Sheath Current Monitoring at HVAC Power Cable Joints Using Fibre-Optic Distributed Acoustic Sensing

Ralf **ALBRECHT**, Sebastian **BOHR**, Jonathan **LUX**, Wieland **HILL**, Gareth **LEES;** AP Sensing GmbH, (Germany), ralf.albrecht@apsensing.com, sebastian.bohr@apsensing.com, jonathan.lux@apsensing.com, wieland.hill@apsensing.com, gareth.lees@apsensing.com

Oliver **HEEB**, Ronny **STEINHAUS**; Brugg Cables AG, (Switzerland),

oliver.heeb@bruggcables.com, ronny.steinhaus@bruggcables.com

☐ **Young Researcher** (Proved full-time engineering and science university researchers and Ph.D.students under 35 YO)

ABSTRACT

A new method for permanent sheath current monitoring is introduced, which uses fibre-optic distributed acoustic sensing (DAS). Fully passive current sensors and signal transducers installed at terminations or link boxes can be connected to a fibre which is interrogated by a DAS system. The DAS can detect and localize third party intrusion (TPI), and cable faults as well as the optically transmitted current data from the sensor locations. Function and performance of the sheath current monitoring system are verified by lab investigations and by the results of a field study.

KEYWORDS

Sheath current, optical fibre, distributed acoustic sensing, permanent monitoring, current sensor, insulated power cable, HVAC, cross bonding, link box

INTRODUCTION

Insulated HVAC power cables are increasingly used for transmission and distribution of electrical power because of efficient installation techniques, less effected by environmental influences and no visual impact which increases the public acceptance and results in a high usage in urbanized areas. Cables are more and more operated close to their technical limits due to the increasing share of weather-dependent and variable renewable energy supply [1]. High load operation of cables makes permanent condition monitoring essential, especially if cables are installed in densely populated urban areas. Distributed fibre-optic sensing (DFOS) systems like distributed temperature sensing (DTS) or DAS are meanwhile widely used in power cable monitoring [2, 3] as they can efficiently monitor the entire length of a cable installation by using just ordinary telecommunication fibres, and because they are immune to electromagnetic interference.

DTS measures the temperature of the cable screen and is used in combination with real-time thermal rating (RTTR) for determining conductor temperatures and for predicting the dynamic ampacity of cables [4]. DAS is used for cable fault detection and localization. An analysis of significant factors on cable failures can be found in [5].

In the present paper, we introduce a new method and accessory for DAS that enables permanent monitoring of sheath currents at cable terminations and joints.

Cables in operation carry capacitive and inductive currents in their sheaths. Excessive currents and voltages that could damage the cable or reduce the ampacity are usually avoided by using proper grounding and cross bonding schemes. Sheath current measurements can detect installation failures and material related degradation of the grounding and bonding system caused by environmental influences. They can also be used to reveal unwanted ground contact, for instance by damaged outer jackets or flooded link boxes [6, 7].

Our approach on permanently measuring sheath currents at terminations and link boxes of HVAC cables is based on conventional current transformers (CT's) connected to piezoelectric fibre stretchers that transform the output of the CT into fibre elongation. The fibre stretchers are integrated into the fibre route of a DAS system. A single DAS can measure the currents at multiple locations and cables by analysing the local fibre elongations.

EXPERIMENTAL

The metal sheath of HVAC cables is grounded at the terminations to reduce induced voltages to a safe level [8]. Since induced currents in a both-side grounded sheath could significantly contribute to cable losses and heating, cross bonding of sheaths from different phases is used at link boxes between cable sections to reduce such currents.

Link boxes and terminations are the locations where the sheath current is accessible for measurements, either in individual conductors at terminations or in coaxial cables carrying the sheath currents of two phase cables at link boxes. Our sensor technology can be installed in these locations and used for a permanent measurement and evaluation of currents.

Sensing principle

The schematic setup of a current sensor and transducer is shown in Figure 1. A CT clamped around a coaxial or single conductor cable is used to convert sheath current (primary current I_p) into a secondary current (I_s) signal that is then further converted to a voltage signal by a burden resistor. The voltage drives a piezoelectric fibre stretcher that elongates the optical fibre wound around the piezo. The periodic elongation of the fibre is thus proportional to the sheath current to be measured:

$$\boldsymbol{strain}\ [\boldsymbol{p\epsilon}] \propto \boldsymbol{I_s} \propto \boldsymbol{I_p}. \qquad (1)$$

To avoid overvoltages and the associated damages of the sensor elements in case of excessive primary currents, a transient voltage suppressor (TVS) diode has been installed. The whole sensor-transducer setup works without any external power supply, just based on the energy harvested by the CT. It should be noted that sheath currents of the phase cables are directly measured at the terminations, whereas the coaxial cables at the link boxes allow for measurements of current differences only.