Novel Audiometer Calibration Device

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Abstract— *Technology has become of key importance in the betterment and care of human lives. With that being the case technology must be accurate and precise, due to the risk of error and possible harm those errors could cause. In the audiology field a design of a novel audio device comprised of a microphone and coupling apparatus was designed to be more cost efficient and simplistic to calibrate audiometers to their necessary specifications. The device will capture the audio signal of the audiometer, and process information to the graphical user interface programmed with features to analyze acoustics from the audiometer in real time. Features to display the frequency, sound level, and distortions will be necessary to accurately calibrate the device and determine necessary repairs.*

I. INTRODUCTION:

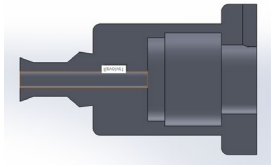
The development of a Novel Audiometer Calibration device is no simple task. The goal above all things here is to make a: cost effective, condense user friendly audio calibration device. The idea is to downsize a relatively cumbersome assembly, and replace it with our simpler easier to use prototype. Another main goal to achieve here, is cost. The cost of some of the components that current audiologist use is fairly expensive. Cost can be mitigated using a (3-dimensional) 3-D printer. There are 3 main components that are the parameters when selecting. There is the software section, this will act as the sound level meter to produce a sound, while also being able to record the sound as well. The next portion will be the hardware, a (Micro-Electro-Mechanical System) MEMS. This is a fairly expensive device. Lastly, there is the coupler. The coupler will allow repeatable, consistent data in a controlled environment so that when measurements are taken, the data will be repeatable. The coupler will act as a housing unit for the hardware. Together there will be a device that will allow repeatable measurements, to calibrate circumaural headphones.

II. OBJECTIVE:

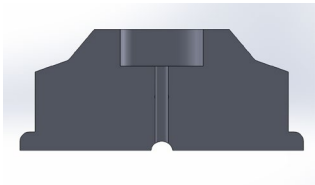
The proposed project is comprised of a microphone coupler to insulate the microphone, a MEMS microphone and amplifier unit to receive audio signals, a USB-Soundcard to convert audio signals to digital signal to communicate the device. The device provides information to the program for real-time analysis. The program allows the device to show sound amplitudes by receiving the audio at sample rate of 44100 Hz, reading chunks by the determined variable $(1024 * x)$. In testing the determined chunks read was 8192 $(1024 * 4)$ chunks. The device displays an amplitude read in decibels over time plot streaming information from the device. The device displays a second screen to show the frequency response in a constant stream utilizing the same stream of the audio and converting the linear device using the Discrete Fourier Transform/Fast Fourier Transform of the audio signal. The frequency response graph allows amplitudes of incoming frequencies to be analyzed by the user. Other important features implemented is the live RMS level of the current max sound level, frequency displayed, and the harmonic distortions.

III. COUPLER APPARATUS:

The coupler has the purpose of allowing the sound to be propagated in a controlled environment. Allowing repeatable, isolated results. Cavities take the shape of a distances mimicking the tympanic membrane, and the ear canal. The coupler also accounts for the necessary pressure that is acquired from headphones compressing on the ears. More specifically over the ears, these are a common headphone that the coupler was designed to calibrate for. The most common are supra-aural, circumaural, and hearing aids. Depending on the type of hearing device that is being calibrated, specific couplers are then used to calibrate. 2 (Cubic centimeter) cc designated for hearing aids. While 6 (cubic centimeter) cc is designated for bigger headphones such as; supra-aural (sits on ear), and circumaural (sits over the ear).



Sectional view of 2-cc



Sectional view of 6-cc

IV. MICROPHONE AND AMPLIFIER:

The microphone used in the coupler system is a High AOP Analog MEMS microphone, the purpose is to have an affordable microphone that can receive the outputs of the audiometer. The microphone is coupled with a wide dynamic range, a high harmonic distortion, a ± 1 sensitivity, and a high signal to noise ratio. These functions will aid in the microphone's ability to filter out any unwanted noise. The amplifier is Low-Noise, High Performance Audio Preamplifier which is used to strengthen the signal of the

microphone's output so that the software can easily receive the signal.

V. Software:

The method to design the program and capture the audio information was designed in the Python programming language. The program utilizes various Python open-source libraries to make the program functional. The program is comprised of multiple sound analysis algorithms for proper audio processing, and displaying the real-time views of the signals, and information received from the processed signals.

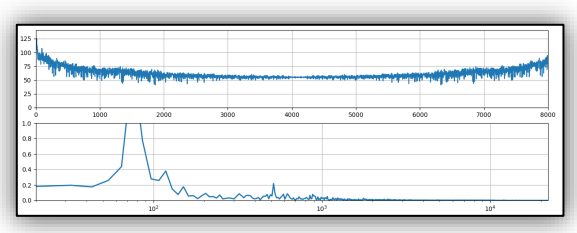


Figure 1.) Display of Novel Audiometer Calibration Device graphical user interface displaying live amplitude and frequency plots.

VI. Conclusion:

The purpose of the Novel Audiometer Calibration Device is to reduce cost, repeatedly allow for a controlled environment to measure the headphones and hearing aid. While making sure to have a computer replace some of the more expensive components in the standard calibration process done by audiologist. With the goal of the project, unnecessary expensive components will not be needed. While also making sure to be portable and easy to use. There are a total of 3 sections that will make up the entire project. These sections are; the coupler a physical device that will allow for the sound to propagate through, in a controlled environment to mimic how over the ear headphones (Circumaural and Supra-aural). Another important section is the software as well. The software will allow real-time data of; frequencies, signal envelopes, sound level, and harmonic distortion. Lastly, we have the microphone which receives the audio that will be outputted from the sound level meter. We have replaced the need of a Sound Level Meter commonly called an (SML). With a standard computer or laptop. All of these components come together and will allow for audiologist to be able to calibrate systems, with ease in terms of transportation, and lowering the overall cost on the standard system.

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