Distributed Temperature Monitoring of Energy Transmission and Distribution Systems

Ensuring a Reliable Supply of Electrical Power for Today’s World

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Load Management – Optimization and Save Grid Operation

As demand for electricity continues to grow, so do the challenges to power companies and power grids. The liberalisation of power supply markets continues apace, resulting in the reorganisation of national and international networks. Events of the past few years – including large-scale blackouts and shortfalls in major markets, and the ongoing addition of alternative sources to existing networks – point up the need for improvements to existing infrastructures. At the same time, there is increased pressure to keep costs to a minimum.

Temperature monitoring is a key factor for the optimisation of underground power transmission and distribution installations. The conductor temperature depends on the load, but other factors such as the thermal soil resistivity, the power line arrangement, adjacent cables and other sources dissipating heat into the surrounding area have an important impact on the performance of the installation. Up to now, it has been almost impossible to foresee the temperature distribution along the cable route, so that the maximum applicable current load was usually set as a compromise between understanding of operation conditions and risk minimisation.

The passive and maintenance-free fibre optic sensor cable is the basis for the EN.SURE real time condition monitoring solution, either integrated directly inside an insulated high voltage underground cable (for instance FIMT, fibre in metal tube) or mounted externally on the cable jacket or installed in a separate duct close to the power cable.
Access the Thermal Conditions of the Power Cable in Real Time

The availability of industrial Distributed Temperature Sensing (DTS) systems that measure in real time temperatures all along the cable is a first step in monitoring the transmission or distribution system capacity. The integrated Dynamic Cable Rating (DCR) or also called Real Time Thermal Rating (RTTR) solution offered by LIOS enables not only to continuously monitor the temperature of a high voltage cable circuit in real time, but to safely utilize the existing network capacity to its maximum. Furthermore it provides the ability to the operator to predict the behaviour of the transmission system upon major changes made to its initial operating conditions.
Meeting the Demands of a Changing Power Environment

In times where power utilities face growing need of energy — forcing operators to stress the power cables to the physical limit - safety and efficiency becomes more and more important. Undoubtedly, knowledge in real time of cable temperature and thermal behaviour of the cable installation are key to control safety and efficiency of a power distribution network. Regardless of cable design, operational limits or installation practice, the fact is that unforeseeable adverse thermal conditions can and do cause system capacity degradations and service interruptions - especially with fatigue.

The EN.SURE monitoring system by LIOS Technology enable the user to locate any cable hotspot before failure, to dynamically optimize the power load and ensure reliable supplies of electricity by:

- Real time temperature profile measurement.
- Precise localisation of hotspots.
- Multiple alert parameter, free configurable for each zone.
- Integrated fibre switch for monitoring different cables resp. cable phases simultaneously.
- Trend analysis and online interface to accurate rating systems.

Technologies Creating Value

The LIOS temperature monitoring solution is based on using passive optical fibres as temperature sensors, either integrated directly an insulated high voltage underground cable (for instance FIMT, fibre in metal tube) or mounted externally on the cable insulation jacket or installed in a separate duct close to the power cable. A solution for overhead lines is also available. In this case the optical fibre is integrated into the core of a phase wire of overhead transmission lines (OPPC). Via joints and high-voltage fibre-optic uncoupling devices, the fibre is linked to the EN.SURE evaluation unit, where the distributed temperature profile is recorded and further processed. The temperature profiles themselves, or the results/events derived from them, can be transmitted via standard interfaces from the evaluation unit as required, and be either displayed or further processed in real time by PC, PLC or SCADA systems.

State-of-the-art Temperature Measurement System

The LIOS’ DTS technology has been successfully proven in critical applications like fire detection in road and rail tunnels and special hazard buildings, power cable and aerial transmission line monitoring, in oil & gas exploration for permanent downhole monitoring and for industrial induction furnaces surveillance, where these systems have been equipped in worldwide projects with more than 3500 permanent installations. Most of these applications are safety relevant and require high reliability and uptime of the sensor system. The EN.SURE DTS product series was carefully designed and thoroughly tested targeting reliable performance and smooth operation in industrial environments. Excellent Mean-time-between-failures (MTBF) of more than 30 years was reached based on the latest statistical field analysis of the current DTS product series.

6 to 500 kV
MV, HV and EHV experience
Setting Standards for Highly Reliable DTS Performance

High reliability is also a result of the unique optical frequency-domain reflectometry (OFDR) technology of the LIOS DTS systems. In contrast to time-domain technology using pulsed lasers with high peak powers, the LIOS OFDR DTS uses a quasi-continuous laser with low peak power resulting in a nonexistent wear out of the laser unit or any other fatigue of other optical components. The exceptional reliability favours the deployment of the LIOS DTS systems in all remote, safety relevant and industrial applications.

Key advantages of Raman OFDR distributed temperature sensing (DTS) systems by LIOS Technology:

- **Highly reliable industrial design** with key components approved by the telecom industry (tested according to Telecordia standard GR-468, with medium lifetime >25-years)
- **Signal processing based on patented Raman OFDR-Technology** (Optical Frequency Domain Reflectometry)
  The essential benefits of OFDR technology are the quasi continuous wave mode employed by the laser diode and the narrow-band detection of the optical backscatter signal, whereby a significantly higher signal to noise ratio is achieved compared to conventional pulse technology (OTDR).
- **Superior hotspot detection along the whole sensor cable length** even at most remote distances based on the invariant OFDR spatial resolution.
  The OFDR technology provides an invariant spatial resolution along the whole sensor length, which ensures to identify and clearly measure atypical hotspots or temperature anomalies at early stages, even at most remote distances. This is in contrast to other measurement principles (e.g. laser pulse principle, OTDR), which are sensitive to dispersion effects and therefore affected by a broadened spatial resolution at longer measurement distances; in other words, the hot spot sensitivity of pulse type measurements degrade with a function of distance.
- **Flexible and direct connection to management systems** such as SCADA (via DNP3, IEC60870-5 or IEC61850 and real time thermal rating (RTTR) software calculation engines based on IEC, AEIC and IEEE standards
- **Up to 16 internal fibre optic channels** – 1 EN.SURE DTS unit can cover the most complex power cable circuits
- **Temperature resolution better than 1 °C**
- **Laser product class 1M according to DIN EN 60825-1: 2007**
- **Maintenance free and simplified outdoor installation capability** with wide operating temperature range (-10 to +60 °C) and lower power consumption. No fan and completely sealed DTS unit design.
- **International Approvals and Certificates – type tested and accredited**
  In conscious of the strong requirements being made in the safety market LIOS provides a highly proven product based on the compliance with international quality standards recognised by various independent international bodies like TÜV Rheinland, VdS, EXAM, UL.
- **Impressive track record with more than 3500 permanent units installed worldwide**
  LIOS Technology is the leading industrial DTS manufacturer with certified production and testing procedures including demanding factory acceptance test (FAT) and site acceptance test (SAT) standards.
DTS installations

LIOS Technology GmbH is a dynamic and international operating company based in Cologne, Germany with offices in USA and China.

The excellent all-round solution to increase grid security and prolong working life of your facilities. Distributed temperature sensing is a powerful tool that allows to accurately rate power transmission and distribution assets based on actual field conditions. The easy-to-install, maintenance-free EN.SURE system offers a multitude of advantages. It is especially valuable for dynamic rating, since the accuracy of the temperature modelling can be coupled with the monitoring and the predictive functions of the dynamic rating system. By enabling dynamic analysis of network structure, it increases the overall safety and reliability of the grid. It facilitates dynamic reactions to transmission requests, resulting in more flexible capacity and revenue management in both the short and long term. And the potential for cost-savings is enormous: Downtimes and blackouts can be avoided, and the need for new lines and upgrades can be greatly reduced.

Customers employing the EN.SURE integrated real time thermal rating system can:

- Increase earnings by activating previously unused resources in existing power lines
- Utilize reserves in extreme situations without having to exceed permissible conductor temperature
- Respond quickly and dynamically to transmission requests by online metering of the grid capacity
- Conduct precisely and in real-time load predictions as new sources of energy are added to the grid
- React quickly to overload conditions

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