DIGITAL SUBSTATION: EXPERIENCES WITH A SUBSTATION AUTOMATION AND PROTECTION SYSTEM BASED ON IEC61850 9-2 PROCESS BUS

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OVERVIEW PROCESS BUSS - GENERAL

- Remove hard-wiring on field-level
- NCIT (non-conventional instrument transformers) feed data to process bus
- Merging Units: Integrate Conventional Equipment
OVERVIEW PROCESS BUS - GENERAL

Environment
Health & Safety
Economic Value
Reliability

Copper Cabling
Overall Material Expenditure

Reduced Time On Site
Reduced Hazards

Customer Expectations

Expenses
Less Copper Wiring
Less Space required for Secondary Systems

Time
Fast Commissioning due to Digitalisation

Safety
No Galvanic Connections (only Fibre-Optic)
No Risk of Overvoltage when Transformer Circuits are open (NCIT)

Fiber vs. Copper Cost
Time for Engineering & Testing
Land Take, Cabinets Size
OVERVIEW DSAS PILOT

Statnett: Digital Substation Pilot Project in a live 300kV Substation

- Tender: Early 2016
- Project: 10/2016 (Specification) – 10/2017 (Installation and Commissioning)

Stakeholders: Statnett (Operator) + Jacobsen Elektro & Sprecher Automation (Vendor + Integrator)

Goal:

- Gather practical experiences with DS technologies
- Evaluate Interoperability
- Gain knowledge on how to create future DS using process bus advantages
OVERVIEW DSAS PILOT

Station Bus with Gateway and HMI

Distance Protection for Lines 1&2 + Bay Control Units.
Line1: SAMU + CIT,
Line2: MU+NCIT

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Switchyard

PCU 1
PCU 2
PCU 3

SCU
SAM U

1) Voltage UL2 from busbar A and B
2) Voltage UL1-L2 from 471V-side for optional OLTC
**CYBERSECURITY CONCEPT**

Network Management: SNMPv3
Security Monitoring: Syslog

- **SCADA**
- **MU / SAMU**
- **SCU**
- **Firewall**
- **IPSec**
- **RBAC**
- **Gateway**
- **Station Bus**
- **PCU**
- **Process Bus**
- **Security Server**
- **Remote Access**
- **Secure Remote Access**
DSAS PILOT FUNCTIONAL SETUP

• Multiple Measurement / Command Chains
  • For validating NCIT vs. CT/VT
  • For creating redundancy

Conventional CT/VT

SAMU

Process Bus

PCU

Non-Conventional Transformer

MU

Process Bus

PCU

Primary Technology ↔ Digital Control System
DSAS FUNCTIONAL SETUP

MU / SAMU

Samples Values
IEC 61850-9-2 LE

IEC 61850 GOOSE Process Bus

Station Bus

Process Bus

IEC 61850 GOOSE

Primary Technology ↔ Digital Control System
DSAS PILOT COMMUNICATION

- VT
- NCIT
- CB Control Room
- Gateway
- MP
- Relayhouse / Control Room
- IEC 61850-9-2 (SV)
- IEC 61850-8-1 (GOOSE) and Precision Time Protocol (PTP)
- Proprietary (NCIT fibre link, VT copper)

IEC 60870-5-104

Dispatchcenter

IEC 61850

Station LAN (MMS)

Gateway

Relayhouse / Control Room

- SCU
- MU/SAMU
- PCU1 Line1&2
- PCU2/3 x Line 1&2

IEC 61850-9-2 (SV)

IEC 61850-8-1 (GOOSE) and Precision Time Protocol (PTP)
TECHNICAL CHALLENGES: AVAILABILITY

- Functional Redundancy: Parallel Command Chains (shown before)

- Network Redundancy: How to protect against network failures?
  - PRP for seamless redundancy
TECHNICAL CHALLENGES

-Time Synchronization: Sub-Microsecond
  - Merging units need to be synchronized
  - Additional synchronization between merging and protection units
  - PTP Power Profile (IEC 61850-9-3)
  - PTP needs to be compatible for all devices

-Bandwidth
  - GB-Ethernet needed! (4kHz sampling rate)
  - Testing doubles the bandwidth consumption
CONCLUSION

• DSAS Pilot in live 300kV substation
  – Evaluate multiple combinations of CIT/NCIT technology with various vendors
  – Experience achievable advantages through DS / process bus
  – Realize pilot within one year

• Technical Challenges
  – Time Synchronization: PTP
  – Availability
    • Network redundancy with PRP
    • Redundant command chains
  – Bandwidth
    • Gigabit-Ethernet needed
    • Using VLANs for Process Bus / GOOSE
  – Vendor Lock-In MU/NCIT
  – Cybersecurity
  – Testing
Thank you for your attention!