Movement to the full Digital Substation

Ravindranauth Ramlachan

CIGRE

10/22/2013
Why Digital - Wiring, wiring, wiring……

• Safety issues – equipment isolation, touch and step potentials, EMC
• Copper – raw material cost has increased 400% in 10 years
• Material cost – cubicle wiring and test costs, labour cost per wire end termination
• Schematic design - verification cost, excessive on-site work content
• Civil work costs – trays, troughing, cable access/egress…
• Maintainability cost
What is a Digital Substation?

**Digital substations** are those which have embedded processing intelligence in order to implement part of their operational duties, and as such typically exceed the capability of their analogue predecessors. The intelligence adds:

- Ease of use
- Asset management
- Modularity
- Vendor interoperability
- Real time awareness

*Realized by digitizing the data related to the primary process at the point where it is measured*
The Digital Substation – Architect Levels

- CIT & NCIT
- CTs and VTs
- Analogue and Digital Merging Units
- Protection Relays
- Phasor Data Concentration
- Station Bus
- Wide Area Control
- Process Bus
- Condition Monitoring Units
- Primary Equipment With Embedded Digital Sensors
- Bay Computers
- Grid Control Rooms
- Advanced Substation Situation Awareness HMI
- Station Control

Presentation title - 24/10/2013 – P 4
Key Drivers

**Improved Safety**
- Eliminate open circuit CTs

**Asset Optimisation**
- Intelligent monitoring of equipment

**Reduced Maintenance Cost**
- Condition-based maintenance

**Optimisation of New Investments**

**Increased Reliability and Availability**
- extensive self-diagnosis capability, redundancy

---

**Why install a digital substation?**

“Not only does it optimise overall lifecycle costs, it is easier to use. Asset managers now have a vital tool that, with less wiring and fewer commissioning tests, accommodates preventive maintenance and can extend transformer and switchgear lifetime. Digital substations are modular, so they can be tailored to system needs and open to third-party devices. It is easy to retrofit protection and control schemes with minimal outage constraints. Ultimately, operators manage a smarter grid, with better, more complete real-time situational awareness, making the system more available and secure.”
Key Drivers

Standardisation and Interoperability
-Multi Vendor

Ease of Refurbishment
-Refurbish with minimum primary outage

Improved communication capability
-Data available to all levels

Environmental Responsibility
-Wiring is reduced by typically 80%.

Why install a digital substation?
“Not only does it optimise overall lifecycle costs, it is easier to use. Asset managers now have a vital tool that, with less wiring and fewer commissioning tests, accommodates preventive maintenance and can extend transformer and switchgear lifetime. Digital substations are modular, so they can be tailored to system needs and open to third-party devices. It is easy to retrofit protection and control schemes with minimal outage constraints. Ultimately, operators manage a smarter grid, with better, more complete real-time situational awareness, making the system more available and secure.”
Technology Enablers and Standards

- Ethernet (typically 100Mbit/s, moving towards 1Gb)

- IEC 61850
  - IEC 61850-8-1 and GOOSE Service
  - IEC 61850-9-2LE for Sample Values

- IEC 62439-3
  - PRP for redundant star architecture
  - HSR for redundant ring architecture

- IEEE C37.118 – phasor measurement

- Precision time synchronising (µs)
  - GPS (1pps)
  - IEEE 1588

- Non Conventional CTs (NCIT) & Merging Units (MU)

- Cyber security
What does IEC 61850 solve?

- Control Centre
- Gateway
- HMI, Station controller

Vendor specific protocols like LON, MVB, SPA, Profibus, FIP, DNP3.0, Modbus etc

Serial communications

Bay Controller
Relay X1
Relay X2

Hardwired with parallel Cu wires

Conventional Switchgear
Conventional CT / VT's

Conventional Switchgear
Conventional CT / VT's
What does IEC 61850 solve?

Control Centre

Router

HMI, Station controller

Ethernet communications

Bay Controller

Relay X1

Relay X2

Intelligent Switchgear

Non conventional CT/VT

Process Bus

Station Bus

Relay X2

Relay X1

Non conventional CT/VT

Intelligent Switchgear
The Digital Substation

Enablers
- Ethernet
- Redundancy
- 61850
  - Station Bus
  - Process Bus
- Precision Timing
- NCIT/MU
- Cyber Security

Presentation title - 24/10/2013 – P 10
© ALSTOM 2013. All rights reserved. Information contained in this document is indicative only. No representation or warranty is given or should be relied on that it is complete or correct or will apply to any particular project. This will depend on the technical and commercial circumstances. It is provided without liability and is subject to change without notice. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.
NCIT Advantages

• **Cost Savings** *(particularly at voltages above 200kV)*
  - Compact and lightweight primary current and voltage transformers
  - Space-efficient, easily transportable

• **Digital Standard IEC 61850-9.2 - Interoperability**
  - Interoperability between conventional CT/VTs, other vendors supporting IEC 61850-9.2, and test equipment
  - Ease of integration in the Total Digital Substation.

• **Safety - Reliability - Availability**
  - No explosion risk
  - No wired cross-site CT connection

• **Measurement Improvement**
  - No saturation, no ferroresonance, accurate transient response
  - High bandwidth: Wide dynamic range for Protection short circuits, whilst retaining accuracy for low-current Measurement

• **Exploitation Ease**
  - Ethernet distribution of sampled analogue values to multiple devices
  - Ease of extension or modification without affecting physical wiring
  - Measurement class accuracy and Protection dynamic range
Digital Substation Challenges

• Redundancy
  • Extends to communication network
  • Same considerations as with “traditional” substation

• Testing
  • How to isolate and test

• Precision Timing
  • Common time source needed
Architecture Redundancy Considerations

- There are numerous ways to increase the reliability and availability of a digital substation through redundancy
  - Redundant sensors
  - Redundant IEDs
  - Redundant networks
SV considerations – isolation and testing

• Set IED into ‘Simulation’ mode

• IED processes SV frames with Test/Simulation indication set
  – Does not operate IED trip outputs
Merging Unit considerations – SV delays

• Different delay in samples from different MUs – could be from different vendors
Merging Unit considerations – SV delays

• Need each MU to be accurately synchronized
  – 1 PPS, IEEE 1588 PTP

• IED processes global/local synchronization indication for SV received
  – Adapts protection functions – e.g. inhibits current differential
  – Alarms on loss of synchronization

• IED should align SV according to maximum time delay between subscribed Merging Units
Pilot Projects

ENDESA substation:
SE Llobregat
145kV
Pilot Project – ENERGIENET, Denmark

ENERGIENET: Denmark – Full digital solution
6 Underground 420 kV Cables differential monitoring

- x6 OHL
- 420kV
- 3000A
- RF 1.2

- NXMU 's
  - In : 3 currents
  - Out : 2x 61850 9 - 2LE

- Cable 1 - 420kV
  - 1500A - RF 2
  - > 20km

- Diff 1
  - 9 - 2LE

AIS scope:
- 72 COSI CT420
- 24 COSI NXMU

SAS scope:
- 24 P546
- 12 P594
The Digital Substation: Conclusion

• The Digital Substation requires:
  - A common, coherent solution integrated using modern communication architectures
  - An optimized solution for customers, with reduced costs of ownership and higher performance

• This is supported by the application of IEC 61850 within the substation:
  - Digitization of data at source
  - Implementation of “real-time” communications
  - Integration of all control, measurement, protection and monitoring functions
  - Test features