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PowerLink CM

Making the most of your transmission lines

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AGENDA

- Benefits
- Highlights
- Use Cases
- System overview
- Functional comparison

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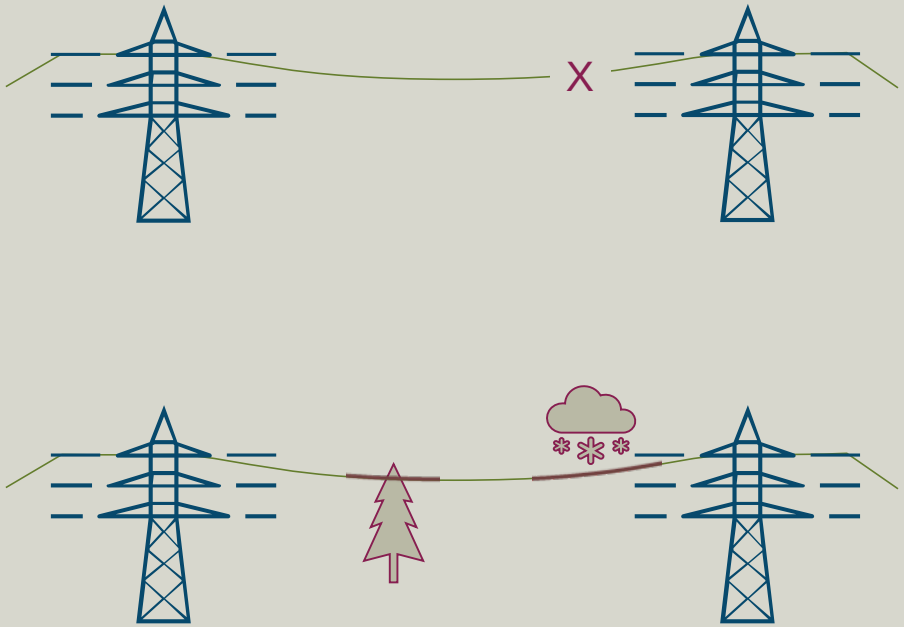
BENEFITS

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



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Benefits of active line monitoring

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BENEFITS	USE CASES	IMPACT
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	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)]
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*	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)]

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

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Condition Monitoring of HVAC and HVDC lines

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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

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HIGHLIGHTS

Support of very long lines
up to 1.000* km

High precision localization
up to ±(100m + 0,1%×length)

Co-existence with PLC systems
configurable frequency band

* double-sided measurement (upon request)

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High quality monitoring based on continuous wave reflectometry

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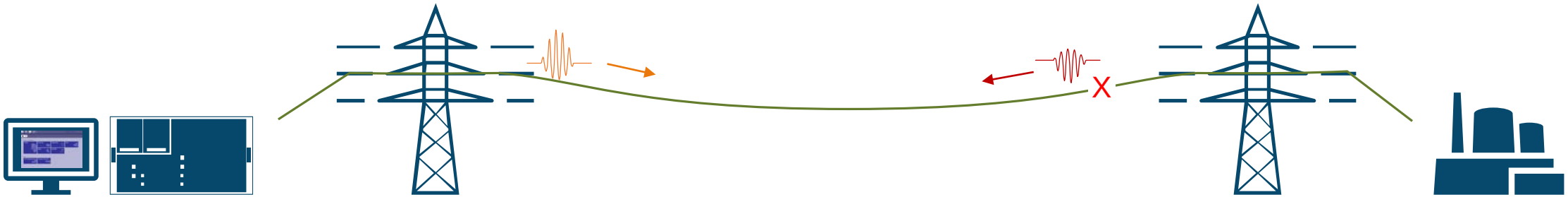
Fault Location



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Use Case: Precise localization of line fault

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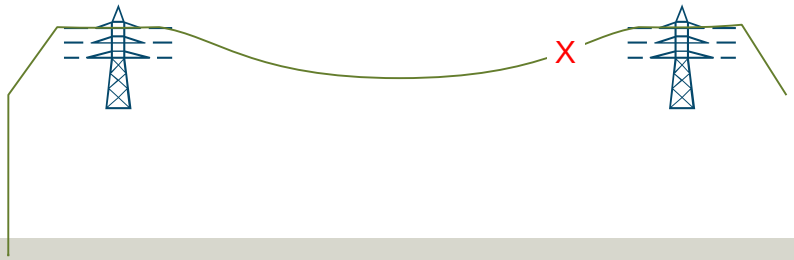

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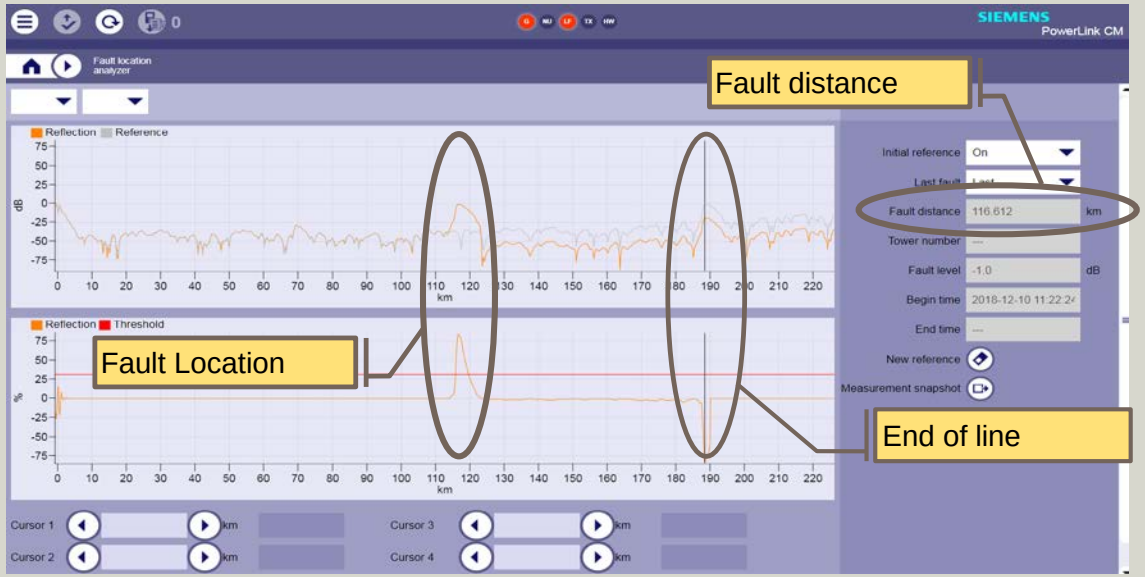

BENEFIT

- **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

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Line calibration to compensate for average line attenuation

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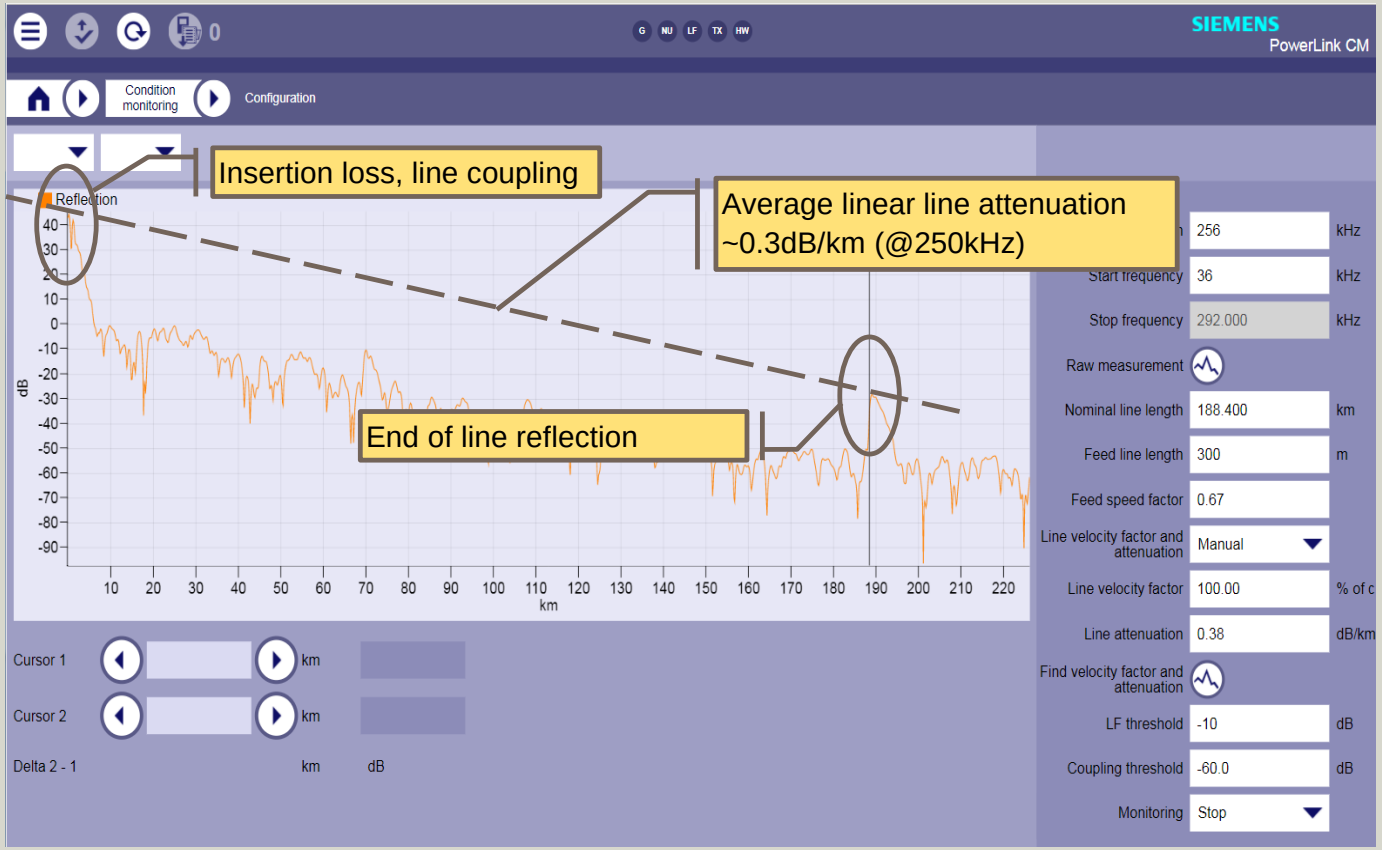

Uncalibrated View

- 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

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Line calibration to compensate for average line attenuation

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Calibrated View

- 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

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High quality monitoring based on continuous wave reflectometry

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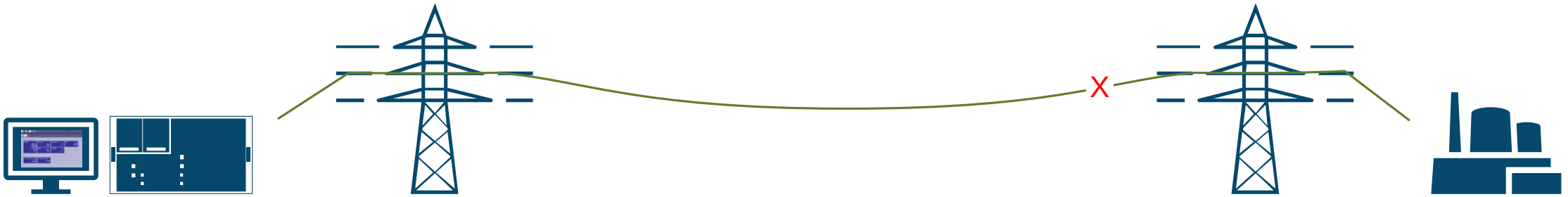
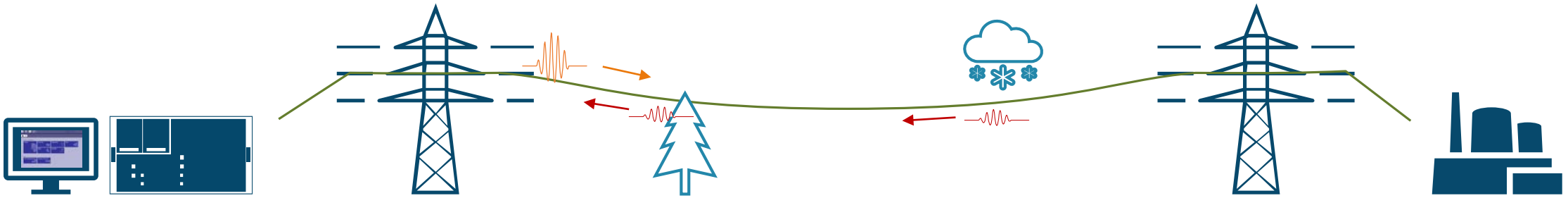
Fault Location



Condition Monitoring



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

Raw measurement available in current release.
Upcoming feature

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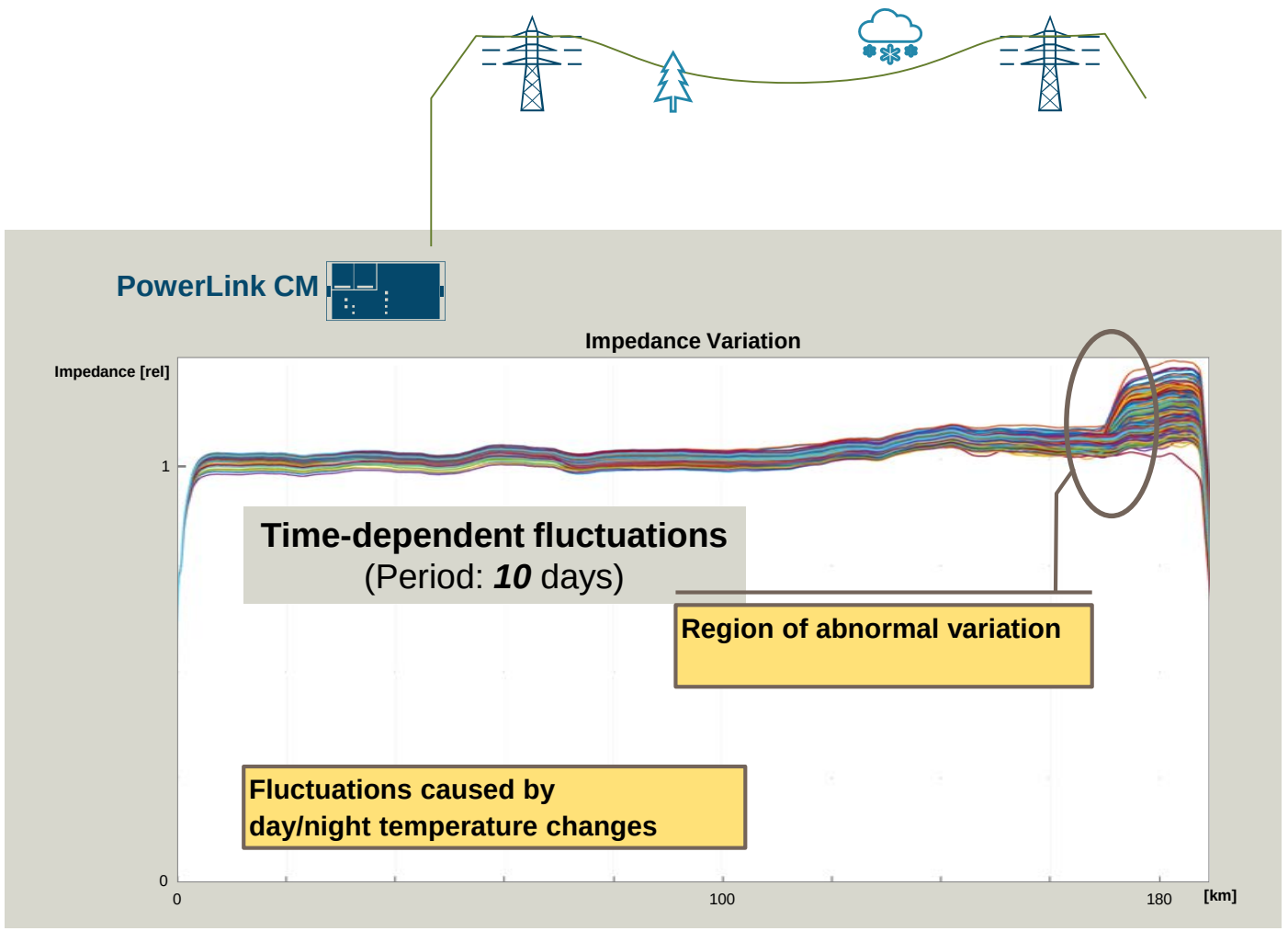

BENEFIT

- **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

Upcoming feature

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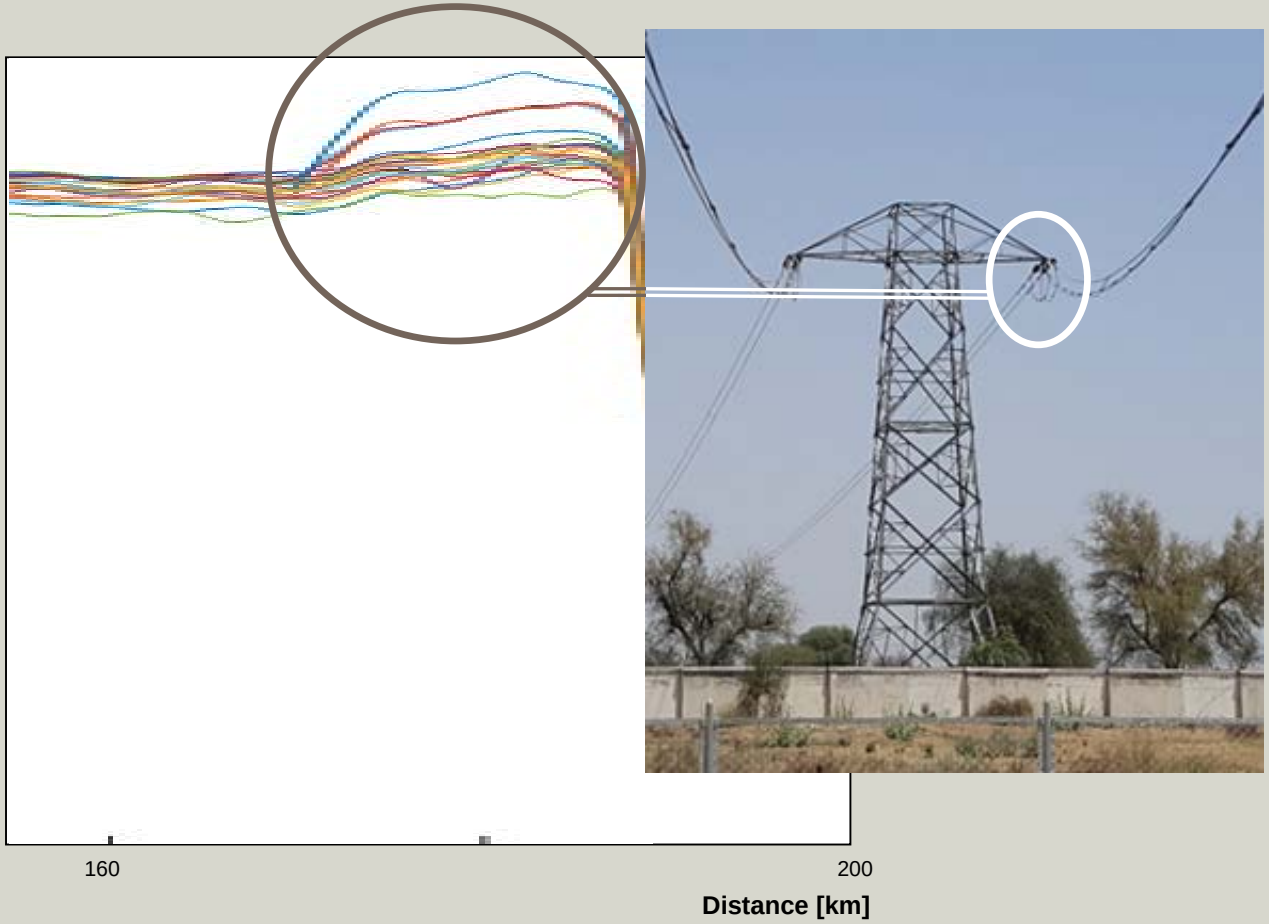

Root cause analysis

- 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.

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Data analysis capabilities and alarming

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THREE OPTIONS

➢ PC / Web UI

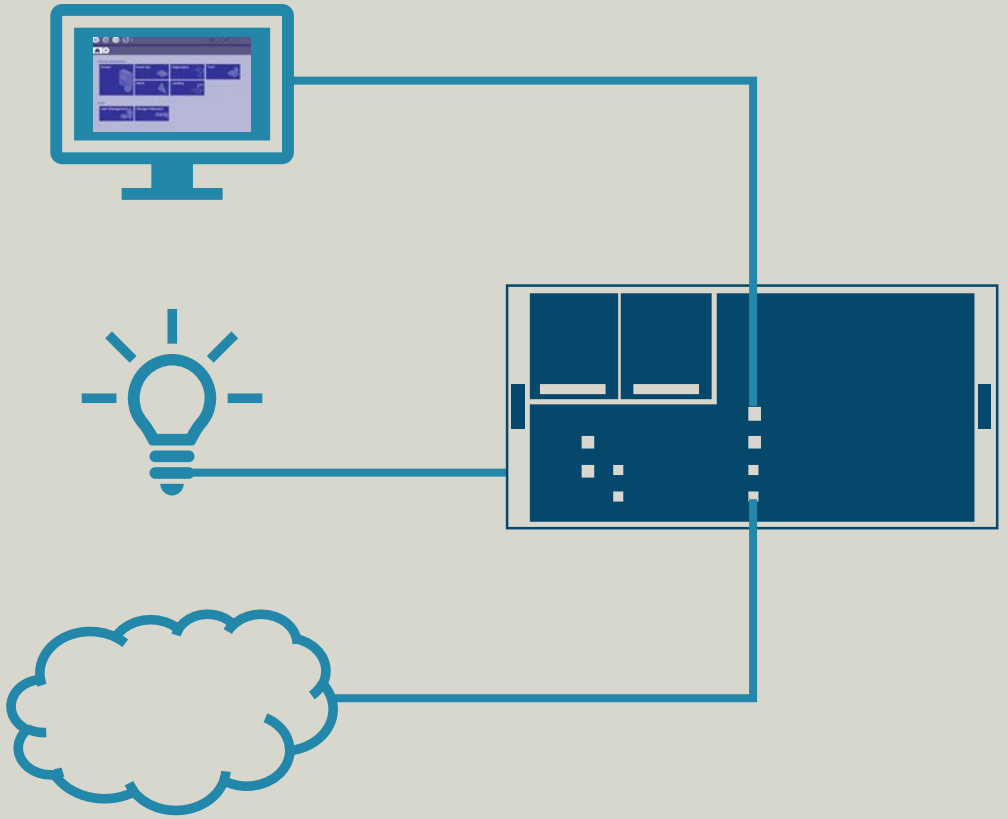
- Data transfer
- Visualization of results

➢ Alarm

- External alarm signalling via relays

➢ Cloud connectivity

- EnergyIP-ready



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Easy to operate – the PowerLink CM management system

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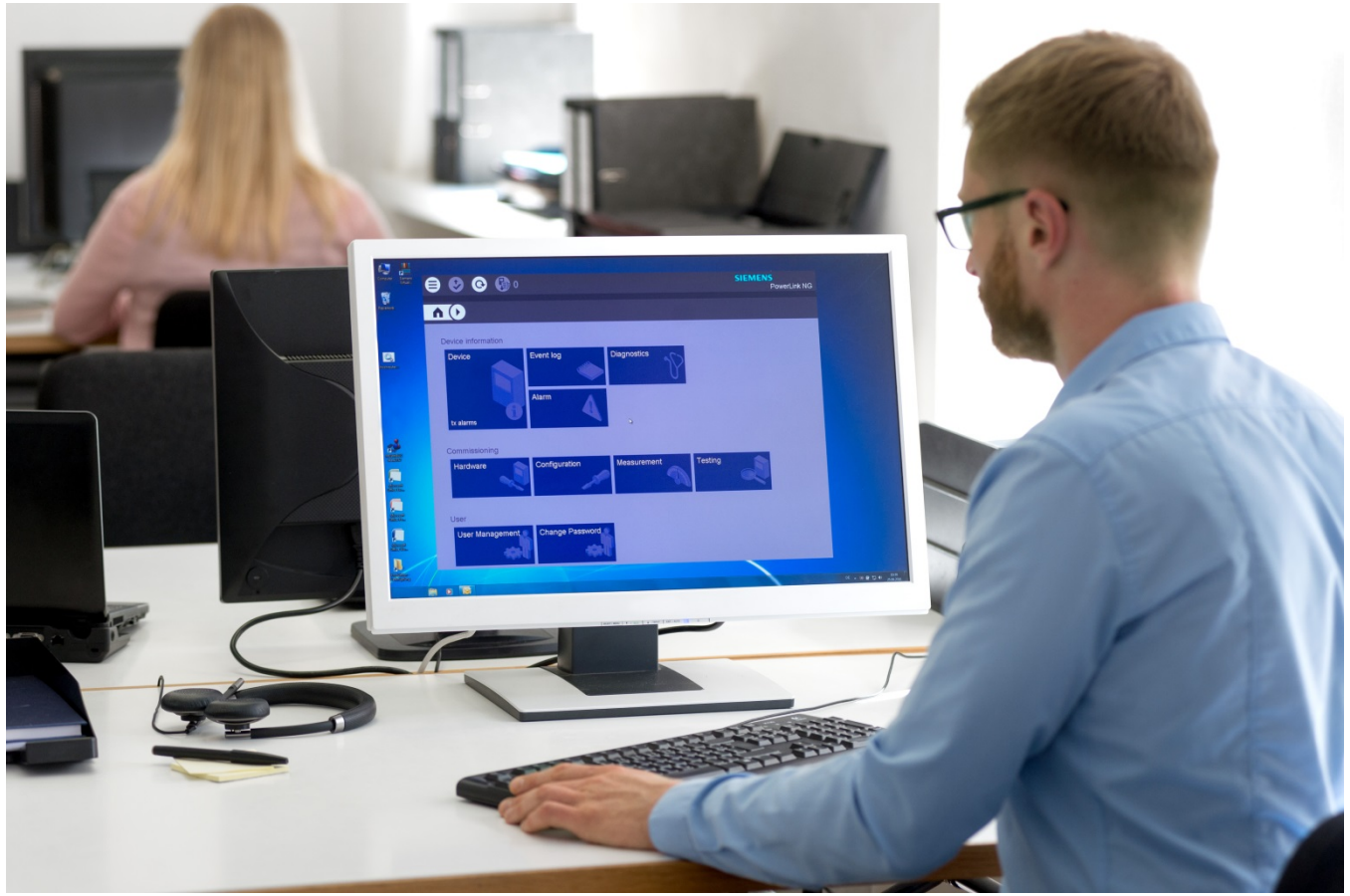

Benefits

- 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

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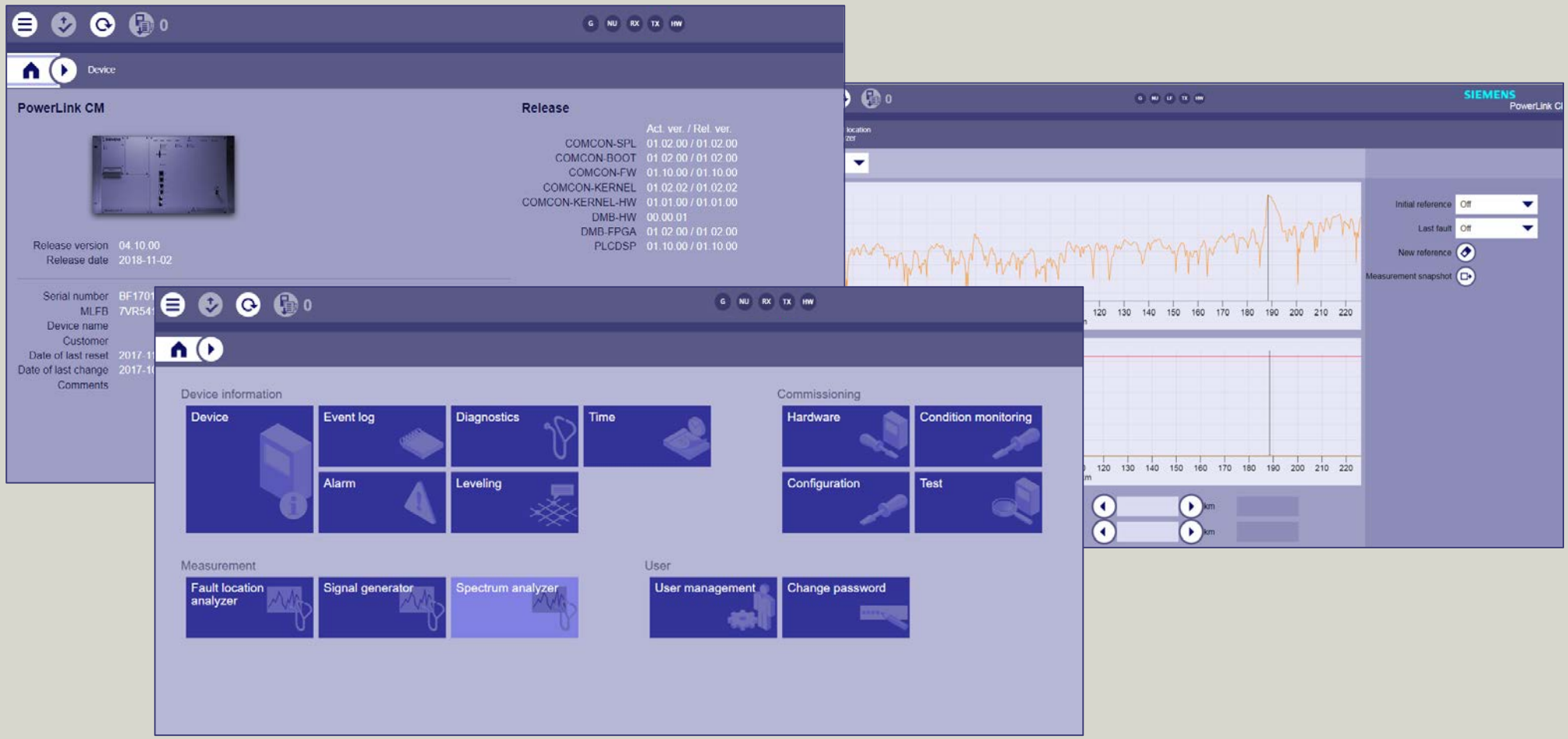
Intuitive user interface and device management



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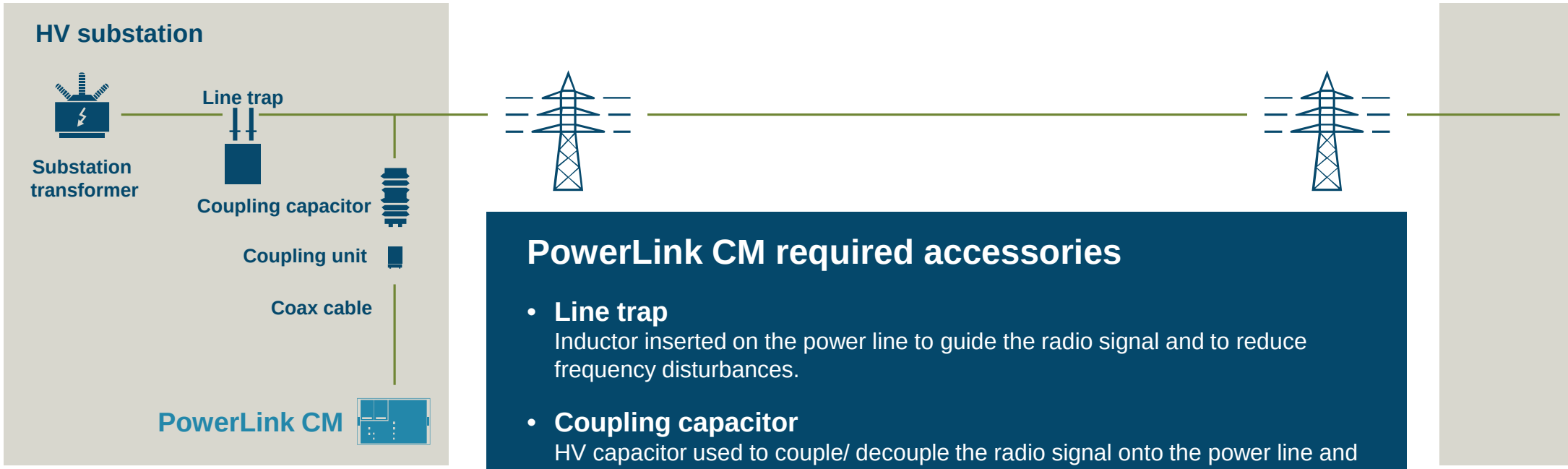
PLC condition monitoring single-sided measurement



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.

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High-accuracy condition monitoring system for HVAC and HVDC lines

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

PowerLink CM
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