PowerLink CM
Making the most of your transmission lines

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September 12-13, 2019 | VAR Partner Day 2019 | Bled, Slovenia

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PowerLink CM
Making the most of your transmission lines

AGENDA

- Benefits
- Highlights
- Use Cases
- System overview
- Functional comparison
PowerLink CM
Making the most of your transmission lines

BENEFITS

PRECISE LOCALIZATION OF LINE FAULTS
- Identification of line breaks or shorts
- Exact localization during and AFTER the fault event
- Fast access to location of copper line theft

ACTIVE CONTINUOUS MONITORING OF LINE CONDITION
- Early indication for line deterioration
- Extension of line’s lifetime
- Minimization of maintenance cycles and duration of outages
## Benefits of Active Line Monitoring

### Precise Localization of Line Faults
- Preventive measure against copper line theft\(^1\)
  - Unpowered line
  - Powered line during maintenance
  - During new line construction
- Rapid access to fault location
- Fast restoration of operation

### Continuous Monitoring of Line Condition
- Preventive maintenance
- Minimization of maintenance cycles and duration of outages
- Line load optimization
- Reduction of CO\(_2\) footprint
- Extension of line’s lifetime

### Use Cases
- Impact
  - Potential annual savings per line due to precise and fast fault location\(^2\):
    - Copper line theft causes damages of hundreds of millions EUR p.a. worldwide
    - Line interruption causes revenue losses of up to 100,000 EUR / h / line\(^3\)
  - Potential annual savings/revenues per line due to continuous line monitoring\(^2\):
    - Each unplanned maintenance interruption causes revenue loss of up to 2 million EUR / d / line\(^3\)
    - Load increase of 0,1% can lead to additional revenue of up to 800,000 EUR / yr / line\(^3\)

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\(^1\) Copper theft presents one of the biggest threats to electrical safety systems and results in escalating costs, operational downtime and threats to life and assets
\(^2\) Rough estimation
\(^3\) Assumption: 220kV line, 380MW
PowerLink CM
Condition Monitoring of HVAC and HVDC lines

**HIGHLIGHTS**

- **Continuous monitoring** of HV lines
  - HVAC and HVDC transmission lines
- **Of unpowered or grounded lines**
  - Earth electrodes, dedicated metallic return (DMR)
- **Single-sided measurement**
  - Only one device for fault location or monitoring

**PowerLink CM**

**HIGHLIGHTS**

- **Support of very long lines**
  - Up to 1,000* km
- **High precision localization**
  - Up to $\pm(100\text{m} + 0,1\% \times \text{length})$
- **Co-existence with PLC systems**
  - Configurable frequency band

*Double-sided measurement (upon request)
PowerLink CM
High quality monitoring based on continuous wave reflectometry
**PowerLink CM**

Use Case: Precise localization of line fault

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**BENEFIT**

- **Date/time-independent localization**
  - Fast online fault detection and localization (≤ 1 sec)
  - Localization after fault event possible

- **Supervision of unpowered lines**
  - Continuous supervision of ungrounded and grounded lines, e.g. earth electrodes
  - Safeguarding of powered lines against theft during (unpowered) maintenance

- **Support of fast fault resolution**
  - Precise and fast identification of location
  - Exact dispatching of service staff
PowerLink CM
Line calibration to compensate for average line attenuation 1 / 2

Uncalibrated View

- Raw data show physical reflection diagram of HVDC line
- Automatic or manual calibration – based on known end of line – for
  - Tx power
  - Average linear line attenuation
  - Line velocity
  - Automatic end of line detection function

* Parameters: FMCW frequency: 30kHz .. 500kHz, sweep time 1s, Tx Power: 50W
PowerLink CM
Line calibration to compensate for average line attenuation

- **Parameters:**
  - FMCW frequency: 30kHz .. 500kHz
  - Sweep time: 1s
  - Tx Power: 50W

- **Condition monitoring performed on earth electrode of HVDC system**
- **End-of-line clearly identifiable at distance of ~200km**
- **Clutter along the line caused by changing line or environmental conditions**

* Parameters: FMCW frequency: 30kHz .. 500kHz, sweep time 1s, Tx Power: 50W
PowerLink CM
High quality monitoring based on continuous wave reflectometry

Fault Location

Condition Monitoring
PowerLink CM – real line test
Use Case: Localization / detection of slow line deterioration

**BENEFIT**

- Early recognition of line condition changes due to e.g.,
  - Vegetation growing closer to overhead line
  - Adverse weather resulting in mechanical stress, for example, by heavy ice on the line
  - Line elongation / wire sag caused by higher load on line segments (self-heating)
  - Other irregularities, such as poor connections or external tampering with line

- Reliable maintenance planning

- Avoidance of unnecessary service
PowerLink CM – real line test
Use Case: Localization / detection of slow line deterioration

Root cause analysis

- Abnormal strong fluctuation at > 170km distance
- Only seen by day, not by night
- Hypothesis: intermittent high impedance disturbance caused by loose jumper in one wire.
  By day, at high temperatures and low humidity, the gap in the jumper may be wider than at night resulting in a higher relative impedance.
- No immediate line fault, but indication for upcoming maintenance need.
PowerLink CM
Data analysis capabilities and alarming

THREE OPTIONS

➢ PC / Web UI
  • Data transfer
  • Visualization of results

➢ Alarm
  • External alarm signalling via relays

➢ Cloud connectivity
  • EnergyIP-ready
PowerLink CM
Easy to operate – the PowerLink CM management system

Benefits

• Remote administration or by local craft terminal

• Use of commercial Web browsers

• Secure access using user specific log-in and password

• State-of-the-art Web user interface in Siemens' digital grid design

• Supports integration into higher-level management systems using SNMP

• Same look-and-feel as Siemens' trusted PLC solution PowerLink IP
PowerLink CM
Intuitive user interface and device management
PowerLink
PLC condition monitoring single-sided measurement

PowerLink CM required accessories

- **Line trap**
  Inductor inserted on the power line to guide the radio signal and to reduce frequency disturbances.

- **Coupling capacitor**
  HV capacitor used to couple/decouple the radio signal onto the power line and to provide safety insulation between HV and LV side.

- **Coupling or Line matching unit**
  Impedance matching between HV line and radio signal, incl. overvoltage protection.

- **Condition monitoring equipment (PowerLink CM)**
  System sending radio signals and receiving their echo along the HV line, located in the substation.
## PowerLink CM
High-accuracy condition monitoring system for HVAC and HVDC lines

<table>
<thead>
<tr>
<th>Operating principle</th>
<th>PowerLink CM</th>
<th>Traveling wave</th>
<th>Distance protection relay</th>
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</thead>
<tbody>
<tr>
<td><strong>Active sensing signal</strong> is fed into line at one end. Discontinuities are located based on time of flight of reflections caused by line impedance changes.</td>
<td>Traveling voltage and current <em>wave caused by fault incident</em> is detected at both ends of the power line. Fault location is calculated based on time of arrival of these waves.</td>
<td>Fault location is based on current and voltage measurement and calculation of the network impedance in case of fault.</td>
<td></td>
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<tr>
<th><strong>Pro / Con</strong></th>
<th><strong>Continuous</strong> monitoring of line condition</th>
<th>+ Popular, field-proven technology + Same coupling as for voltage and current measurement - GPS synchronization of both stations required - No continuous line monitoring - Less sensitive for high impedance faults (ground fault vs. short circuit)</th>
<th>+ No additional hardware required - Low accuracy - Further declining accuracy in case of high impedance faults (ground fault vs. short circuit) - No continuous line monitoring</th>
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<td>+ Detects any type of faults (ground fault, short circuit, …) + Same <strong>coupling as PLC</strong> systems + Works on powered or <strong>unpowered</strong> lines</td>
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