Headset with Built in Hearing Analysis and self-equalization capability

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Abstract

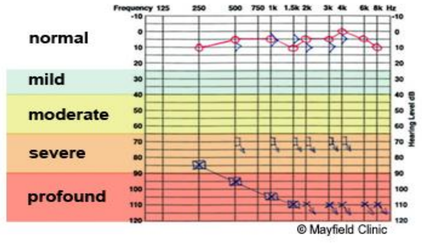
The gold of this project is to design an embedded system which can connect to the Telephonics TDH headset. The embedded system will provide two functions, automating industry standard hearing test & self-equalization based on the hearing loss determined by the hearing test.

Introduction

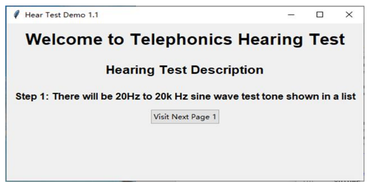
The Raspberry Pi 4 is chosen for the project development platform and provides the hearing test, and an audio sound card is selected to provide the self-equalization capability. The hearing test will play a sine wave audio, which is 20 Hz to 12k Hz, then users can point out which frequency band they cannot hear.
Then the hearing will record the frequency band and using Matlab to set up EQ filter parameters. The equalizer filters can amplify the frequency band. Our equalizer filters have eight different frequency bands provided to the users, and the users are allowed to adjust the equalizer filters again to have the more accurate and comfortable output sound wave outputs.

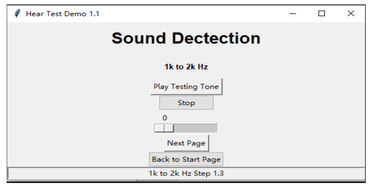
Background and Hearing Research

According to the National Institute for Occupational Safety and Health(NIOSH), about 30 million U.S. workers have different hearing loss levels due to a noisy working environment. When people are working in a high noise environment, like military pilots, subways workers and trains workers, they have shown levels of hearing loss because of prolonged exposure.
The healthy human ear can hear sound frequencies bands between 20Hz to 20,000Hz, but the normal hearing range is 250Hz to 8000Hz. The hearing loss is often separated to five level, normal, mild; moderate, Severe and profound

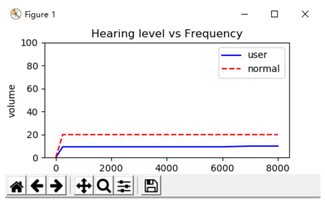


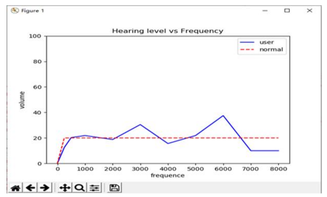
Hearing Test User GUI





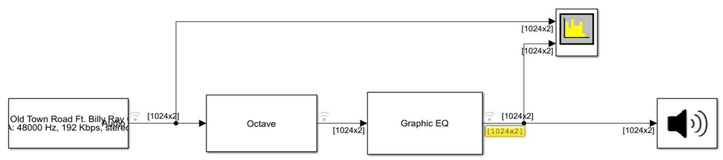
Hearing Test Result Graph Example



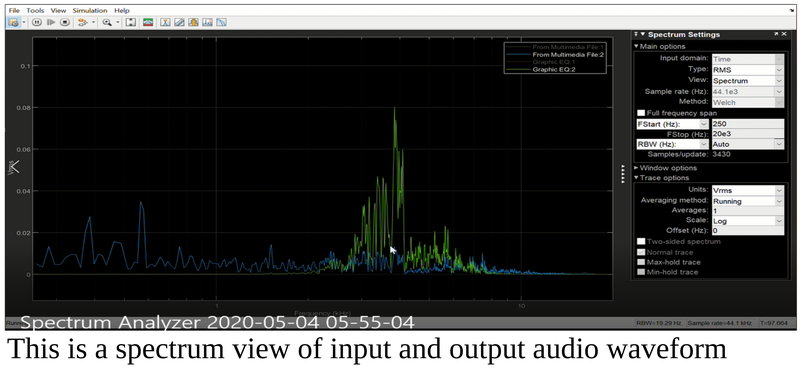


After the user goes though the hearing test each step, the hearing result wll pop up.

MatLab SimuLink

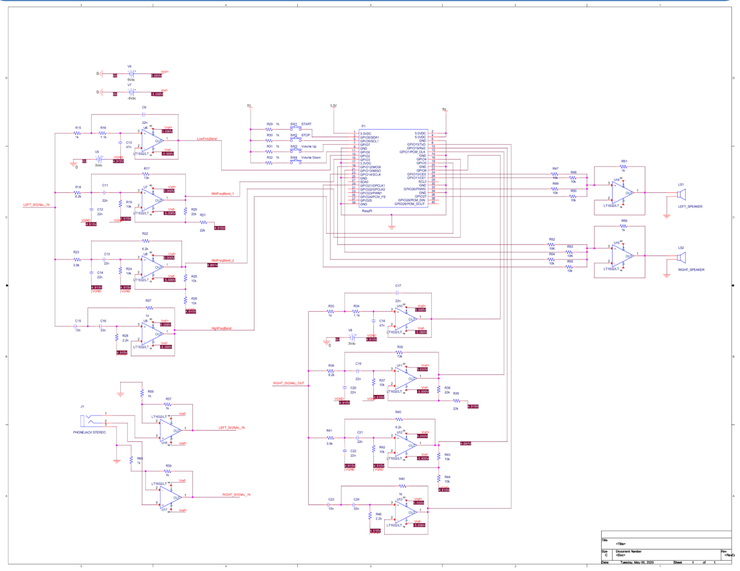


EQ simulation with mp3 input



This is a spectrum view of input and output audio waveform Blue is the input, and Green is the output, and EQ filters set to increase the gain of frequency bands of 4kHz to 8kHz.

Schematic of System



Top center is Raspberry Pi pinout connections. On left and bottom, the two similar circuit blocks are filter banks. Each filter bank filters the input signal into 4 segments base on its frequency. First with frequency from 0 Hz to 300Hz. And 300Hz to 3K; 3k to 8 K. and rest of signal with frequency above 8k hz. On bottom left is dual channel audio input.
System is powered by 600mAh battery with 5V output voltage. Using voltage divider to giving out a 3.3V voltage source to drive Raspberry Pi.

Glossary

Degree of Hearing Loss – Terms utilized to represent the thresholds of hearing graphed onto an audiogram to help describe the different degrees of hearing impairment expected.

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