Designing a new IEC 61850 substation architecture

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Proof of Concept project objectives

• Design a new control and communication architecture replacing the current RTU/PLC based one
• Use 61850 communication standard to follow industry trend
• Implement zone controllers to keep Manitoba Hydro (MH) substation layout
Example MH Substation
MH divides the substation in zones

High Voltage zones (115kV)

Low Voltage zones (66kV)
Zone characteristics

• Zones are sized to provide distributed system reliability & maintainability
• Zones are mainly based on voltage level
• Zones can include transformers
• Zones contain 1 or more breakers with all associated switches
Scope of Proof Of Concept

• Based on simplified subset of 115kV and 66kV station
• Have complete A-B protection and control scheme
• Complete redundant communication architecture
• 1 high and 1 low voltage zone
• Use IEC 61850 communication and DNP3 for legacy devices
• Demonstrate multi vendor relay interoperability
• Local HMI on 2 levels
  – Virtual safety tagging on HMI operator interfaces
• Interface to remote HMI
• System test or extension mode
Scope of Proof of Concept
Control/communication solution
Network redundancy

- 3 fiber optic rings
- Redundant connections where possible
A-B scheme protection IEDs

• For each breaker there are 2 protection IEDs of different vendors
• Protection IEDs use GOOSE for communication
• A and B communication rings are physically separated
• Operator Open & Close operations are done through hardwired I/O modules
A-B scheme zone controllers

- IEC 61850 proxy server to substation gateways
- IEC 61850 client to protection and I/O
- Integrated HMI driver
- Completely independent
- Remote access to IEDs
HMI Visualization and control

• There are 3 levels of visualization and control
  – Remote SCADA
  – Local Substation HMI
  – Local Zone HMI

• There are no panel control breaker switches

• Selection between control authority is done through selectors
  – Substation Remote/Local
  – Zone Remote/Local
A-B scheme HMI

- Independent data acquisition from Gateways
- Synchronization of HMI data through network
- Ability to split redundant scheme into independent A-B systems
Example of safety card

CAUTION1

The line is under maintenance.
Zone controller HMI details

Selecting a controllable device displays the control bar.

Base single line with real time values.
System extension mode

• Splitting of substation network
• 2 independent working systems
• 1 side stays fully functional in either SCADA or Local control as determined by 43LM switch
• System in extension mode is in opposite control mode as system in "run"
• Outputs of system in extension / test mode are blocked
• Allows testing to either SCADA or local HMI
System extension mode

Example:

- 43LM = Remote
- A = Normal
- B = Test

- A system = Normal/SCADA control
- B system = Test/Local control
System extension mode - procedure

- 1 Side stays fully functional
- Update & commission other side of the system
  - IEDs
  - Zone controller
  - Substation gateway
- Reverse roles
- Update second side of the system
- Put back together
Conclusion

- Multilayer redundant control architecture is possible
- IEC 61850 interoperability from different vendors
- IEC 61850 proxy servers in zone controllers is possible and gives a standard interface independent of used protection IEDs
- Zone controllers integrate IEC 61850 and legacy devices (DNP3, Modbus, etc.)
- Network layout is important when separation is needed
Next steps

- Finalize zone controller IEC 61850 interface
- Finalize control logic for first deployment
- Standardize zone controller design including I/O for more modular design
- Optimize engineering tools
- Zone controllers should have 4 Ethernet ports for added redundancy
Contact information

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