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ABB Digital Substation

Digital Substation, bridging the gap between analogue and digital technologies.

Claudio Marchetti, Power Grids, Global Product Manager
INTRODUCTION:

• ABB Digital substations are synchronizing technologies for reliable power.
• Bridging the gap between analogue and digital technologies brings unseen.
• Opportunities for modern utilities. Built on the international standard IEC 61850.
• ABB’s world-leading digital substations achieve new heights in reliability.
• Interoperability and real-time performance. We protect investments while stepping up to meet the challenges of tomorrow.

COURSE OBJECTIVES:

• Introduce digital substation concept and its components and benefits.
COURSE CONTENT

• Introduction and context
• Rational for Digital Substation
• Digital Substation Concept
• Digital substations for Transmission and for Distribution applications
• Non-conventional instrument transformers
• Solutions for retrofit
• Monitoring and Diagnostics
• Long term field experience
• Customer values
• Summary
Introduction
Current challenges and changes facing utilities

Aging infrastructure
Nearly 70% of the transformers in the US are more than 25 years old.¹

Reliability
There is increasing pressure to continually improve reliability and customer satisfaction.

Need for improved customer engagement
Customers expectations of “engagement” are changing. 25 billion devices (not counting smartphones, tablets or computers) will be connected to the IoT by 2020.³

Business model disruption
By 2020 non-utility players will seize 20% of the energy retail market. 2.5 GW of electricity will be generated by 20% of Fortune 500 companies, who will wholesale their distributed energy resource excess power through utility-independent subsidiaries.⁴

Transitioning workforce
40% of the workforce at America’s electric and natural gas utilities will be eligible for retirement in the next five years.⁶

Renewables penetration
Global renewables capacity has increased by 8-10% y-o-y since 2010, and the trend will continue with over 150GW added annually (2/3 of all capacity addition).

Spending justification
Continued revenue challenges and regulatory inspection will drive Totex focus and cost constraints.

Cyber security
Attacks on critical infrastructure are increasing in terms of regularity and sophistication. Through 2018, 50% of IoT device manufacturers will not be able to address threats from weak authentication practices.⁷

Grid of the Future

Rapid rate of change and requires higher velocity of decision making

The world of energy is changing

Supply
- Dramatic renewables growth
- Increasing intermittency
- Greater volatility, less predictability
- More feed-in, take-off points (e.g., data centers and ev-charging)
- Increasing complexity, need for stability On-and off-grid Control
- Automation on “local” level

Demand
- Continuing electrification of society
- Emerging market consumption growth

Control & information flow is key
Utility customers will increasingly have to deal with very dynamic grids

The need for faster decisions and real-time action requires visibility of the entire business

Digitalization is the only answer for the necessary agility and decision-making velocity
**ABB – uniquely positioned and a pioneering technology leader**

Enabling a smarter stronger greener grid

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Continuously breaking records: more power over longer distances (12 GW over 3,000 km)

Digital substation: smart configuration and interoperability, up to 80% less cabling, up to 50% less outages

Transformers: up to 70% less losses GIS³: up to ~100% less greenhouse gases FACTS: more capacity in existing lines

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¹ Flexible Alternating Current Transmission Systems
² Voltage Source Conversion
³ Gas Insulated Switchgear
What is a Digital Substation?
How ABB Ability™ solutions deliver value

What is Digitalization?

**Digitization** Conversion of analog information in any form to digital form with suitable electronic devices so that the information can be processed, stored, and transmitted through digital circuits.

**Digitalization** is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; moving to a digital business.

**ABB Ability™ value proposition – expertise**

Providing **expertise** to our customers conveys clear customer benefit.

Expertise will be the focus of differentiation to position ABB as a high-value provider using a combination of people, products/technology, and digital know-how.

Partnerships will be key
Digital solutions with ABB Ability

Providing an end-to-end solution from the field to the board room

- Field
  - Digital Substations
- Control Room
  - Network Control
- Operations Center
  - Connected Asset Lifecycle Management
- Board Room
  - Energy Portfolio Management

ABB Ability enables the digital transformation of

- Devices
- Grid
- Business processes
- Business strategy

Time horizon

- Milliseconds
- Seconds
- Minutes
- Hours
- Days
- Weeks
- Months
- Years

ABB Ability = ABB’s deep expertise + Digitalization + Best in Class Partner capabilities
Digital substations
The power of data analysis

Industry 4.0 maturity level

Business value

Industry 3.0
Industry 4.0
Development roadmap

Computerisation
Connectivity
Visibility
Transparency
Predictability
Adaptability

What is happening?
“See”

Why it is happening?
“Understand”

What will happen?
“Be prepared”

How to react autonomously?
“Self-optimizing”

Source: Reinhart, Gunther; 2017; Handbuch Industrie 4.0
Substation evolution
From wired to optical communication
Digital Substation and IEC 61850

Conventional

Conventional substations

IEC 61850 Station Bus
Replace wiring and legacy protocols between bays by digital communication

Interface to field
Hardwired point to point connections between primary and all secondary equipment

Thousands of hardwired point-point connections
Digital Substation and IEC 61850

Digital

Digital substations with process bus

- All signals digital on station and process level
- All information available on communication network analog measurements, switchgear status, monitoring data
- Control and protection commands on highly available fiber optics
- Information is acquired ones and distributed on the bus

The process bus reduces cabling and efficiently distributes information
Digital Substation and IEC 61850

IEC 61850 communication services

Client-Server
- Reliable point to point sessions for central monitoring and control
- Commands, reporting, logs, file transfer,…

GOOSE
- Real-time data broadcast for station wide applications e.g. interlocking
- Binary data, indications, commands

Sampled Values (SV)
- Real-time data broadcast for collecting measurements from process
- Sampled analog values
What is a digital substation?

- 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
- Communication system
- 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
ABB Digital Substation solutions
Primary system solutions
Digital substations
Digital technology from end to end

Utility communication on MPLS/TP and existing SDH networks with FOX615

Relay room with process bus based protection

Process bus

FOCS optical CTs: free-standing or integrated in DCB* SAM600 process bus IO to bridge the gap between analog and digital

GIS w. NCIT for U&I Smart local control cubicle with MSM switchgear monitoring

SAM600 to digitize bushing CT measurements CoreTec transformer monitoring with CoreSense

UniGear Digital MV switchgear with NCITs

High Voltage

Medium Voltage

From high voltage to medium voltage, AIS and GIS

Asset and system management

Operator workplace

Cyber security on substation borders, system level and in the electronic devices

Mobile workforce management

SDM600 Data manager

FOXMAN NMS

Asset Health Center

Intelligent substation HMI

SDM600 Data manager

Asset Health Center

SDM600 Data manager

FOXMAN NMS

Asset Health Center

Intelligent substation HMI

Operator workplace

Mobile workforce management

From process to network level

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ABB solutions for digital substations

**Portfolio and architecture**

- Digitization of the signals in the process level
- Communication via IEC 61850
- System-wide engineering via integrated software
- Visualization, system and access control on the field level
- Connection to higher-level network management and asset management solution via MLPS-TP
- Connectivity to Microsoft Azure Cloud

**Communication networks**

- FOX615 Multiplexer
- NSD570 Teleprotection
- IEC 61850
- IEC104, DNP3.0

**System Engineering Software Tools**

- IET600
- PCM60
- ITT600
- System configuration
- Device configuration
- System Testing

**AIS and GIS Primary switchgear (NCIT)**

- FOCS CP3,04,14
ABB solutions for digital substations

Instrument transformers with NCIT (sensors)
Targets of digital solutions
Smaller and saver GIS substations with reduced maintenance

Smart primary equipment

Increased safety through NCITs
- GIS with non-conventional instrument transformers for current and voltage measurement

Optical process bus replaces tons of copper cables
- Smart local control cubicles with IEC 61850 connectivity for smooth integration into substation automation systems

Digital GIS for even more compact substations with high safety and short installation time
**ELK-CP 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
- Available for transmission level GIS since 1997 (initially with proprietary communication)
Targets of digital solutions
Smaller and safer AIS substations

Smart primary equipment FOCS

Increased safety and higher flexibility through NCITs
– Optical current sensors eliminate the risk of open CT circuits and do not know saturation

More compact substations through combination of various functions in one primary apparatus
– Integration of optical CTs in circuit breakers
– Modular and compact mixed technology systems

Standard compliant connectivity
– IEC 61850 on process level

Digital AIS substations can be more compact, are quicker to install and safer to operate
ABB solutions for digital substations
NCITs solutions for GIS

Sensors solutions for HV AIS

Free standing optical CT, FOCS-FS
- Filled with N2 instead of SF6 it is safe and environmentally
- Metering, protection and control accuracy in a single device

Disconnecting circuit breaker (DCB) with FOCS
-Disconnecting circuit breaker with integrated optical CT for maximum space reduction
- Metering, protection and control accuracy in a single device
FOCS sensor and electronics
- Installation of sensor heads on bushings of dead tank breakers, transformers etc.
✔ Redundant
✔ FOCS replaces many CT cores → Less foundations
✔ No iron core → No saturation and linear

FOCS sensor head
FOCS+DCB
FOCS-FS
FOCS electronics
FCB optic fiber integrated to DCB asses with inbuilt redundancy
ABB solutions for digital substations
Modular GIS system with direct IEC 61850 connectivity

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

- Digitally controlled motordrive for CB operation
- Drastically 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
ABB solutions for digital substations
MV switchgear solution

Unigear Digital switchgear solution
- Non-conventional current and voltage sensors
- 615 series IEDs exchange GOOSE and IEC 61850-9-2 sampled voltage values on station bus within the switchgear
- IEDs can act as publisher and receiver of sampled values
- Only voltage values are exchanged

Features
- Lower losses due to sensors
- Faster delivery due to flexibility
- Environmentally friendly
- Smaller foot-print (no extra metering cubicle)
- Easier engineering, less hard wiring
- IEC 61850 standard
ABB solutions for digital substations
Primary equipment monitoring

MSM modular switchgear monitoring

MSM SF₆ monitoring allows users to:
- Early detect SF₆ leakages and thus minimize SF₆ emissions
- Have more time to prepare countermeasures
- Get a detailed report of banked SF₆ in the equipment and simplify preparation of SF₆ balance sheets
- Reduce inspection work and maintenance cost ¹)

SF₆ density

Time

SF₆ stage 1 gas warning

SF₆ stage 2 gas alarm

Early detection of critical leakage rates

How much time do I have?

¹) Reduction of SF₆ leakages and emissions can lead to cost savings and environmental benefits.
ABB solutions for digital substations
Primary equipment monitoring

CoreTec transformer monitoring

- Transformer electronic Control CoreTec
- Monitoring and diagnostics functions
- Cooling control
- Dissolved gas analysis by CoreSense
- Connectivity of CoreTec to IEC61850
- Data Analysis in Asset Health Monitoring to optimize operation and maintenance

CoreSense

Accessories
- Oil Level Indicators
- Temperature Indicators
- Breathers
- Buchholz Relay

Tap Changers
- Oil & Vacuum
- Mechanical and Motor Drives

Intelligent Electronic Devices
CoreSense™ for gas and moisture PD Sensors (Acoustic and Electric)

User Interfaces
- WEB
- Asset Performance Management
- SCADA
- CoreTec™ Intelligent Control
  Monitoring and Diagnostics
  Communication (DNP3 and IEC 61850)
The ABB offering for digital substations
Secondary system solutions
ABB solutions for digital substations
Modular process IO system for new and retrofit installations

SAM600 process bus IO system

Bridging the gap between analog and digital technologies
SAM600 modular process bus IO system is placed in the field to connect conventional equipment to IEC 61850 process bus

SAM600-CT
– Current measurement for protection and metering

SAM600-VT
– Voltage measurement for protection and metering

SAM600-TS
– For time synch and more

SAM600-IO
– Scalable IO for binary signals from disconnectors, earthing switches, breakers, transformers…
SAM600 – ABB’s process bus IO system

Digitizing primary signals made easy

**Modular IO system**

For interfacing primary equipment to IEC 61850 process bus
- Connects to conventional current or voltage transformers
- Provides time synchronization (optional)
- Adapt to different applications types by chaining SAM600 modules into a system

Compact and optimized form factor
- DIN-rail mountable for fast installation and replacement
- Installation in station panel or marshalling kiosks

Termination of primary cabling on SAM600 modules
- Termination of process and auxiliary signals
Enabling digital substation solutions

Benefits

Easy to use
- The module-per-primary object concept allows for intuitive and flexible system design

Unrivalled flexibility
- SAM600 modules fit to any substation layout (double busbar, 1½ breaker, ...)
- Large number of communication ports minimize the need for switches in process bus

Cost saving retrofits
- Modular system enables “non-invasive” retrofit with minimum outage time and step-wise commissioning

Unique modular approach
SAM600 – the digital substation enabler

Application example – transformer feeder
ABB solutions for digital substations
Protection and control for any application

Relion series protection and control IEDs

**650/670 series protection and control IEDs**
- IEC 61850 process bus for all application
- Support of pure digital as well as mixed applications with digital and conventional IO
- Redundant communication on station and process bus
- Precise time synchronization over Ethernet (IEEE1588/IEC 61850-9-3)

**PWC600 Switchsync**
- Controlled switching with process bus connectivity

**REB500 distributed busbar protection**
- For any station size and layout supports IEC 61850-9-2 process bus
Relion® 670 and 650 series
Enabling digital substations

Support for various digital substation architectures

- Up to 6 Ethernet ports that can easily be configured for MUs
- Typical solutions:
  - Station bus is with redundancy PRP
  - Process bus with redundancy HSR
  - Time sync via PTP IEC/IEEE 61850-9-3 (Legacy PPS)
- Connectivity to 3rd party IEDs/sensors/MUs using standardized methods:
  - Communication: IEC 61850-8-1, IEC/UCA 61850-9-2LE
  - Time sync: IEC/IEEE 61850-9-3 (PTP)
  - Redundancy: IEC 62439-3 (link redundancy PRP/HSR)

Easily adaptable to most digital substation topologies
**Relion® 670 and 650 series**

Enabling digital substations

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**Conditional blocking**

With conditional blocking, only dependent functions are blocked instead of everything.

Increased availability by providing protection, control, monitoring as much as possible based on quality of inputs.

In the example here: with loss of NCIT input from one side of the transformer, only dependent functions are blocked (greyed out).

E.g., OC4PTOC.Beh=Blocked

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Increased availability, cost effective
Targets of digital solutions
Intelligent station HMIs

Substation data management

Station level systems and HMIs in digital substations gain on importance, fulfilling functions like
- Substation monitoring and control
- Data management
- Cyber security management
- Primary equipment monitoring
- Secondary equipment management
- Providing data to higher level asset health system

The intelligent station HMI provides better data for efficient operation and maintenance
ABB solutions for digital substations
Station solutions

Station level solutions for any station size

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

RTU500 series
– Flexible and modular RTU to adopt to a variety of electrical and process automation applications

SDM600
– Substation data manager for service and security data across substations. E.g. to:
  • Collect disturbance records
  • Consolidate version information
  • Manage user accounts and receive security events
ABB solutions for digital substations
SDM600 System data manager

See the unseen from a new perspective

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
System Data Manager SDM600
Management of disturbance recorder data

Independent and automatic

- Automatic upload of disturbance recorder (DR) files from IEDs
- Supported protocols: IEC 61850-8 (MMS), FTP, ABB RTU500 and Windows File System access to integrate legacy protocols
- Polling the IEDs for new files
- Seamless integration into existing substation automation system
- Send DR info and Short Report via email
- Visualization of DR Data
- Export DR files to file system for integration into another system
**System Data Manager SDM600**

Central user account management

**Manage your users**

- System wide user management
- Role based access control (RBAC) according IEC 62351-8
- Enforce password policies
- For Relion 670/650 2.1, Windows PCs, MicroSCADA Pro and any RADIUS capable device.
- In accordance with NERC CIP and BDEW whitepaper requirements
System Data Manager SDM600
System wide cyber security event logging

Monitor your system

- Store user activities and other security events from IEDs or system level components
- Integration of any device using Syslog protocol (UDP and TCP)
- Integration of Windows computers (converting Windows Event Logs)
- Categorization of unknown events based on rules
- Built in visualization and reporting
- Integrate SDM600 into an existing event logging system
System Data Manager SDM600
Track service relevant data

Collect and track service data

- Reading service relevant data from supervised Devices
- Tracking configuration versions from IEC 61850 IEDs, Windows PCs, RTU500 and SNMP devices
- Visualization of changes in the dashboard and dedicated event list
System Data Manager SDM600

User interface

When did it happen
Where did it happen
Correlations
User activity and configuration changes
DR Event representation
Targets of digital solutions
Highly available and reliable utility communication

Technology shifts in utility communication

IEC 61850 instead of copper wires for truly digital integration of utility communication equipment
Using the benefits of IEC 61850 to communicate across substations
Move from TDM to packet-switched communication for operational, maintenance and protection data

Utility-grade equipment to ensure the reliable operation of the power grid is required
ABB solutions for digital substations

Utility communication for digital substations

FOX615: fiber optic multiplexer
- Hybrid SDH/MPLS-TP multiplexer with integrated teleprotection functionality and IEC 61850 GOOSE interface

NSD570: teleprotection
- Solution for the transmission of protection commands over all kind of communication media.
- Support for IEC 61850 GOOSE

AFS switch family
- IEC61850 Ethernet family including switch, router and firewall functionality
ABB solutions for digital substations

Revenue meters for digital substations

**Metering with IEC 61850-9-2 process bus**

- **Landis+Gyr E880**
  - Grid meter with IEC 61850-9-2LE connectivity.
  - First installations already back in 2004
  - Proven track record on accuracy with ABB NCITs
  - (See Cigré paper B3-211, Cigré 2014 von Jakob Widmer, Landis+Gyr)

- **Prosoft ARIS EM**
  - Revenue meter capable to handle multiple IEC 61850-9-2LE streams

ABB NCITs provides measurements with 0.2s accuracy class *)
SAM600 provides measurements with accuracy of 0.1%

*) AIS FOCS measurements with 0.1s accuracy class
Concepts and applications

Digital substations
Fully separated station and process bus

- Fully separated station and process bus enables highest availability, performance and security.
- Mission critical data (e.g. SV and goos for trip) is separated from the bulk data on station bus.
- Highest performance on process bus network.
- Clear separation of bulk and protection data enables safe and simple maintenance.
- Separate security zones.

Critical for control “only”

Critical for protection and control

Separate station and process bus

Station bus
- MMS, GOOSE
- PTP (SV of BB voltage)

Process bus
- GOOSE, SV
- PTP

Optional station bus connection for monitoring and health data (MMS)

Station HMI
Gateway
GPS clock

Control
Protection

Merging unit
Switchgear control unit

Bay level IEDs acting as PTP boundary clocks
Digital substations for greenfield and brownfield
Modular process IO system for new and retrofit installations

SAM600 process bus IO system
Bridging the gap between analog and digital technologies
SAM600 modular process bus IO system is placed in the field to connect conventional equipment to IEC 61850 process bus
SAM600-CT
– Current measurement for protection and metering
SAM600-VT
– Voltage measurement for protection and metering
SAM600-TS
– For time synch and more
SAM600-IO (release Q4/17)
– Scalable IO for binary signals from disconnectors, earthing switches, breakers, transformers...
Digital AIS substation
Air insulated switchgear

Station level:
- MicroSCADA Pro station HMI and gateway
- RTU500 series as Gateway, HMI, data collection
- SDM600 Substation data manager
- IET600/ITT600/PCM600 on engineering workstation

Protection and control panels:
- Relion series protection & control IEDs with IEC 61850 station & process bus
- 9-2 revenue meters (e.g. from Landis+Gyr)

Outdoor panels:
- SAM600 process bus IO system
- FOCS opto-electronic modules/merging units

Primary equipment:
- Disconnecting CB with integrated FOCS optical CT
- FOCS-FS, free-standing optical CT
Digital GIS substation
Gas insulated switchgear

**Station level:**
- MicroSCADA Pro station HMI and gateway
- RTU500 series as Gateway, HMI, data collection
- SDM600 Substation data manager
- IET600/ITT600/PCM600 on engineering workstation

**Protection panels:**
- Relion series protection IEDs with IEC 61850 station & process bus
- 9-2 revenue meters (e.g. from Landis+Gyr)

**Integrated local control cubicle (LCC):**
- REC650/670 bay control IED and process interface
- Merging units for NCITs and CITs (where required)
- MSM switchgear monitoring

**Non-conventional instrument transformer:**
- ELK-CP NCITs for current and voltage
Digital GIS/AIS substation

Power transformers

Station level:
MicroSCADA Pro or RTU500 station HMI and gateway, including IEC 61850 data from CoreTec CoreTec Web HMI
Data connection to Asset Health center

Transformer protection and control:
RET670 transformer differential protection with 9-2 (and conventional inputs)
Tap change control in separate IED or integrated in RET670

Outdoor cubicle:
SAM600 stand alone merging units to digitize bushing CT measurements
SAM600-IO for binary data (e.g. tap changer positions and controls)

Monitoring equipment
CoreTec with CoreSens and other sensors...
Testing and maintenance
Engineering and testing of digital substations

Tools overview

Conformance certified configuration tools

Interoperable system design using conformance certified engineering tools.
- IET600 system configuration tool and PCM600 IED configuration tool are IEC 61850 Ed.2 conformance certified

Simple and save testing using easy to use software
- IET600 SA Explorer is an easy to use IEC 61850 testing tool for station and process bus
Testing and maintenance
Impact on protection and control testing

“Wiring” test
Done automatically through self-supervision features of NCITs, MUs and IEDs

Protection and control testing
- “Non-conventional” secondary injection
  - Simulation of IEC 61850-9-2 LE traffic instead of secondary injection
- Test modes to simulate U/I, by
  - NCITs and merging units
- Primary injection
  - Stability and directional tests
- Software based isolation of trip circuits
Efficient analysis of digital data
Testing of binary signals

Hardwired signal exchange

IEC 61850 station bus
Bay level IEDs
Hardwired connections

Testing wire by wire, signal by signal with voltmeter

IEC 61850 GOOSE signal exchange

IEC 61850 process bus
GOOSE

Testing of several signals at the same time
Time measurement between status changes
Recording for offline analysis
Efficient analysis of digital data
Testing of analog measurements

Hardwired CT/VT connections

IEC 61850 station bus
Bay level IEDs
Hardwired connections

Testing requires access to CT and VT circuits

IEC 61850 sampled analog values

IEC 61850 process bus
Sampled values

Collection, display and evaluation of sampled analog values
- Oscilloscope display
- Phasor diagram
- Quality information
- Online and offline analysis
Efficient testing without system down time

IEC61850 Ed2 – Test mode and simulation

Testing procedure

1. Prepare protection IED and Switchgear controller for testing by setting IEC 61850 “Mod” and “Sim” attribute
   • The protection IED shall accept simulated SV and send GOOSE marked as test
   • The switchgear controller shall accept GOOSE marked as test but block its trip outputs
2. Connect test set to Ethernet network
3. Start injection of simulated values from test set
4. Protection IED will initiate a trip with q.test=TRUE
5. XCBR will receive GOOSE but not trip
   XCBR output can be verified through OpOk and tOpOk attributes
Clear information for operators

For efficient operation and maintenance:
- Permanent system supervision of all intelligent electronic devices.
- From communication gateways to MUs and NCIT electronics
- Supervision diagrams for fast overview of the substation health
- Not requiring expert know-how of operation personnel
ABB Ability™ Asset Health Center™
A fleet-wide analytics platform to improve processes through risk-based optimization

Continuous optimization and improvement

All data sources:
- Sensors
- Historian
- Databases
- EAM

Expert models
(ABB, third party)

Statistical models
(Azure Machine Learning)

Connect / collect
Analyze / predict
Inform / prescribe

Advanced operational business intelligence

Enterprise asset and work management

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ABB solutions for digital substations
Operation and maintenance efficiency

Condition instead of time based maintenance

Asset Health Center, part of ABB Connected Asset Lifecycle Management™ leverages ABB’s substantial, industry-leading expertise in electrical equipment manufacturing and service to ...

- Consolidate information from a variety of sources
- Determine current condition of electrical assets
- Predict and enables planning based on risk of failure and operational criticality
- Leverages real-time operations data for improved efficiencies
- Provide recommendations for corrective action
- Improves responsiveness by delivering the right work at the right time to the right people
- Prioritize maintenance and replacement across the fleet and aid in creation of Work Requests

Predictive analytics for efficient asset maintenance and management
Prevented at least one $5M transformer failure in the first year!
Digital Substation benefits
Benefits of digital substations

Overview

Main benefits

- Safety
- Reduced substation footprint
- Interoperability
- Reduces copper cabling
- Ease of configuration
- Maximum reliability and availability
- Real-time performance
- Smart Grid communications capabilities
- Reduces cost of ownership

Digital substations are safer to operate, future proof and require less space
Benefits of digital substations

Less space in switchyard

**Space requirement reduced by half**

Reduction of AIS switchyard footprint by up to 50%
- By using circuit breakers with integrated disconnecting functionality and optical current transformers
- Less material and foundations, reduced installation and engineering effort
- Higher reliability due to less stressed equipment

Reduction of GIS footprint by up to 30%
- By using NCITs for current and voltage
- By integrating LCCs to GIS switchgear

High function integration and NCITs enable space reduction in the switchyard
Benefits of digital substations
Less space required, “One bay one footing” concept

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<td>Reduce needed space with DCB, Disconnecting Circuit Breaker</td>
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<tr>
<td>2</td>
<td>Minimize the footprint even further with integrated optical CT</td>
</tr>
</tbody>
</table>

Disconnector  DCB+FOCS  Conventional current measurement  Disconnector

---

Disconnector  fiber-optic current sensor

Disconnecting circuit breaker
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 required
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

Conventional substation

Digital substation

Up to 80% copper cable reduction

* in transmission level AIS substations
Benefits of digital substations

Less space in relay room

Space requirement reduced by half

- 60% and more reduced space for protection and control panels
  - The IEDs require less space due to absence of conventional IOs
  - Absence of terminals enable integration of more IEDs per panel
  - Integration of more functions in IEDs enables further space reduction

High function integration, smaller IEDs and fewer conventional components enables space reduction

Up to 60% less space in relay room
Benefits of digital substations
Shorter installation time

**Shorter time for secondary system installation**

- 40% reduction of installation time for new protection and control systems.
  - Fewer panels to install
  - Fewer cables to be pulled, connected, tested
  - More testing in the factory means less testing on site

---

Shorter installation time decreases project runtime
**Benefits of digital substations**

Shorter outage time during secondary system retrofits

**Shorter time for secondary system refurbishment**

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
- Flexible placement of new protection panels, without depending on SS cabling

**Shorter outage times increase system availability and 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

Increased safety

Reduced risk of electrical shock

- Handling of current transformer circuits and signaling voltage poses a threat to life and equipment
- Process bus eliminates the galvanic connection between protection and control panels and the switchyard.
- Eliminates CT and VT circuits in the protection & control panels
- Replaces conventional 110/220VDC indications with fiber optics

Eliminates the electrical connection between primary and secondary
ABB reference cases
# Laying the foundations of Digital Substations

**ABB dedicated to technology leadership**

<table>
<thead>
<tr>
<th>1990</th>
<th>2000</th>
<th>2010</th>
<th>2020</th>
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</thead>
<tbody>
<tr>
<td>1992</td>
<td></td>
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<tr>
<td>ABB is awarded the first patents for FOCS technology</td>
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<td>1999</td>
<td></td>
<td>2004</td>
<td>2012</td>
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<tr>
<td>ABB installs iPASS digital substations with NCITs and process bus</td>
<td>2004</td>
<td>ABB installs the first IEC 61850 multivendor substation</td>
<td>IEC 61850 Ed.2 is released</td>
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<tr>
<td>2014</td>
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<tr>
<td>ABB installs the world’s first Asset Health Center for a transmission utility</td>
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<tr>
<td>2017</td>
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<tr>
<td>ABB ships 1'000th UniGear Digital panel</td>
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<tr>
<td>2017</td>
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<tr>
<td>More than 1'000 CoreTec are installed on ABB and 3rd party transformers</td>
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Digital substations

**Highlights, worldwide**

- **UK, 2014**
  - GIS NCIT, 670 series

- **US, 2016**
  - DTB with FOCS, SAM600, 670 series

- **Brasil, 2017**
  - SAM600, 670 series

- **Switzerland 2009**
  - GIS NCIT, 670 series, REB500

- **Switzerland 2011**
  - GIS NCIT, 670 series, 3rd party

- **India, 2017**
  - SAM600, 670, 615 series

- **Poland, 2017**
  - AIS FOCS NCIT, 670 series

- **Germany, 2012**
  - 3rd party NCIT, REB500

- **CN, 2016**
  - (several) DCB with FOCS 3rd party

- **Taiwan, 2014**
  - SAM600, 670 series, 3rd party

- **Taiwan, 2017**
  - SAM600, 670series, 3rd party

- **Australia, 2009**
  - GIS NCIT, 3rd NCIT 670 series

- **Australia, 2011**
  - GIS NCIT, 670 series, REB500

- **Australia, 2017**
  - GIS NCIT, 670 series, 3rd party

- **Australia, 2019**
  - 3 more projects in AU are under execution

- **Laboratory tests**
- **Installations**

* Under execution
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
IEC 61850-9-2 process bus and NCITs – Australia CP Sensors for HV GIS

Full substation with NCITs and process bus, Powerlink Queensland / AU

Voltage level 275kV, Year of commissioning 1999, upgrade in 2011 with 9-2

Customer’s need
- Secondary system upgrade of existing 275kV substation with ABB NCITs, protection and control with proprietary process bus
- Future proof, fully IEC 61850 compliant protection and control system with process bus

ABB’s response
- Upgrade to IEC 61850-9-2 compliant system by keeping primary equipment
- Conformance tested CP-MU merging units, Relion 670 series IEDs, REB500, and PWC600 with IEC 61850-9-2 process bus

Customers benefit
- Latest generation, IEC 61850 compliant protection, control and SA system
- Minimum outage times during commissioning

Switchgear with NCITs in service since 1999!
Digital substations follow the industry trend for better information that enables forward looking decision making.

ABB's digital portfolio ranges from high to medium voltage and process to network level.

Digital substations require less space, are safer to operate and enable reduction of operational expenditures.

### Less space, safer to operate, reduce OPEX

### Complete portfolio

### Improved maintenance planning

### Main benefits

- Safety
- Reduced substation footprint
- Interoperability
- Reduces copper cabling
- Ease of configuration
- Maximum reliability and availability
- Real-time performance
- Smart Grid capabilities
- Reduces cost of ownership

ABB is shaping the digital evolution with first patents and igniting the creation of today’s most used standard in substation automation.