

The Adaptive Hearing Aid

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INTRODUCTION

The problem addressed by this project is that hearing aids can be very expensive and most people with hearing disabilities cannot afford them. The main reason for these high costs is that each individual's hearing problems are unique and hearing aids have to be custom made in order to fix a particular hearing problem. This high cost limits the amount of help that a disabled person can afford. An effective solution needs to be found that can be mass-produced and consequently, made cheap.

There are four main hearing problems that are addressed by this design. First, there is difficulty hearing at certain frequencies. In this case, a hearing aid that amplifies everything does more harm than good. Second, many people have problems hearing in noisy environments because of the background noise. Next, hearing loss in only one ear is common due to a gun shot, diving accident, etc. Finally, there are the cases of severe hearing loss that can dramatically hinder a person's ability to perform daily activities.

This design's solution to these four problems is to use analog electronics to design a network of filters that can adjust the gain for a wide range of different frequencies. An additional feature will be the ability to adjust the amount of gain in each ear that the user hears. The goals of this project are to make the design flexible enough to help a majority of the people with hearing loss, make the design cheap, and to make the design small enough so as not to get in the way of every day life.

Before beginning the design, the design requirements have to be set. The first requirement of this design is that it must be able to handle the entire frequency range of sound. The second requirement of this design deals with the gains for each of the signals. The volume of the output signal falls into two categories: the volume of each frequency band, and the volume to each ear. This design requires that the minimum gain for this device be low enough so that hearing is not damaged any further and also that the maximum gain is loud enough to help extreme cases of hearing loss.

According to the Occupational Safety and Health Administration, any noise louder than 85 decibels (dB) can cause hearing loss over an extended period of time. Therefore, this design should make sure not to exceed that level or else it would be doing more harm than good.

SUMMARY OF IMPACT

Using this method, all four of the main hearing problems mentioned earlier can be solved. The system of filters allows the user to amplify only the frequencies that they need, while the directional microphone that is used removes a majority of the background noise present in a noisy environment taking care of the second type of hearing loss mentioned.

The potential for this design is very interesting. One application for this device would be to have individuals who would like a hearing aid take a hearing test. Then based on the results of that test, the designer could set the value of the gain for each frequency stage as well as the gain to each ear, and provide the user with a product where he or she only needs to worry about the master volume of the device.

The overall cost of this project ended up being around thirty dollars. When compared to the current cost of almost \$1000 for a programmable hearing aid on the market today, this solution is very cost effective. More importantly, this design offers a solution to many of the hearing problems that people live with on a daily basis.

TECHNICAL DESCRIPTION

The design uses a system of five analog filters: one low-pass, three band-pass, and one high-pass filter. Each filter covers a different range of frequencies and the gain for that filter can be adjusted by the user. The design also includes a circuit to adjust the volume from one ear to the other if the user has hearing loss in only one ear. The result is a system much like a graphic equalizer, allowing the user to adjust the hearing aid to best fit his or her own personal hearing problems. Finally, a circuit was added that allows the user to also send the signal to either the left or right ear, or send an equal signal to both ears.

Once the device was built, testing could begin to understand if this device functioned as well as theorized when first approaching the topic. Currently the device does a number of things very well. First, all five frequency ranges can be easily adjusted and there is a noticeable difference in the signal coming in when they are. During testing, adjustments allow for the subject wearing it to tune into the television or to a certain style of music. When adjusted properly, it also reduces a large amount of background noise and allowed the user to hear the person in the foreground more clearly. The device adjusts the volume between the left and right ear very nicely as well.

However, there are some drawbacks that occurred during testing. The high-pass filter was designed differently than the other four filter stages. This resulted in a much lower input impedance than the other four filters. The low input impedance of the high-pass filter meant that it drew more current than the other filters which produced a soft high-pitch tone no matter how the filters were adjusted. At times the tone became very loud if the gain on the high pass filter was turned all the way up because then it drew almost all of the current and none of the signal went to the other filters. To solve this problem, a wide band pass filter should be used instead of the high-pass filter. This would provide a similar input impedance to the rest of the filters, and would hopefully remove this design flaw.

The packaging for this design is also a small cause for concern. The prototype clips onto a belt and headphones are plugged into a stereo jack. This seems a little bulky, but if it went into production, then the size could be reduced by half, if not more.



Figure 1: Photo of the Finished Prototype

The power consumption of this device is equal to about 4.1 W, which is slightly higher than hoped for when doing the original design. This implies that the device would need to be powered by a rechargeable battery in order to be practical. The design works for about 10 hours before the signal begins to get clipped, at which point the hearing aid becomes useless.

On the whole, this design has a lot of potential and could revolutionize how hearing aids are designed and manufactured. This design's ability to help such a wide range of the hearing problems that people experience today at such a low price could improve the lives of millions of people in the world today.