PRECISION ACOUSTICS

FOHS product update

KEY DIFFERENCES BETWEEN V1 & V2

- **New Connector** – The fibre connector has been changed from an exposed screw fit connection to a shuttered push fit. This change leads to reduced contamination and improved connection repeatability for better system performance.
- **Enhanced temperature measurement** – Improvements have been made to the temperature measurement capabilities of the system at the software level.
- **Improved electronics** – The electronics of the system have been upgraded to enhance reliability, resulting in fewer performance issues. The latest version of the tunable laser module improves optical performance when compared to V1.
- **Easier to service and repair** – A sacrificial internal connector has been implemented between the fibre connector on the front panel and the circulator. This results in reduced repair time and cost in the event of wear or damage to the front panel connector.
- **Certified** – The FOHS V2 has been certified by TUV SUD in accordance with the relevant Safety and EMC standards.

Figure 1 - Image of FOHS V2

COMMON APPLICATIONS AND USES

- Characterisation of therapeutic devices. The FOHS is optimised for this application because of the following factors:
  - The fibres are cheap to replace if damaged.
  - The fibres are more robust at higher pressure fields than our piezoelectric hydrophones.
  - The FOHS offers simultaneous measurements of ultrasonically induced temperature change and pressure waves causing it.
- In-situ measurements in tissue phantoms and ex-vivo tissue samples
- In-vitro monitoring of externally applied HIFU, both in terms of received ultrasonic signal and resultant temperature rise.
- Determination of pressure signals close to devices with continuous wave output (thereby avoiding interference of EM and acoustic signals).

Figure 2 - Image of a V2 fibre optic sensor

- Determination of source pressure signals according to IEC 61689 where you need to measure VERY close to the transducer and thus risk hydrophone damage.
- Measurement within micro-fluidic channels which require very small sensor diameter.

THEORY BEHIND THE SYSTEM

The FOHS features a dual-sensing fiber-optic hydrophone capable of simultaneous acoustic pressure and temperature measurements at the same location. This tool is designed for characterising ultrasound fields and ultrasound-induced heating.

The system setup is illustrated below. A tunable laser operating in the telecoms C band (1528-1564nm) serves as the light source. Light is transmitted via the fibre to the sensor tip, where it is modulated by ultrasound and reflected back to a photodiode through the system's internal optics. The laser's wavelength tuning is controlled by a PC.

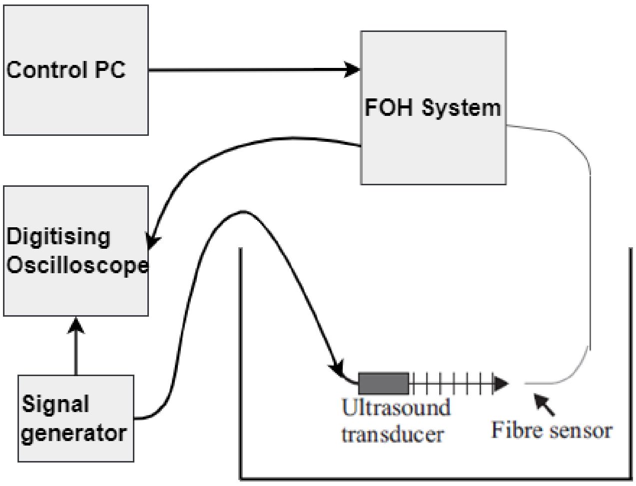
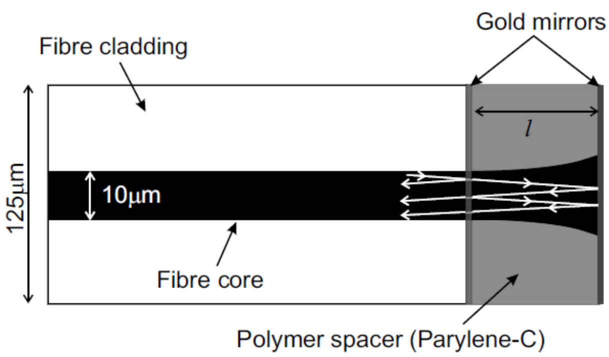


Figure 3 - Schematic of the fibre-optic hydrophone system V2



A schematic of the tip of the fibre-optic hydrophone is shown on the left. The sensing element is a Fabry-Pérot interferometer (FPI) which compromises a thin Parylene-C polymer film spacer sandwiched between a pair of partially reflective gold mirrors.

Figure 4 - Schematic of FPI sensor

The acoustic transduction mechanism detects thickness changes in the Parylene layer. Light from the laser is guided down the optical fibre to the sensing element. Some light is reflected back into the fibre by the first gold mirror, while the rest transmits into the Parylene layer, repeating at the second mirror. The total reflected optical power depends on the phase shift, which is influenced by the Parylene layer's thickness.

The Interferometer Transfer Function (ITF) plot shows the light reflected from the sensor as a function of optical phase. The point where the derivative is maximum is the optimum phase bias point, where the sensor is most sensitive. A wavelength tunable laser biases the sensor to this phase.

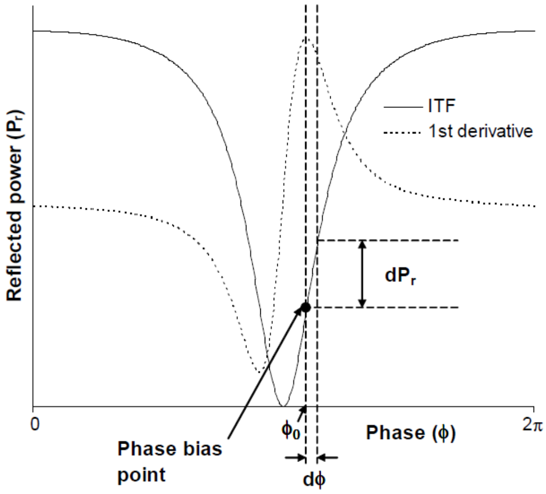


Figure 5 - Interferometer Transfer function

Given the interest in ultrasound-induced temperature rises, the ability to monitor temperature changes while measuring acoustic pressure is particularly useful. Acoustic measurements reflect intensity changes at ultrasound frequencies, while temperature changes cause a shift in the ITF along the optical wavelength axis. Mapping intensity changes to shifts in optimum bias wavelength allows temperature tracking while the system operates in acoustic mode.

Datasheet available to download here