OPTICAL FIBRE HYDROPHONES

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INTRODUCTION

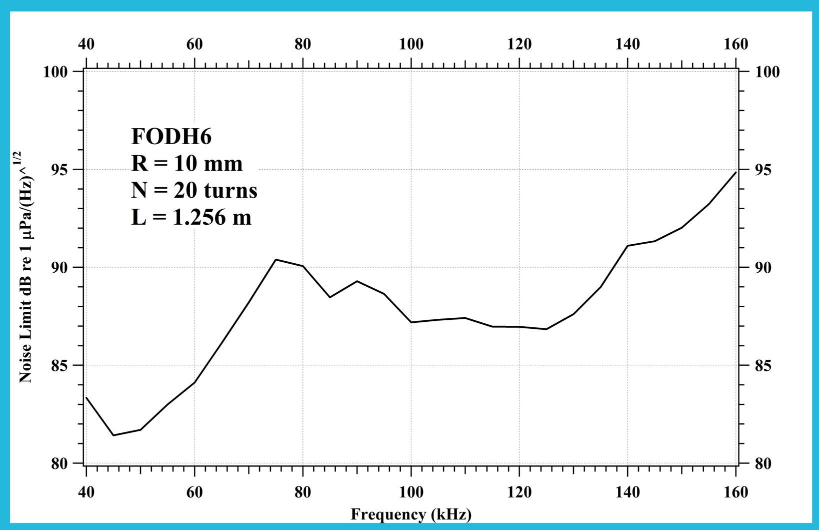
The **traditional acoustic navigation systems** for autonomous underwater vehicles provide speed and height from the seabed making use of **ceramic piezoelectric sensors**. Optoelectronic detectors, based on **optical fibre technology**, can offer a promising alternative. Indeed, the **apparatus is not affected by electromagnetic noise**, beeing connected to the remote electronic only through dielectric connection (**fibre link**). They can **operate at high frequencies**; moreover, it is possible to **arrange different sensors in form of an array**, interrogated by a common optoelectronic unit. Last but not least the single sensor can be **quite inexpensive**.

COIL SENSOR

Coil fiber sensor tested

The **pressure wave** acts mechanically on the structure, inducing a **plastic deformation** on it. In this way a **strain** occurs on the fiber length, which is detected by means of an **interferometric technique** with a diode laser as illuminator.

To this purpose, a **Michelson interferometer** has been built. The coil of the sensor is inserted in the detection arm, while in the reference arm an Acousto-Optic Modulator (**AOM**) operating at a frequency of **80 MHz** provides a carrier RF modulation to be employed for the phase heterodyne detection.

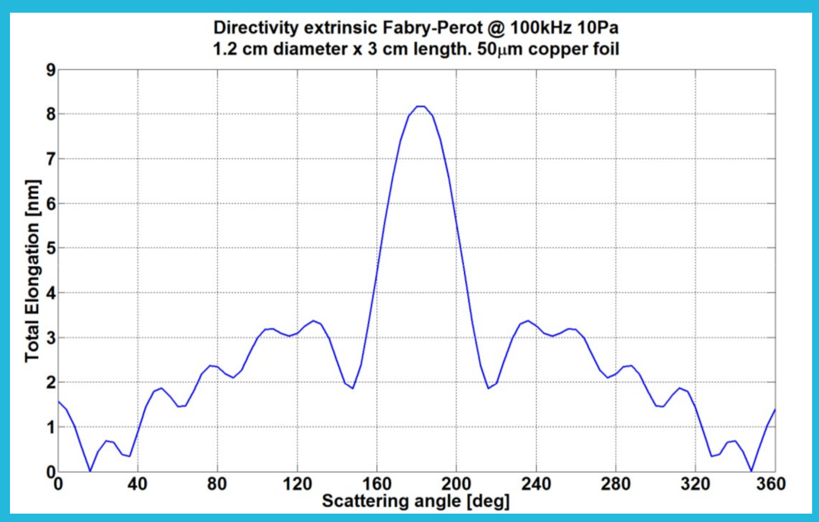


Coil sensor noise equivalent level (experimental data)

EXTRINSIC FABRY-PEROT SENSOR

The deformation is induced by the acoustic wave on a **thin elastic foil**. The foil closes at one end a small brass tube. A telecom C-band single mode fiber, terminated with a standard FC/PC connector and a collimation anti-reflection coated optic, is fixed at the other end of the tube to form a **low finesse Fabry-Perot cavity** between the exit surface of the fiber and the foil.

The extrinsic Fabry-Perot sensor

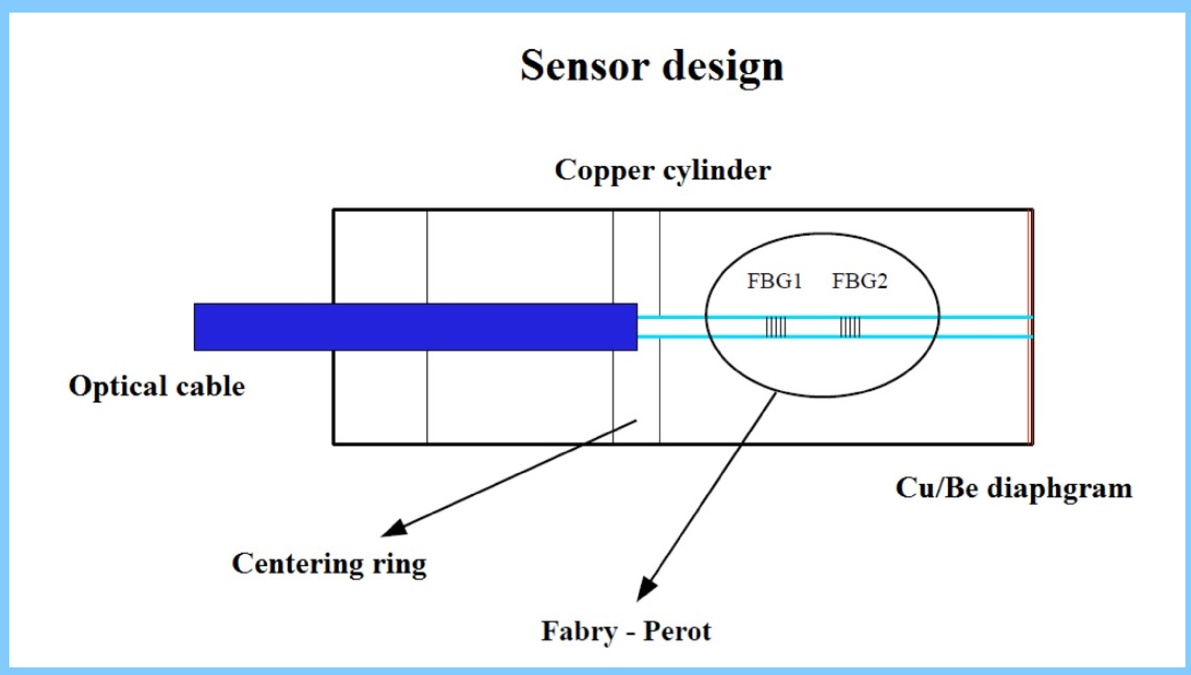


Extrinsic F.-P. directivity (COMSOL simulation)

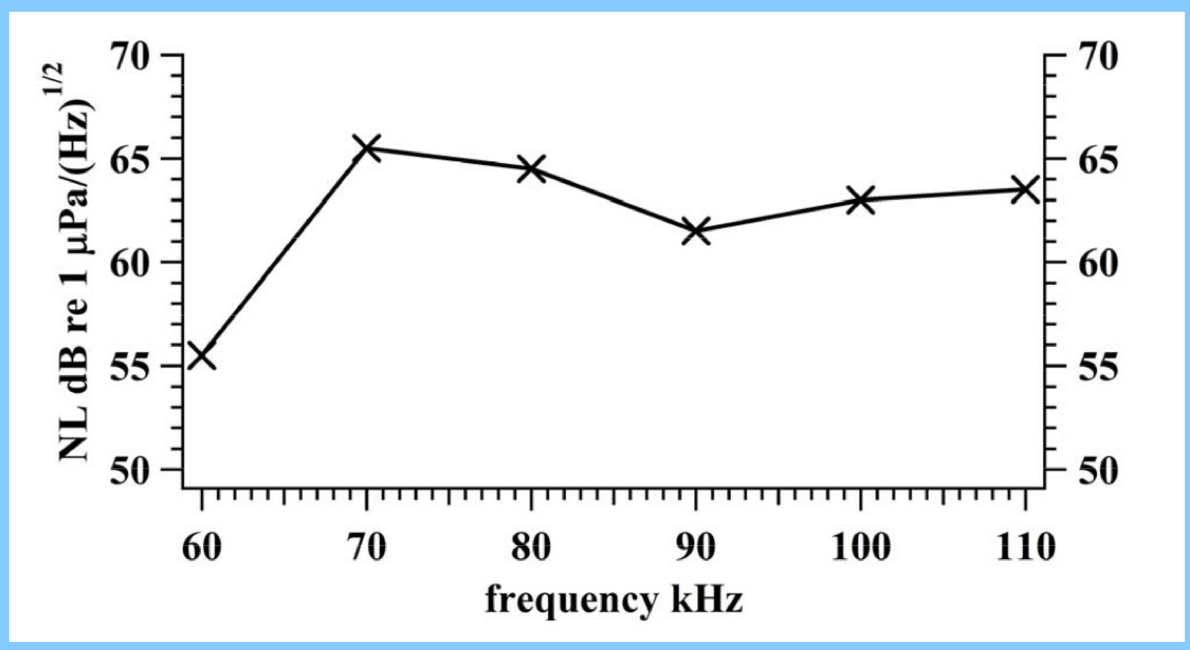
The incoming pressure wave acts on the metallic diaphragm **changing the length of the cavity** and the spectral position of its reflection maxima and minima. The **frequency** of the diode laser source is **locked** to the **maximum** discrimination point by means of a **side-fringe** technique.

IN-FIBER FABRY-PERROT SENSOR

The acoustic wave acts on a thin foil closing a metallic hollow **cylinder**. The **foil deformation** is detected by measuring the **strain of a fiber** glued at one side to the center of the foil, and at the other side to the bottom of the cylinder. This strain can be measured with very high sensitivity if a **Fabry-Perot cavity** is built by writing **two Bragg grating mirrors** in the fiber.



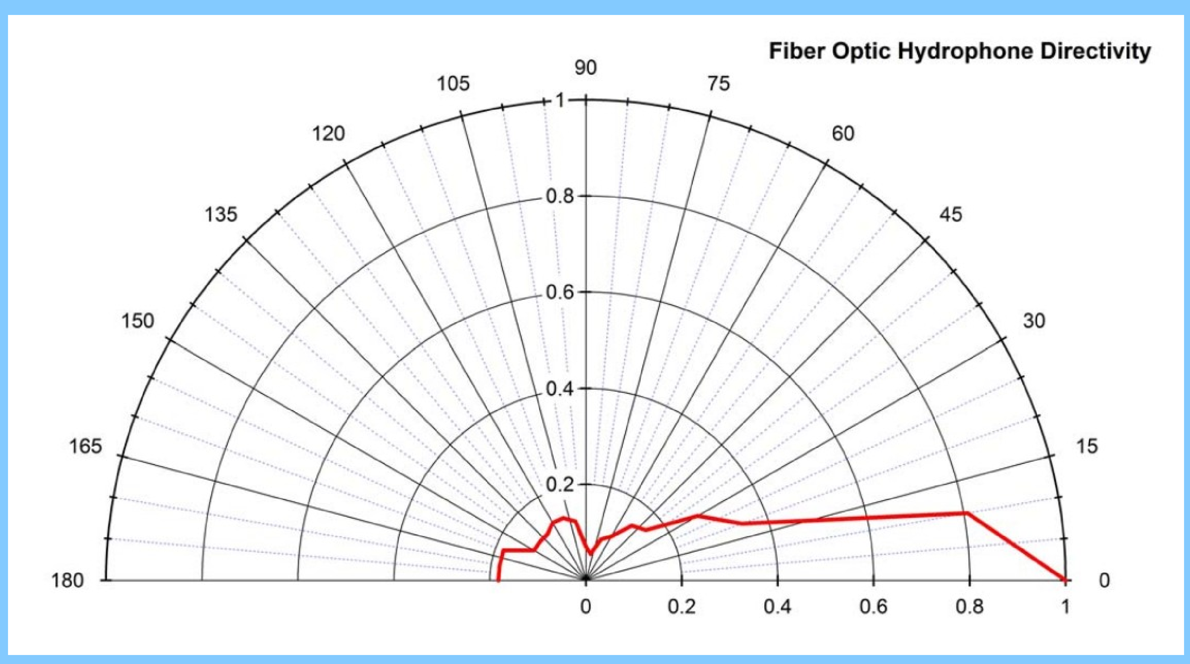
Mechanical layout of the tested fibre optic hydrophone



Noise equivalent power as a function of the acoustic frequency

We demonstrated that both the **sensitivity** and the **directivity** could be strongly enhanced by inserting a **metallic horn structure** at the top of the copper tube, around the membrane. The horn has a mouth-to-throat ratio of 5.7:1 and a length of 50 mm.

The in-fiber Fabry-Perot sensor equipped with the acoustic horn



In-fiber Fabry-Perot normalised directivity
Notice the half-cone at half-signal of 15°

CONCLUSION

We have studied, both through multiphysics finite element modelling and experimental test on prototypes, different configurations of optoelectronic sensors that can be used as acoustic hydrophones, characterizing their noise level and their directivity. The last kind of hydrophone is the most promising one, both in terms of absolute performance in laboratory conditions and of real application to autonomous underwater vehicle navigation.

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