AWA Limited
(INCORPORATED IN NEW SOUTH WALES)

AWA RESEARCH AND DEVELOPMENT
OPTICAL NETWORKS SECTION

INTERFEROMETRIC FIBRE-OPTIC SENSOR HYDROPHONE DEVELOPMENT

The Research Laboratory at AWA Limited, North Ryde, is pursuing an active program to assess the potential of fibre-optic sensors and, in particular, the fibre-optic hydrophone for fixed and towed acoustic arrays.

Fibre-optic sensors offer potential advantages over conventional sensor technologies. In the case of the hydrophone, advantages include --

* Increased sensitivity with respect to present-day piezo-electric devices
* The inherent EMI immunity of optical fibre
* Operation over a wide range of hydrostatic pressure - in other words, performance is depth insensitive
* Compactness and lightweight
* Lower cost
* An electrically passive sensor head leading to optically addressable passive sensor arrays
* An underwater sensor is subject to water ingress, and a system which does not include electrical conductors and components is obviously very desirable.

Fiber-optic interferometric systems have been shown to give superior performance over the alternative fibre-optic amplitude modulation schemes. Influence of mechanical stress upon the optical path length in an optical fibre provides the transduction medium. Optical path length is affected by both a change in physical length and by a change in refractive index: the former predominates in the hydrophone sensor head. A popular coherent fibre sensor easily constructed with optical directional couplers in the optical-fibre medium is the Mach-Zehnder interferometer, and the demonstrator system presented at AIDEX89 shows the feasibility of a sensor based on this technique.

As a means of detecting the change in relative optical path difference between the signal and reference arms of the interferometer, a PGC-homodyne detection technique has been chosen for the demonstrator. In order to overcome signal fading, due to ambient pressure and temperature fluctuations, and also to lift the detected signal out of the region of low frequency laser noise, a sinusoidal phase generated carrier (PGC) is applied to the reference arm. This is accomplished by applying a large amplitude phase shift at a frequency outside the acoustic signal band. The signal thus appears as side bands on the PGC carrier and on its harmonics.

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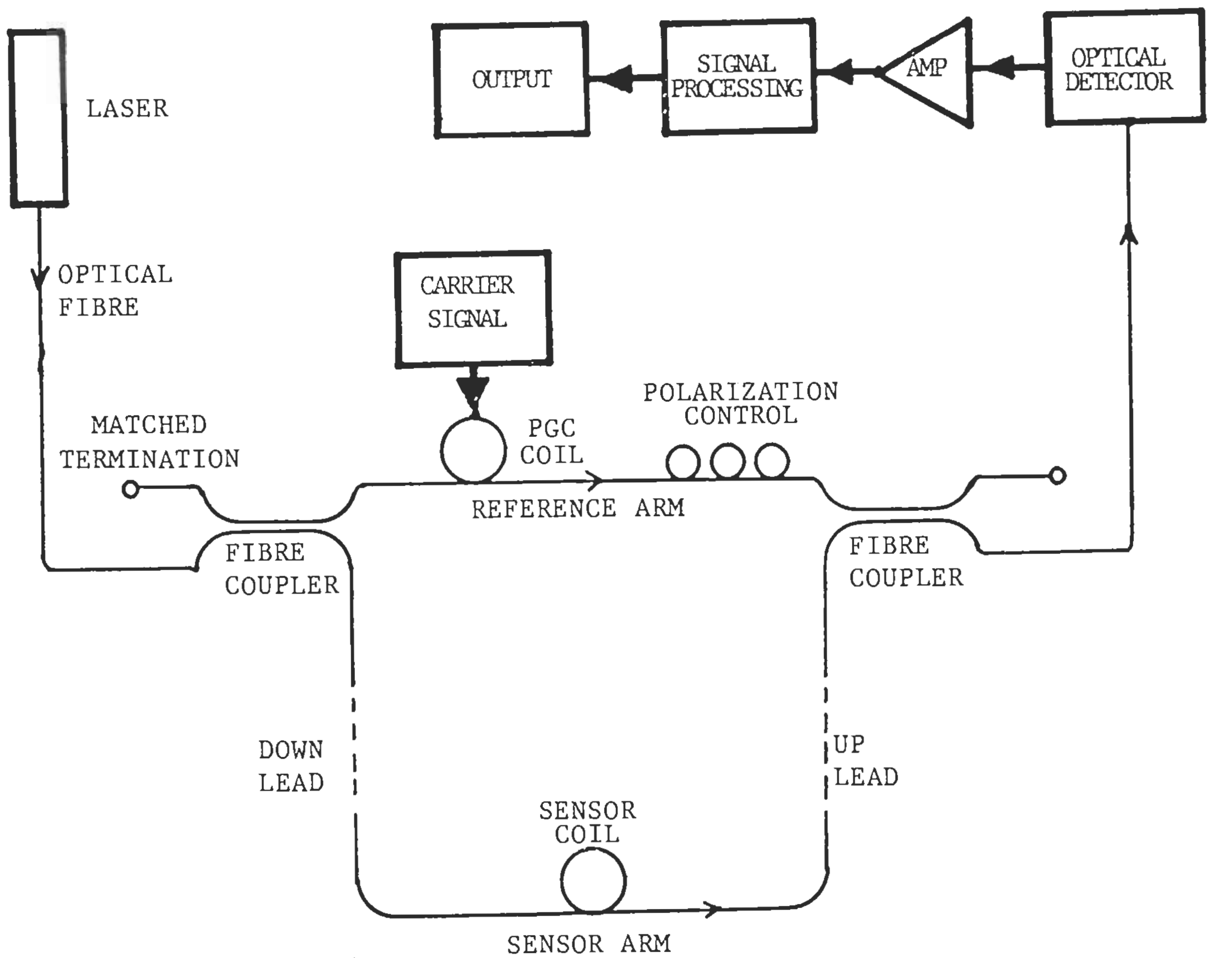
A schematic, depicting the system configuration and detailing the principal components of the sensor, is presented. For purposes of this demonstration, the sensor coil consists of 445 turns, 6cm in diameter, of standard telecommunications single mode optical fibre. Single mode rather than multimode fibre is necessary in the interferometer to avoid multiple modal optical paths in the multimode fibre.

As shown in the block diagram of the demonstrator, optical detection - and subsequent signal processing - can be performed remotely from the sensor element itself, thus eliminating the need for any electrical component to be underwater. The distance between detector and sensor is limited only by fibre loss at the operating wavelength.

The premiss is that electrically passive optical sensors will offer an attractive alternative to traditional piezoelectric devices in next generation sonar systems and, in particular, passive sonar arrays. The objective of this research is to realise the potential of fibre-optic sensor technology, and to establish guidelines for future development.



BLOCK DIAGRAM OF ACOUSTIC SENSOR DEMONSTRATOR