An introduction to fibre optic Intelligent Distributed Acoustic Sensing (iDAS) technology for power industry applications

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ABSTRACT

This paper provides an explanation of the general principles of operation of the Intelligent Distributed Acoustic Sensing technology and focuses on the current areas of interest and applications of this technology within the industry. Currently the technology is mainly used for perimeter monitoring of utility assets and third party intervention monitoring on buried pipelines. In the oil & gas sector distributed acoustic measurements are used in vertical seismic profiling and flow allocation measurements. The paper explores some of current applications of this technology. This paper also explores and provides information that will enable the potential for future applications.

KEYWORDS

DAS, DVS, DTS, Smart Grid.

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INTRODUCTION

The application of new technologies to the existing and future electric transmission and distribution network, with real-time knowledge of current and possible future demand, status of present infrastructure is coined by the term Smart Grid. Running in parallel to this complex changing network demand structure we see that technology is changing at a rapid pace. Increasing computing processing power and ability to communicate with a variety of network infrastructures has enabled new possibilities and applications to enhance the electric industry's demand for real-time monitoring.

Changes in the distributed optical sensing area are happening fast with ever improving capabilities in terms of distributed temperature measurement and interpretation of the immense amount of data such systems produce into meaningful user friendly data. We see this through the active deployment and integration of DTS and DCR technologies. The introduction of tried and proven distributed fibre optic acoustic sensing technology may help to provide further capabilities in terms of real-time monitoring and could have potential to be retrofitted into existing network infrastructure.

POINT AND DISTRIBUTED SENSORS

Firstly however let us define what we mean by distributed and point sensors in terms of optical fibre based sensing technologies. Fibre optic point sensors are generally passive point based transducers that are designed to provide the quantification of a measurand (temperature, strain, displacement, sound, gas concentration etc.), and through interconnecting fibre optic cables, communicate that quantity to a remote sensor control unit. Generally the sensor control unit will convert that optical signal to a digital or analog value, to be further processed within the control system. Such systems have been successfully deployed with the electric industry for monitoring applications related to transformers, busbars, generators, switchgear etc.

With distributed sensors on the other hand, an optical fibre core with a fibre optic communication cable, is the distributed transducer. There are no additional transducers within the optical path. The sensor control unit in this case will tend to interrogate the fibre optic cable using laser pulse sequences, and records the response due to naturally occurring light scattering phenomena within the fibre. Responses can be taken continually along the entire length of the optical path. Such fibres tend to utilise standard multimode and singlemode fibre optics used in data communications applications and are currently deployed to quantify a number of measurands e.g. sound, vibration, temperature, strain etc. As such, there is the potential to utilise existing fibre optic network infrastructure and so may provide the opportunity for retrofit type applications.

Classically, point sensors, which typically have a higher signal to noise ratio than distributed sensors, have been used where high precision, fast measurements are needed; with distributed sensors favoured where extensive coverage is needed, with a compromise made on either measurement time or resolution/accuracy. Here we report on a new type of intelligent Distributed Acoustic Sensor [1], which achieves both the precision of a point sensor with the wide coverage of a distributed sensor. This system measures the true acoustic signal at every point along an optical fibre. By using digital signal processing, the acoustic response along the fibre can be combined to enhance the detection sensitivity, thereby exceeding the sensitivity of point sensors, as well as achieving highly directional information, facilitating super resolution imaging. Here we report on different array processing techniques which can be effectively used for seismic applications using the new sensor.

Raman and Brillouin Systems

At the core of each of these technologies is the technology known as Optical Time Domain Reflectometry (OTDR) technology. This technology was originally developed for the telecommunications industry as an effective means to determine the optical losses within a fibre optic circuit and produce a loss profile for that circuit. With OTDR technology a light signal is launched into the fibre and transmitted along its entire length. The OTDR