Abstract — Conductive hearing loss is a common defect in infants and younger children that can occur at birth or in later years. Conductive hearing loss involves physical deformation of the outer and middle portions of the ear [3]. If hearing loss is not resolved within a few days after being discovered, the infant may have trouble in developing language, speech, and communication skills throughout their life. The current solutions for conductive hearing loss include bone-anchored and cochlear implanted hearing aids [2, 3]. The problem with these devices is that they require invasive procedures such as surgery or implantable aid, which is not an ideal method to be carried out on newborn infants and younger children. The purpose of this device is to create a non-invasive solution for conductive hearing loss that is suitable for infants and young children.

I. INTRODUCTION

According to Boston’s Children Hospital, “conductive hearing loss is the most common cause of hearing loss in infants and young children. It happens when something is blocking the outer or middle ear and preventing sound waves from reaching the inner ear.”

II. PROJECT DESIGN

The design for this project is a miniature device that has a strip like form factor that sits on the hairless portion of skin behind the user’s ear. This emulates the functionality of typical bone-anchored and cochlear implanted hearing aids without the need for any invasive procedures. The uniqueness of this design is that using a contact actuator, the device will be able to vibrate against the skull and send signals to the inner ear [3,4]. These vibrations will be perceived as sound, making the device safe for children as it requires no invasive procedures. The focus of this project is to prove this concept by designing a prototype of the miniaturized hearing aid. The prototype has proven that the simplistic miniature design can be achieved through further research and development [3]. The main components for this device include a micro-electromechanical systems (MEMS) microphone, piezoelectric actuator, breadboard, and other necessary electronic components (resistors, capacitors, etc.) to fulfill the design needs for the project. Figure 2 shows an overview of the device’s functionality in the form of a flowchart along with an image of the prototype.

III. RESULTS

The output of the device is tested by removing the MEMS microphone device and replacing it with a signal generator so that a constant signal is being sent through the device to get accurate results. Figure 3 represents the data collected from the experiment comparing the Input signal to the output voltage. From the graph it is made clear that there is almost no signal loss from the system.
when tested from a frequency range of 20Hz-20kHz. The only major deficiencies occurred when the device was operating from 20-100Hz, this is because at lower frequencies the electronic components struggle to pick up such small signals.

A test that was run involved testing the device with the MEMS microphone and the PE actuator connected. In this test it was observed that when speaking into the microphone the vibrations created by the PE actuator do in fact correspond to the audio signal being inputted [2,5]. The image in Figure 4 shows the input signal from the microphone in yellow and output audio signal going into the PE actuator in green.

Additional testing was done to characterize the actuator [3]. The chosen actuator has a small radius and is thin (less than 1um). This actuator would have a resonance frequency below 1kHz in order to encompass the most common noises and was driven by the circuit used for the device [2,5]. Dampening of the actuator (by PDMS) was taken into account when deciding the final prototype actuator. In Figure 5 the input signal (green) versus the output signal of the chosen actuator (yellow) is shown.

**Figure 3: Graph of Frequency vs. Vpp Out**

**Figure 4: Input/Output signal of the device via speech**

**Figure 5: PE actuator signal compared to input signal**

### IV. Conclusion

The next step to improve the device would be to fabricate the circuit and try to package the device in a smaller form factor which allows the device to be tested on individuals to see if the vibration signals are producing a strong enough signal for the individual to hear. This prototype has provided the proof of concept for future research and development. Along with that the device needs to be tested with a battery device such as a flexible battery as the external power source being used in this prototype is obviously not miniaturized for the final design.

**ACKNOWLEDGMENT**

Members of this group would like to thank faculty mentor and client, Dr. Mohammad J. Moghimi and TA, Sandhya Chapagain for their support and guidance through this project. The group would also like to thank Mr. Edward Miguel for allowing the group to work in his lab and help us with our circuit design needs.

**REFERENCES**


