Digital Substations
With the Future built in
Digital substation –
Assignment of the 6 aspects

1. **Digitalization of Station Level**
   - Non-conventional Instrument transformers (LPITs)
   - Provide primary values to the merging units based on new principles

2. **Digitalization of Process Level**
   - Merging Units (MU)
   - Converts analog primary values of the LPITs in digital information (Sampled Measured Values)

3. **Cyber Security**
   - Process Bus
   - Communicates field data to protection and control system based on IEC 61850-9-2

4. **Asset Management**
   - Sensors
   - Provide more information on current status of the electrical equipment

5. **Grid Operation**
   - IoT
   - Value-adding central applications
   - Big data analytics IT/OT integration

6. **Integrated Engineering**
   - Digital Control Room
   - More data acquisition, intelligent decentral applications; cyber security
   - Digital Control Room
   - Digital protection and automation with station bus based on IEC 61850
NCIT’s for GIS

January, 2019
Do you know ...

Non Conventional Instrument Transformers (LPITs) will reduce HV switchgear size by 30%.

You can save cost by reduced wiring.

Non Conventional Instrument Transformers weigh 90% less.

You can achieve higher performance in measurement.

You gain flexibility throughout lifetime to adapt easily to future needs.

Remote maintenance and testing saves cost.
Digital Process Level
Size reduction of 30% and weight -1,500 kg

Inductive Current and Voltage Transformers (conventional)

Current and Voltage Sensors (non-conventional)

Shown: GIS Clean Air 145 kV
Digital Process Level
Summary - Shown: GIS Clean Air 145 kV

Previously

3.2 m

5 m

Copper cabling

Analog values

50 – 250 m

Parallel wiring

Station bus

Protection House

Digital

2.9 m

3.5 m

LPI

Merging Unit

Fibre optic cabling

Ethernet

IEC 61850-9-2

Process bus based on IEC61850-9-2

Protection House
DIGITALIZATION OF PROCESS LEVEL - GIS LPIT
Conventional /Low Power Instrument Transformer Technology

Conventional Instrument Transformer Technology

- Inductive Voltage Transformer (VT)
- Inductive Current Transformer (CT)

Low Power Instrument Transformer (LPIT) Technology

- 1 x Electric Field Probe for Voltage Measurement
- 2 x Rogowski Coils for Current Measurement (redundant)

Cast resin partition with integrated voltage and current sensors

3.2 m
5.5 m
2.9 m
3.7 m
Pilot customers

- Pilot customer
- In operation pilot mode in Verkhouse substation, Finland
  - Hybrid solution (conventional transformers plus LPIT)
  - No “hot” connection to e. g. trip coils
  - Connection to the SCADA system (direct comparison of values and reactions)
Pilot customer, Configuration of Hybrid solution example
LPIT Technology in gas isolated switchgears

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Page 10 January 2019

SIEMENS
Ingenuity for life.
Optical CTs for AIS
Current state of technology – product presentation
Characteristics of optical current transformers - Trench

- **Environmental aspects**
  Environmental friendly insulating system “Clean Air”

- **More compact CT Design**
  Small and light-weight units compared to conventional CT design

- **High-performance measurement behavior**
  Wide dynamic range due to saturation-free measurement principle

- **Improved operational safety**
  Galvanic separation between primary and secondary side

- **Reduced losses**
  No magnetic losses and no ferro-resonance effects

- **Reduced cabling effort**
  Single fiber-optic cable instead of several copper cables with large cross-sections

- **Passive system**
  No electronic components within the optical CT
Proposed installation scheme for new and future projects
New SIPROTEC 5 based MU – coming from 2019 Q3.

- Optical CTs
- IO245 for TOCTs
- Protective relay with process-bus input (SIP5)
- Master clock
- GPS antenna
- Sync transceiver
- Outdoor
- Indoor
- ≥1 km
- Option: Ethernet-Switch (RSG 2288)
- Option: Meter with process bus interface
- Or PTP/IEE1588
- Energy Management | Digital Grid
SIPROTEC 5 Merging Unit –
One base module adapts to all sensor types

Key functions
- Digitalization of all primary data close to the process
- Adapts to all sensors
- Direct tripping of CB
- Trip circuit supervision
- Backup protection functions
- CB wear monitoring
- Adapts to your requirements

### SIPROTEC 5

#### 6MU85

<table>
<thead>
<tr>
<th>6MU85 equipped with</th>
<th>CT</th>
<th>VT</th>
<th>Rogowski Coil</th>
<th>Field Probe, RC-Divider R-Divider</th>
<th>Optical CT</th>
<th>BI</th>
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SIPROTEC 6MU85 planned for Q3 2019
**SIPROTEC 5 Merging Unit 6MU85 – Perfectly tailored fit to your requirements**

### Perfectly tailored fit

- Adoptable to multiple CT, VT, LPIT inputs
- Scalable BI and BO
- Direct “high speed” tripping of circuit breaker <1 ms
- Collection of additional data (temperature, pressure, tap changer positions, …)
- Redundant power supply
- Expendable by a 2nd row

#### SIPROTEC 6MU85 planned for 2019; currently available SIPROTEC 6MU085

<table>
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<th>Single</th>
<th>CT</th>
<th>4 Rogowski</th>
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<tr>
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PCIT … Protection CIT, MCIT … Measurement CIT
Modularity of SIPROTEC 5 Merging Unit 6MU85 supports customized CIT and LPIT core assignments

One MU per CIT core

Redundant MU for all CIT cores

Redundant MU and LPIT cores
DIGITALIZATION FROM PROCES LEVEL TO STATION LEVEL
SIPROTEC 5 based MU’ and SIPRPTTEC 5 protection devices

Conventional Instrument Transformers

SAMU

SIPROTEC 5 Platform
With SMV communication Module

Non Conventional Instrument Transformers

Rogowsky Coil
Field Probe

Air Isolated Switchgears

Gas Isolated Switchgears

Third Party Standard Merging Units

3rd party MU

Proprietary
Interoperable
SIProtec 5 process bus
Benefits using process bus

1. No secondary voltage or current anymore on terminals.
2. No secondary wiring in relay protection or secondary cabinets.
3. More safe substation operation as less maintenance faults.
4. Less maintenance – cheaper to run (reduces OPEX).
5. Less boxes (reduces CAPEX).
Cyber Security needs a holistic approach

People
Awareness and understanding of cyber security

Products
• Support of CIA criteria (Confidentiality, Integrity, Availability)
• Comply with industry standard

Processes
• Covers the whole product life-cycle
• Foster solution and operational requirements
Cyber Security
The Threats are real
Cyber Security
The Threats are Real

Possible Attackers
• Criminal Organizations
• States
• Political activists
• Script Kiddies
• Insiders
• ...
Cyber Security
The Threats are Real

Conditions:
- Critical Infrastructure
- 24 h Operation
- Windows and Linux standard components
- Interfaces to unsecure networks
- Interfaces to office networks
- Legacy components
- Proprietary technology
- Mix of components from different vendors with different technologies
Customer point of view
Cyber Security needs a holistic approach

Are you prepared for Cyber Security?
Cyber Security – Improved system security with certified secure substation framework based on IEC 62443

Siemens Secure Substation framework certified by TÜV SÜD according to
• IEC 62443-2-4 – Integrator processes
• IEC 62443-3-3 – Technical functionalities

Cyber security measures

- Access control and account management
- Security logging and monitoring
- System hardening
- Security patching, Backup and restore
- Malware protection
- Data protection, data integrity and system architecture
- Secure remote access
Asset Management
IoT connectivity to Energy IP
Substation Device Management (SDM)

Benefits
• Transparency of current installed base
• Simplified documentation and reporting
• Efficient Cyber Security patch management
• Enabler for support, field activities asset management
Architecture Overview – Substation Device Management

SDM runs on:

- Siemens Private Cloud
- Enterprise Private Cloud
- On premise

Remote Monitoring and Analysis

Substation Automation & Protection Assets

Advanced Device Management | EnergyIP™ SDM | Connection to SVM DB (CERT) | ...

Monitoring and analysis platform EnergyIP™

Substation Data (Version information)

EnergyIP™ ISDM – Local Collector

Protocols: IEC 61850, SNMP, WMI

Protection relay | Substation PC | RTU | Router/Switch | ...

Long video on the SDM website:
http://www.siemens.com/substation-device-management
Cyber Security EM DG
Products - Keeping the Substation Secure and Up-to-date

Siemens side

- Single point of contact
  - Siemens ProductCERT
  - Central Database

- Security Researchers
  - Pentesters
  - Free-time Hackers
  - IT-Security Contractors

- CERT network
  - US ICS-CERT
  - BSI
  - ...

- 3rd Party Vendors, OSS
  - ...

- 3rd Party Vendors, OSS
  - ...

- Monitoring and Information
  - Monitoring

- Notification

Operator side

- Asset Owner's Patch Management Process
  - Patch qualification/testing/deployment

- Siemens Digital Grid Products
  - R&D
  - Service
  - Sales

- Security Advisories
  - Security Newsletter
  - Service Contract

- Defect Database
EnergyIP™ ISDM – Asset Information

Information delivered by EnergyIP™ ISDM via standard protocols, automatically from supported devices

Main attributes (automatic)
- Component Name
- Serial Number
- Software / Firmware Version
- Ordering-Number (MLFB)
- Vendor Name
- IP-Address
- Hardware Version (if delivered by device)

Additional attributes (manual entry)
- Topology Information (substation / voltage level / bay)
- Expected SW/FW Version
6 | Digitalization of the engineering process
Engineering with SITIPE

Benefits
- Efficient use of typicalls and project data
- A single master data is set for all work steps
- Seamless automatic data exchange between engineering steps
- High degree of data quality
- Reduced time to operation
- Optimized refurbishment by easier updating of documentation and testing

Primary engineering
Primary engineering
Protection settings
Simulation and testing
Data Analytics
Secondary engineering
Secondary engineering
RTU configuration
Test engineering
Test engineering

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Energy Management | Digital Grid
**Future Vision**
- Interface between planning and specification
- Datamodel based specification supported by tools
- Standardized interface between customer and supplier
- Semiautomatic project engineering based on bay templates
- Feeding the engineering deliverables back to the customer

**Integrated Engineering**

**Planning**
- Utility

**Specification**
- Utility

**SITIPE Platform**
- Supplier Engineering Process
- Single line diagram
- Secondary drawings
- Device Configuration
- Test Cases
  - Protection devices configuration
  - RTU configuration
  - HMI configuration
  - Test engineering
  - Asset management

**Traditional Approach**
- Planning and specification completely decoupled
- Book writing
- Exchange of .pdf-s
- Copy/Paste with abundant entering of data
- No link between engineering and operation suite
SITIPE Integrated Configuration

- Circuit Diagrams Engineering
- Protection devices configuration
- RTU configuration
- HMI configuration
- Templates Store
- Project specific data
- IEC 61850 SCL?

- Project specific Protection (SIP5, other IEDs) configuration
- Project specific RTU (PAS/A8000…) configuration
- Project specific HMI configuration
- Project specific test scenarios

SITIPE Integrated Configuration

- Circuit Diagrams Engineering
- Protection devices configuration
- RTU configuration
- HMI configuration
- Templates Store
- Project specific data
- IEC 61850 SCL?
Evolution in Substation Automation –
From Standard Cabling to Digital Substation 4.0

1st generation – Standard cabling
- Mimic board
- Fault recorder
- Protection
- RTU
- Parallel wiring

2nd generation – Point-to-point connections since 1985
- Control Center
- HMI
- Substation controller
- Other bays
- Serial connection

3rd generation – Digital Station Bus since 2004
- Control Center
- HMI
- Substation controller
- Station bus

Digital Substation 4.0 - Process Bus and IoT Connectivity
- Control Center
- Apps and Data Analytics
- IEC 61850
- Process bus
- Station bus
- IoT Interface

IEC 61850
- CT
- VT
- Digital Merging Unit
- Digital and analog Merging Unit

EnergyIP powered by MindSphere

Parallel wiring
Bay...
Bay...
Bay...
Bay...
Bay...
Bay...
Bay...
Station bus

Siemens
Ingenious for life

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Energy Management | Digital Grid
Substation Automation Systems (Today)
Typical Network with IEC 61850 Station without IoT connectivity

Selected amount of Data Objects:
- Status messages (primary Equipment)
- Alarms and faults as group alarms (primary and secondary Equipment)
- Measured values (current, voltage, frequency)

Required amount of Data Objects:
- Status messages (secondary Equipment)
- Alarms and faults also as single messages
- Protection messages (for example general excitation, fault records, fault location)
- Measured values (V, I, Z, Temperature, pressure, etc.)

Big amount of Data Available:
- Measure values (V, I, Z, Temp, etc.), calculated values which include Partial results of protection and automation functions
- Setting parameters
- Detailed protection messages (e.g., phase excitations, loop and direction information) & status messages
Substation Automation Systems (Today’s Future)
Unlocking Full Potential – Digital Substation V4.0 with IoT

IEC 61850
IEC 60870-5-104
SIPROTEC 5, SIPROTEC 4, SIPROTEC Compact
SICAM A8000, SICAM SCC
Q200/Q100
SICAM PAS, SICAM SCC

EnergyIP powered by MindSphere
- Data consolidation and visualization
- Applications, e.g. SIPROTEC Dashboard
- Value-Added services (e.g. data analytics)

IEC 61850, Modbus, IEC 60870-5-103, ...

3rd Party

...
Grid IoT Services
IoT Enablement and Objective

Protection Relays
Automation Devices
Field Devices
Sensors (e.g. Sensformer)
Third Party Devices
Other „Things“

EnergyIP
powered by MindSphere

IoT Platform

“Increasing reliability, efficiency and security in network operation through in-depth data analysis and correlation”

http://demo.gds-energy.siemens.cloud:8081/
Grid IoT Services
Scalable Pilot Offering Benefits – Illustrated Example

Transparency
Improved transparency of network assets through the use of analytics and dashboard views:
- Measured Data Object
- Calculated Data Object
- Controllable Data Objects
- Integer Values, etc.

Understanding
- Improved Maintenance
  - Scheduled Maintenance acc. to ‘Real assets Operation’:
    - Adapted maintenance freq.
    - Less Spare Parts & consumables
    - Less corrective maintenance
    - Etc.

Improving & Increasing Efficiency
- Exploration of new business models
  - Optimization of the Operational & Maintenance Expenses.
  - Better Planning of Capital Expenses

Traditional Operation
Partial transparency of network assets through traditional and limited data:
- Measured Values
- Alarms
- Protection messages
- Etc.

Traditional Maintenance
Scheduled Maintenance Cycles independent of ‘Real Operation’ and Equipment/Devices Conditions:
- Preventive Maintenance freq.
- Corrective Maintenance
- Recurrent Failures
- Etc.

Traditional Business
Increased OpeX costs due to equipment aging and unfavorable Operating Conditions (incl. severe failures)

Making Capital Investment based on ‘Traditional understanding’ of Equipment Lifecycles.
SIPROTEC 5 – DIGITAL TWIN

![Image of SIPROTEC 5 - Digital Twin](image-url)
First release at Hannover Fair 2019

- Training of device handling
- Process Data Simulation (analog and digital values)
- Test of CFC-Logic and customer specific application
- Test of communication
  - to SICAM substation automation systems
  - IEC 61850 GOOSE between devices e.g. interlockings
- Protection Data interface
- To Engineering PC with DIGSI 5
- Fault analysis e.g. replay of records
Contact

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