THE ROLE OF DISTRIBUTED TEMPERATURE SENSING IN SMART GRID IMPLEMENTATION

By Kent Kalar, CEO of SensorTran

Smart Grid is a major transformation of the existing electrical infrastructure. As electric utilities across North America, Europe, and the rest of the world implement Smart Grid, cost effective monitoring tools will be required to optimize circuit and feeder loads.

Initial Smart Grid efforts have primarily been focused on system nodes related to the management of power generation and storage elements. However, with the shift from distant to localized renewable power generation and the need for the Grid to accept power injections from many types of energy resources, the reliability, efficiency, and usable capacity of the power cables between the nodes must also be properly managed.

The retooling of the electricity infrastructure in Europe and North America is expected to occur within the next 30 years. Such a large changeover comes with a unique set of challenges, such as standardization of technologies and protocols, synchronization of cross-border regulations, and major decisions regarding interfaces between old and new systems.

Continuous, cost-effective monitoring of these interfaces within the new Grid structure is essential to the successful implementation of Smart Grid.

The Smart Grid initiative is a major undertaking that the European Commission Directorate-General for Research has compared to the leap the Internet has made into the Web 2.0 age. In a similar manner that Web 2.0 features user-generated content, Smart Grid incorporates user-generated power. As power begins to move throughout the Grid in multidirectional flows, it becomes more important to actively monitor all the power cables – not just the EHV transmission lines at the core of the traditional Grid system.

DTS AND THE SMART GRID

Distributed Temperature Sensing (DTS) technology is the leading technology available for power cable monitoring, as it enables rapid and dynamic collection of continuous, precise, and accurate temperature measurements across distances ranging from 1 to 40 km with 0.5m sampling resolution and temperature resolution below 0.1°C.

By continuously monitoring the cables themselves, DTS makes it easy to identify temperature events (hot spots, cable damage, over-current conditions, etc.) – reducing the risk of failure associated with operating above a cable's specified maximum temperature. Because the temperature is measured directly – rather than estimated based on load and environmental conditions – the usable capacity in monitored lines is maximized. Utilities today use conservative mathematical models to estimate the cable temperature for given load conditions, building in a "factor of safety" to ensure the cable does not overheat. While these models are effective at protecting the cables from failure, they are ineffective at maximizing the usable capacity of circuits.

Distributed Temperature Sensing (DTS) technology is the leading technology available for power cable monitoring, as it enables rapid and dynamic collection of continuous, precise, and accurate temperature measurements across distances ranging from 1 to 40 km with 0.5m sampling resolution and temperature resolution below 0.1°C.

Through DTS-based, real-time dynamic monitoring, the cable's temperature is empirically – rather than theoretically – obtained, allowing cable to operate close to its maximum capacity. Maximum capacity results in load shifting flexibility that is a key component in the realization of Smart Grid functionality.

HOW DTS WORKS

DTS is a temperature sensing solution that employs a standard telecommunications-grade fiber optic cable, functioning as a probe, providing temperature measurements at every half meter along that probe. DTS systems use the light source from a laser to record temperature traces, deriving the temperature information from backscattered signals.

The earliest installations of DTS for power cable monitoring were focused on identifying problem areas and hot spots. For Smart Grid, however, DTS serves a critical role in load management. As costs for DTS systems continue to decrease, utilities can now obtain and use real-time, dynamic temperature measurements across all circuits. With the injection of renewable energy and consumer-generated surplus power into the system, it is critical to control variable bi-directional flows of current in order to ensure efficient, failure-free Smart Grid operation. Using DTS, utilities can closely manage load balancing using actual rather than calculated temperature data.

Continued on page 14

Continued from page 12

DTS INSTALLATION

Recent technological advances in DTS technology have greatly reduced the time, energy, and expertise required to successfully deploy fiber optic-based monitoring systems. The latest DTS systems offer Active Plug & Play, enabling self-calibration, continuous verification of calibration, and auto-correcting calibration. These capabilities have greatly simplified DTS management, enabling field crews to set up and operate systems without needing to involve highly-skilled technicians. DTS operators can define zones and set alarms through a standard control panel. After configuration, systems alert the operator immediately when pre-specified temperature thresholds are approached and/or crossed (and communicate the various alarm conditions to the operator's SCADA system).

New DTS systems also provide the ability to view temperature and alarm information mapped to the actual asset being monitored – enabling both quick and intuitive data interpretation. For example, the SensorTran AssetViewer image below illustrates a system-wide view of a substation, including satellite imagery as well as a schematic representation of the actual substation facility.

To date, the vast majority of fiber deployments for power cables have been during new construction projects. In this situation, the fiber is placed inside the cable itself or externally bound/banded to the cable. If properly planned for by both the utility and installer, this type of deployment is straightforward and easily accomplished.

For situations where existing infrastructure is to be monitored, the fiber optic probe must be retrofit onto the cable or into the cable duct bank. DTS field tests have proven that fiber probes can be successfully retrofit into existing facilities without damaging the power cables, even in situations with sharp angles of up to 90 degrees. This ability to effectively retrofit fiber probes is one of the key elements that makes DTS a unique, cost-effective, and important contributor to realizing the full potential of Smart Grid.

FUTURE DTS ENHANCEMENTS

In addition to providing real-time distributed temperature data, many DTS software packages will soon include an Ampacity estimator. Using dense DTS temperature measurements made over time as inputs, SensorTran is developing a proprietary algorithm that will predict future cable conditions based on various load scenarios.

Because DTS software has access to actual measurements, the resulting estimate of heat transfer rates will be available in real-time and immediately actionable. This capability will be available without requiring any additional hardware, further enhancing the value of DTS deployments. The ability to use one cost-effective system to continuously assess a circuit's immediate condition and the implication of future loads makes DTS a critical technology in fulfilling the Smart Grid vision.