Design, Simulation, and Testing of Piezoelectric Directional Acoustic Sensors Biomimetic of the fly Ormia Ochracea Hearing

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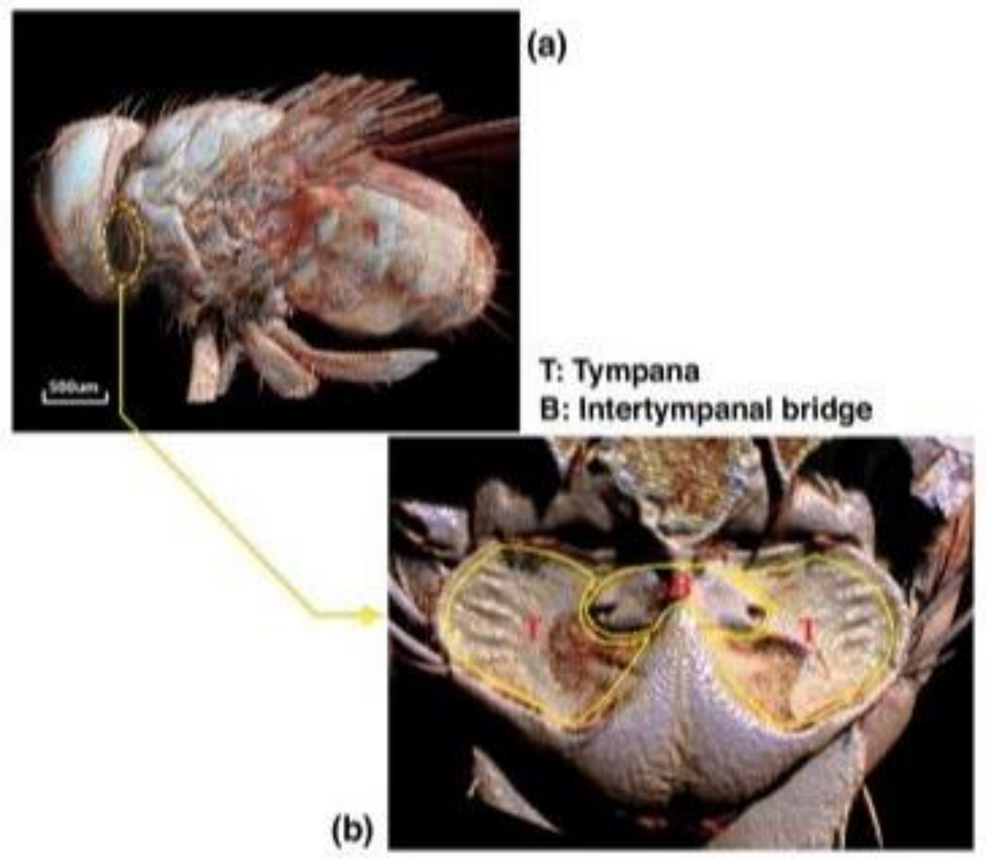
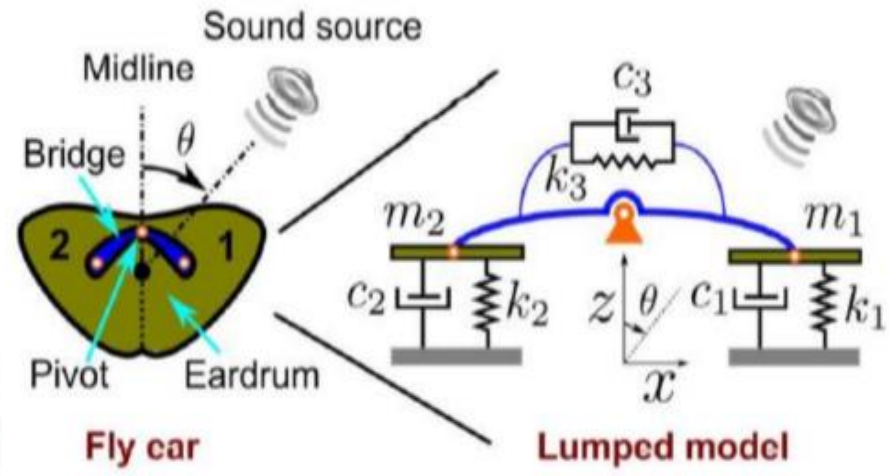
Objective

The purpose of this project is to design, simulate and test an acoustic sensor mimicking the hearing abilities of the fly Ormia Ochracea. Unlike other designs which implemented MEMS (Micro Electro-Mechanical System) on a chip, an upscale version of the fly's hearing mechanism was implemented using thin layer piezoelectric material.

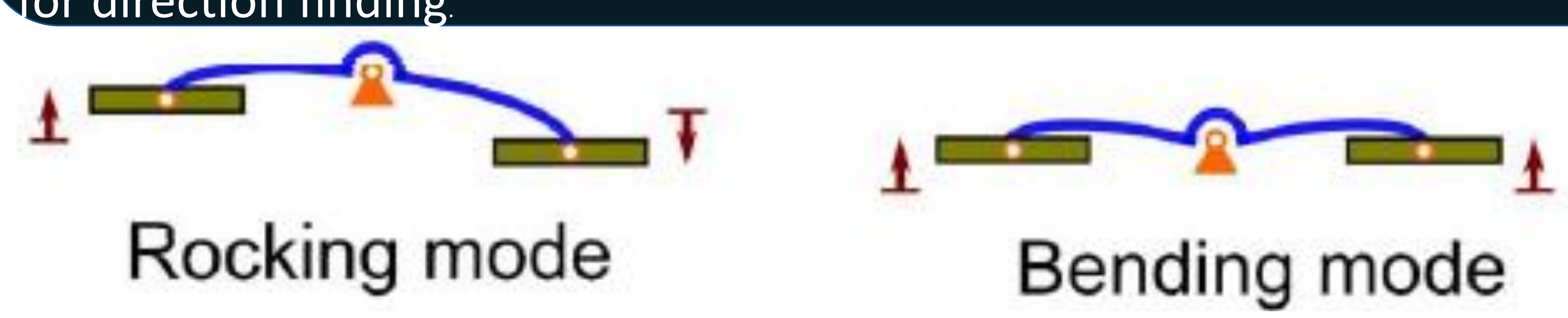




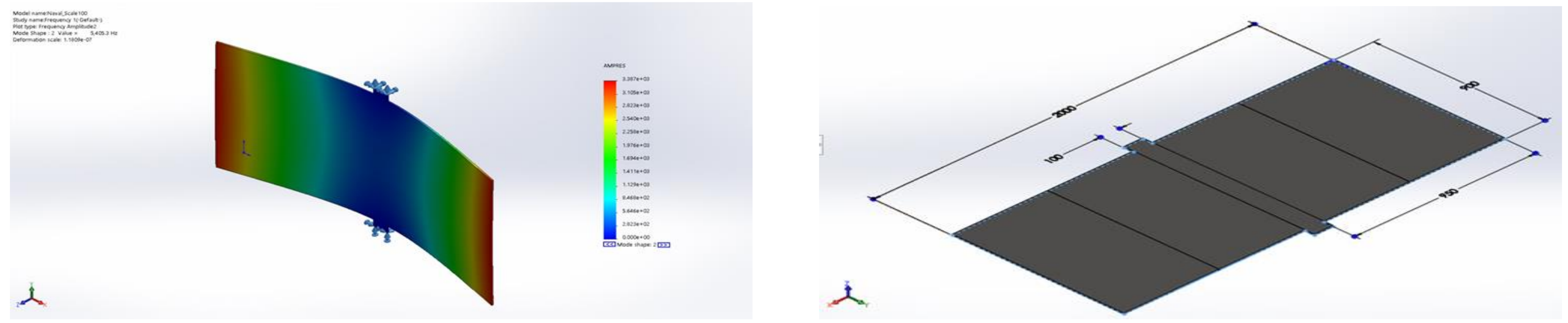
Mechanical representation of the fly's hearing system

Introduction

The fly Ormia Ochracea can determine the direction of sound produced by its host cricket. The fly's hearing is directional and frequency specific. The eardrums of the fly are coupled by a tympanal bridge which couples the two eardrums. This in effect makes the fly's hearing system hypersensitive to a specific frequency of approximately 10KHz and allows for direction finding



The tympanal bridge allows the hearing organs to work/ resonate at two main modes, namely: Rocking(flying) and Bending(tilting) mode (see figure above). The superposition of these modes allow directionality of a sound source to be determined.

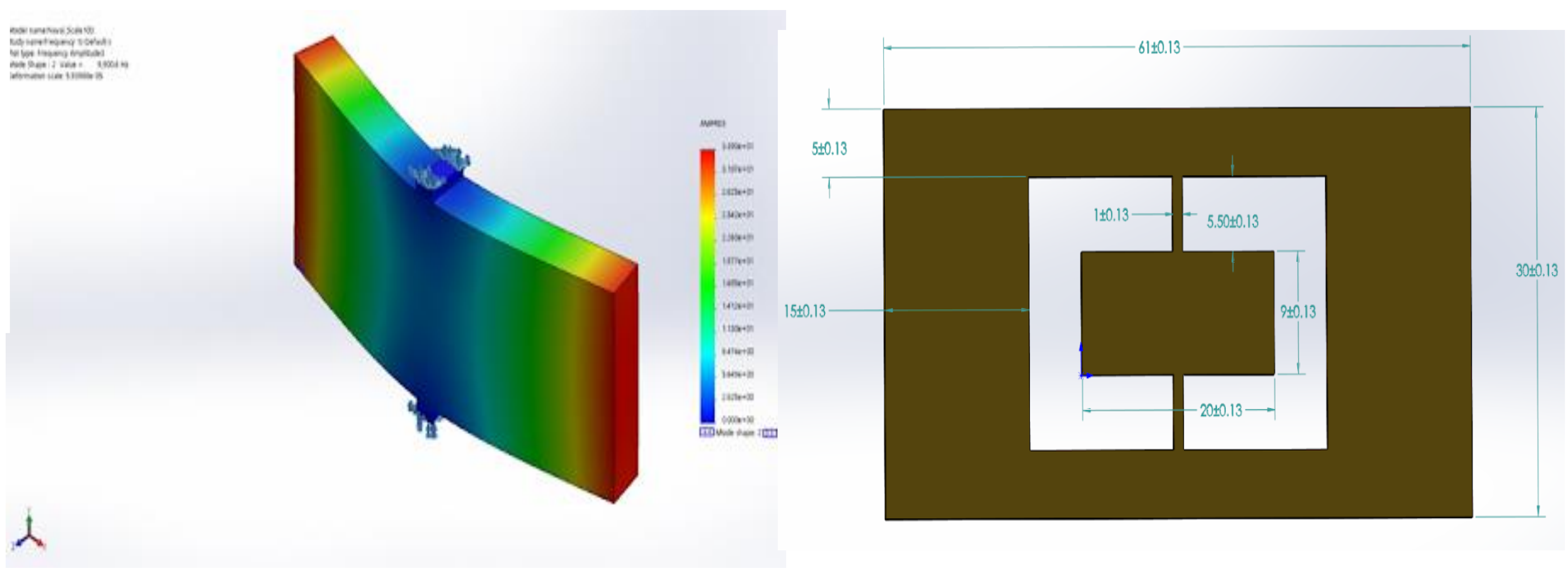


previous PiezoMUMPS Solidworks simulations and dimensions

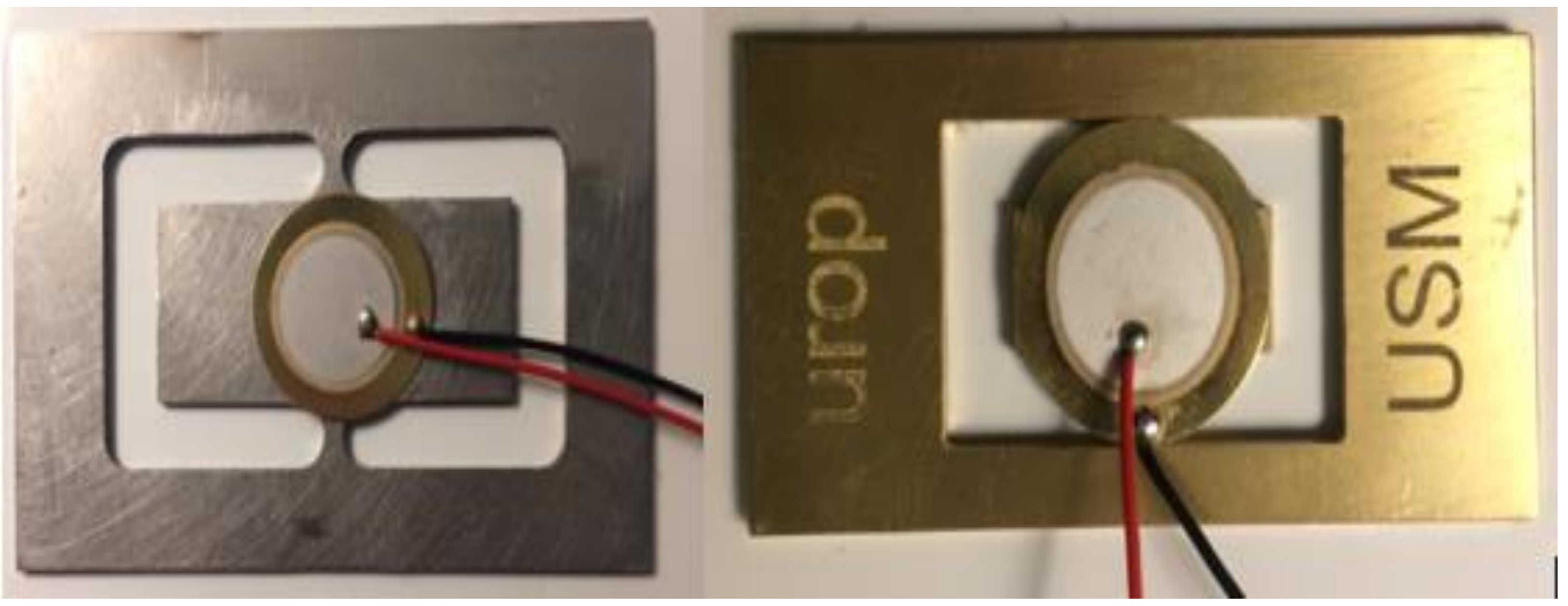
Design

$$\omega_1 = (1.875)^2 \sqrt{\frac{EI}{mL^4}}$$

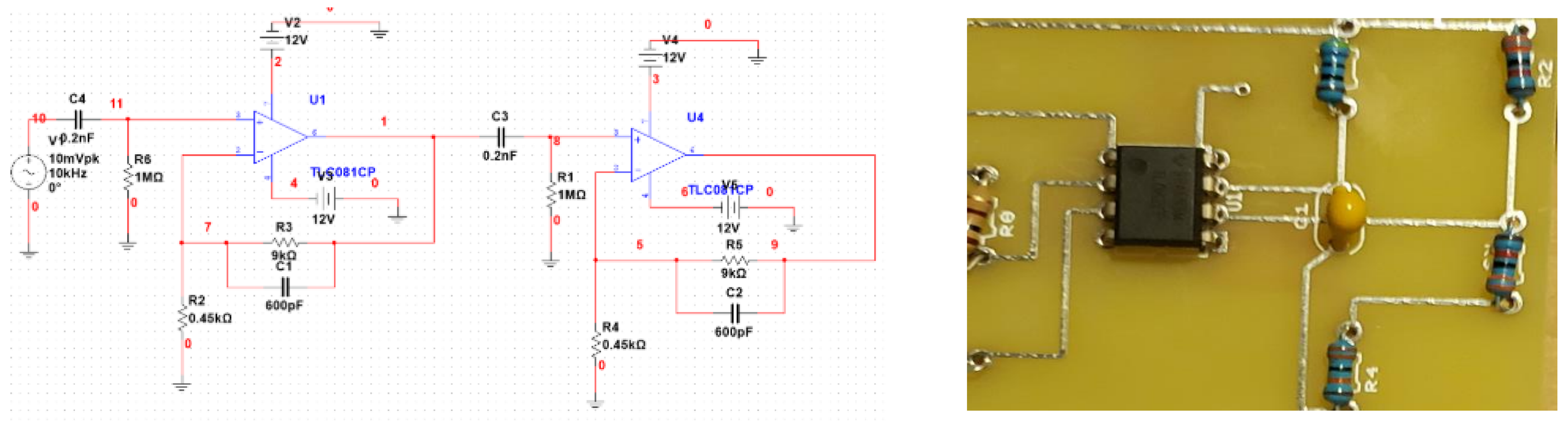
A previous design using PiezoMUMPS was upscaled. As material Steel and Brass were used to make the upscaled resonator. The signal was then be captured using Piezoelectric material. This signal will then be amplified to create a useful output. Solidworks was used for simulations to determine which resonator size will lead to the desired frequency. Multisim simulations was used for amplifier design and PCB layout.



Upscaled design Solidworks simulations and dimensions

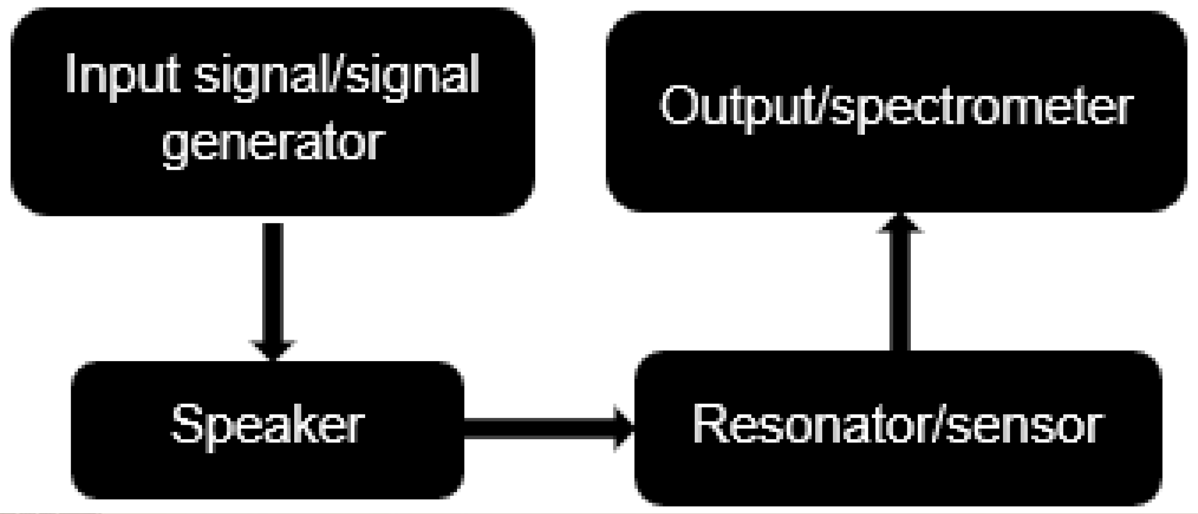


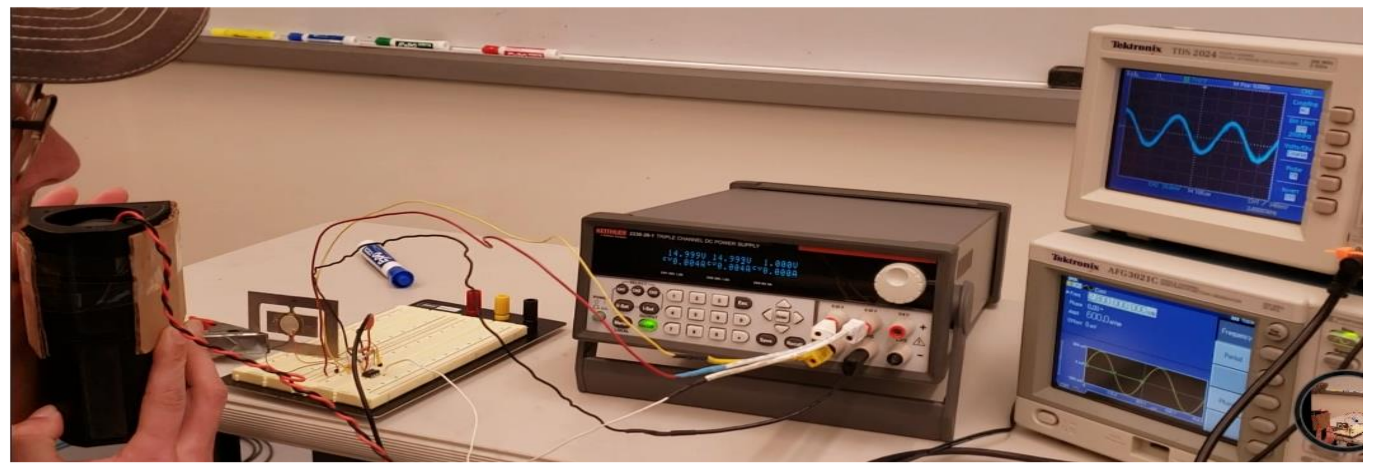
Resonator designs using Steel (left), and brass(right). See piezoelectric sensor location on each design



Signal amplification using a charge amplifier

Test set up

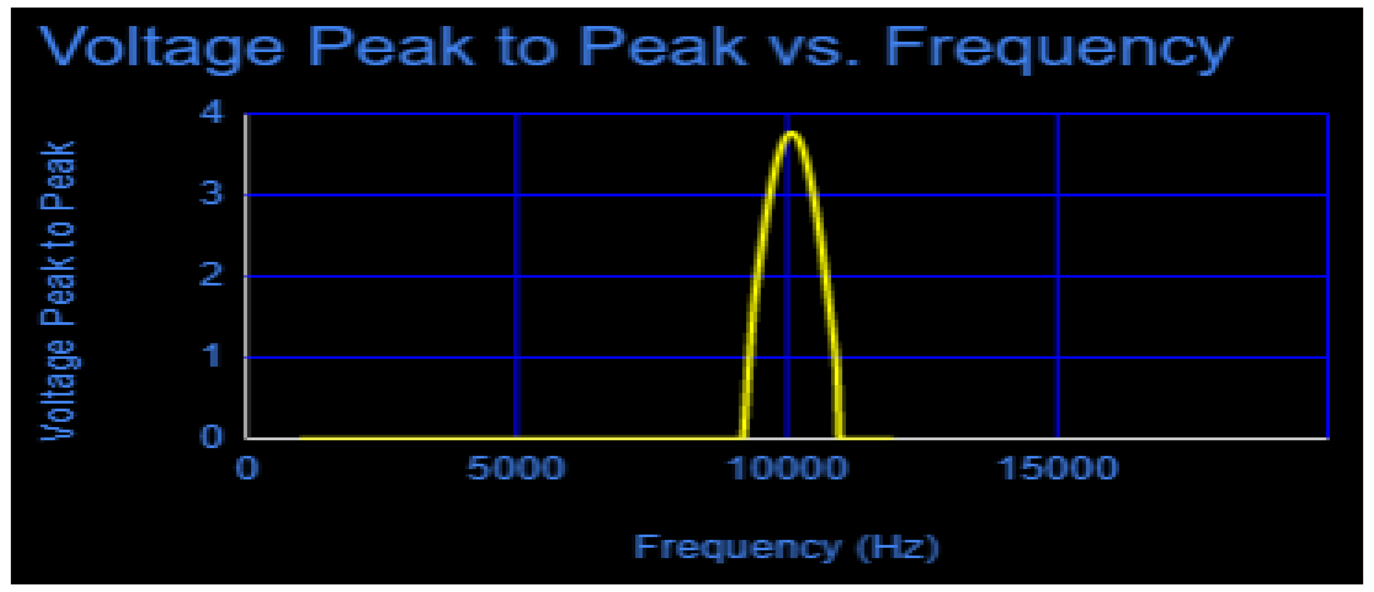




Results

The first iteration using steel produced resonant frequencies well below the desired value. This was due to manufacturing, material selection, and design. These issues were corrected using brass and the desired value of 10kHz was achieved.

The resonant frequency at bending mode: steel (left) =4kHz Brass (right) ~10KHz



Frequency response of the resonator using brass