Distributed Acoustic Sensing of Partial Discharge: Initial Findings

Laurie **KIRKCALDY**, James **PILGRIM;** University of Southampton, (United Kingdom), laurie.kirkcaldy@soton.ac.uk, jp2@ecs.soton.ac.uk

Rosalie ROGERS, Gareth **LEES,** AP Sensing, (United Kingdom), rosalie.rogers@apsensing.com, gareth.lees@apsensing.com

ABSTRACT

This report investigates novel, initial experimentation in detecting and measuring Partial Discharge along an insulated cable using a fibre-optic-based Distributed Acoustic Sensing system. Initial detection of in-air corona and discharge has successfully been observed with a high signal-to-noise ratio, thus more sensitive signals will be able to be measured towards the goal of detecting partial discharge. This method could present numerous advantages over conventional Partial Discharge measurement techniques including accurate positional information, greater detection distance and immunity from electrical noise.

KEYWORDS

Distributed Acoustic Sensing (DAS), Partial Discharge (PD), measurement, detection, void discharge, distributed measurement, fibre-optic, power cable monitoring

INTRODUCTION

Power cable PD detection and location is now a necessary part of operating and maintaining a cable system and is routinely used for condition monitoring. Conventional test methods do not allow for the location of PD along cable circuits to be determined accurately. This work presents an optical fibre-based detection system that uses the minute vibrations caused by Partial Discharge which disturb the fibre, providing location and possible characterisation about the event. A Distributed Acoustic Sensing (DAS) system allows for precise localisation of PD without electrical signal degradation at great distances. Other measurements could be taken using the same system using multiplexing, such as detection of mechanical damage or larger discharges such as break-down events.

Present online detection methods such as high frequency (HF) current and single-point acoustical emission monitoring only provide very limited range and have no ability to provide accurate localisation data other than through time of flight between multiple sensors. By knowing the location and size of discharges, it is possible to make more informed asset management decisions.

Currently as far as the authors are aware, DAS systems have not been used for fully distributed detection or location of discharge activity. Therefore, this research is required to investigate whether DAS is suitable for the detection of discharge activity within a cable. Further research can demonstrate whether discharge characterisation is possible from DAS measurements alone.

OUTLINE OF DAS SYSTEMS

DAS typically uses a method called c-OTDR for detection of vibrations that can be reconstituted into an acoustic signal. Coherent Optical Time Domain Reflectometry (c-OTDR) is a well understood technique used to measure the Rayleigh backscatter along an optical fibre. A highly coherent laser pulse is launched into the sensing fibre which generates scattered light that is then collected on a detector. The returning scatter then constructively and destructively interferes with each other, as in an interferometer, causing a change in the phase relation and/or amplitude that is measured. However, as this Rayleigh backscatter changes based on the strain that the optical fibre experiences, by use of a fast-repetitive scan of the fibre acoustical signals can be reproduced along the continuous length of fibre. From comparison between the time of launch to detected reflections and the known speed of light down the fibre, the distance at which those scattered reflections originate from can be determined.

As the returning signal is of very low power, collection of this scattered light has to be taken over a measurable amount of time. These time slots in which the scattered light is measured, gives an inherent “binning” of physical segments along the fibre known as spatial resolution or gauge length. The sensitivity and SNR (Signal to Noise Ratio) of the system is affected by the selection of this spatial resolution. The measurement sections overlap by a length known as “spatial sampling distance” thereby allowing the spatial resolution to be accurately sampled.

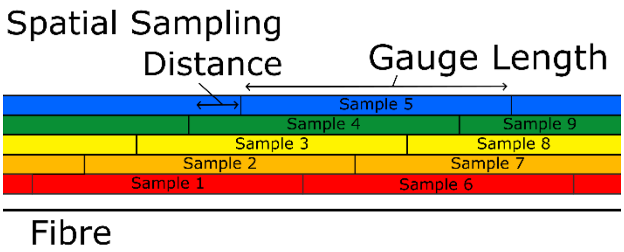

Figure 1: Graphical drawing of sampling terms used in DAS

c-OTDR techniques are able to provide a long measurement range, however longer ranges do provide a limitation in that the spatial resolution and repetition frequency are often impacted. A DAS system has recently been reported with a measurement range of 125km, with a spatial resolution of 8m [1]. As the measurement range increases, the amplitude of the received backscatter decreases due to fibre attenuation and therefore increased light should be launched into the fibre to maintain a good SNR. This can be achieved by increasing the optical pulse width which therefore decreases the spatial resolution. The repetition frequency decreases simply due to the time that the light pulse takes to reach the end of the fibre before a new pulse can be launched. Therefore, experiments in lab conditions can achieve much greater sampling frequency