Hearing aid.

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Abstract

Hearing aids have improved drastically over the past decade, mainly due to the advancement of digital technology. The next decade should see an even higher number of innovations to hearing aid technology, and this article attempts to predict in which areas the new developments will take place. Both incremental and radical innovations in digital hearing aids will be lead by research advances in the following fields: Wireless technology, digital chip technology, hearing science, and cognitive science. The chances and limitations for each of these areas will be discussed. Additionally, emerging development such as connectivity and individualization will also develop new technology, and these are discussed within the context of the areas given here.

Keywords: Hearing aid, Impairment, Disabilities, Ear.

Introduction

Hearing impairment effects a staggering 360 million people across the world. Unlike other disabilities, like blindness, hearing impairment does not garner the much needed attention it deserves causing the person to be at a great disadvantage when interacting with the world around them [1]. Yearly, several thousand people are injured or killed in car accidents where they couldn't hear threats approaching before it was too late [2]. The current solution to this problem is the simple hearing aid [3]. A hearing aid amplifies all sounds to emulate a fully functioning ear. This device hasn't changed since its creation which leads to several issues, one of which being its clunky and rather unappealing aesthetic that deters young children from wearing them, leaving them at great risk. Furthermore, the un-adapted hearing aid is not compatible with today's devices which is a great hindrance to the current young population. We believe we can create a device that greatly improves the quality of life of today's young and hearing impaired.

Objective

To create a hearing aid which amplifies important sounds while ignoring unwanted noise in an effort to improve the quality of life of the hearing impaired (Figures 1 and 2).

Literature Review

Electronic components required for noise cancellation:

1 × pair of over ear headphones

6 × LT1056 OpAmp

2 × ECM-60PC-R electret mic

2 × 3.5 mm Audio jacks

2 × 0.01 µF cap

4 × 1 nF cap

8 × 10 µF cap

2 × 100 Ω res

2 × 1 k Ω res

2 × 2.2 kΩ res

2 × 4.7 kΩ res

8 × 10 kΩ res

2 × 13 kΩ res

2 × 22 kΩ res

2 × 1 M Ω res

2 × 500 k potentiometer

Wires:

- A power supply (± 8 V) capable of at least 30 mA.
- Breadboard to build and test.
- Oscilloscope for testing.

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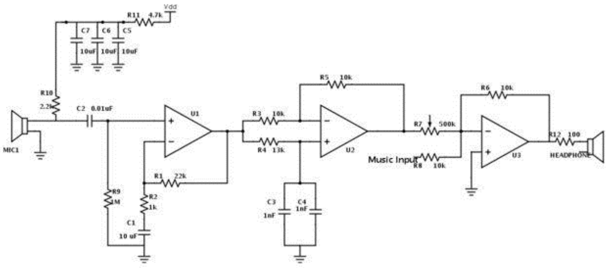

Figure 1. Oscilliscope.

Electronic components required for audio amplification:

- Amplifier-LM386 (IC1)
- An 8 ohm, 1 watt speaker (LS1)
- Two 10 µF, 16 V (C1 and C2)
- Two 220 µF, 16 V (C3 and C4)
- 10 kohm potentiometer
- 6 v battery

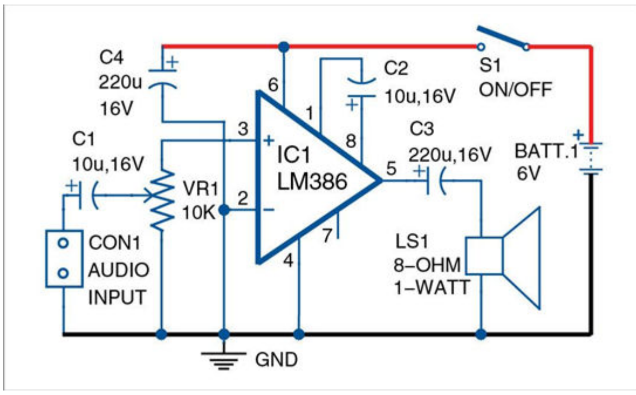

Figure 2. Microphone.

Discussion

Cancellation of noise

Mic setup and power supply filter: The microphone stage is constructed according to the schematic above. The low pass filter on the power supply Vdd (R11, C5, C6, C7) is needed to remove high frequency noise from appearing at the mic output [4]. This is especially important if you are using a digital power supply. R10 is used to properly bias the mic and C2 is an AC coupling capacitor used to remove the DC offset and only pass the noise signal that the mic is detecting [5]. This configuration was found on the data sheet for the mic. The output of C2 leads to the preamp stage.

Mic pre amp: The mic preamp stage is used to amplify the noise signal to a level where we can actually process it. The gain of this part actually depends on the frequency of the incoming signal. In simple terms, this stage acts as a unity gain amp for DC and a non-inverting amp with gain R1/R2 (22/1 here) for all other frequencies [6]. This is again to reduce the DC component of the noise-cancelling signal. The problem with DC is that it causes an offset in the noise cancelling signal which will cause the system to not work correctly.

All pass filter: The all pass stage delays the noise cancelling signal and preserves unity gain. The delay is needed because the noise sound that we wish to cancel takes time to get from the mic to your ear [7]. Electronic signals are much faster than sound so it is necessary to slow down the noise cancelling signal or else the two will not arrive at your ears at the same time.

Summing Amp: This final stage adds the music to the processed noise signal and inverts the sum. The key part here is to tune the gain of the noise cancelling signal so that its amplitude matches the amplitude of the sound signal. This is one of the more difficult parts of the design and is why the potentiometer has been added [8]. The music input's gain will be 1 (R6/R8), while the noise cancelling signal will have a gain of R6/R7. After setting up the system, we adjusted this potentiometer until it sounded like there was noise cancellation occurring [9]. This may sound arbitrary, but audio engineering where one of the signals that you are using is a sound wave is very difficult to quantify or see on an instrument. The music input comes from one channel of the 3.5 mm audio jack.

The final stage of the system is a current limiting resistor in series with the headphones. The headphones we chose have an impedance of 24 Ω. With using power rails of ± 8 V this means that the output current could be up to 333 mA [10]. With the R12 added the max current is reduced to 65 mA. This is done to protect the headphones (based on power rating) and your ears (more current means way louder).

The output of R12 is attached to the 3.5 mm audio jack so that standard headphones can be connected.

Amplification of required frequencies

Four electrolytic capacitors (two 10 µF, 16 V (C1 and C2) and two 220 µF, 16 V (C3 and C4)) are used in this circuit. C1 is connected to the middle terminal of 10 k potmeter VR1. C2 is connected to pins 1 and 8 of IC1. Pin 5 of IC1 is its output terminal, which is connected to speaker LS1 through C3.

C4 is connected to the positive terminal of 6 V battery and ground. Positive side of 6 V is connected to pin 6 of IC1 and the other side to ground terminal to pin 4.

Inverting pin 2 of IC1 is connected to ground and non-inverting pin 3 is connected to the input terminal through VR1. Audio input is fed to CON1. VR1 is used to control volume.

Conclusion

A hearing aid is a device developed to improve hearing by making sound audible to a person with hearing problems. Hearing aids are classified as medical devices in most countries, and regulated by the respective regulations. Small audio amplifiers such as Personal Sound Amplification Products (PSAPs) or other plain sound reinforcing systems cannot be sold as hearing aids.

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Previous devices, such as ear trumpets or ear horns, were passive amplification cones developed to capture sound energy and pass it into the ear canal. Modern devices are computerised electroacoustic systems that improve environmental sound to make it audible, as per audiometrical and cognitive rules. Modern devices also use sophisticated digital signal processing to try and improve speech intelligibility and convinent for the user. Such signal processing consists feedback management, wide dynamic range compression, directionality, frequency lowering, and noise reduction.

After assembling the circuit on a PCB, enclose it in a suitable box. Fix connector CON1 on the front panel for input and loudspeaker LS1 at the rear side of the box. Connect VR1 on the front panel for controlling the volume.

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