Apr 30th, 12:00 AM

MEMS Directional Acoustic Sensors

Colby Damren
University of Southern Maine, colby.damren@maine.edu

MEMS Directional Acoustic Sensors

UNIVERSITY OF SOUTHERN MAINE
PORTLAND • GORHAM • LEWISTON • ONLINE

Colby Damren, Electrical Engineering |Dr. Mustafa Guvench, Advisor

Abstract

The purpose of this project is to test and verify two Micro-Electro-Mechanical-System (MEMS) microphones. These microphones were designed to exhibit directional capabilities. The devices will be tested for directionality inside a wooden box acting as a sound chamber. These results will be compared to SolidWorks and ANSYS simulations to verify the functionality of the designs.

Introduction & Objective

The MEMS devices are biomimetic microphones that were designed from the eardrums of the Ormia Ochracea. The Ormia Ochracea is a parasitic fly that uses directional hearing to find a host cricket and lay their eggs. The MEMS microphones mimic the eardrum spacing of the Ormia Ochracea. The devices utilize a spacing of 1000um. This is roughly twice the size of the Ormia Ochracea's eardrum spacing.

The objective of this project is to test the directional capabilities of the MEMS devices. This will be done through acoustic testing.

The initial MEMS devices experienced a failure at the "spine" of the device. A stress fracture formed due to handling and testing, causing the damaged devices to be unusable for testing. Both MEMS models underwent a revision change to address this issue. Fillets were added to the point of failure to strengthen the spine, with the intention of preventing failure at that point. The new revision of devices will be tested for directionality.

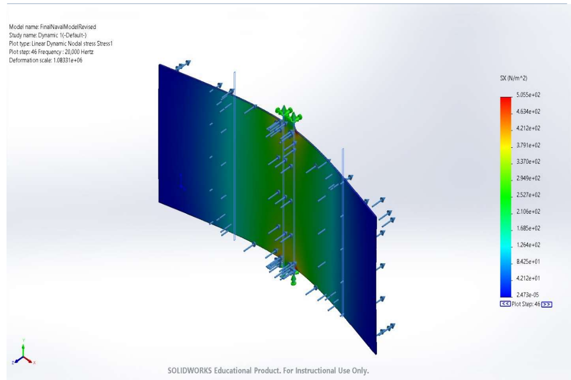

Figure 1. Naval Model SolidWorks Stress Simulation Results

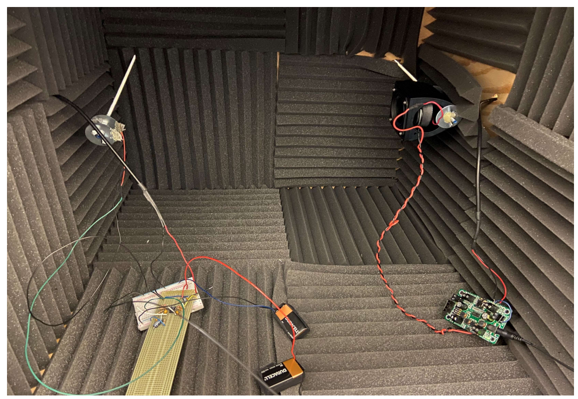

Figure 2. Testing Apparatus

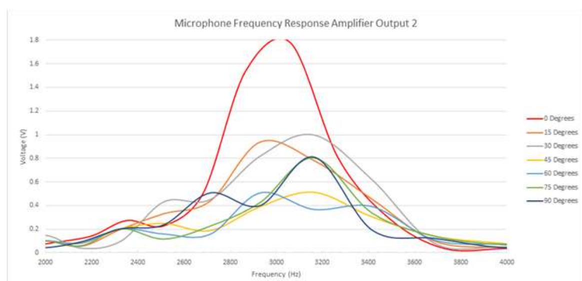

Figure 3. Microphone Frequency Response from 2 – 4 kHz

Methods

The SolidWorks simulation was conducted by applying 0.03Pa, equivalent to 60dB of sound, to the entire structure. Figure. 1 shows the results for the Revised Naval Model.

Figure. 2 shows the testing apparatus. The microphone is placed 19" (48.62cm) away from the speaker. The microphone can be rotated from 0 – 90 degrees to test for directionality. Figure 3. shows the initial results from testing a scaled-up version of the Naval Model microphone.

Conclusions & Next Steps

The SolidWorks simulations concluded that the revision changes to the devices successfully reduced the stress in the targeted area. However, further testing is needed to determine if the revised devices will break during testing.

Testing the frequency response of the microphone shows directional behavior. Figure. 3 shows the frequency response of the microphone from 2000 – 4000 Hz. At 3000 Hz, the amplitudes of the waveforms show the directional behavior of the microphone at different angles of incidence.

Further work needs to be done to improve the design of the testing apparatus. The method for mounting the microphones needs to be revisited. Additionally, further works needs to be done in ANSYS to simulate the electrical performance of the MEMS devices. The simulation results can then be used to compare and verify the performance and directional capabilities of the devices.

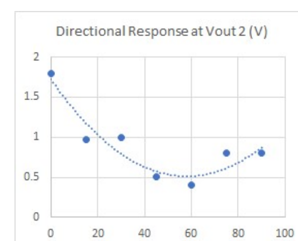

Figure 4. Microphone Directional Response at Different Angles of Incidence

Acknowledgements
I would like to acknowledge Brendan Francis's efforts, as both of our projects were closely correlated. Both projects used the same test apparatus and equipment, resulting in a combined effort.

References
L. J. C. D. G. T. H. M. Y. Haijun Liu, "Understanding and mimicking the dual optimality of the fly ear," Scientific Reports, 2013.

B. M. S. S. James Fitz, "MEMS Directional Acoustic Sensor," Gorham, 2018.