Subsea Power Cables: Monitoring via Fibre Sensing

Analysis of appropriate Offshore Wind Farm Construction and Operations Plan (COP) options, Employer Requirements (ER), Operations & Maintenance Plans (OMP)

Target Audience: Cable Engineers, O&M Managers

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1 Intent

Guidance for Interconnect & Wind Farm Developers, O&M Professionals, Installers and Insurance Stakeholders

This document analyses and provides options for appropriate content to insert in Construction and Operation / Operations and Maintenance plans pertaining to understanding the health of cables for Failure Prevention and exploiting the utility of systems and devices for both Power Level Control and Failure Location. The document is vendor agnostic and focuses on the use of fibre optic sensing; it seeks to de-mystify the technology and enable successful application.

Importantly the enabling technologies discussed below are non-invasive and utilize a single optical fiber from those commonly provided for communications and Supervisory Control and Data Acquisition (SCADA) or Distributed Control (DCS) systems within Offshore Wind Farm (OSW) Array, Export and Interconnector cables.

The technologies considered do not impact at all the design of the cables which are uniformly supplied with multiple standard single mode fibre optic cores in a loose tube, gel filled configuration.

Section 2 describes the technologies and our advice is provided in Section 3 in the form of paragraphs (together with explanation) that can be placed by developers and consultants directly into their plans.

The level of technology overview is appropriate to early plans and is not a detailed dive – a following document aimed at procurement will cover technology options in clear, unambiguous specification language. The language used throughout indicates statement of intent on behalf of developer.

1.1 Document content

- Section 2 provides an overview of the sensing systems considered by means of background
- Section 3 provides suggested COP / O&M statements for both the sensing hardware and the separate utility software. Each section covers appropriate text for first the sensing hardware and then the utility software
    - 3.1 Temperature Monitoring
    - 3.2 Vibration / Acoustic Monitoring
    - 3.3 Strain Monitoring

2 Sensing Technologies Considered

Short primer on non invasive fibre optic sensing approaches

This document pertains to cable sensing via existing optical fibres and the benefits of health monitoring and does not consider ancillary approaches such as online electrical monitoring or strap on / ancillary discrete sensors.

For further information on general purpose Health Monitoring Requirements (technology agnostic), the reader should consider the open source (Wiki Commons) publication: Cable Health Monitoring DEX-0038.

This document focuses on the following three common technologies, each available from multiple suppliers.

- Distributed Acoustic Sensing / Distributed Vibration Sensing (DAS).
- Distributed Temperature Sensing (DTS)
- Distributed Strain Sensing (DSS)

FOSA Introduction to Fiber Optic Sensing

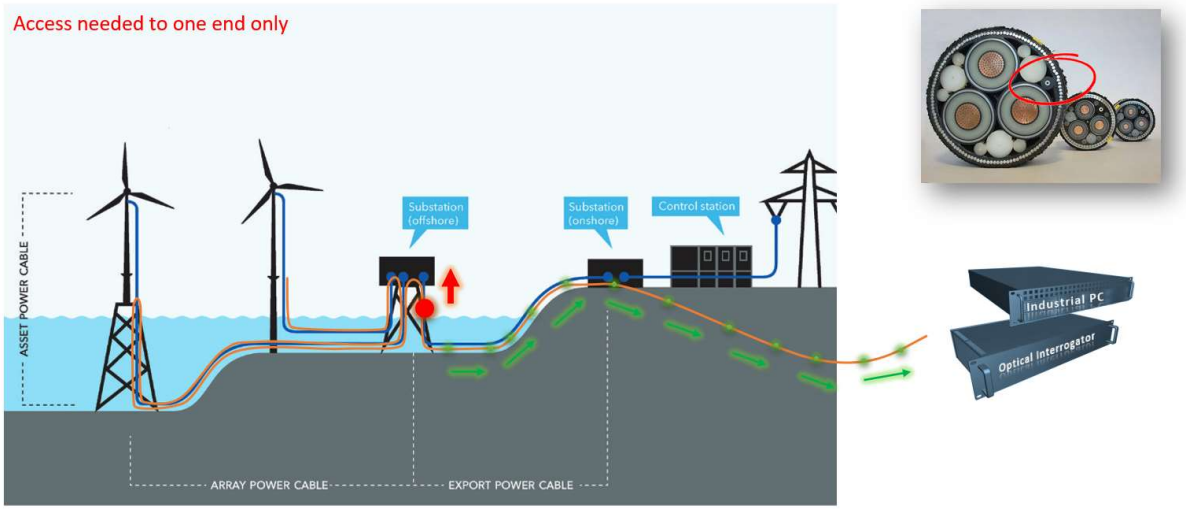
FOSA Introduction to Distributed Acoustic Sensing

FOSA Introduction to Distributed Strain and Temperature Sensing

Each system referenced above utilizes a single, passive optical fibre that is provided as a standard component of the target cable. To activate sensing, the sensor fiber is coupled at one end of the system to an Interrogator Unit (IU) that is dedicated to DAS, DTS, DSS or some combination thereof, each requiring a single separate fibre.

Notably, each of the systems described provide “distributed” measurements in their respective measurand domains. Such distributed measurements can be viewed as an extensive array of virtual sensing points along the full length of the sensing fibre. These points are highly configurable and spatial resolutions can be modified and/or set using the IU. Spatial Resolutions for these applications are typically of the order of 10 meters but can range from 1 meter to hundreds of meters.

The basis of the operation is straightforward – a short pulse of light is introduced into a fibre (the red dot in the figure below). Although the glass fibre is as clear as possible, nonetheless a tiny fraction of the red light is reflected[1] by the glass and travels back towards the source – we’ve coloured that green in the image below but that’s just to make things clear. It’s all infrared.



[1] Technically it’s called backscatter – but that’s not important right now. But you may hear the name.