**Noise Canceling Proposal**

# Introduction

As implied by the moniker "high fidelity," the fundamental goal of hi-fi equipment is to create a reproduction of sound that is as faithful and accurate to the original recorded sound as possible. However, most products that strive for this goal neglect one important factor. Not everyone perceives sound the same way. Many start to lose their ability to perceive specific frequency ranges early in life, and each individual experiences subtly different forms of hearing loss. Our project aims to provide the most accurate headphone listening experience possible not only by utilizing high-end audio drivers and an active noise canceling system, but also by tuning its frequency response to the individual listener, offering them the ability to experience a recording as if their hearing was perfect once again.

# Problem Description

The noise canceling headphones will tackle two problems. The first is a poor listening experience due to random noise interference. Noise will exist within the range of the audible spectrum. Noise is always a problem. It exists indoors and outdoors to varying degrees but will cause some interference with the sounds produced by a headphone and create an imperfect listening experience. The second problem is that of psycho acoustical differences between humans. A person might be biologically incapable of properly hearing music due to deficiencies in hearing ability that come with either damage or age.

# Proposed Solution

In order to properly hear music you must tackle the psychoacoustic and noise problems. The psychoacoustic aspect will be dealt with through a hearing exam upon set up of the headphones. Through this data we will be able to extrapolate which frequencies need to be equalized and to what extent to come as close to an objective listening experience as possible. Next we will use noise cancelation to deal with external noise interference. This will be done by capturing the external noise and then producing its inverse so that the net noise destructively interferes and is not perceived.

# Demonstrated Features

In May, we expect to demonstrate a working prototype consisting of a headphone body containing the primary audio drivers and noise canceling hardware, and an encased circuit board connected to this body containing our primary microcontroller which will run the code enabling the active noise canceling and personalized frequency response. The following subsystems will be fully functional:

* Active noise cancelation (planned for demonstration in December) - A subsystem which actively senses the waveform of outside noise and generates the antiphase of that signal, canceling the noise. This will utilize a microphone embedded on the outside of the headphone body and the speaker of the headphone to produce the canceling signal.
* An app-based hearing exam which produces a personal profile for a given listener, which is communicated to the microcontroller via bluetooth. The microcontroller will then use this profile to filter the input signal appropriately for the listener.

# Available Technologies

To start we will acquire broken pairs of noise cancelling headphones and then gut them. We can use the shell of these headphones to start producing our own design. We can probably still use the drivers on these. It will depend on the condition of the product that we receive. Depending on the drivers that we use we may also need to use an amplifier to better reproduce the original sound.

We plan to use Digital MEMS microphones for the ANC. MEMS stands for Micro-electromechanical System. Converts incoming soundwaves (i.e. noise) into a digital signal.

Another possibility that we plan to investigate is reaching out to Christian Femrite. As he owns Resonado, he may be able to help us get some of the hardware at wholesale prices. We may also want to use his headphones as a base as the drivers do not use much power and are thin, which may help us fit our chip in the headphone body.

While we are still in the early stages of acquiring equipment for this project, a high end price estimate would place our total budget at ~$100 for the board, assuming a higher price due to the greater precision mandated by size constraints, ~$100 for a headphone shell and drivers, ~$40 for two DMEMS microphones, and ~$20 for microcontrollers, including redundant parts. The total then comes to ~$260, well within budget constraints.

# Engineering Content

**Noise Cancellation**

An external microphone will receive all external sounds that the user would normally hear. This is converted to an electrical signal that will be received by the microchip. The microchip will then output to the drivers in addition to the traditional audio signal the cancelation signal which will counteract incoming noise. This requires a serious consideration of delay/timing, and some digital signal processing.

**Tuned Headphone Experience**

We will design a test that produces pure tones at a range of frequencies and powers to determine the overall capacities of the individuals ear. We will pass this test data onto a microchip. The microchip will then use that data to modulate incoming digital sound data which will then be sent to the headphone to be played. In other words we are going to set equalization levels for music based on the exam. This will an understanding of both practical digital signal processing and human psycho-acoustics. It will also require the development of a smartphone app.

**Bluetooth Interface**

The control board will make use of a bluetooth interface for both data communication with the phone app and audio streaming. There are two options for implementing this. The first is to use a PIC microcontroller and a peripheral bluetooth communication chip, which would require purchasing the bluetooth audio library from Microchip, which is a significant cost. The other option would be to utilize a SoC designed for bluetooth headphones, such as one of the Qualcomm QCC-300x series chips, and develop our other subsystems on top of the processor built into that chip. Either way, this will require an understanding of bluetooth protocols and hardware.

# Conclusions

We anticipate that the active noise cancellation will be the most difficult task to realize. As such, we will be focusing on getting that working this semester. The challenging part is making sure that our digital circuitry isn’t too slow and it is timed correctly to attenuate the proper signal. Overall, we look forward to being able to tackle this challenging project and hopefully create a product that is close to being market ready.