

ASTROSE[®] - Autonomous sensor network for condition monitoring of power lines

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Outline

- **Introduction / Motivation**
- **ASTROSE[®] - Monitoring system**
- **Connection to the control system**
- **Field tests and results at 110 kV power lines**
- **Summary and outlook**

Introduction / Motivation



Peak current of renewable energies or high summer temperatures causes **overheating** and leads to **damaging of power lines**

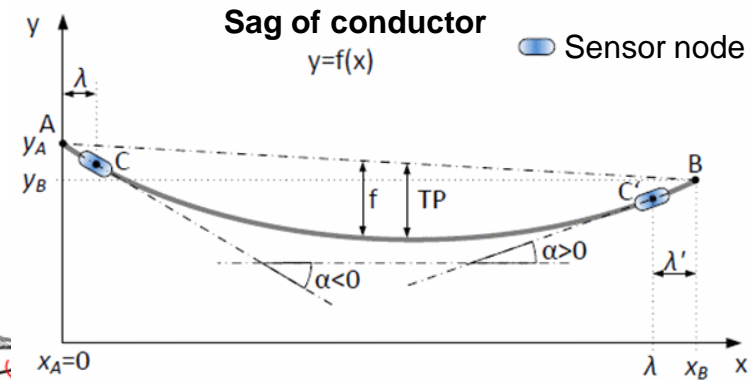
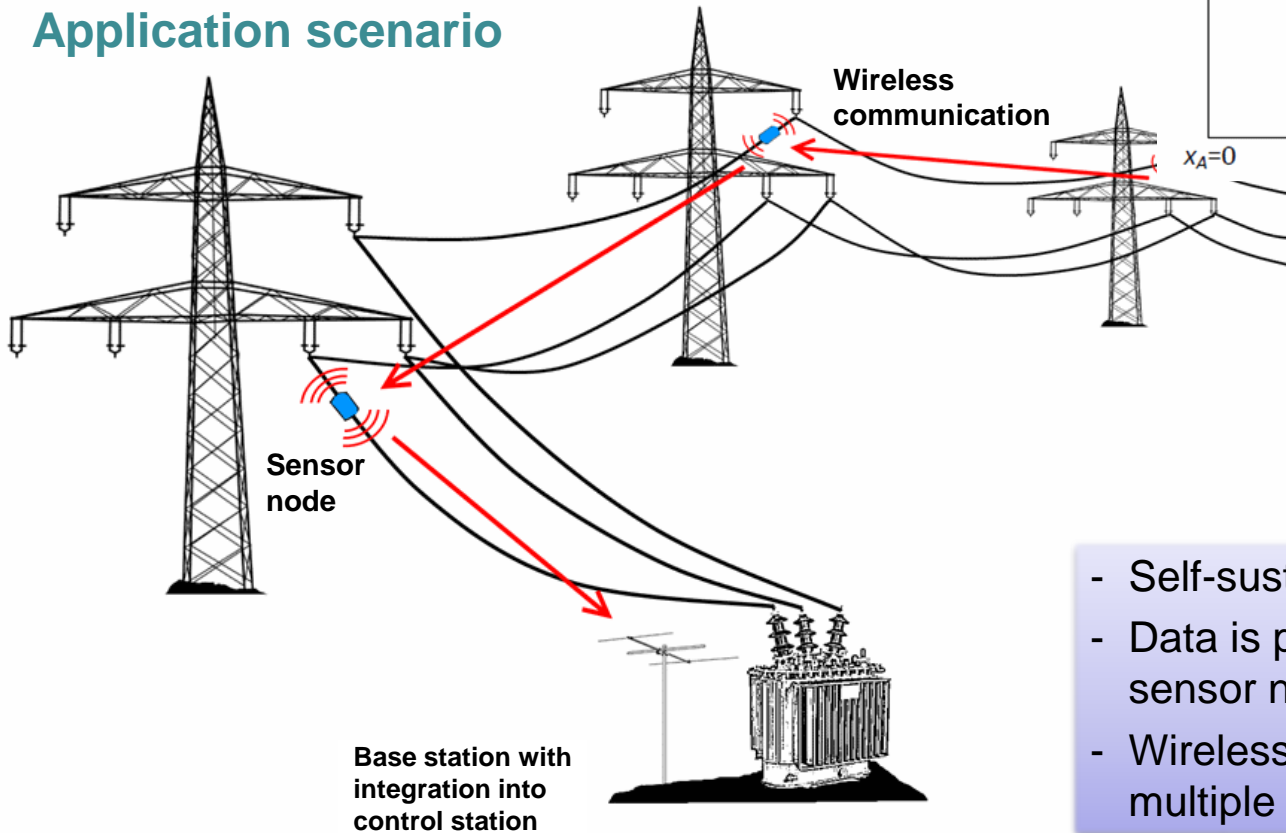


Ice loading during winter session stress power lines and mast and causes big **damage to power system**

- **Online monitoring** of parts of the power system concerning **temperature and sag** for obtaining real-time data
- **To localize the danger area and to prevent damage to power lines**
- **To reduce costs of maintenance / of repair**

ASTROSE[®] - Monitoring system

Application scenario



- Self-sustaining network
- Data is passed along the chain of sensor nodes to the base station
- Wireless communication with multiple redundancy

→ Applicable for high (>110kV) and extra high (>230 kV) voltage power networks

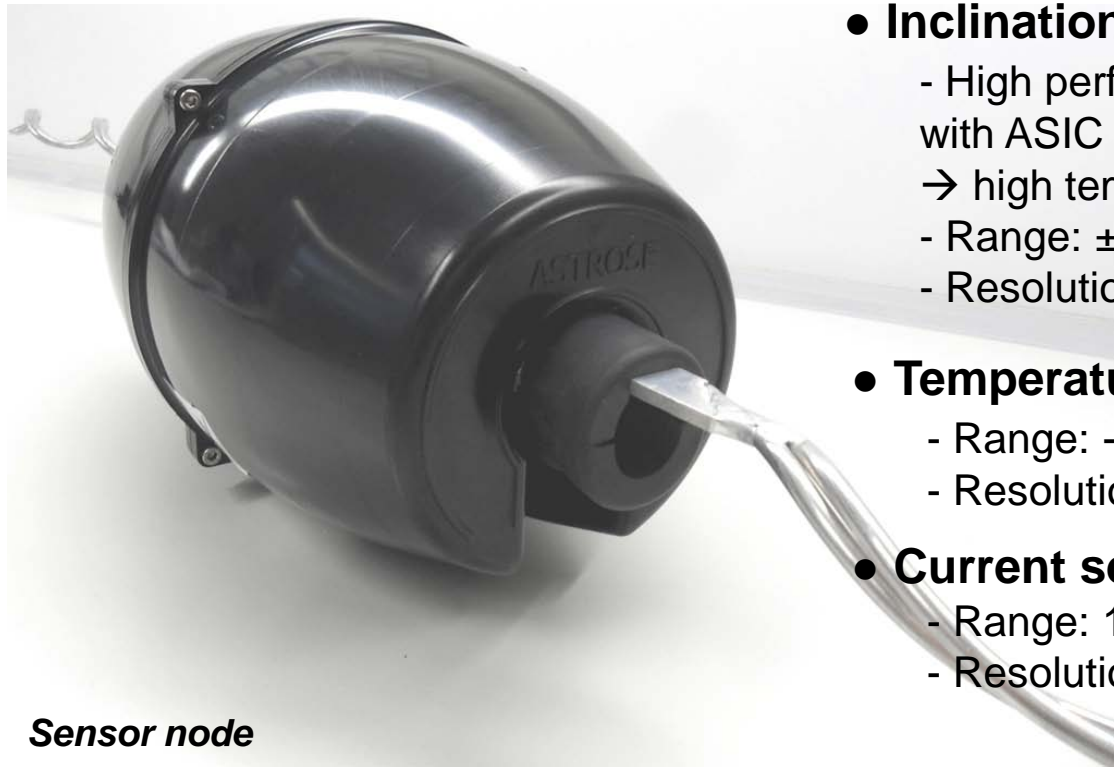
ASTROSE® - Monitoring system



Sensor node

- **Robust housing** with slit and mounting part (diameter 150mm, length 200mm)
- **Easily mounting system** (mounted in few seconds)
- **Self-sustaining system**
 - Supply from electrostatic fringing field
 - No batteries necessary
 - Maintenance-free
- **Wireless communication**
 - High operating distance \approx 1km
 - Multiple redundancy
 - Robust against strong interference signals (partial discharge)

ASTROSE® - Monitoring system



Sensor node

- **Inclination sensor**

- High performance MEMS (AIM technology) with ASIC
- high temperature stability
- Range: $\pm 20^\circ$ range
- Resolution: 0.01° (change of sag $\approx 20\text{mm}$)

- **Temperature sensor**

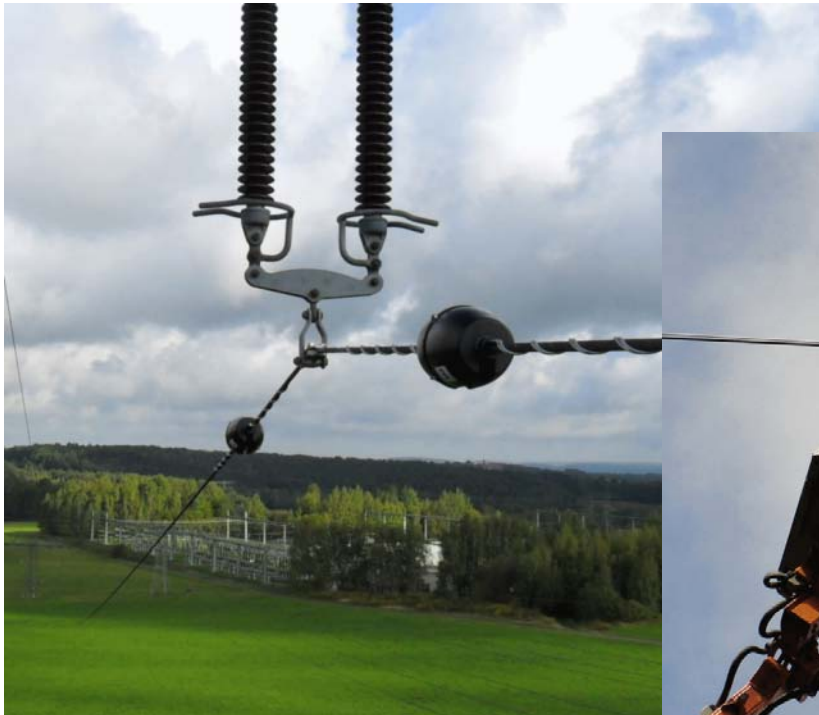
- Range: -40° to $+125^\circ\text{C}$
- Resolution: 0.5°C

- **Current sensor**

- Range: 10A to 4000A
- Resolution: 5A

ASTROSE® - Monitoring system

Mounting at power line



Sensor nodes at power line

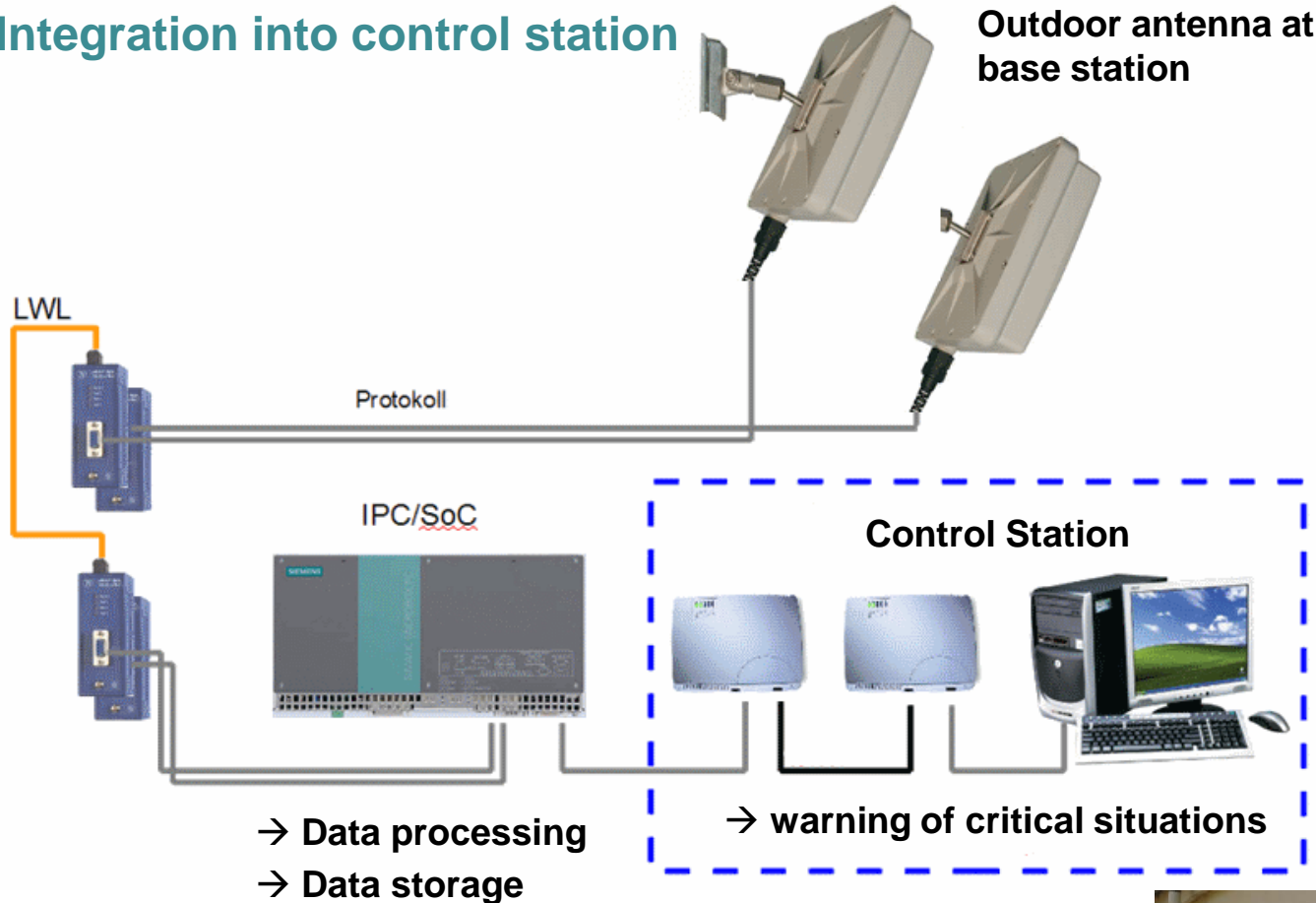


Mounting of sensor nodes at power line



ASTROSE[®] - Monitoring system

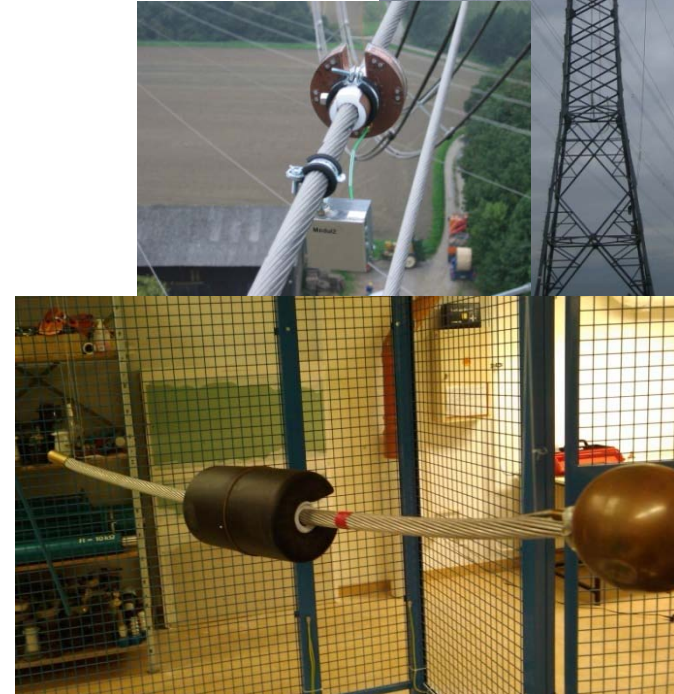
Integration into control station



Characterization

Preliminary tests

Test of communication range on 380kV power line



Test of communication range on 110kV power line

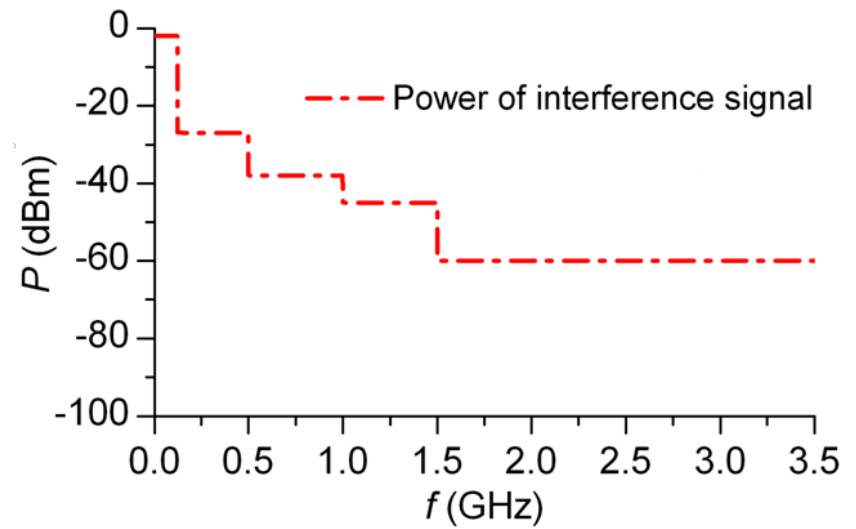
Function tests in high voltage laboratory

Characterization

Preliminary function tests



Function tests in high voltage laboratory (up to 110kV)



Partial discharge (generated in high voltage laboratory, measured with spectrum analyzer)



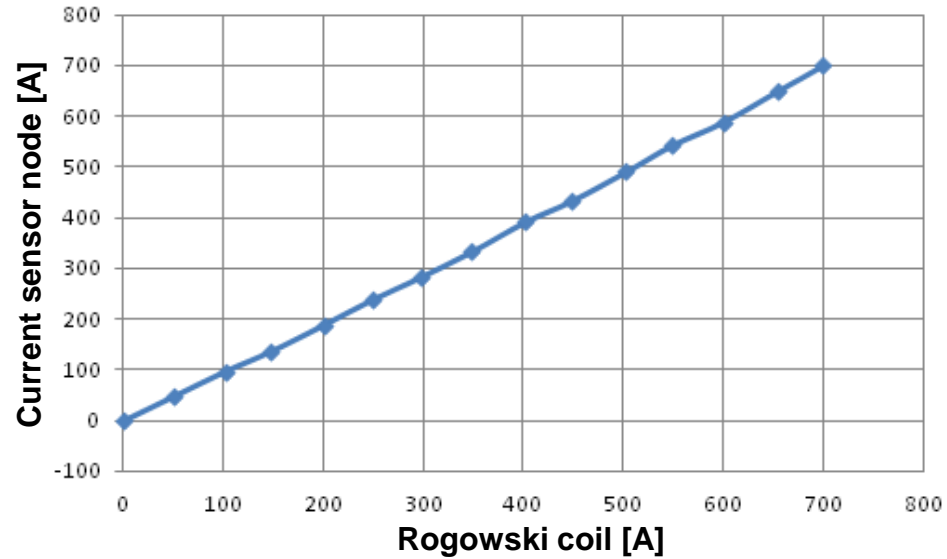
Lightning surge generator (Test robustness of RF components)

Characterization

Preliminary function tests



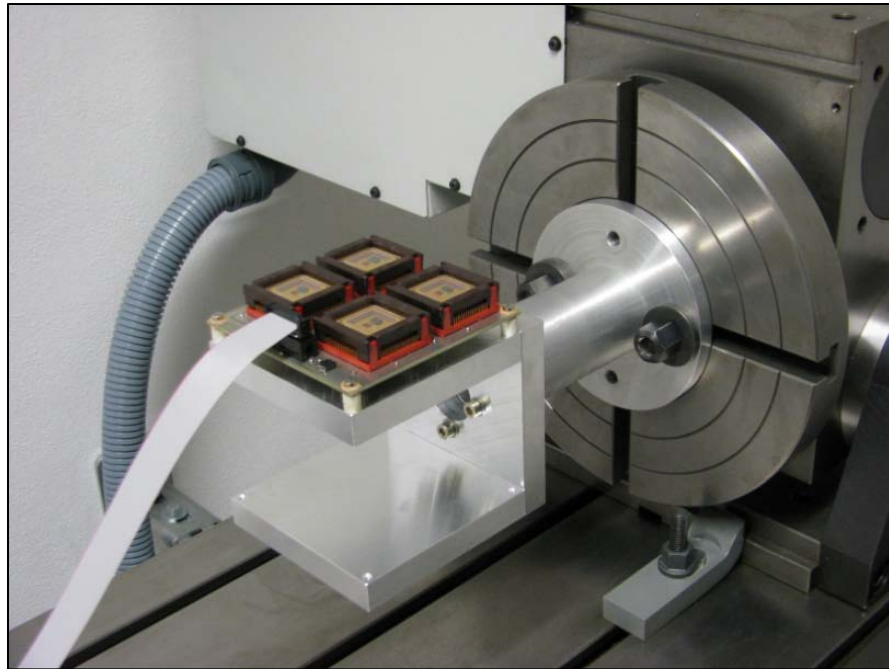
Function tests in high current laboratory



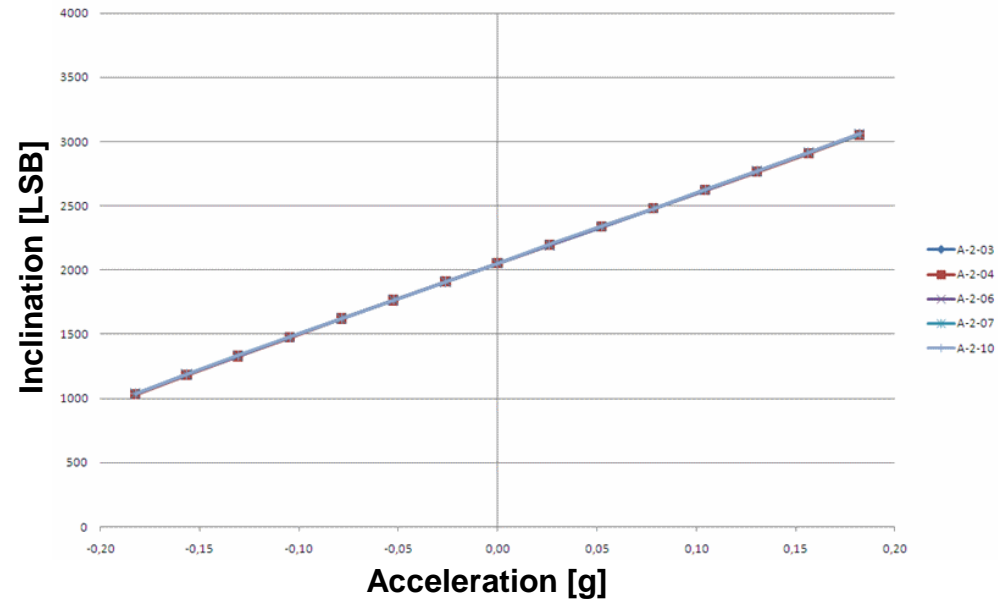
Current sensor (comparison with calibrated Rogowski coil)

Characterization

Preliminary function tests



Calibration and test system for inclination sensor



Inclination sensor (linearity and measurement range)

Characterization

Field tests at 110kV power line

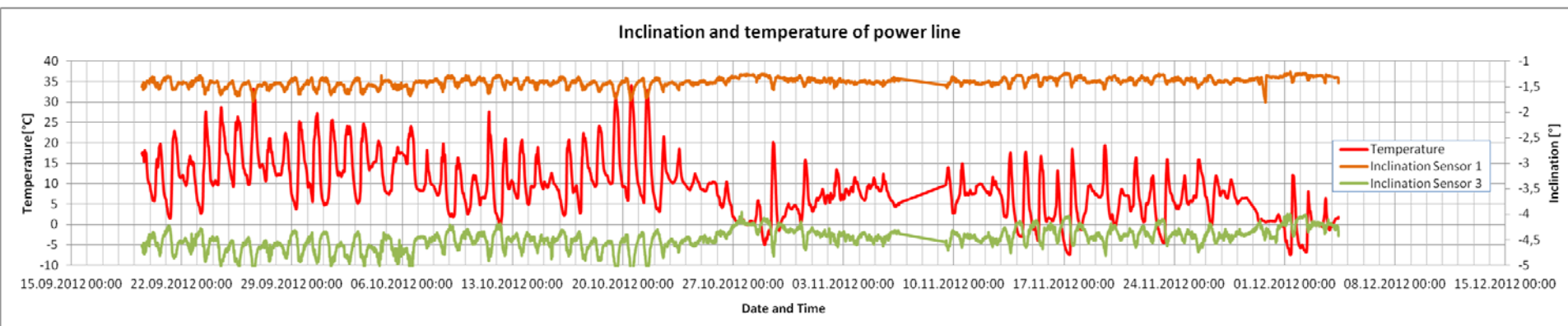
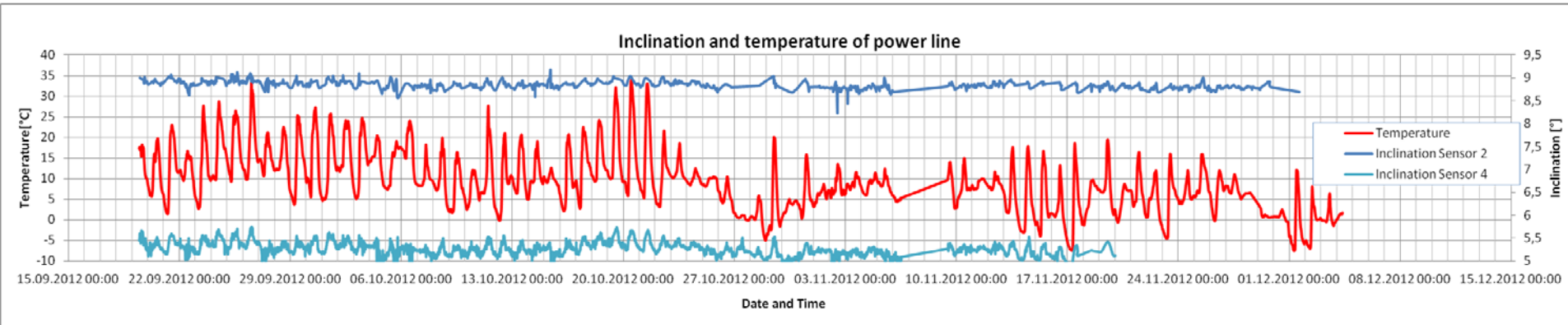
- **Long-term test since 19.09.2012**
(near Chemnitz, Germany)



Characterization

Field tests at 110kV power line

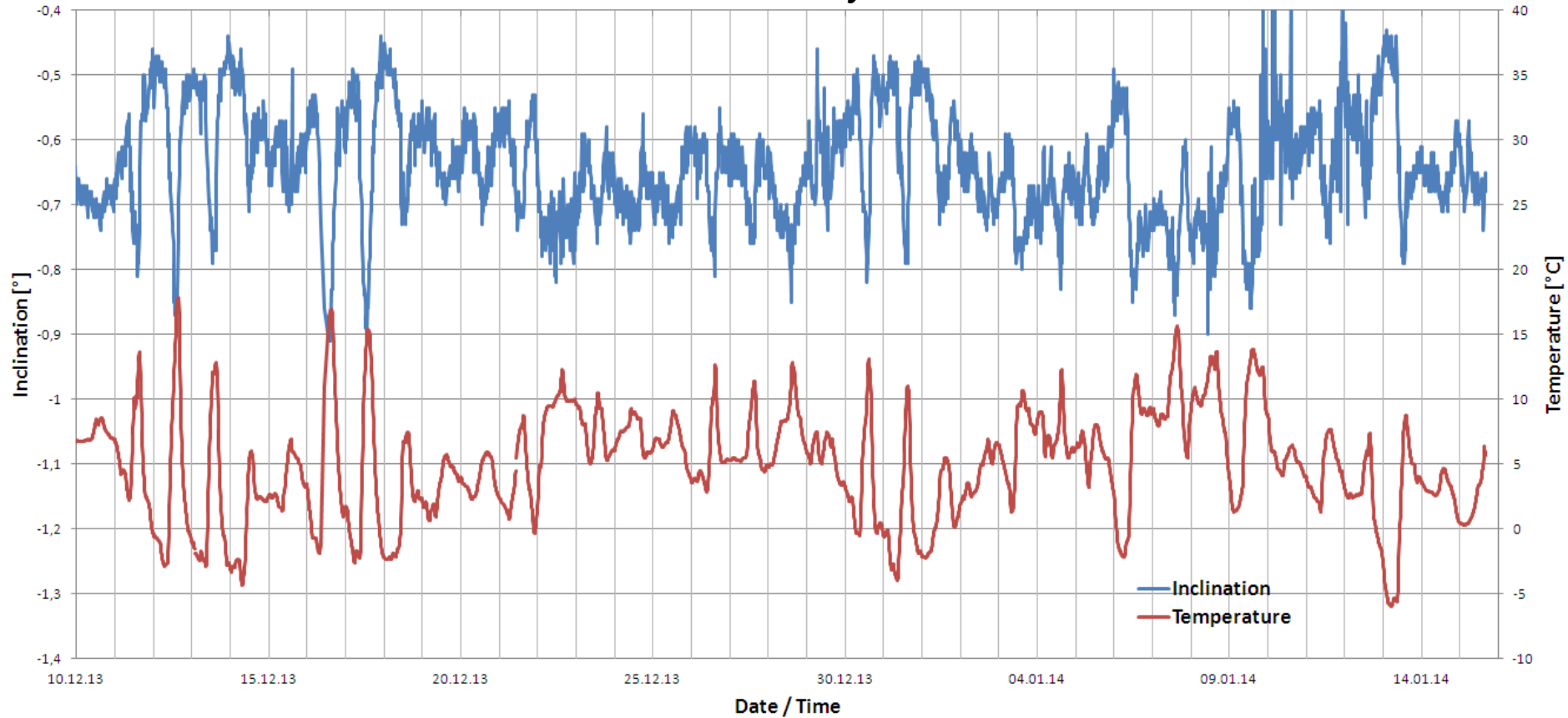
Data from beginning ...



Characterization

Field tests at 110kV power line

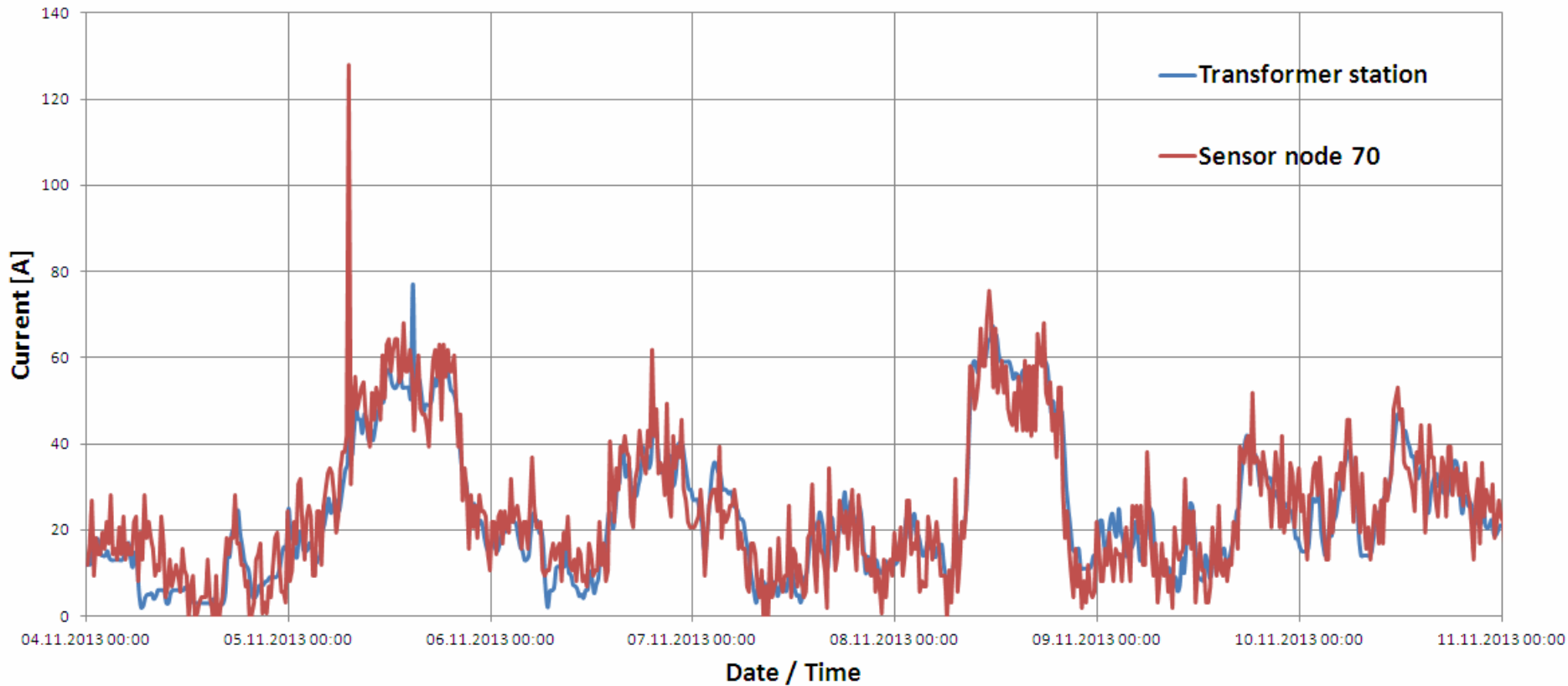
... and last days ...



Characterization

Field tests at 110kV power line

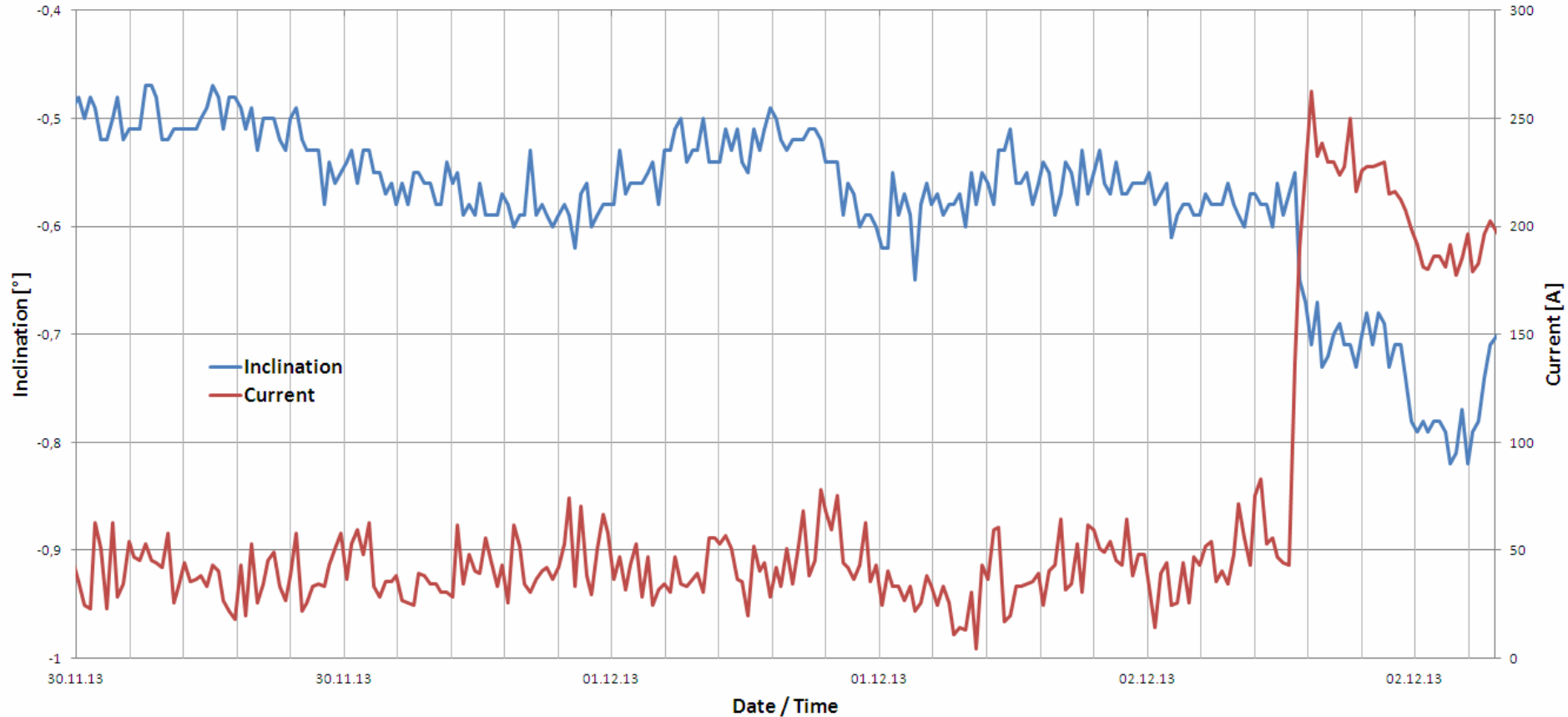
Comparison of current from transformer station and sensor node



Characterization

Field tests at 110kV power line

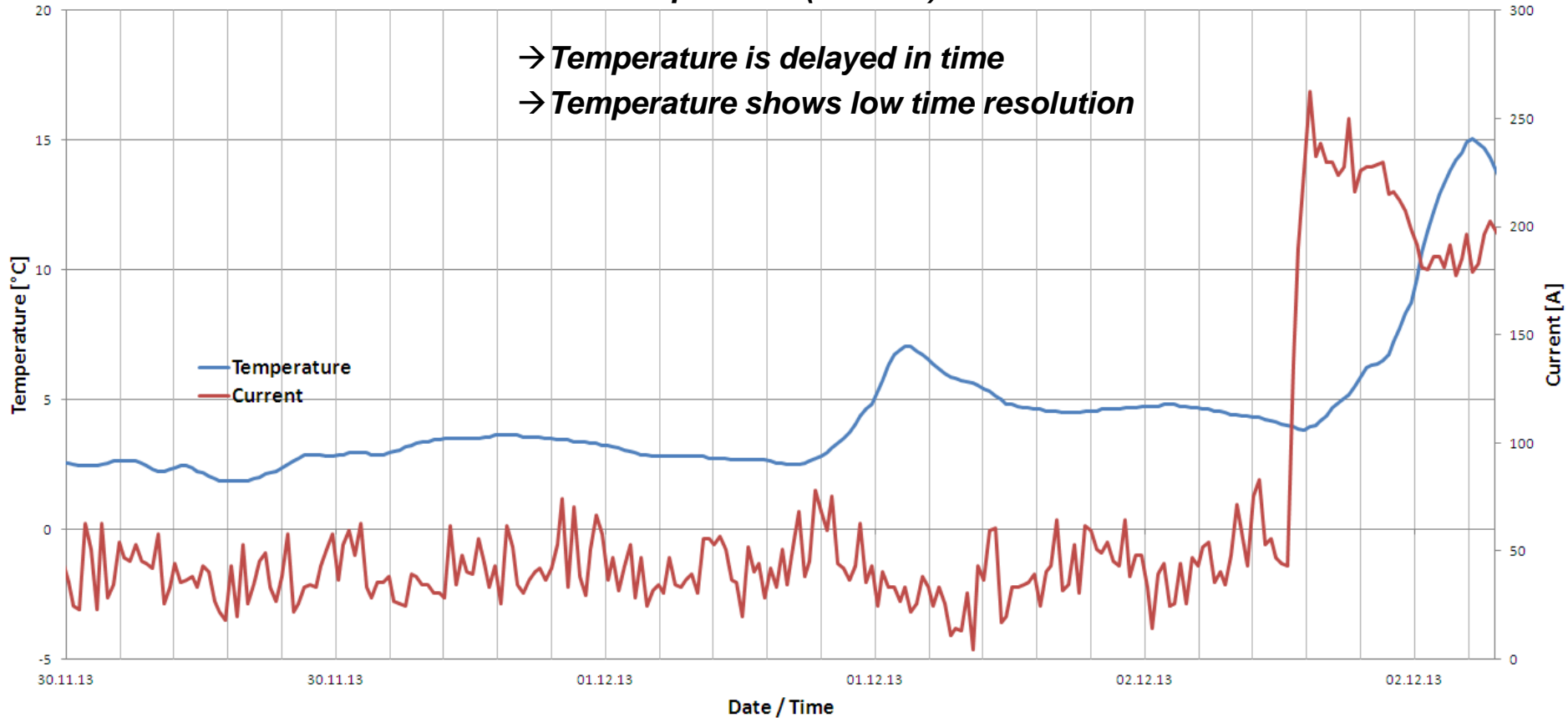
Relation of inclination and current



Characterization

Field tests at 110kV power line

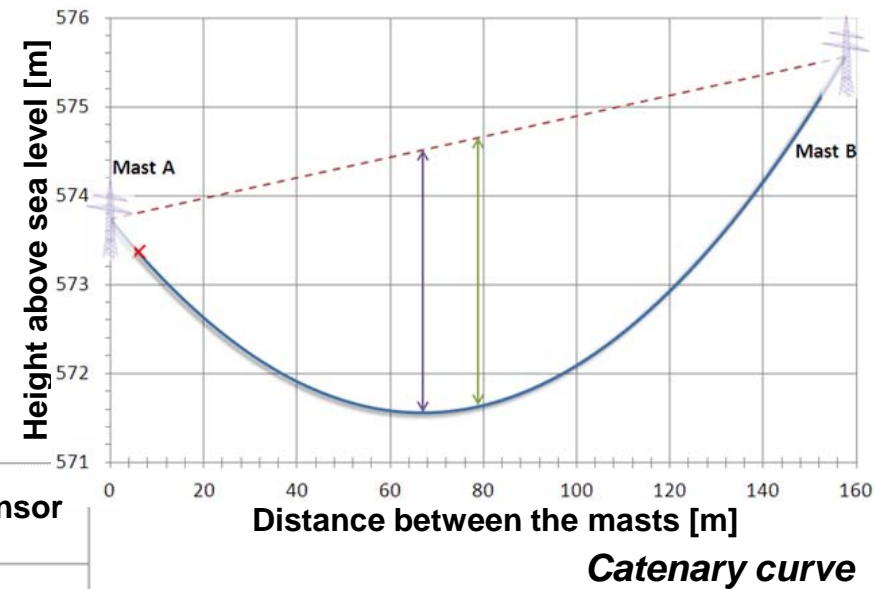
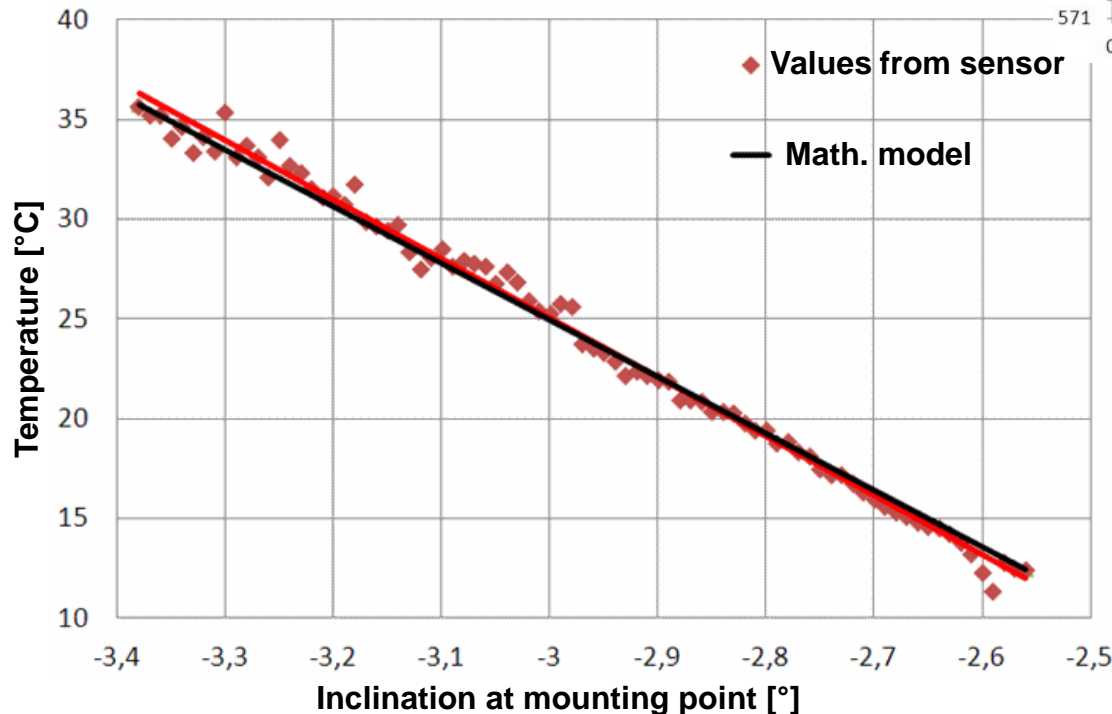
Relation of temperature (internal) and current



Characterization

Field tests at 110kV power line

- Correlation of inclination and temperature



- Sensor values follows mathematical model (catenary curve and thermal expansion of power line)
- Validation of sensor concept: sag can be determine with inclination

Summary and Outlook

- Energy self-sufficient extensive sensor network (ASTROSE[®]) for measurement of the operating states of overhead power lines
- Measurement of temperature, inclination and current in the sensor node and data transmission to the base station (under high voltage)

- ASTROSE[®] system is still under development
 - Further improvements of temperature range and reliability are continued

Our expertise

- Wireless communication

- Robust under rough conditions (high voltage, partial discharge)
- Special antenna and filter design (eliminating distortion by partial discharge)
- High operating distance (> 1km)
- Proprietary communication protocol with extremely low power consumption

Bluetooth (IEEE 802.15.1) - ca. 100m

Zigbee (IEEE 802.15.4) - ca. 100m

WLAN (802.11n) - ca. 250m

Our expertise

- High precision MEMS sensor (inclination, acceleration)
 - High temperature stability
 - High resolution
 - Fabrication in own Fab (ZfM, Chemnitz)
- Energy harvesting
 - From electrostatic fringing field of 110kV power line (and higher)
- Electronic design
 - Robust under rough conditions (high electric and magnetic field)

Thank you for your attention

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