- **RTU 500 Series** – Proven, powerful and open architecture
- **MicroSCADA** - Advanced control and applications
- **Tropos** – Secure, robust, high speed wireless solutions

*We combine innovative, flexible and open products with engineering and project services to help our customers address their challenges.*
Thank you for your participation

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