Application Note

Power Transformer Hot Spot Monitoring using Proximion Optical Fiber Sensing

THE CHALLENGE

Accelerated power transformer ageing and component degradation can occur if internal temperatures are allowed to rise above recommended levels. Degradation is driven by time and temperature under an Arrhenius relationship, wherein a 40C increase in temperature can accelerate ageing by a factor of 100 [1].

Real time monitoring of operating temperature and hot spots within power transformers can provide actionable data from which asset owners can manage machine loading and carry out condition-based maintenance. Using such an asset management system, operators can reduce the total cost of ownership by:

- Extend the lifespan of the transformer
- Performing planned maintenance when least disruptive
- Avoid expensive, in-service failure
- Avoid unnecessary, routine maintenance

Such hot spot temperature monitoring relies on the use of multiple sensors to directly measure temperature within the transformer windings and, where used, the transformer oil. The more temperature measurements that can be taken, the greater the ability of the system to detect a local hot spot. There can be significant technical challenges for conventional electronic sensors to make these measurements, including:

- High electromagnetic interference
- Exposure to moisture and/or corrosive fluids
- Difficulty to achieve enough measurement points
- Non-dielectric sensors can't measure where needed

Fiber optic sensors, in which electromagnetically immune measurements are made using miniature dielectric glass fibers, can overcome some of these challenges, and a few commercially available fiber optic sensing solutions are available for power transformer temperature monitoring. However, these solutions are limited to one temperature measurement at the end of each fiber so there is a trade off between the number of measurements made, and the cost / complexity of the monitoring system. Inevitably, this leads either to a compromised system with fewer measurement points than is required, or to no system being installed. In each case, the potential value of power transformer hot spot monitoring is not exploited.

1. IEEE Power and Energy Society, PC57.91 - Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators. 1995

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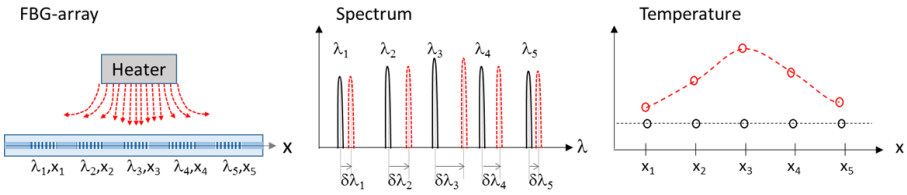
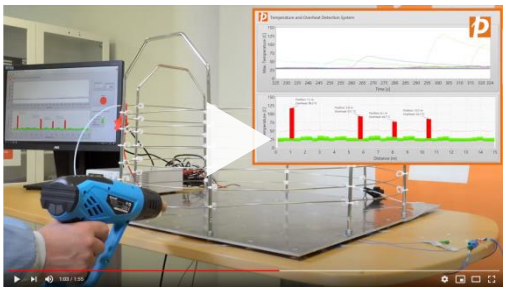
THE SOLUTION

The fiber Bragg grating (FBG) is a fiber optic sensor which offers the recognised benefits of electromagnetic immunity and harsh environment tolerance, plus the additional advantage of multiplexing where many measurements can be made per fiber.



Showing how the wavelength changes of multiple FBGs on a fiber can measure a distributed temperature profile.

FBGs are miniature, in-fiber wavelength selective mirrors. Many FBG sensors can be written into a single fiber, with each sensor reflecting a wavelength that varies with temperature. Proximion has developed a unique process for writing more than 100 customised fiber Bragg gratings in a single fiber at separations as low as 5mm. This allows for an extraordinarily high number of measurements points to be distributed throughout the transformer components during manufacture, using one or more optical fiber. Additionally, Proximion has created bespoke hot spot detection software that quickly identifies the severity and location of an overheat event. This provides for a highly effective power transformer hot spot monitoring system that creates a 3D temperature map throughout the machine, such that localised hot spots are not missed, and false positive readings are minimised.

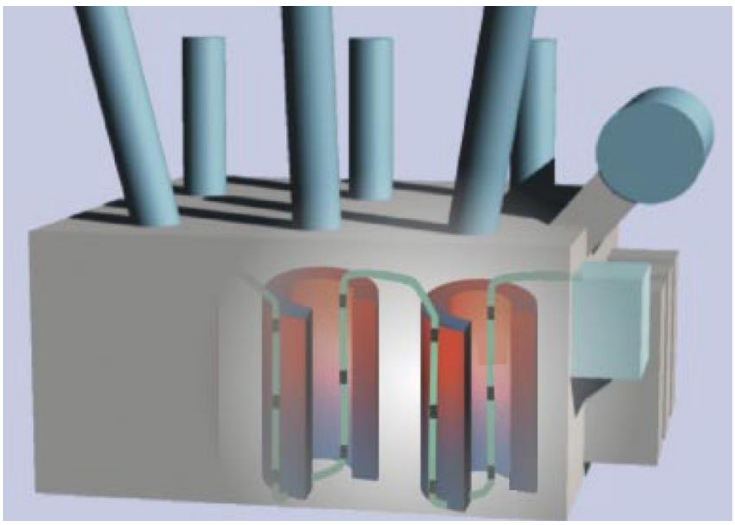


Click image to see a video demonstration of Proximion's fiber optic overheat detection system

Where multiple transformers operate in a single plant, they can all be instrumented with FBG sensors and monitored by a single, multi-fiber FBG interrogator, so simplifying monitoring system architecture and reducing costs.

FBG technology offers the following, unique advantages to power transformer hot spot monitoring:

- Hundreds of measurement points with minimal connectors or penetrations
- A dense 3D temperature map with no missed hot spots
- All dielectric sensors with no electromagnetic sensitivity
- A single, centralised monitoring instrument for multiple assets



Power transformer instrumentation scheme: A single fibre array installed during transformer manufacture to directly monitor hot-spots caused by over-loading or component degradation

THE COMPANY

Part of the huge Hexatronic Group, Proximion AB designs and manufactures customized, high performance fiber optic sensor systems for use in numerous harsh environment applications. Proximion technical experts have experience applying the unique advantages of FBG technology to a wide range of industrial assets, including electric motors, generators, steel foundries, chemical reactors and aircraft.

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