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Fiber Optic 4C Seabed Cable for Permanent Reservoir Monitoring

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Abstract

Recent advances in fiber optic sensing technology have provided the oilfield service industry with a new tool for reservoir monitoring in deep water. A fiber optic 4C Permanent seabed cable has been successfully demonstrated in the GoM. Advances in the cable design and optical sensors, including a 3-axis optical accelerometer, have turned this system into a practical tool for 4C permanent reservoir monitoring. The cable design and performance of the new system are reviewed. An 800 m cable with 4C sensor stations located every 50 m was tested along side a 4C cable with conventional electrical sensors. While the cable tested was limited in size, we have demonstrated the optical systems capabilities beyond 3000 m depth and with channel counts in excess of 2000 over 12 km in the lab. Data collected from the field tests have proven the prototype optical system meets the performance required of the deepwater permanent reservoir monitoring. The test results presented herein were acquired in during a development project with Chevron. Current projects include pilot test on active reservoirs and we will report the current status and test reports as available.

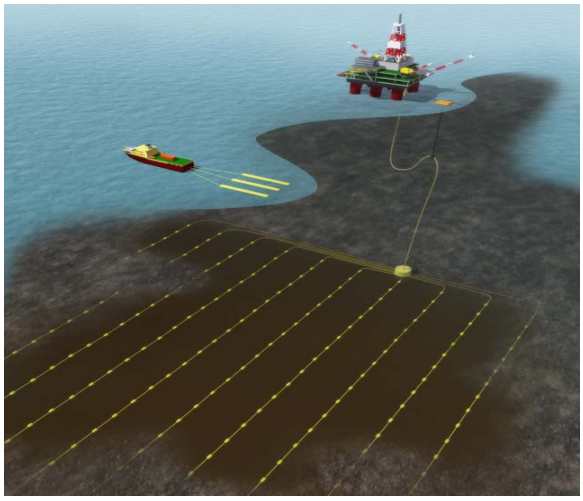

Figure 1: An artist view of a permanent installation

Introduction

Traditional seismic acquisition hardware relies on sensors that produce an output voltage that is amplified, multiplexed and transmitted up a cable to the recording system using distributed in-sea electronic circuit cards and modules. The passive nature of the optical telemetry system eliminates the need for costly in-sea electronics and the problems associated with them, providing a more reliable, less expensive, safer system to deploy and operate. Optical sensor based systems are ready to replace the traditional technology in the oil field, this is already being seen in the low channel count high stress environments of temperature and pressure sensing in-well. Advances in PGS optical technology provides a system that is expandable beyond the capabilities of current seismic systems.

Optical sensors used in acquiring seismic data are typically constructed from optical interferometers. In this paper we present the seabed system that was tested in the Gulf of Mexico summer 2006, we describe the cable and sensor construction, the optoelectronic system and the recording interface. We also compare the data quality between the electrical and the fiber optic cables.

The fiber optic system

The cable utilizes a Dense Wavelength Division Multiplexing (DWDM) telemetry scheme to optically power the sensors. An optoelectronic cabinet and recording system provides the optical signal to the passive optical network of sensors. The basics of the system include a frequency-modulated laser source passing through an interferometer, where stress from the outside environment causes a phase shift in the light as it passes through the interferometer. The light is then detected and the phase information extracted to output a signal equivalent to the input stress.

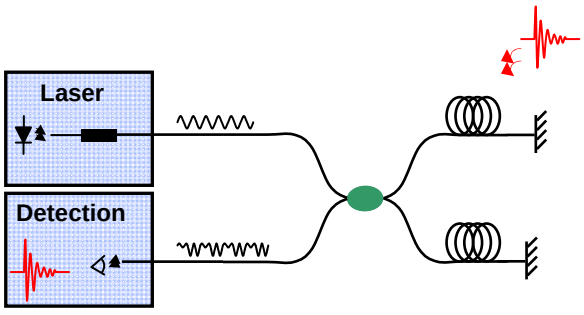

Figure 2: An optical interferometer

The sensors

The hydrophone and 3-axis accelerometer in each sensor station are optical transducers fabricated using Michelson