Study of Parameters that Affect the Resonant Frequency of a Wearable Sensor in Identifying Vibration Profiles

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INTRODUCTION: Design of an Accelerometer includes Judicious selection of Design parameters and the task of structural design. MEMS devices having the advantage of miniaturized designs have become popular in actuators and Sensors. Accelerometer being one such sensor has diversified applications in the field of Automobile, Medical devices, Aviation[1]. Designing the geometry on a CAD tool and performing simulation analysis is the best way to optimize it and verify the performance with theoretical values. The presented sensor is designed to detect low frequency signals in the order of Hz.

Figure 1. IMU placement can detect the shoulder motion[2]

COMPUTATIONAL METHODS: The model is designed using COMSOL Multiphysics® version 5.4. The Solid Mechanics interface is used to solve the physics and analyze the frequency response. The design posed challenges in selecting the geometrical ranges of the structure and also in finalizing the structure itself so that it has maximum, uniform and symmetric displacement in Z direction. Frequency of operation depends on Spring constant and mass.

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \qquad k = \frac{1}{\propto} E \frac{hw^3}{l^3}$$

A force of 1N is applied in negative Z-direction on the flat surface of the proof mass. Changing the amount of force applied has not created any change in its frequency of operation while changing the length, width and thickness of the geometry has considerably given a difference in the operating frequency. The geometry is shown in figure 2. The frequency response of the geometry is analyzed using frequency domain study.

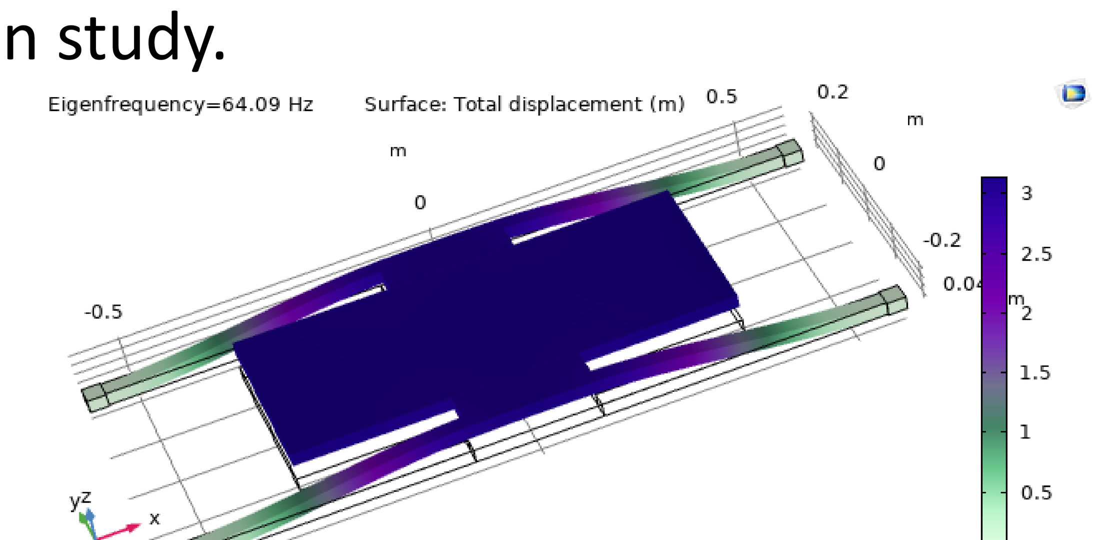

Figure 2. Proof mass showing displacement in positive Z Direction

RESULTS: Frequency analysis on the structure has shown that with optimizing the length, width and thickness, the frequency of operation reached a low value and has given a bandwidth around (50- 100)Hz in which the displacement is maximum . The contour in figure 4 shows that maximum displacement is at the center and has symmetric distribution on either sides.

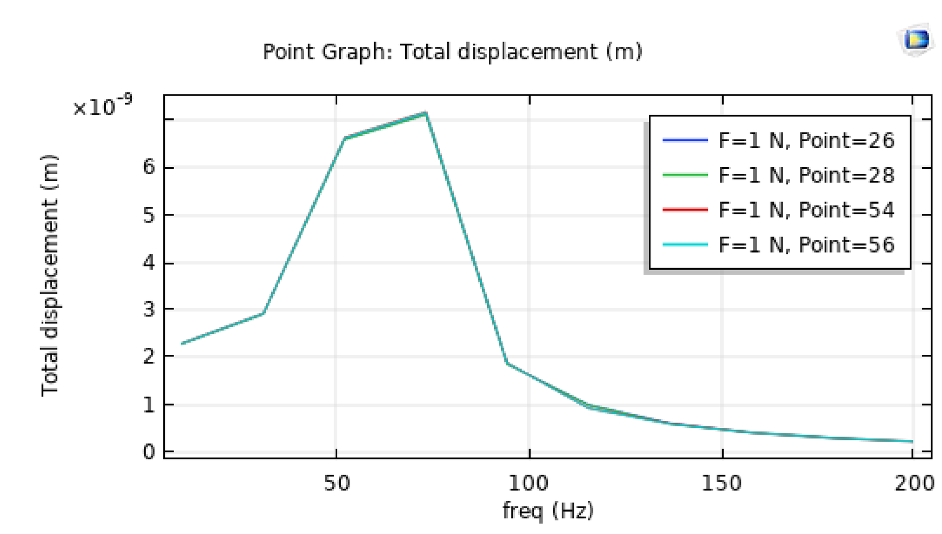

Figure 3. Maximum displacement over a Bandwidth of frequencies

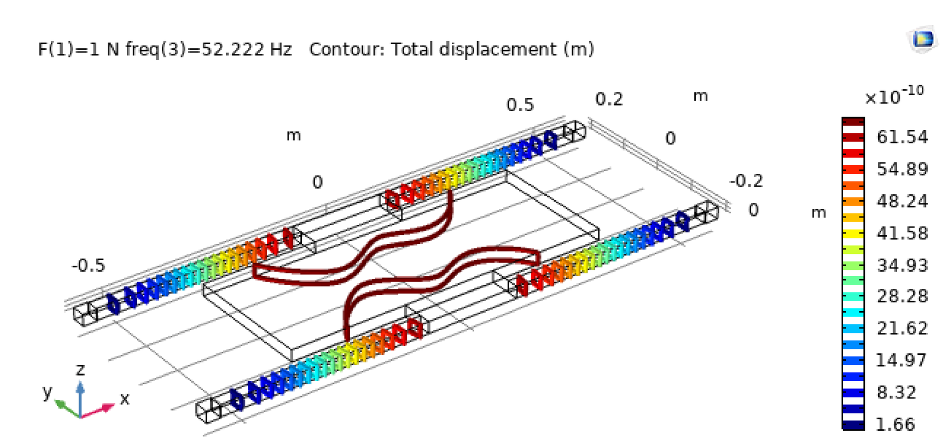

Figure 4. Contours showing uniform displacement at the center of the proof mass.

CONCLUSIONS: Using Comsol Multiphysics® and performing a parametric sweep over the geometric values like length, breadth and thickness of the structure has helped with optimizing those values in order to perform preliminary simulation and find the operating bandwidth. The vibration of Proof mass still has the problem of cross sensitivity, which on improved geometrical design will reduce the cross sensitivity in Y and X axis.

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