The Intelligent MV/LV substation an Important Module for Optimizing Distribution Grids
Distribution Networks & Distributed Energy Resources

Drivers in Europe

- Meshed system
- Adaptive protection
- High automation degree
- Bidirectional communication
- Radial system
- Simple protection
- Simple or no automation
- Simple or no communication

Today:
- Unidirectional power flow
- Simple distribution transformer
- 0.4 kV
- 20 kV
- 110 kV

Tomorrow:
- Bidirectional power flow
- Generation/Consumption at LV level
- Energy Storage
- Intelligent meters
- Tap changer distribution transformer
- Generation at MV level
- E-car infrastructure
Distribution Automation / Feeder Automation
From blind spot to full vision

- Improve availability
- Reduce outage time
- Improve Power Quality
- Meet power quality standards

Black: without automation
Blue: three point automation
Red: all stations are automated

![Interruption Graph](chart)

![Power Quality Graph](chart)
Distribution Automation
1. Improve availability

Improve availability

Reduce outage time

<table>
<thead>
<tr>
<th>Interruption(%)</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black: without automation</td>
<td></td>
</tr>
<tr>
<td>Blue: three point automation</td>
<td></td>
</tr>
<tr>
<td>Red: all stations are automated</td>
<td></td>
</tr>
</tbody>
</table>

Black: without automation
Blue: three point automation
Red: all stations are automated
Application of a cable network
Solution for centralized not automated configurations

20kV

1703 Smart IED
Feeder Automation

0.4 kV

SmartGrid
Control Center

SICAM
Substation
Automation

Normally open point
Application of a cable network
Solution for centralized not automated configurations

1. Fault information to Substation in next level switch gear and Control Center
2. Open circuit breaker automatically to de-energize the ring

SIEMENS
Application of a cable network
Solution for centralized not automated configurations

1. Fault information to Substation in next level switch gear and Control Center
2. Open circuit breaker automatically to de-energize the ring
3. Setup time for service crew
Application of a cable network
Solution for centralized not automated configurations

1. Fault information to Substation in next level switch gear and Control Center
2. Open circuit breaker automatically to de-energize the ring
3. Setup time for service crew
4. Due to fault indicator the right station can be found easily
Application of a cable network
Solution for centralized not automated configurations

- **1703 Smart IED**
  - Feeder Automation

- **20kV**
  - **SICAM**
    - Substation Automation

- **0.4 kV**
  - **SmartGrid Control Center**

- **Normally open point**
- **Fault information**
  - to Substation in next level switch gear and Control Center
- **Open circuit breaker**
  - automatically to de-energize the ring
- **Setup time for service crew**
- **Due to fault indicator**
  - the right station can be found easily
- **Open load switches sides on one side of the fault location**
Application of a cable network
Solution for centralized not automated configurations

- Fault information to Substation in next level switch gear and Control Center
- Open circuit breaker automatically to de-energize the ring
- Setup time for service crew
- Due to fault indicator the right station can be found easily
- Open load switches sides on one side of the fault location
- Traveling to Normally Open Point
- Close the Normally Open Point
Application of a cable network
Solution for centralized not automated configurations

1. Fault information to Substation in next level switch gear and Control Center
2. Open circuit breaker automatically to de-energize the ring
3. Setup time for service crew
4. Due to fault indicator the right station can be found easily
5. Open load switches sides on one side of the fault location
6. Traveling to Normally Open Point
7. Close the Normally Open Point
8. Traveling to second side of fault location
9. Open load switches sides on second side
Application of a cable network
Solution for centralized not automated configurations

1. Fault information to Substation in next level switch gear and Control Center
2. Open circuit breaker automatically to de-energize the ring
3. Setup time for service crew
4. Due to fault indicator the right station can be found easily
5. Open load switches sides on one side of the fault location
6. Traveling to Normally Open Point
7. Close the Normally Open Point
8. Traveling to second side of fault location
9. Open load switches sides on second side
10. Control Center Restore services by closing the infeed circuit breaker
Application of a cable network
Self Healing - Service restoration in 4 steps

20kV

SICAM
Substation Automation

Smart IED
Feeder Automation

0.4 kV
Application of a cable network
Self Healing - Service restoration in 4 steps

1. Fault information to Substation in next level switch gear
2. Open circuit breaker automatically to de-energize the ring
Application of a cable network
Self Healing - Service restoration in 4 steps

- Fault information to Substation in next level switchgear
- Open circuit breaker automatically to de-energize the ring
- Open load switches on both sides of the fault location and close at the same time the normal open ring automatically

Fully automated Service Restoration
Application of a cable network
Self Healing- Service restoration in 4 steps

1. Fault information to Substation in next level switch gear
2. Open circuit breaker automatically to de-energize the ring
3. Open load switches on both sides of the fault location and close at the same time the normal open ring automatically
4. Restore services by closing the circuit breakers at ring infeed in less than 3 minutes
Distribution Automation

2. Meet power quality standards

Improve Power Quality

Meet power quality standards

![Diagram showing power quality standards](image)

- $U_{\text{max}} + 10\%$
- 230 V
- $U_{\text{min}} - 10\%$

Time
Distribution Automation
Power Quality

Classical voltage curve of an feeder without decentralized in feed

Distribution Transformer → I → R+jX → R+jX → R+jX → R+jX → Load

Voltage limits

U

+10% U_max

230 V

U_min

-10%

No Overvoltage
Local over voltage depends on size of infeed and network impedance.

Voltage Curve of decentralized infeed and asymmetric loads.
Distribution Automation
New concepts of voltage regulation
Low-Voltage Distribution
Energy-Distribution solution

MV Distribution

Keep voltage limits
Reduce voltage dips
Increase load capacity

Distribution-Network Optimization

DLC Modbus
SICAM CMIC

AMIS Meter
SICAM T
SINVERT Solar

Improved power quality to reduce side effects
Improved load capacity for decentralized power infeed
Postpone costly network upgrades

LV Distribution

Seite 21 August 2012
Intelligent Transformer Substations
Offer Additional Economic Advantages

This offers further economic advantages:

- Increase distribution reliability
- Improve distribution operations and maintenance
- Leverage small decentralized generation
- Handle bidirectional power flow
- Increase distribution power quality
- Leverage of increasing number of e-cars
- Integration of metering data

Siemens → the right component for every task

- Medium-voltage switchgear 8DJH
- Telecontrol system: SICAM mic
- Smart IED: SICAM emic/cmic, 7SC80
- Substation automation/telecontrol node: SICAM PAS
- Sensors and actors with various partners
- Communication: conventionally and WiMAX / BBPL
- Network control system SINAUT PowerCC
- Decentralized energy management DEMS
- Power Quality SIMEAS (MV/LV)
- Electronic Meters AMIS
- Network planning
- Application competence
Thank you for your attention!
Backup Slides
The Intelligent Transformer Substation
“3 Levels of Intelligence”

1. Monitoring
   - Higher availability
   - Faster fault location

2. Telecontrol
   - Minimization of down times
     ("h" $\rightarrow$ "min")

3. Power-flow control
   - Minimization of losses
   - Management of decentralized power supplies

- Transformer
- Low voltage
- MV switchgear
Two possible designs for Intelligent Transformer Substations:

1) RTU integrated in MV-Switchgear
2) RTU in separate “RTU-Box”
Secondary Transformer Substations: The Key Positions in the Network

Functions of SICAM Smart IED resp. AMIS DC

Low-voltage (LV) management

- LV monitoring
- Integration of meter data
- LV cable protection
- Power-quality monitoring
- Reactive power / harmonics compensation
- Transformer regulation on secondary side
- Coordination of infeed and load

Distribution-system management

- Remote control/monitoring of secondary transformer substations
- Automatic restoration of Power-supply
- Data source for MV monitoring
- Coordination of infeed and load
- Communication manager (peer-to-peer)

Components under development

- Existing components
- Components under development

Dezentrale Energieeinspeisung

Seite 27 August 2012 Distribution Automation Siemens AG / IC SG EA PRO
Today's Economical Compromise
“3-Points” Automation as an Interims Step
Communication Situation Today - No Direct Communication Infrastructure

Setup change for communication:
(Pros and Cons for Communication alternatives)

- **Cable / pilot wire**
  - expensive, - time consuming setup

- **GPRS**
  - unbuffered, - 3rd party dependency

- **Tetra-Net**
  - availability, - hierarchical

- **WiMAX**
  - cost optimized, + Networking ability

- **BPLC**
  - cost optimized, + Networking ability

* Broad Band Power Line Communication
Upcoming Communication Systems Introduce New and Cost-Efficient Possibilities

- Spectrum Power CC
- DSCADA/DMS
- Energy Management System
- DEMS
- Fiber Optic Network
- WiMAX
- BPLC*
- SICAM
- Substation Automation
- SICAM PAS
- SICAM CMIC
- SICAM EMIC
- AMIS
- Electronic Meter
- DSCADA/DMS
- Fiber Optic Network

1. Dezentralized Energy Infeed

* Broad Band Power Line Communication

** depending on progress in Working Group 17

1. 0.4 kV
The way for the future: Modbus Communication within the Transformer Substation

**SICAM CMIC**
Compact Micro RTU especially designed for Secondary Substations

**SICAM FCM**
Feeder Condition Monitor with in 8DJH integrated Medium-voltage sensors

Motor Control Unit
The electronic switch controller for 8DJH

FITformer® REG
Transformer with LV Tab changer

**SICAM P50**
Low-Voltage measurements
8DJH – Secondary Distribution Switchgear
for Ring Main Units

- Up to 17.5 kV, 25 kA or 24 kV, 20 kA
- Busbar 630 A, feeders up to 630 A
- Factory assembled, type tested switchgear acc. to IEC 62271-200
- Metal-enclosed
- Single busbar
- Gas-insulated, sealed for life
- Flexible due to extension option and block formation

Individual panels and block versions
FITformer® REG – your sustainable success model for integrating renewable energies

- Range of ratings up to 630 kVA; highest voltage for equipment: 36 kV
- Low-voltage load regulation range in three steps
- Operational characteristics and dimensions correspond to those of common distribution transformers
- Additional setting range on the high-voltage side for optimum operation
Compact mechanical design

Designed for rugged environment conditions:

- Highest EMC (5kV)
- -40 to +70°C
- Integrated UPS (excl. Batteries)
- Add. Voltage outputs for
Monitor for Medium Voltage Distribution Systems
SICAM Feeder Condition Monitor

Use as Short Circuit / Earth Fault Detector with directional information

Condition Monitor
– U / I / P / Q / S / cos φ / f and load flow direction

SICAM FCM

LC-Display for Information and Configuration

3 x I – Phase currents
2 x I – Phase + 1 x I sensitive earth
Inputs Low Power IEC 60044-8 or 1A

3 x U Phase Voltages (230 V; 100V/√3; 3.25V/√3)

Archive
15 Minute Values of all currents
Trailing pointer for 15 min upto 1 Jahr

Communication: Modbus RTU

Power Supply: 24-60VDC /230VAC
integrated Battery for ~20 Years
Environmental condition: -30°...+85° C
Current Solutions For Intelligent Transformer Substations

Integrated RTU:
1. SICAM EMIC
2. Lead gel battery
3. Power-supply unit for battery
4. MCB
5. Modem
Current Solutions For Intelligent Transformer Substations

Separate RTU box:
1 SICAM EMIC
2 Wireless modem
3 UPS with Power-supply unit + battery
4 MCB
5 Local-remote switch
Current Solutions For Intelligent Transformer Substations

Definition von intelligenten Stationen

- Standard CNS ohne Intelligenz
- Stufe 1: Übertragung Kurzschlussanzeiger, U/I - Messung NS, Stellungsrückmeldungen. Vorbereitung Wandoberseite, U/I Anzeige, NS Temperaturüberwachung Trafo
- Stufe 2: + Messwertübertragung; Powerquality-Meter
- Stufe 3: + Stellantriebe für Lasttrennschalter
- Stufe 4: + Mechanismen zur Netzstabilität, z.B. Einsatz von regelbarer 10 kV, 4 kV Transformatoren
- Stufe 5: + Mechanismen zur Schaffung von intelligenten Energieanreizsystemen
Optimized Future Solution For Intelligent Transformer Substations