

# Condition-Based Monitoring System for Ageing Detection in Transformer Oil

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Transformers are essential to power networks because they regulate voltage and eliminate losses, allowing voltages to be distributed to customers in a safe and efficient manner. Despite the fact that insulation degrades with time, the insulation system plays a vital role in ensuring that power transformers can safely execute their duties. Even though there is a risk of loss of life, sample contamination, loss of person-hours, and the possibility of missing critical incipient ageing responses that occur outside the maintenance cycle window, the vast majority of conventional oil ageing detection methods are performed offline and are therefore best suited for scheduled maintenance.

In this study, the optical fibre sensor transduced output voltage (OFSTOV) of an intensity-modulated optical fibre sensor was used to predict refractive index (RI), breakdown voltage value (BDV), dielectric dissipation factor (DDF), dissolved decayed products (DDP), total acid number (TAN), interfacial tension (IFT), and oil quality index (OQIN) of existing dataset. Using the most precise machine learning model that could be applied to the unique Simscape interface, a real-time monitoring dashboard for detecting senescence in transformer oil was developed.

As a result, highly correlated models were developed and reported in this study; they may facilitate the transition from standard offline planned maintenance to online prescriptive ageing detection. This research also lays the groundwork for the incorporation of digital-twinning capabilities into in-situ transformer oil ageing detection, which will boost reliability, minimise risks, and cut operational costs.

**Keywords:** Ageing, Bootstrap, Fibre Optic Sensor, High Voltage, Machine Learning, Online, Transformer Oil