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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.





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ABB Protective Relay School Webinar Series

Realizing the digital substation: Introduction to the process bus (IEC 61850-9-2) David Hart & Jose Ruiz August 13, 2013



Presenter



David G. Hart, Ph.D.

Dr. David G. Hart is Executive Director Automation Solutions at ABB in Raleigh, NC. Dr. Hart is a native of Union, SC and holds a Ph.D. in Electrical Engineering and a MS in Electrical Engineering from Clemson University, in Clemson, SC.

In 1992, Dr. Hart joined what was then ABB Transmission Technology Institute where he held various engineering and managerial positions. His initial areas of focus included generator protection, transmission protection, and distribution protection and control. His later position in ABB was working on distribution and feeder automation. After moving to ABB Meters (later Elster), he was the Senior Vice President of Systems and Products, responsible for the Product Management, Engineering, and Quality organizations.

Dr. Hart has numerous technical disclosures and patents in smart metering, power system protection and control, and in automation. Dr. Hart is a Senior Member of the IEEE.



Presenter



Jose Ruiz

Jose L. Ruiz is with ABB Substation Automation Products group, North America. He joined ABB as a post graduate student.

During his graduate study, he learned and tested IEC 61850 with different vendor relays. In his current role with ABB, Jose shares his expertise in IEC 61850 with customers in the power industry in trainings, projects, and providing technical support.

Jose received his M.S. degree in Electrical Engineering from the University of Tennessee at Chattanooga in 2012 and is a member of the IEEE PES.



Learning objectives

- Brief introduction to IEC 61850
- IEC 61850 Process Bus
- UCA Implementation Guidelines
- System Architecture
- Project example



SA System Architecture - RTU / Hardwired

- IEDs do not have communication capability
- Status monitoring and control via RTU hardwired connections
- Significant amount of connections / documentation





SA System Architecture - DNP / Modbus

- Integration of status monitoring into IEDs
- Reduction/elimination of RTU cabinet
- Defined protocol stack
- Non standard modeling of substation equipment and functions
- Non standard data format
- Integration requires intimate knowledge of each device
- Protocol conversion may be necessary





IEC 61850 SA system

- Integration of status monitoring, protection, automation, and control into IEDs
- Digitization of copper wires
 - 61850-8-1
 - 61850-9-2
- Modeling of the substation, equipment and functions
- Protocol stack
- Interoperability by standardization and verification





IEC 61850 - 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



Introduction to process bus

- The process bus is i.e. a communication network at the process level
- It is responsible for publishing the quantities related to the process; i.e.
 - Voltage
 - Current
- IEC 61850 9-2 Defines the mapping of "Sampled Values" over Ethernet
- "Sampled Values" are current and voltage samples obtained from CTs and VTs
- IEC61850 9-2 define the communication protocol over Ethernet that enables the publication of such samples for the purposes of protection, monitoring, and metering



Introduction to process bus





Introduction to process bus What is a merging unit



Introduction to process bus



conventional connections to CT/VT and drives ocess bus to merging units for current and voltage sensors – conventional and non-conventional ITs Process bus to merging units for current, voltage and binary signals

Introduction to process bus



- The process bus is a communication network on process level, and also connecting the process to the bay level
- IEC 61850-9-2 describes the transmission of sampled analogue values over Ethernet
- IEC 61850 also allows transmission of binary data on process level (GOOSE, MMS)



Introduction to process bus What is process bus for sampled analogue values



- Sampled analogue values are transferred as multicast messages and can be received by all IEDs on the same network
- The receiving IEDs decide whether to process the data or not
- The transmission time of the messages on the network is not deterministic
 - A time reference is required to align samples from different sources



Introduction to process bus

- IEC 61850 9-2 allows protection relays to operate based on digitized current and voltage signals that are distributed on a communication network in the form of Ethernet frames
- Voltage and current signals from different CTs and VTs are "published" on the network and available to all devices that are connected to it
- Galvanic CT and VT inputs to the relays are no longer necessary
 - Safety
 - Wire reduction
- CT and VT signals are processed by the Merging Unit (MU), an intelligent device that samples the current and voltage signals, creates their digital IEC 61850 9-2 form, and publishes them on the network
- Allows integration of non-conventional Instrument Transformers (IT) for improved performance
 - e.g. Can use Rogowski technology for current sensing output is not at 1A or 5A - to avoid traditional CT saturation issues for protection



Introduction to process bus IEC 61850-9-2 standard and implementation guideline



- The standard: IEC 61850-9-2

- Communication networks and systems in substations Part 9-2: Specific Communication Service Mapping (SCSM) - Sampled values over ISO/IEC 8802-3
 - The standard leaves wide room for implementation and considerable effort is required for full implementation



Implementation Guideline for Digital Interface to Instrument Transformers using IEC 61850-9-2

- To facilitate implementation, the UCA International Users Group created an implementation guideline that defines a subset of IEC 61850-9-2.
 - Commonly referred to as IEC 61850-9-2LE for "light edition"



Introduction to process bus Difference between IEC standard and implementation guideline

Area	Standard IEC 61850	Implementation guideline (IEC 61850-9-2LE)
Sampling rate of analog values	Free parameter	80 samples per period for protection and metering 256 samples per period for power quality
Content of dataset	Configurable	3 phases current + neutral current 3 phases voltage + neutral voltage
Time synchronization	Not defined	Optical pulse per second (1PPS)
Logical device "Merging Unit"	Content and naming is not specified	Specified with rules for logical device name and contained logical nodes



61850 9-2 Ethernet Frame

- Destination: multicast mac address
- Source: source mac address
- Vlan info (Priority tagged)
- Ethertype: 0x88BA
- Ethertype APPID: 0x4000
- Sampled Values Protocol Data Unit (APDU)



61850 9-2 Ethernet Frame

- ASDU: Application Service Data Unit
- svID: Sampled Values ID
- Each Ethernet frame contains 1 sampled of Va, Vb, Vc, Vn, Ia, Ib,Ic,In
- For protection applications the transmission rate is 80 frames per cycle (4800 per second)

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61850 9-2 Ethernet Frame

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Introduction to process bus Time Synchronization

- Time synchronization is needed for IEDs to properly align the current and voltage samples
- Pulse Per Second (PPS) is the defined source of time synchronization in the current implementation guidelines published by UCA
- The source must have an accuracy of +-1 micro second
- IEDs are given a small period of time to ride through any transient loss of time synch. This is based on the magnitude of the drift the IED's clock has



61850 9-2 Sample Project



- Powerlink Queensland's 275kV substation is located next to Brisbane in Australia
- The substation is supplying parts of Brisbane and the tourist region Gold Coast with electrical energy
- With the Loganlea secondary system upgrade ABB undertook its first commercial NCIT installation with IEC 61850-9-2LE process bus and protection and control IEDs
- The station has been completed and handed over to the customer in December 2011

IEC 61850-9-2**LE** stands for "Implementation Guideline for digital Interface to instrument transformers using IEC 61850-9-2". Defined by UCA International Users Group.



ABB's solution Process bus overview



REC670 Control Simplified one of RET670 Main X protection systems



ABB's solution IEC 61850 compliant SA system





ABB's solution 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



ABB's solution REB500 busbar and breaker failure protection system



- 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



ABB's solution CP-MUP merging unit for protection and control



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- The world's first UCA-certified merging unit
- IEC 61850-9-2LE-compliant
- Interfaces with ELK-CP14/ ELK-CP3 sensors of up to three three-phase measuring points
 - Reducing the number of components in 1½ breaker and double busbar arrangements
- Multiple Ethernet ports bring high flexibility to system design
 - Reducing the need for Ethernet switches in protection circuits

The UCA International Users Group is a not-for-profit corporation focused on assisting users and vendors in the deployment of standards for real-time applications for several industries with related requirements.



ABB's solution ELK-CP sensors for metal-clad switchgear

ELK-CP14

Nominal values: 100 ... 4000A 175 ... 300 kV/√3



ELK-CP3

Nominal values: 100 … 4000A 330 … 550 kV/√3



The already installed sensors are early versions of today's ELK-CP sensor. That are...

- 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



ABB's solution Connection from primary to secondary equipment



- Merging unit for protection CP-MUP

- Merging and timely correlation of current and voltage from the sensors
- Supply values at IEC 61850-9-2LE interface
- Synchronization by optical pulse per second (PPS)
- The CP-MUP consists of 4 logical merging units 3 logical MUs to merge and timely correlate the current and voltage values from 3 times 3 phases 1 logical MU for summation of measured currents from the other 3 logical MUs

5 optical Ethernet ports for IEC61850-9-2LE

*PPL: Point to Point link, one fiber for U and I per sensor phase



ABB's solution Retrofit to conventional sensors

- Hybrid solution can use conventional ITs and convert to digital process bus
 - Utilize IEC 61850-9-2LE with 80 samples/cycle for protection and operational metering

 Supporting the digital substation architecture





ABB's solution Retrofit to conventional sensors



ABB's solution Fully redundant and independent system design



ABB's solution Highly available process bus without Ethernet switches



Extract of the applied concept:

Control and redundant line and busbar/breaker failure protection

- Highest availability of the process bus system was achieved by
 - Building two fully independent process bus and protection systems from NCIT to protection IEDs
 - Minimizing number of components without using Ethernet switches
 - Refraining from common devices across feeders and the redundant protection system

ABB's solution Protection concept – Line 1 (PDIF)





ABB's solution Protection concept – Line 2 (PDIS)





ABB's solution Protection concept – Transformer 2





Testing and maintenance Impact on protection and control testing







Testing and maintenance Tool support

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Software replaces multimeter

- Intelligent software for the collection, display and evaluation of sampled value streams
 - Oscilloscope display of V/I values
 - Phasor diagram
 - Quality information of all values
- Built-in diagnostic functions in sensors, merging units and IEDs for supervision of:
 - Device health status
 - Connections
 - Time synchronization
 - Quality of samples and telegrams



Benefits against conventional technology Process bus



Increased operational safety

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

Reduced life cycle costs

 Permanent real-time system supervision increases system availability by increasing maintenance cycles and reducing outage times

Reduced copper cabling

 By replacing parallel copper wires with optical process bus

Future-proof interoperable design

 By applying the established IEC 61850 standard This webinar brought to you by the Relion[®] product family Advanced protection and control IEDs from ABB

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Thank you for your participation

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