

Analysis of High Sensitivity MEMS Hydrophone for Underwater Applications

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ABSTRACT: Sensors are objects whose aim is to detect events or changes in the environment, and then providing output. A sensor is a type of transducer, sensors may provide various types of output, but uses electrical or optical signals. MEMS (Micro electro mechanical systems) sensors play a crucial role in detecting the changes in the underwater. In this paper, T – shape. MEMS Hydrophone using Comsol Multiphysics is proposed. Using the T- shape model the sensitivity of the hydrophone can be analyzed, several mechanical properties like Stress, frequency response, deformation and sensitivity can be found out.

KEYWORDS: Mems, PZT, Stress, Sensitivity, SNR

I. INTRODUCTION

MEMS is a technology that is used for the fabrication of electromechanical systems. The physical dimensions of the MEMS device can vary from one micron to mm. The hydrophone is a microphone which is used to measure the acoustic pressure and the acoustic particle velocity vector at a certain point of acoustic field. Combining MEMS with Hydrophone will help us to have a better SNR (Signal to Noise Ratio).

T-Shaped vector hydrophone is based on MEMS Technology inspired by a fish lateral line which produces a first order resonant frequency of 1900 Hz.

PRINCIPLE AND STRUCTURE

PRINCIPLE:

Peculiar sensory organ fish is the lateral line, consisting of hair shaped mechanoreceptors or neuromast, covered with jelly like cupola, which is located on the skin. The motion in the fluid gets into the lateral line, making a displacement of hair cells. This displacement causes a stimulation to be transmitted to medulla oblongata through nerve fiber.

STRUCTURE

The structure of the T-shaped hydrophone is similar to that of the lateral line of the fish.

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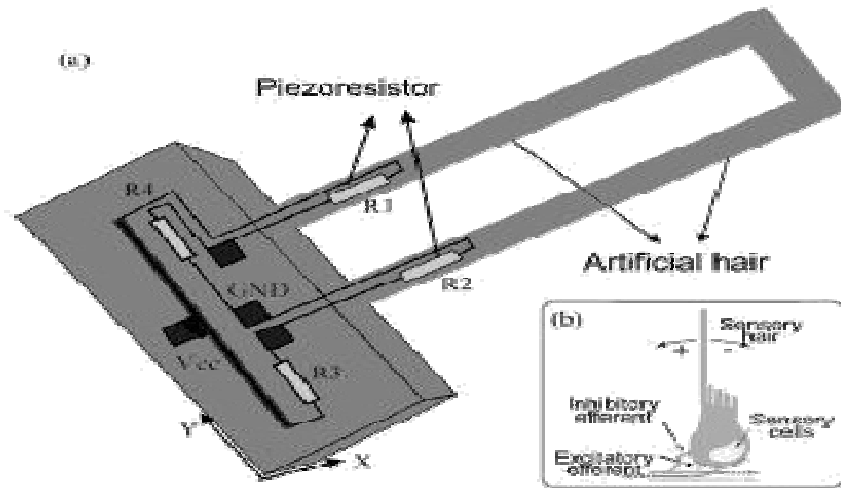


Figure: - T-shaped hydrophone

TOOLS USED

- ❖ COMSOL Multiphysics
- ❖ Coventorware Fabrication Tool

TYPE OF PHYSICS:

Piezoelectric (PZT) Physics is used in designing the T- shaped Hydrophone. The word Piezo means “To Press “ derived from Greek work, which means electricity generated from Pressure. Some of the typical piezoelectric materials include quartz, lead zirconatetitanate (PZT), polyvinylidene fluoride (PVDF), polyvinyl fluoride (PVF). Piezoelectric materials have the ability to transform from mechanical to electrical energy and vice versa. When a mechanical force is applied to the pzt material an electrical voltage is produced and when an electrical voltage is applied to the pzt material it gets deformed. Owing to these characteristics piezoelectric materials can be used as a sensor, as well as an actuator.

II. RELATED WORK

When signal acts on a cantilever beam , it will lead to the deformation of cantilever beam which cause change in resistance of piezoresistors. So the Wheatstone bridge, consisting of piezoresistors R1, R2 and the reference resistors R3, R4, will get the output. According to the output, both the direction and pressure of underwater acoustic signal can be obtained. With the simulation results the same structure is built using CoventorWare for fabrication purpose.

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III. EXPERIMENTAL RESULTS

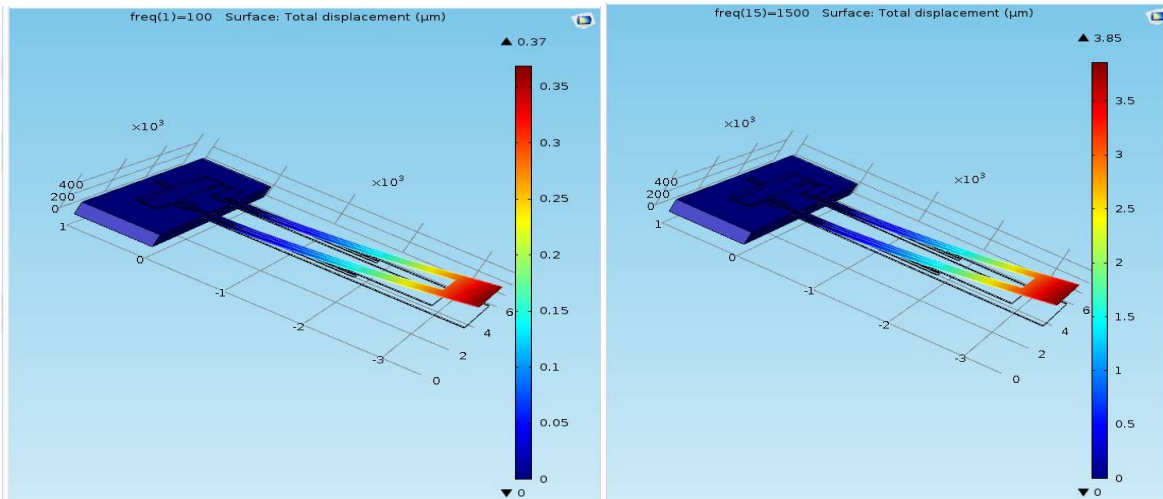


Fig 1: Change in displacement w.r.t frequency ranges

Fig 1. Depicts Change in displacement i.e movement of the Hydrophone from initial point to the other point when pressure of 1 pascal is applied. With respect to the six modes of eigen frequencies, the first two modes are taken into consideration for finding the best frequencies and frequency domain analysis is done, the displacement with respect to the first two modes of frequencies is calculated using Comsol tool.

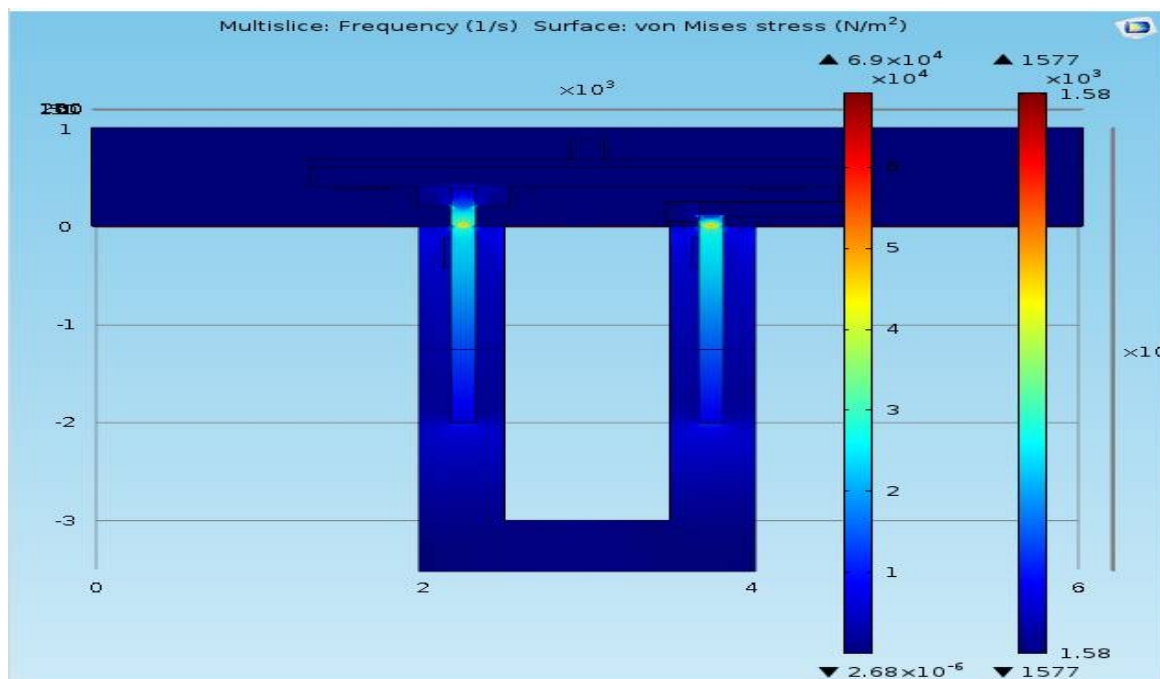


Fig 2: Stress and Maximum frequency

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Fig 2. Shows the stress across the patches when pressure of 1 pascal is applied on the beam , the above stress depicts von mises stress, which uses distortion theory concept which predict failure based on the different mechanisms.Von mises stress is popular approach than a principal stress theory because of its approach in treating failure criteria. In finding the failure criteria of the materials von mises stress is compatible than the principle stress.

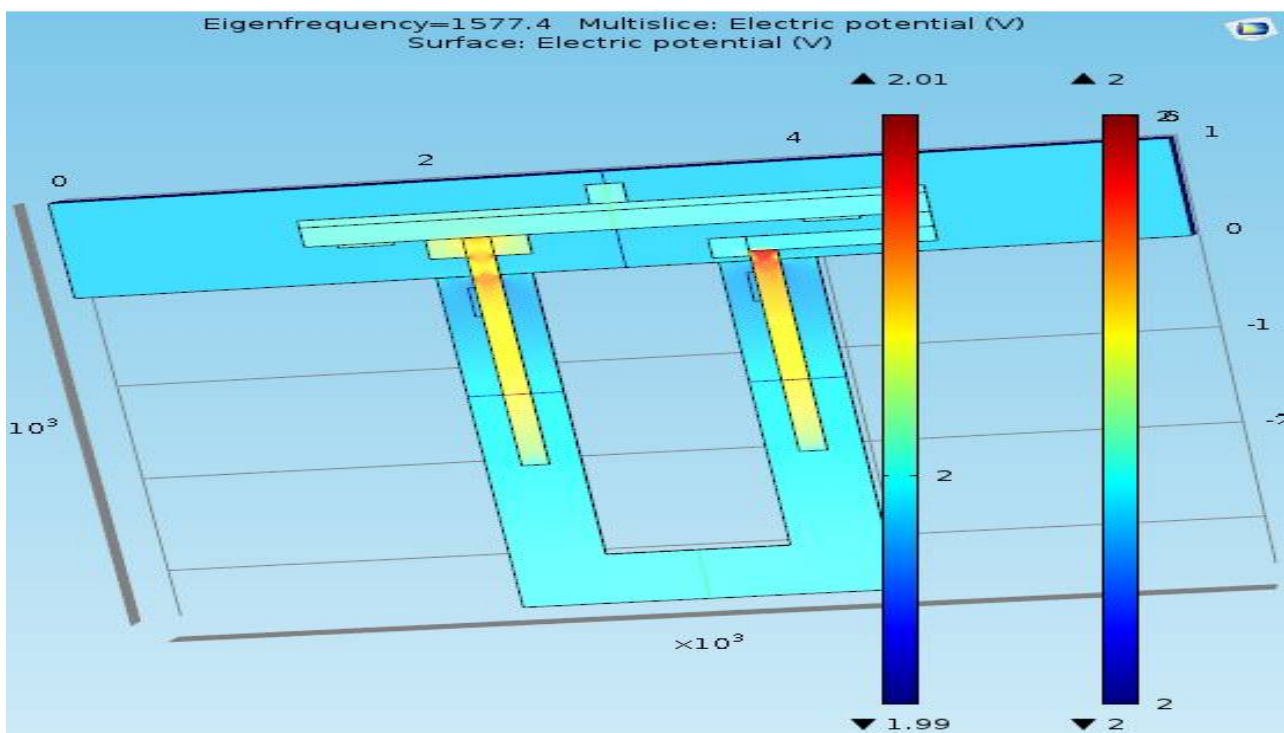


Fig 3: Frequency and Electric potential

Fig 3. Shows the voltage when pressure of 1 pascal is applied to the beam, as a result of applying pressure on the beam ,there will be change in resistance in turn there will be a change in voltage. The voltage across the PZT is found to be 2v.

APPLICATIONS

- ❖ Fish tracking / Fish population studies.
- ❖ Monitoring the noise in the water during installation of oil, gas & renewables.
- ❖ Underwater sound detection / monitoring.

IV .CONCLUSION

Design of T- shape Hydrophone using Comsol Multiphysics is done. The results of stress, resonant frequency, voltage across the beam is found out.

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