COVID HEARING AID

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1. Introduction

1.1. Background

Due to the COVID-19 pandemic, people around the world have been recommended or even required to wear masks to prevent themselves and others from becoming infected. There is consistent scientific evidence that this levels the curve of infection, and thus mask-wearing is now an important societal norm. However, this causes significant communication issues for people with hearing loss, as mask-wearing muffles sound and prevents lip reading. Existing solutions such as clear masks to allow lip reading or wearable amplification systems must be used by the talker, and would require every person to use one in order for the hard of hearing to be able to understand everyone. Furthermore, clear masks actually muffle a speaker's voice even more than cloth masks because they are made of plastic. And standing closer to the speaker is not a good solution because physical distancing is also necessary to curb the infection rate.

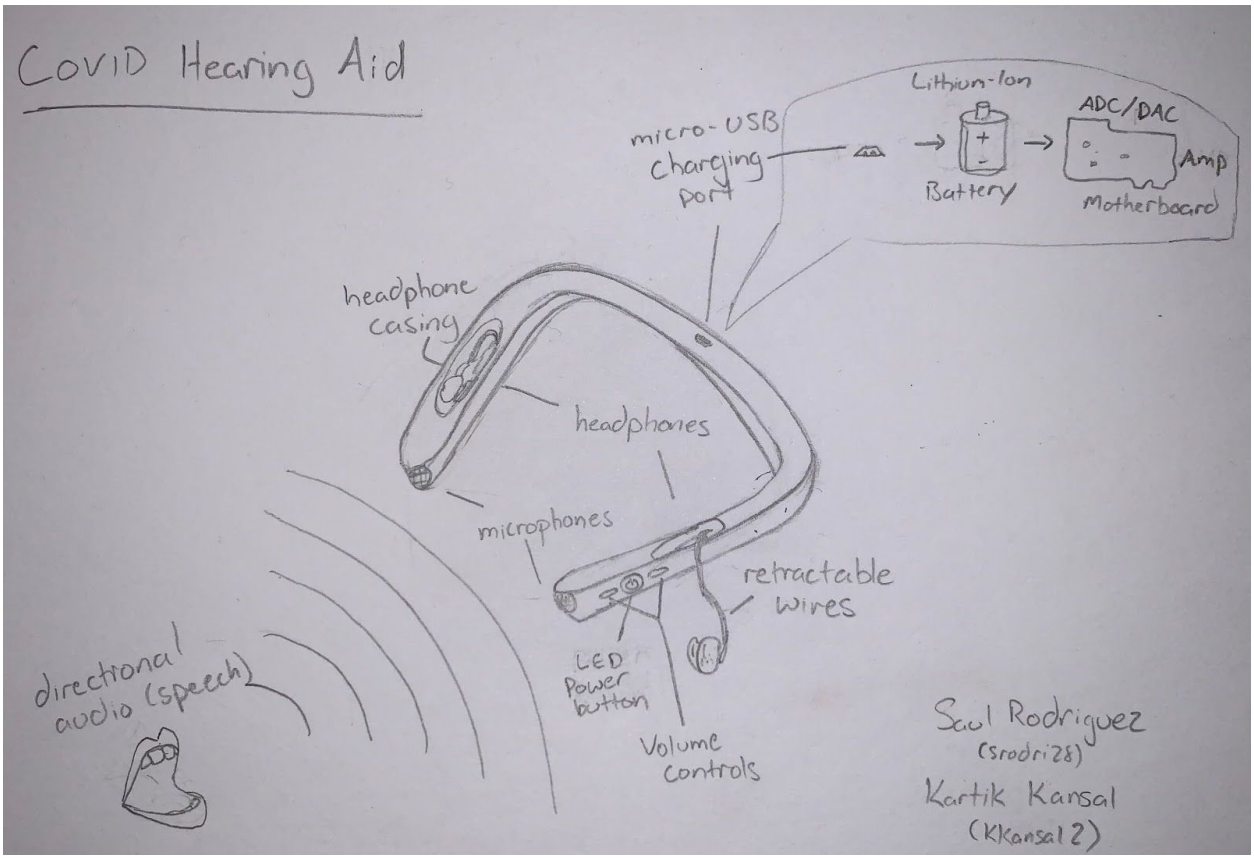
1.2. Objective

To solve this issue, we must focus on the perspective of the listener alone. Our solution is a hearing aid device that can amplify sounds that come from a good distance in front of the listener. This device should be able to receive input audio, amplify sounds that are understood as human voice, and filter out the background noise coming from other directions. The hearing aid will be lightweight so that it is easy for the user to wear and carry around. Furthermore, it should be easy to use, easy to produce, and relatively inexpensive compared to other hearing aids, especially since this is a time of financial hardship for many.

1.3. Physical Design

The device will be shaped like an open necklace, which is a piece of plastic that should encase all the required components, such as the battery and motherboard. There will be a

microphone on either end, as well a retractable, wired headphone on either side. There will also be a power button with an LED indicator light, as well as two buttons for controlling the volume.

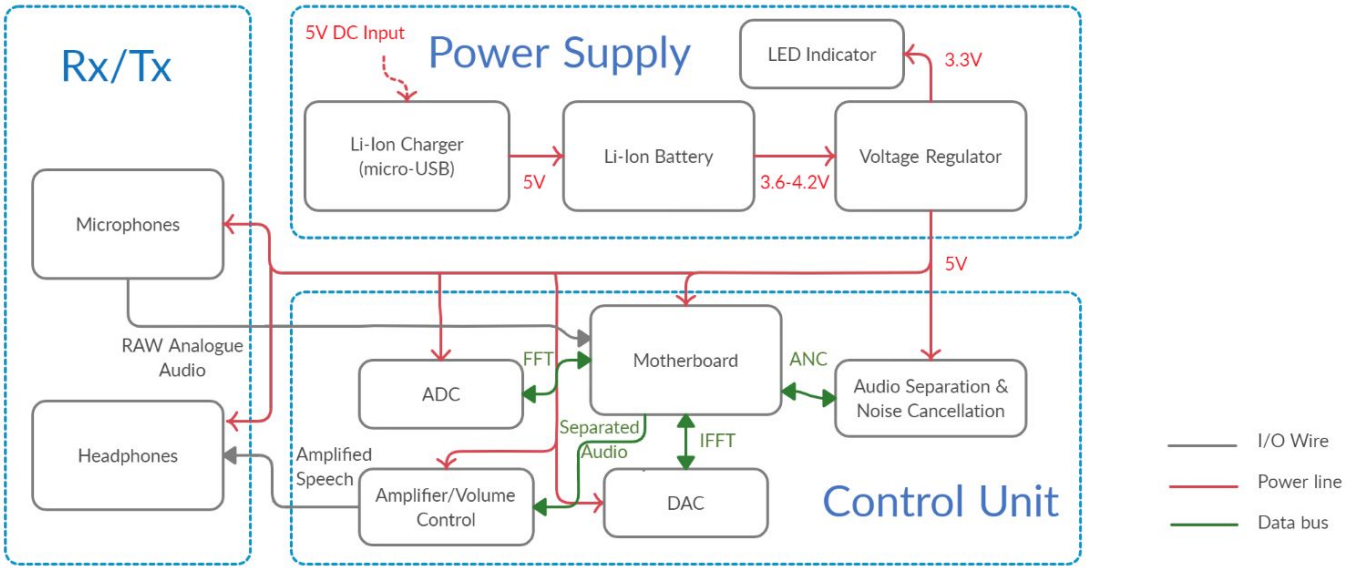


1.4. High-Level Requirements List

- A portable and rechargeable power delivery system should allow the device to function on the go for at least 6 hours while turned on.
- The microphones should be able to pick up on sounds that are at least 60 dB and from 20 to 20,000 Hz.
- The device should be able to amplify sounds to about 90 dB in order to accommodate those with profound hearing loss.

2. Design

2.1. Block Diagram



2.2. Functional Overview and Block Requirements

1) Receiver/Transmitter Module
    a) Microphones
        i) Overview: In order to amplify the speaker's voice, we first need to receive it digitally through our microphone. Also to implement noise cancellation we need a minimum of two microphones to compare and distribute audio.
        ii) Requirements: The microphones should be able to pick up frequencies ranging from 20 to 20,000 Hz, because this is considered to be the “normal” hearing range for a healthy, young person [1]. Thus the microphones should ideally sample at the Nyquist frequency of 40,000 Hz. Furthermore, the microphones should definitely be able to pick up sounds that are at least 60 dB, as this is the sound intensity of a normal conversation. [2]

b) Headphones

i) Overview: Headphones will allow the separated voice audio to be redirected and transmitted directly to the user. These will be designed to be released and retracted on the user's will from the front sides of the device.

ii) Requirement: should be able to deliver sounds amplified to about 90 dB, as a hearing loss of >90 dB is considered to be profound hearing loss [3]. Should be the same size as typical earphones, such as those meant for listening to music.

2) Power Supply Module

Overview: A lithium-ion battery will be the sole power source for the device. A micro-usb input will allow the battery to be charged for on the go use. An on/off button with an LED indicator will control the power delivery to the rest of the device.

Requirements:

a) Lithium Ion Charger: the input voltage for this will be 5 V via a micro-usb cable/port.

b) Lithium Ion Battery: this should be able to continuously supply 500 mA at 5 V +/ 0.5 V. Also, the battery should be rechargeable and should supply for at least 6 hours before having to be recharged.

c) Voltage regulator: we will use this to get us around 3.6–4.2 V. Also, the lithium ion charger, battery, and voltage regulator should be small enough to fit into the plastic encasing of the open necklace.

3) Control Unit Module

Overview: The motherboard will handle the main processes for the system. This will take the audio received from the microphones, separate the background audio from the speaker's voice, and transmit/amplify their voice to the headphones.

Requirements:

a) Motherboard/ADC, DAC, ANC: this should have a very low latency, around 5 ms, to ensure that there is not too much of a delay between the real-world sounds received by the microphone and what is heard by the user.
b) Amplifier/Volume control: this should be controlled by two buttons (for increasing and decreasing volume) that are small enough to fit onto the plastic encasing of the open necklace. Should be able to amplify sounds to about 90 dB.

2.3. Risk Analysis

The block that poses the greatest risk to successful completion of the project is the control unit. We need to be able to sample at 40 kHz and perform proper FFT analysis as quickly as possible, but this may cause some delay/latency issues. The FFT filtering and active noise cancellation could accidentally filter out some of the important input audio. Furthermore, the sound amplification could amplify too much undesired noise that passes through the filter. Another concern is that the components necessary for this design will not be small enough to fit into the plastic encasing, which would result in a device that is very awkward to use, carry, and wear.

3. Ethics and Safety

While building this project we will be sure to adhere to the IEEE Code of Ethics—in particular, “to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design…” [4].

One of the safety concerns is the use of the lithium ion battery, which could potentially overheat and cause damage to someone’s skin/hair. The other electrical components, like wires, pose a similar concern. In order to prevent this, we will ensure that all electrical components are properly encased in the plastic open necklace. If necessary, we could also add a thermal regulator to prevent overheating.

Another safety concern is the possibility of audio being over-amplified. Although this device is mainly meant for people who are hard of hearing, there is still the risk of audio

becoming too loud and unpleasant. In order to prevent this, we are incorporating a volume control option for the user. Also, we should not amplify the sound to more than 90 dB, because although the most severe hearing loss before deafness is about 90 dB, sounds above 85 dB are considered harmful to human ears [2].

4. Citations and References

[1] National Hearing Care. (2020, May 19). The Normal Hearing Range: Hearing Health Blog. Retrieved September 21, 2020, from https://nhc.com.au/blog/human-hearing-range

[2] Harmful Noise Levels. (n.d.). Retrieved September 21, 2020, from https://www.healthlinkbc.ca/health-topics/tf4173

[3] Degree of Hearing Loss. (n.d.). Retrieved September 21, 2020, from https://www.asha.org/public/hearing/Degree-of-Hearing-Loss/

[4] "IEEE Code of Ethics", Ieee.org, 2020 [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 20- Sep- 2020].