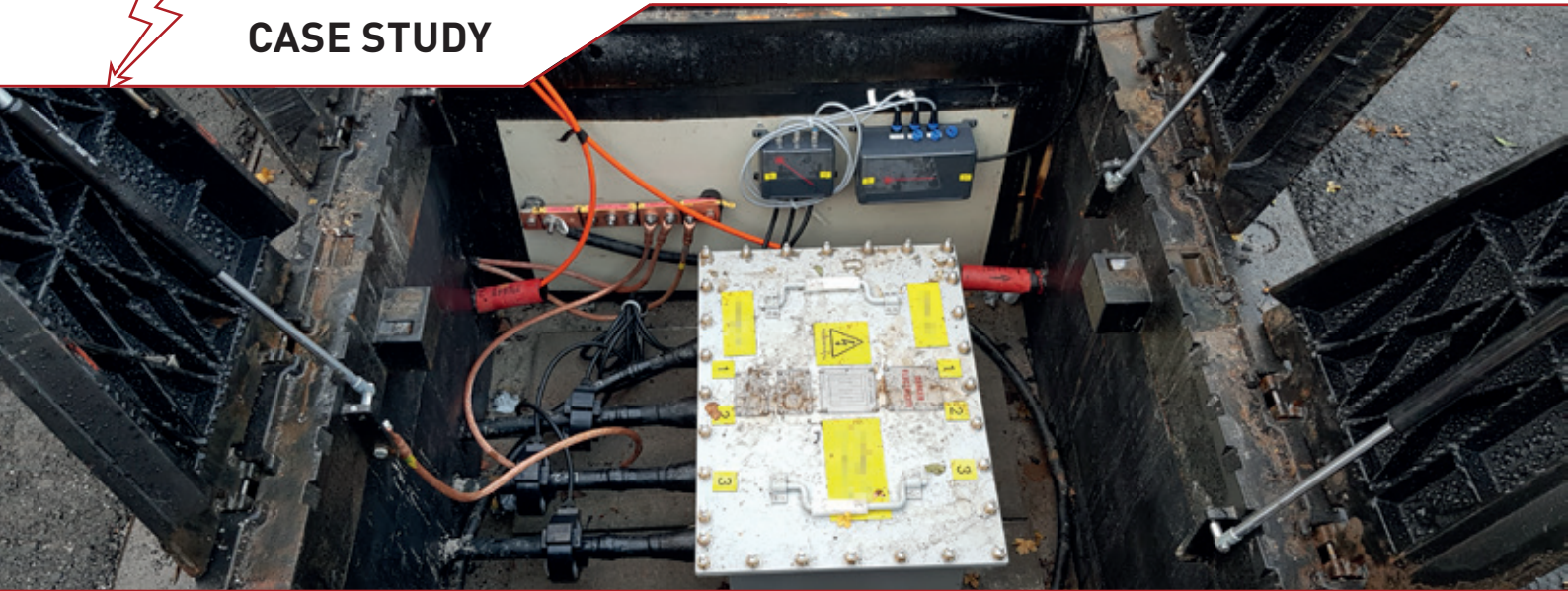




CASE STUDY



Fiber-based current monitoring (FbCM)

Copenhagen/Denmark

Project Overview

HVAC power cables are vital for power transmission, and monitoring their condition is crucial for ensuring safe operations and promptly addressing defects or faults to minimize downtime. To enhance reliability, Energinet and AP Sensing implemented a pilot installation of AP Sensing's fiber-based current monitoring solution (FbCM) on a new 132 kV HVAC cable connecting two substations in Copenhagen. This cable, installed in a cross-bonding configuration, spans two major sections totaling 3.7 km.

Solution

An AP Sensing distributed acoustic sensing (DAS) instrument was installed in one of the substations, offering exceptional asset monitoring capabilities, such as detecting cable faults and third-party intrusions. This DAS system was complemented by AP Sensing's fiber-based current monitoring (FbCM) solution, which

was connected to each bonding lead at all five link boxes (four cross-bonding and one grounding box) and to a telecom fiber running parallel to the power cable.

The FbCM is completely passive, requiring no power supply, and is galvanically isolated from the HVAC cable and link boxes. This design ensures that no cable components need to be disconnected for installation, allowing the system to be installed on an operational cable.

The FbCM creates strain on an optical fiber proportional to the current in a bonding lead by using a stretcher element driven by a current transformer. This strain is measured by the DAS and converted back into current, which is then reported as the 50 Hz component to AP Sensing's SmartVision asset viewer.

Background

- 132 kV HVAC power cable required diligent monitoring to ensure safe operating conditions.
- Traditional condition monitoring should be expanded to include sheath currents for comprehensive assessment.

Solution & Benefits

- Fiber-based current monitoring (FbCM) sensors installed in all manholes (in total 5 link boxes) and connected to DAS.
- Sheath Current Monitoring enables detection of faults in HVAC bonding and cable degradation.
- DAS Capabilities provide standard condition monitoring, including cable faults and third-party intrusion.
- 24/7 real-time monitoring ensures continuous assessment and immediate response to any issues.

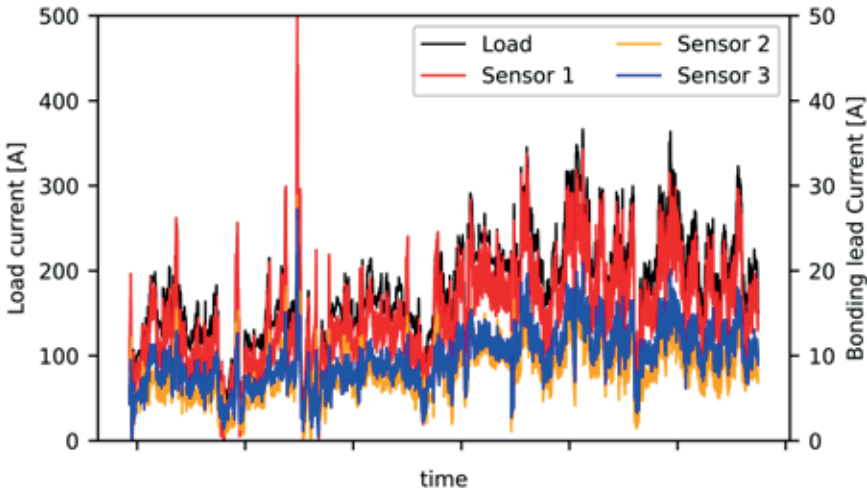


Figure 1: Load and bonding lead currents at a link box for a period of 6 weeks. The applied load to the power cable (black line) refers to the left scale. Meanwhile the sensor readings of the sheath currents in bonding leads 1,2,3 (red line, yellow line, blue line) refers to the right scale.

Results

The bonding lead currents were monitored for a full year, providing a comprehensive history across various operating conditions. Our evaluation of the cable performance yielded positive results. Continuous monitoring confirmed stable operation without any observable degradation or season-related effects. Notably, the cable maintained consistent performance even under challenging conditions, including significant power fluctuations and directional changes, confirming a reliable and safe cable installation.

Since the sheath currents are induced by the load current, they closely follow the load, showing a strong correlation. Due to length imbalances between minor sections of the HVAC cable, the relationship between bonding lead currents and load currents varies in scale and shift between link boxes and phases. Additionally, variations in inductance

and capacitance between minor sections lead to changes in this relationship.

With the measurement history, changes in the correlation can be used as indicators of the cable’s health. Events like link box flooding or ground faults will lead to drastic changes, while the gradual degradation of cable components

will show more subtle changes over time. In the event of a fault, measurements from multiple link boxes and all phases can help localize the issue by analyzing which sensors are affected.

Conclusion

AP Sensing’s FbCM solution represents a significant advancement in HVAC cable condition monitoring. It complements existing Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS) technologies by extending their reach to a wider range of cable system components. This broader monitoring scope includes critical areas such as link boxes (e.g., link box flooding, SVL defects) and cable degradation itself. By incorporating FbCM, a more holistic understanding of cable health is achieved, empowering proactive maintenance strategies and enhancing system reliability.

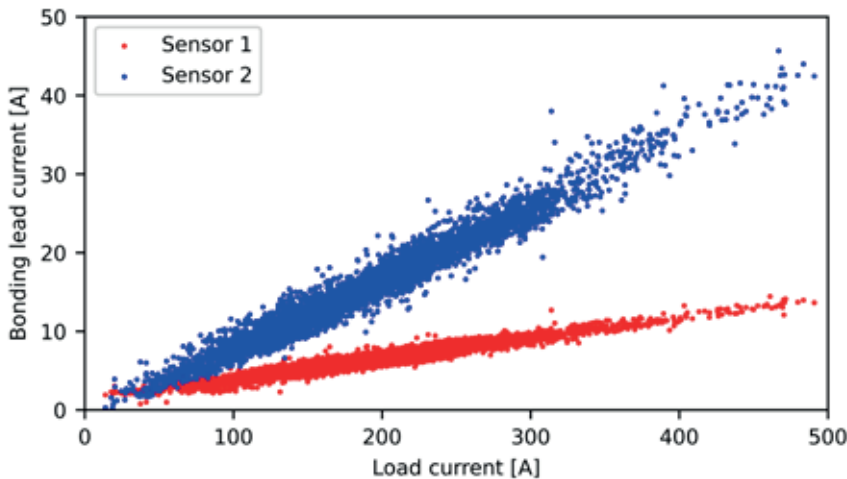




Figure 2: Typical correlation between bonding lead currents and load currents for two sensors connected to different link boxes.

For more information:

-  www.apsensing.com
-  info@apsensing.com