Digitalization
What it means, and impact on utilities
What do we mean by Digitalization?

Exploiting the benefits of digital protection, control and communication technologies.
## Digital transmission - standardization vs benefits

<table>
<thead>
<tr>
<th>Transmission grid</th>
<th>Standards area</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 3</td>
<td>Condition monitoring</td>
<td>Interoperability</td>
</tr>
<tr>
<td>Grid management and control</td>
<td>Data and communications security</td>
<td>Improved asset management</td>
</tr>
<tr>
<td>Layer 2</td>
<td>Teleprotection and telecontrol</td>
<td>Increased grid stability</td>
</tr>
<tr>
<td>Automation and communication</td>
<td>Station bus</td>
<td>Backwards compatibility</td>
</tr>
<tr>
<td>Layer 1</td>
<td>Process bus</td>
<td>Cyber security</td>
</tr>
<tr>
<td>Power technology</td>
<td></td>
<td>Future proof</td>
</tr>
</tbody>
</table>

Convergence of international standards for power utility automation unlocks benefits in all layers of the grid.
## Distribution grid automation – tech vs applications

<table>
<thead>
<tr>
<th>Distribution grid</th>
<th>Technology area</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 3</td>
<td>Integrated IT/OT solutions</td>
<td>Management of unplanned outages</td>
</tr>
<tr>
<td>Grid management and control</td>
<td>Communications</td>
<td>Storm outage restoration</td>
</tr>
<tr>
<td>Layer 2</td>
<td>Monitoring and control</td>
<td>Management of planned outages</td>
</tr>
<tr>
<td>Automation and communication</td>
<td>Intelligent Electronic Devices (IEDs)</td>
<td>Power flow management</td>
</tr>
<tr>
<td>Layer 1</td>
<td>Distributed energy resources</td>
<td>Predictive operation within grid constraints</td>
</tr>
<tr>
<td>Power technology</td>
<td>Medium voltage equipment</td>
<td>Volt/VAr management</td>
</tr>
<tr>
<td></td>
<td>Low voltage equipment</td>
<td></td>
</tr>
</tbody>
</table>

Revolution in distribution communication technologies and power of microprocessor based protection and control devices underpins distribution automation.
Digital Substations
Agenda

What is a digital substation?
Benefits of digital substations
The ABB offering for digital substations
Project references
New challenges for utilities and suppliers

Substation automation challenges

- Increasing demand on refurbishment of substations
- Project execution under increasing cost and time pressure
- Better utilization of existing assets
- Increased expectations on transmission system availability
- Safeguard investment over the entire life cycle
- Sustainability in the qualification of operators and suppliers

Digital substations respond to today’s utility challenges
Substation evolution

<table>
<thead>
<tr>
<th>Network Level</th>
<th>Station Level</th>
<th>Bay Level</th>
<th>Process Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Management</td>
<td>Serial Communication</td>
<td>Copper Cables</td>
<td>Conventional marshaling cubicle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Conventional AIS bay</td>
</tr>
<tr>
<td>Network Management</td>
<td>Ethernet Communication</td>
<td>IEC 61850</td>
<td>Conventional marshaling cubicle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Process interface units in digital marshaling cubicle</td>
</tr>
<tr>
<td>Network Management</td>
<td>MPLS-TP</td>
<td>IEC 61850</td>
<td>DCB with FOCs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
What is a digital substation
Comparison of conventional and digital

Conventional substation

Digital substation

Digital substations reduce cabling, need less space and increase safety.
What is a digital substation

Building blocks

- Substation automation protection and control system with IEC 61850 station bus
- Advanced system and equipment supervision for efficient asset management
- Non-conventional instrument transformers increase safety and reduce footprint
- IEC 61850 process bus, connecting the switchyard to the protection and control system
- Stand-alone merging units, bridging the gap between analog and digital world. Compliant to IEC 61850

IEC 61850 process bus, connecting the switchyard to the protection and control system
Agenda

What is a digital substation?

Benefits of digital substations

The ABB offering for digital substations

Project references
Benefits of digital substations

Overview

Conventional substation

Digital substation

Up to 80% copper cable reduction*

Up to 60% less space in the relay house

Up to 50% reduction of space in the switchyard*

30t less material transports*

40% shorter installation phase

Operational cost reduction

50% outage time reduction

* Based on a typical conventional 400kV double busbar AIS substation compared to a modern variant using SAM600 process bus I/O system and FOCS integrated in disconnecting circuit breakers.
Benefits of digital substations
Less copper

Reduction in copper cables by up to 80%*

- By replacing copper cables between switchyard and relay house by fiber optics
- By replacing horizontal wiring between protection and control IEDs with IEC 61850
- By reducing number of connections between primary apparatus and redundant process interfaces modules
- Copper cables remain for power supply and short connections between primary apparatus and marshalling kiosks in the switchyard.

Point to point copper connections get replaced with fiber optics

* in transmission level AIS substations
Benefits of digital substations
Less transport

30 tons less material

- More than 30 tons material can be saved for an average sized transmission level substation with 7 feeders
- The weight of the fiber optic cabling is around 90% less than the copper cables it replaces
- By using optical instead of conventional CTs almost 80% weight reduction on CTs is achieved

Less transport, less CO₂, less heavy lifting equipment used
Benefits of digital substations
Space reduction

Space requirement reduced by half

30 to 60% reduced space for protection and control panels
- Same number of IEDs require less space due to absence of conventional IOs
- Higher integration of control and protection functionality allows for further space reduction

Reduction of switchyard footprint by up to 50%
- By using circuit breakers with integrated disconnecting functionality and optical current transformers

High function integration in relay room and switchyard enable space reduction

Up to 60% less space in the relay house
Up to 50% reduction of space in the switchyard
Benefits of digital substations
Less installation and outage time

Shorter time for secondary system installation and refurbishment

40% reduction of installation time for new protection and control systems.
- Fewer panels to install
- Fewer cables to be pulled, connected and tested

Reduction of feeder outage time by 40 to 50% during secondary system upgrades
- Full system test from process IO to protection, control and scada system off-site
- Installation of new FO based system while station is in service

Shorter outage times increase utility revenues
Benefits of digital substations
Operational cost reduction

Savings in maintenance and future retrofits

- Efficient maintenance
  - Supervision of all exchanged data, reduces the need for periodic maintenance testing
  - Permanent supervision enables fast and precise actions in case of failures

- Fast and save testing
  - IEC 61850 testing and simulation features enable fast and save isolation and testing of protection functions

- Standard compliance enables efficient future retrofits of secondary system

Lower operational costs thanks to supervision and standards
**Benefits of digital substations**

**Installation and operation phase**

### Installation phase

- **Standardized and factory-tested panels**
  Building blocks, e.g. analog and binary IO kiosks

- **Late customization, even after project delivery**
  All communication digital based on IEC 61850

- **Material reduction**
  Less P&C panels, cabling & cable engineering. Less CT/VT cores, space reduction

- **Outage time reduction**
  Faster installation through pre-tested process bus systems

### Operational phase

- **Increased safety**
  Digitizing all signals right at their source reduces the risk of electrical hazards

- **Effective maintenance**
  More supervision → knowing better what & where equipment failed

- **Easier maintenance**
  Upgrading equipment with less need for outages

- **Standardized process interface**
  Fast replacement process and bay electronics during primary equipment lifetime
Agenda

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Benefits of digital substations
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Project references
Digital Transmission portfolio and architecture

Network Management & Control
- SDM600 Security & Data management
- Asset management
- Network Control Center
- PSGuard WAMS

Station Level
- AFF66x Firewall
- IEC 61850 / Station bus
- SDM600 Security & data management Workstation
- MicroSCADA SYS600C Computer HMI
- AFR677 Router
- SYS600C Gateway
- IEC 61850 / Station bus

Bay Level
- AFS67x Ethernet Switch
- Relion 670/650 Bay control
- Relion 670/650 Protection
- REB5xx Busbar protection
- IEC 61850 / Process bus

Process Level
- SAM 600 Process bus I/O system
- FOCS Merging unit
- SAM 600 Process bus I/O system
- CP-MU Merging unit for NCITs
- IEC 61850 / Process bus

Communication Networks
- FOX615 Multiplexer
- NSD570 Teleprotection

System Engineering Software Tools
- IET600
- PCM600
- ITT600

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The ABB offering for digital substations

Station level

MicroSCADA Pro
- Monitoring and control of all kinds of substations for any voltage level. From local and remote.

SDM600
- Substation data manager for service and security data across substations

RTU500 series
- Flexible and modular RTU to adopt to a variety of electrical and process automation applications
The ABB offering for digital substations
Utility communication

- **FOX615**
  - Perfect combination of traditional TDM technology and sophisticated Ethernet/IP features

- **NSD570**
  - For the transmission of protection commands over all kind of communication media.
  - Support for IEC 61850 GOOSE

- **Asset Health Center**
  - Predictive analytics software designed for utilities
The ABB offering for digital substations

UniGear Digital

Digital MV switchgears

- Non-conventional current and voltage sensors that increase safety and reduce footprint
- Horizontal exchange of GOOSE and IEC 61850-9-2 sampled analog values reduces wiring and accelerates testing and commissioning time
- UniGear Digital features 615 and 620 series feeder protection and control IEDs
The ABB offering for digital substations

Relion® family protection and control IEDs

- 670 series protection and control IEDs with IEC 61850-9-2LE process bus for any application

- REB500 distributed busbar protection system supports IEC 61850-9-2LE
The ABB offering for digital substations
NCITs* for GIS

ELK-CP3, ELK-CP14 NCITs for GIS
- Redundant, combined current and voltage sensors for gas insulated switchgear (Rogowski coils, capacitive dividers)
- Metering, protection and control accuracy in a single device
- World’s first IEC 61850-9-2LE-compliant, UCA-certified merging unit
- From 175 to 550 kV

*NCITs: Non-conventional instrument transformers
The ABB offering for digital substations
NCITs for AIS

- FOCS-FS, free standing optical CT
  - Filled with N₂ instead of SF₆ it is safe and environmentally friendly

- DCB with FOCS
  - Disconnecting circuit breaker with integrated optical CT for maximum space reduction
The ABB offering for digital substations
SAM600 process bus IO system

Modular IO system
- One hardware module per primary object
  - Conventional current or voltage transformers
  - Time synchronization
- Modules are chained into a system to optimally adapt to different applications

Compact, optimized form factor
- DIN-rail mountable for fast installation and replacement

Termination of primary cabling on SAM600 module
- One module terminates all process and auxiliary signals (e.g. VT fuse failure)
The ABB offering for digital substations
PASS with motordrive

PASS (Plug and Switch System) with Motor Drive™ 1.4

- Digitally controlled motordrive for CB operation
- Drastical reduction of moving party enables highest reliability
- Local control of all switching objects in PASS
- IEC 61850 interface for integration in protection and control system
The ABB offering for digital substations
Primary equipment monitoring

MSM modular switchgear monitoring
- Continuous monitoring of SF$_6$ density
- Trending of SF$_6$ density
- Forecasting of Time to Alarm
- IEC 61850 interface

CoreTec™ Transformer monitoring
- Advanced monitoring of power transformers
- Predictive functions enable plannable, condition based maintenance
- IEC 61850 interface
The ABB offering for digital substations
SDM600 System data manager

The comprehensive software solution for automatic management of service and cyber security relevant data across your substations

- Disturbance recorder handling
- Cyber security management
- Maintenance and service data management

SDM600 sets new marks in ease of configuration and visualization of data
Asset Health Center
Predictive analytics software designed for utilities

Leverages ABB’s substantial, industry-leading expertise in electrical equipment manufacturing and service to programmatically...

- Consolidate information from a variety of sources
- Determine current condition of electrical assets
- Identify problems using a variety of methods (trending, thresholds, rate of change, statistical correlation and probabilistic theory)
- Provide recommendations for corrective action
- Prioritize actions across the fleet and aid in creation of Work Requests
Agenda

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Digital Substations
Bridging the gap between analog and digital technologies

Bridging the gap with digitalized technology solutions

+10,000
IEC 61850
Substation Automation
Systems installed worldwide

+15
IEC 61860-9-2
Digital Substation projects in 2015

Worlds 1st
IEC 61850 Edition 2
Conformance tested
system and device engineering tools

Process Bus developments
Stand alone merging unit (SAM600) process bus IO systems enabling efficient upgrades and retrofitting
ABB’s experience with IEC 61850-9-2 process bus
Project highlights

Pilot installation
Braemar, AU
GIS NCIT, 670series

Pilot installation
SvK, SE
DCB with FOCS, 670series

Pilot installation
Nehden, DE
3rd party NCIT, REB500

Real installation
Millmerran, AU
GIS NCIT, 670series, REB500

Pilot installation
Vattenfall, SE
AIS 3rd party NCIT, 670, 630, 615series

Pilot installation
TW
SAM600, 670series, 3rd party

Real installation
UK
SAM600, FOCS 670series, 3rd party


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

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

Pilot installation
CH
GIS NCIT, 670series, 3rd party

Real installation
Braemar, AU*
GIS NCIT, 670series, REB500

Real installation
Vattenfall, SE
AIS 3rd party NCIT, 670, 630, 615series

Pilot installation
UK
SAM600, 670series, 3rd party

Pilot installations
CN
DCB with FOCS 3rd party

Pilot installation
US
DTB with FOCS, SAM600, 670 series

Pilot projects are installations to verify technology and compare to traditional systems
Real projects are installations without traditional backup
NCITs and process bus - Australia
NCITs for gas insulated switchgear

Real-life NCIT experience

350 pcs CP-type sensors for current and voltage measurement, installed in 6 substations of Powerlink Queensland in Australia
In continuous operation since more than 15 years (with a proprietary communication system)

- Not one of the installed primary sensors has failed
- Experience data predict MTBF* of secondary converters close to 300 years

Customer:
Powerlink Queensland - Australia

Year of commissioning:
1999-2001

Voltage level:
275kV and 325kV

*MTBF: mean time between failures
IEC 61850-9-2 process bus and NCITs - Switzerland
First NCIT and process bus installation

Since 6+ years in continuous operation

NCIT and IEC 61850-9-2 pilot installation
- ELK-CP3 NCIT for current and voltage
- REL670 line, REB500 busbar protection
- E880 revenue meters from L+G

- Simple commissioning thanks to in-built supervision features of used products
- System in permanent and stable operation since 2009
- Protection performance is same as conventional system
- Measuring accuracy meets expected class 0.2s

Customer:
EGL, Swissgrid - Switzerland

Year of commissioning:
2009

Voltage level:
400kV
IEC 61850-9-2 process bus and NCITs - Sweden
FOCS with disconnecting circuit breaker

Fiber optic current sensor FOCS

Project description
NCIT and IEC 61850-9-2 pilot installation with optical CT, integrated in disconnecting circuit breaker and REL670 line protection
Installed in parallel to conventional system to assess performance and long-term behavior

Pilot experience
FOCS (optical CT) measurements meets expected accuracy
Protection is running stable and meeting performance requirements
Followed by official release of life tank breaker with integrated optical CT

Customer:
Svenska kraftnät - Sweden
Year of commissioning:
2010
Voltage level:
400kV
IEC 61850-9-2 process bus and NCITs - Australia
Full substation with NCITs and process bus

Retrofit of NCIT substation

Customer’s needs
Secondary system upgrade of existing substation with ABB NCITs, protection and control with proprietary process bus
Future proof, fully IEC 61850 compliant

ABB’s response
Upgrade to IEC 61850-9-2 compliant system by keeping primary equipment and sensors
Conformance tested CP-MU merging units, Relion 670 series and REB500 protection IEDs

Customer’s benefits
Latest generation, IEC 61850 compliant protection, control and SA system
Minimum outage times during commissioning

Customer:
Powerlink Queensland - Australia

Year of commissioning:
first SS in 2011

Voltage level:
275kV
IEC 61850-9-2 process bus and NCITs - Germany
Pilot project with 3rd party NCIT

Busbar protection with conventional and digital bays

Project description
- 3rd party optical CT with IEC 61850-9-2 and REB500 busbar protection system, installed in Amprion’s Nehden intelligent substation project
- REB500 system consists of 6 conventional and 1 bay unit with IEC 61850-9-2

Pilot experience
- REB500 system runs stable since commissioning
- Combination of conventional and process bus enabled bay units demonstrates usability of REB500 in modern substation extensions and retrofits

Customer:
Amprion, Germany

Year of commissioning:
2012
IEC 61850-9-2 process bus and NCITs - Switzerland
Pilot project with NCIT

GIS NCITs with protection and metering

Project description

- 220kV GIS substation with
- ELK-CP14 NCIT with redundant measurement of U&I and CP-MU merging unit with IEC 61850-9-2 connected to REL670 distance protection and 3rd party protection IED
- L+G revenue meters with 9-2 and conventional inputs

Pilot experience

- Initial challenges with NCIT calibration could be solved on site, during operation
- Stable operation since commissioning

Customer:
BKW, Switzerland

Year of commissioning:
2012
IEC 61850 Process bus – Brazil, Paraguay
500kV/220/66kV substations

Process bus for binary values

Project description

- 500kV/220/66kV AIS substations
- 46 Relion series IEDs installed in the switchyard as process interface units
- GOOSE for communication to bay level IEDs
- MMS reporting of events and alarms from primary apparatus

Pilot experience

- System up and running since commissioning
- Temperature measured in the outdoor cubicles stays within the acceptable range for the installed electronics

Customer:
Itaipu Villa Hayes, Brasil, Paraguay

Year of commissioning:
2013
IEC 61850-9-2 process bus and NCITs - Switzerland
Pilot project with NCIT

GIS NCITs with protection and metering

Project description
- 400kV GIS substation with
- ELK-CP14 NCIT with redundant measurement of U&I and CP-MU merging unit with IEC 61850-9-2
- REL670 distance protection, RED670 differential protection, REC670 control IED
- Line differential protection with 3 line ends (local end with NCITs, the remote ends with conventional CTs)
- L+G revenue meters with 9-2 and conventional inputs

Pilot experience
- Commissioning of NCIT and protection completed

Customer:
NG, United Kingdom

Year of commissioning:
2015
IEC 61850-9-2 process bus with SAM600
Stand-alone merging units in existing substation

SAM600 modular IO system distributed in existing panels

Project description

- SAM600 installation in existing 161kV substation
- RET670 and 3rd party protection IED with IEC 61850-9-2 process bus
- Verification of correct operation compared to traditional installation

Pilot experience

Equipment installed and successfully commissioned in January 2015

Year of commissioning: 2015
Voltage level: 161kV
IEC 61850-9-2 process bus and NCITs - UK
Wishaw 275 kilovolt (kV) substation

SAM600 modular IO system distributed in existing panels

Customer’s need

- Demonstrate interoperability in a multi-vendor IEC61850 digital substation, with optical CTs, protection, control & phasor measurements
- Expert partner to develop the FITNESS project (Future Intelligent Transmission Network Substation)

ABB’s response

Process bus system with:

- FOCS optical CT
- SAM600 process interface units
- 670 series protection IEDs

Customer’s benefits

- Expectation: 10 percent saving in overall substation costs; footprint reduction of around 15 percent

Customer: Scottish Power Energy Networks (SPEN)
Year of commissioning: 2017
ABB’s experience in NCITs and process bus

Various

- ABB’s CP-MUP merging unit was the first to be UCA conformance tested by an independent accredited test lab.
- Verification and validation of IEC 61850-9-2LE protection and control IEDs as well as merging units at ABB’s UCA certified System Verification Center.
- ABB protection IEDs have been used for IEC 61850-9-2LE simulation testing by test equipment manufacturers, like Omicron and RTDS Technologies.
- Various testing activities at ABB’s and customers laboratories.
- …
Digital substations
ABB is bridging the gap between analog and digital

http://www.abb.com/digitalsubstations
Power and productivity for a better world™