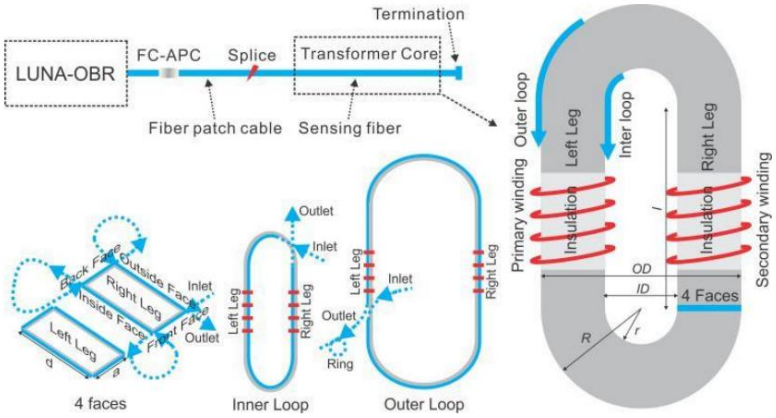
TECHBRIEF

NETL Ref. No: 18N-32

Distributed Fiber Sensing for Power Magnetics



Schematic diagram of the OFDR based sensing system including the layout of the sensing fiber instrumented on the transformer core.

Opportunity

Diagnosing internal conditions in energized transformers and other power magnetics components requires sensing approaches that can operate in high-voltage, high-temperature, and electromagnetically noisy environments where conventional probes cannot be placed. Engineers at the U.S. Department of Energy's National Energy Technology Laboratory (NETL) and Carnegie Mellon University (CMU) established an optical frequency domain reflectometry (OFDR) approach that uses standard optical fibers to perform real-time distributed measurements throughout transformer structures. Rayleigh backscattering in the fiber acts as a location-specific optical signature created by nanoscale refractive index variations; when temperature or other stimuli alters the local index, the corresponding spectral shift can be mapped along the entire fiber length. By installing the fiber directly on windings, cores, or within insulation regions, the system provides spatially and temporally resolved temperature profiles that reveal non-uniform heating, emerging faults, and operational behavior inaccessible to point sensors. The same platform can be extended to detect magnetic fields, electric fields, or changes in oil or gas chemistry when paired with thin film functional coatings. This technology is available for licensing and/or further collaborative research from NETL in collaboration with CMU.

Problems Addressed

- Power transformers are indispensable assets within the electrical grid, and their long operational lifespans, coupled with their critical function, mean that failures can lead to significant economic losses.
- There are major challenges in managing these complex, often custom-built components that stem from the difficulty in obtaining comprehensive, real-time diagnostic information about their internal state.

Potential Commercial Applications

- Real-time Condition Monitoring Power Magnetic Components: provides critical internal temperature data for transformers, enabling early fault detection and predictive maintenance.

Competitive Advantages

- Enhanced Spatial Resolution: enables real-time, distributed temperature measurements within power transformers, including previously inaccessible areas like the magnetic core laminations.
- Improved Fault Detection: provides detailed internal temperature profiles. The technology facilitates early detection of potential faults, reducing the risk of catastrophic transformer failures.
- Cost-Effective Implementation: using low-cost, commercially available optical sensors, the system offers a more economical solution compared to specialized, high-cost monitoring equipment.

Publications

Lu, Ping, et al. Real-Time Monitoring of Temperature Rises of Energized Transformer Cores With Distributed Optical Fiber Sensors. (2019). IEEE Transactions on Power Delivery. DOI: https://doi.org/10.1109/TPWRD.2019.2912866

Intellectual Property Status

A U.S. patent (US11067458) was issued on July 20, 2021, and expires on March 16, 2039.

Licensing / Collaboration

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