

ECE 445 FALL 2020

COVID-19 Hearing Aid

(Sponsored by Ryan Corey)



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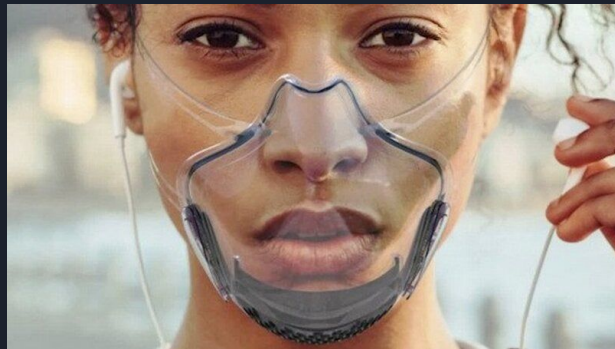


Brief Disclosure

We are a two-person online group,
limited to the tools we've personally
acquired and could afford.

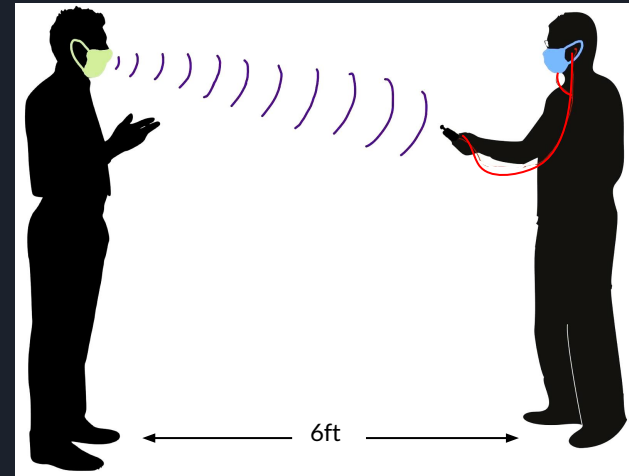
Background

- Covid mask issue:
muffled speech as well as
preventing the listener from
reading the speakers lips
- Previous solutions:
 - Clear masks
 - Hearing aids



Introduction - Our Solution

- A portable, powered, and unidirectional microphone
- Adjustable amplification
- User required headphones



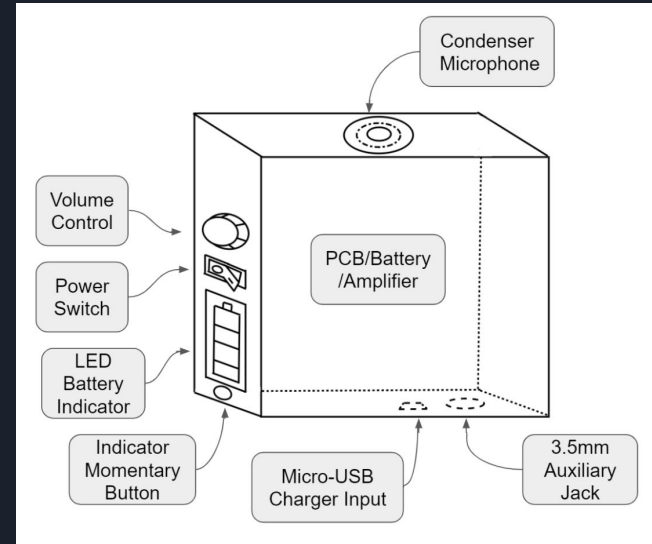
Objective

- Allow the user to control the volume/amplification via a dial

as well as used their own

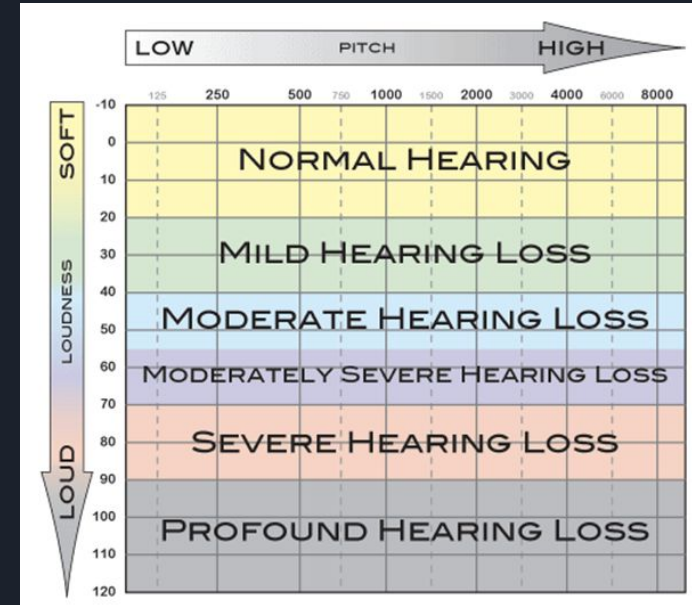
preferred headphones.

- Create everything cost effectively
and with simplicity to allowing for DIY
inspiration and replication



Design Considerations and High-Level Requirements

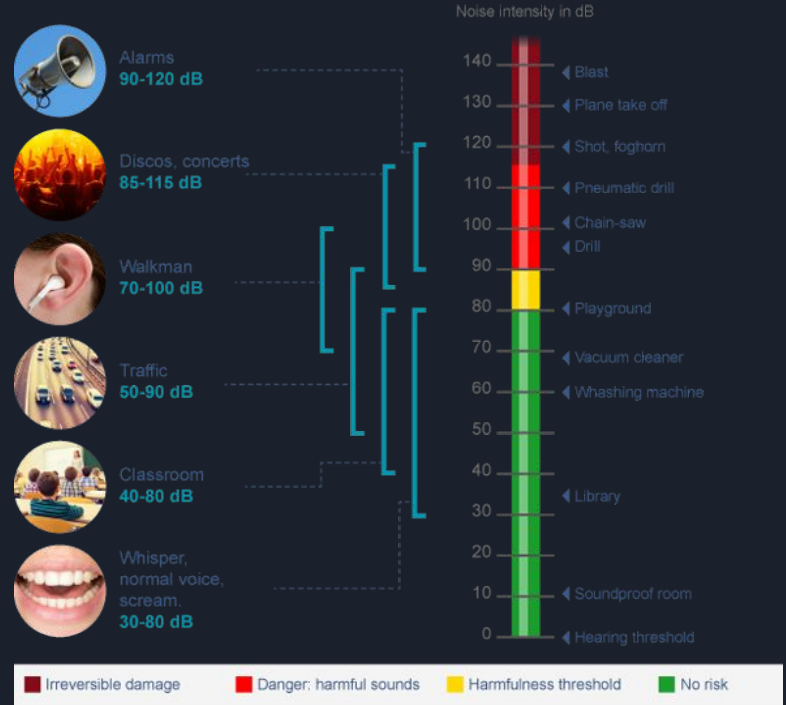
- Device should amplify sounds to at least 90 dB in order to accommodate those with profound hearing loss [1]
- Should pick up sounds as low as 54 dB, which is the incoming sound pressure level from a normal conversation from 6 feet away [2]
- Need to pick up sounds in at least the range of 80–260 Hz, which is the frequency range for typical speech [3]



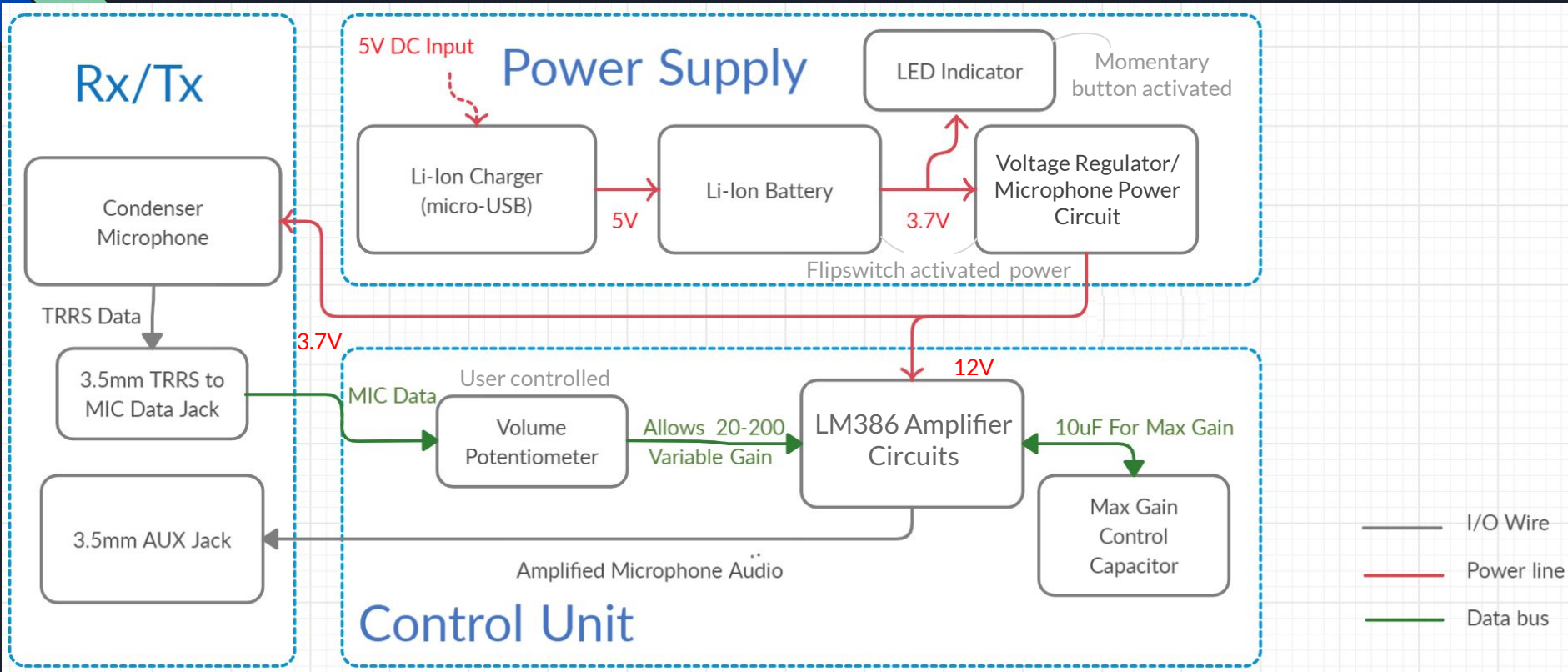
Distance		Voice Level (dB PSIL)			
(ft)	(m)	Normal	Raised	Very Loud	Shouting
1	0.3	70	76	82	88
3	0.9	60	66	72	78
6	1.8	54	60	66	72
12	3.7	48	54	60	66
24	7.3	42	48	54	60

Ethics and Safety

- Prolonged sounds that are about 80 dB and louder are considered harmful to human hearing [4]
- In order to accommodate people with profound hearing loss while also not harming the hearing of others, it was necessary to implement a volume control dial



BLOCK DIAGRAM



Physical Model



Physical Model

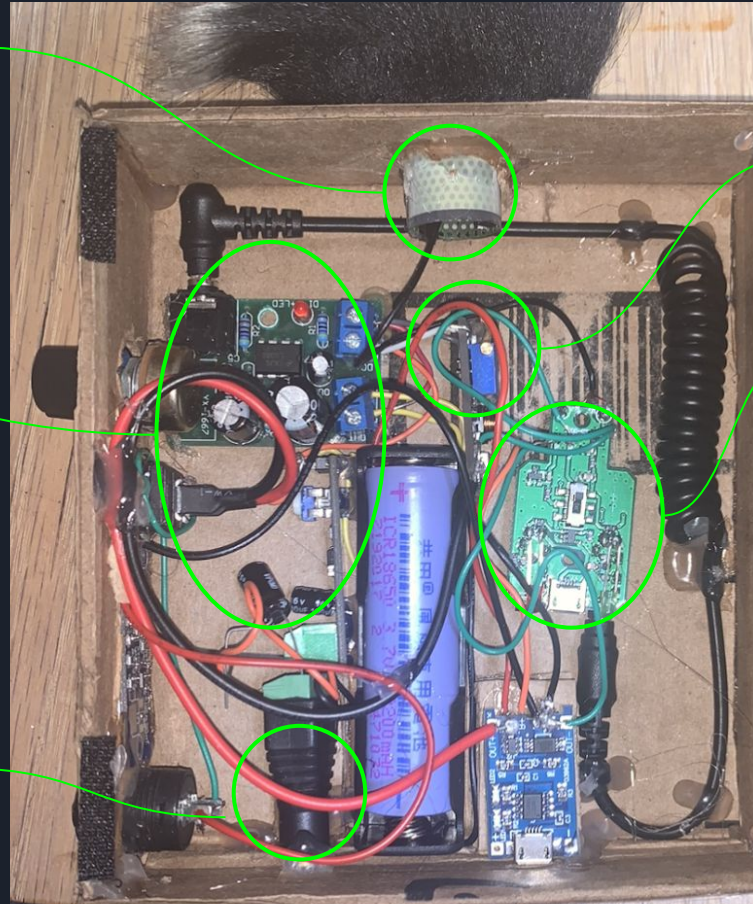
Condenser
Microphone

Amplifier
Circuits

3.5mm
Auxiliary Jack

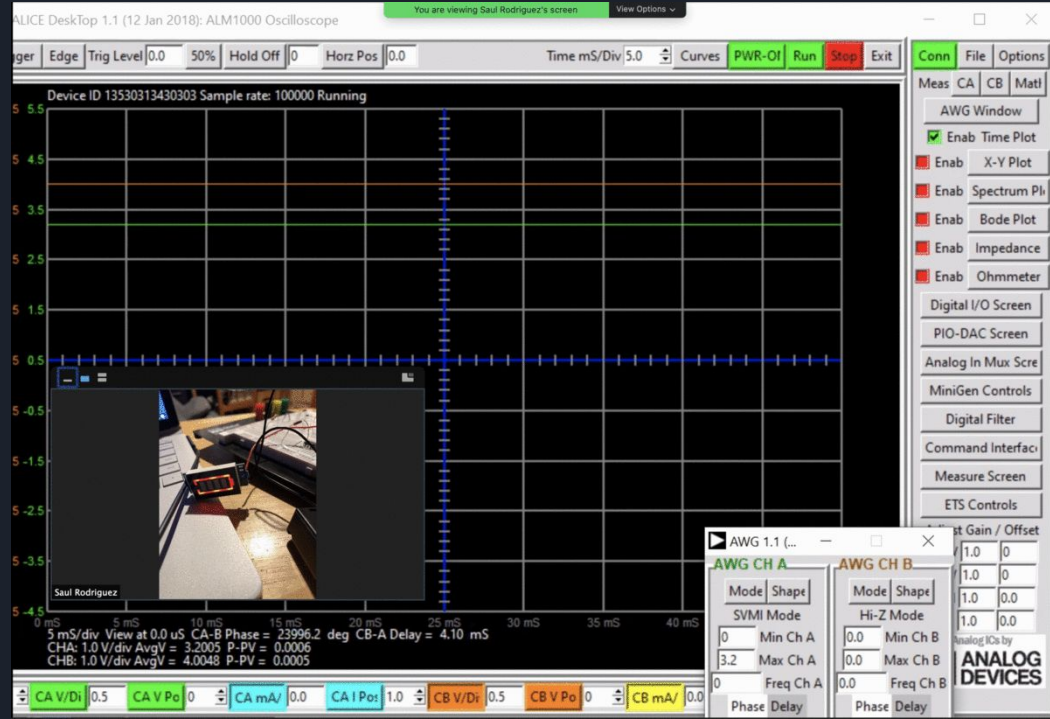
Voltage
Regulator

Microphone
Power Circuit

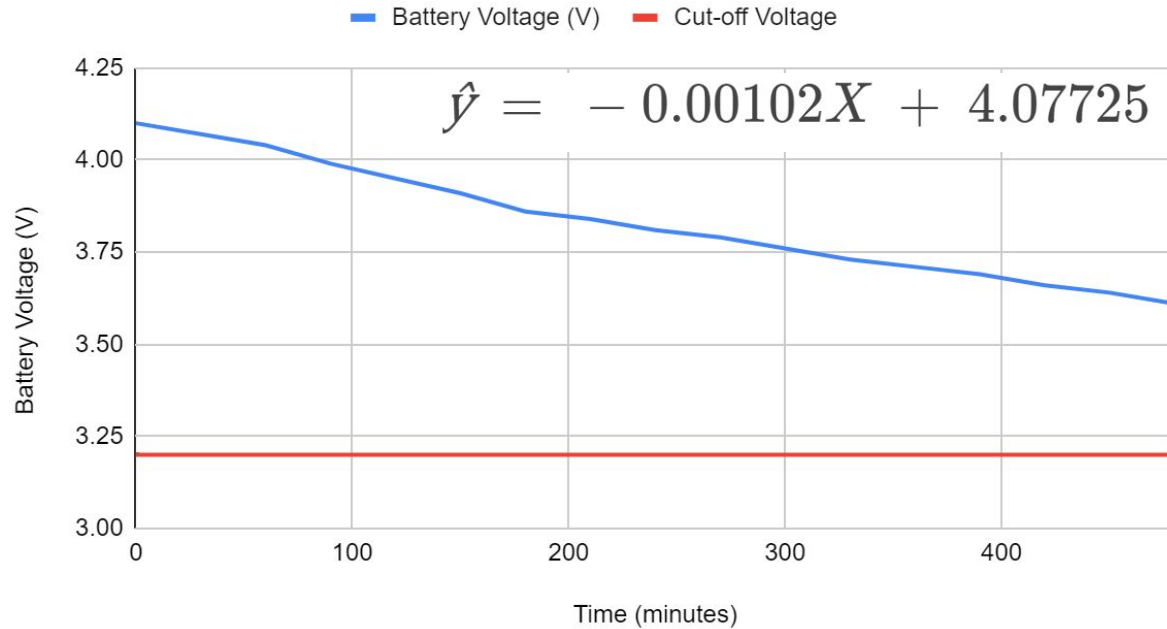


Battery Indicator

- Tested battery indicator using Alice
- At 3.2 V, the battery is just barely turned on
- With each increase in 0.2 V, one additional LED indicator turns on
- At 4 V, all four LED indicators are on



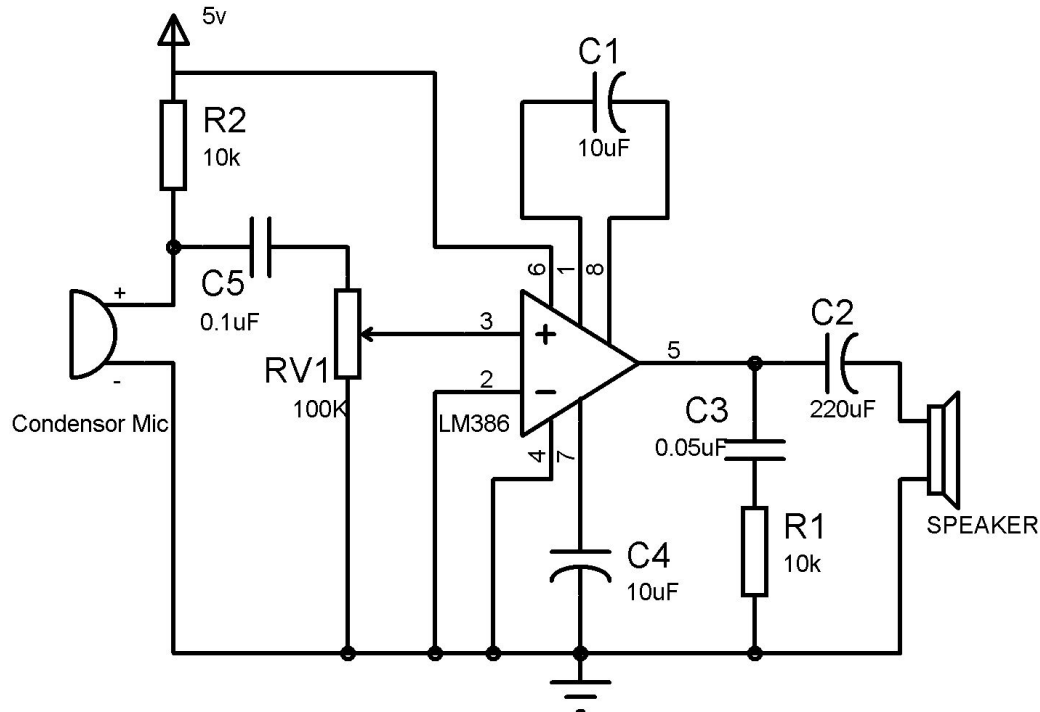
Battery Voltage vs. Time



Operation Time: Goal (6 hrs) Achieved (at least 8 hrs)

Using Linear Regression and setting \hat{y} to the cut-off voltage (3.2)
estimate run time equals approximately 860 min or 14.33 hrs

The Amplifier Circuit



- In place of the R2 pull down resistor we've applied the microphone power circuit
- RV1 is the Variable Resistance adjusted with a 100k ohm potentiometer
- The node where C3 in series with R1 and C2 in series represents where filtering raw signal begins.



Gain Multiplication

- Microphone sensitivity is $-42 \text{ dB} \pm 1 \text{ dB}$, with 0 dB producing 1 V/Pa
- 1 Pa (pascal) equals 94 dB sound pressure (SPL)
- Every -6 dB decreases voltage by one half
- The expression that gives the gain (A_v) between a reference V_0 and a measured V_1 (in dB):

$$20 \cdot \log(V_1/V_0)$$

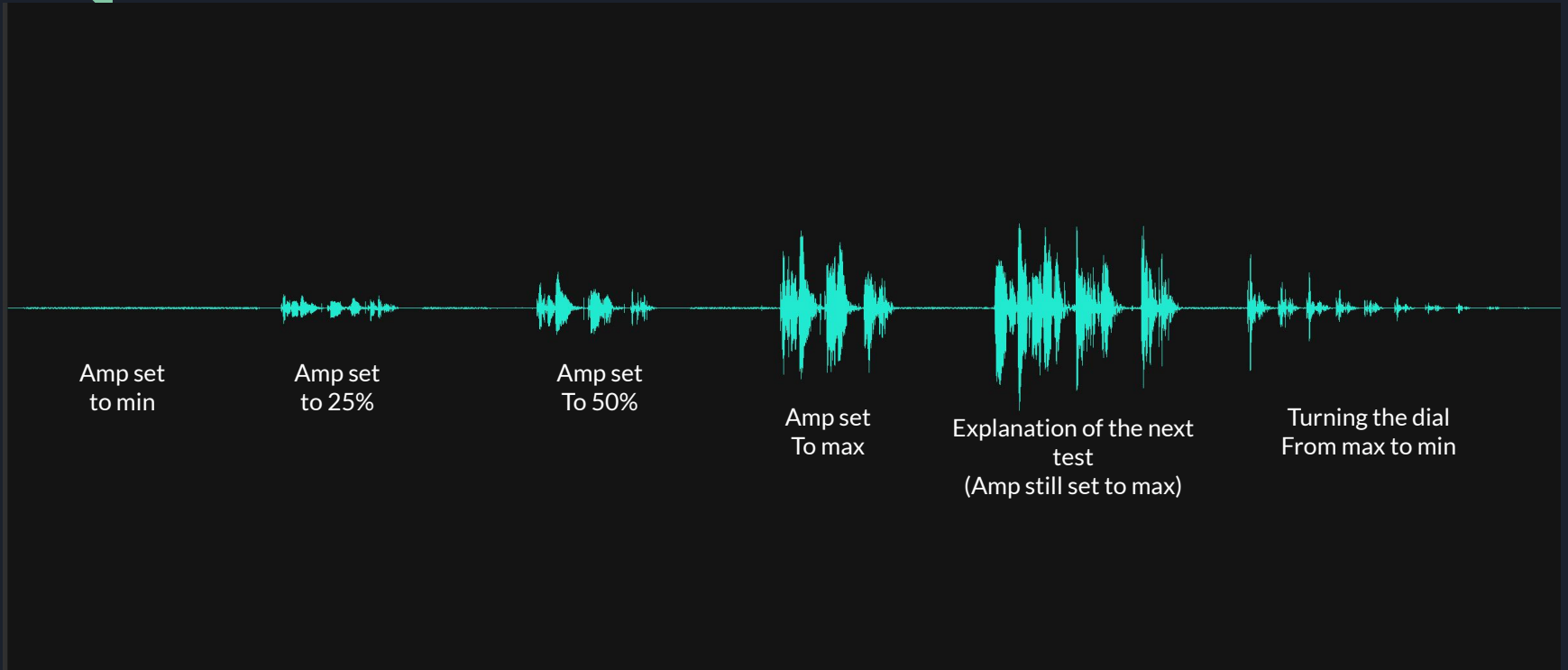
$$V_0 = 1V \cdot \left(\frac{1}{2}\right)^{\frac{-42 \text{ dB}}{-6 \text{ dB}}} = 7.8125 \text{ mV}$$

$$V_1 = 7.8125 \text{ mV} \times 200 (\text{Gain}) = 1.5625 \text{ V}$$

$$A_v = 20 \cdot \log\left(\frac{1.5625 \text{ V}}{7.8125 \text{ mV}}\right) \approx 46 \text{ dB}$$

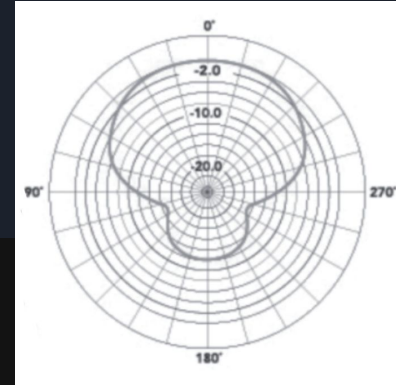
$$94 \text{ dB} - 42 \text{ dB} + 46 \text{ dB} = 98 \text{ dB}$$

Tunability - Amplification Control



Unidirectionality Testing

(Cardioid Pattern)



Speaking
directly in front
of the mic (0°)



Speaking at 15°
from zero point



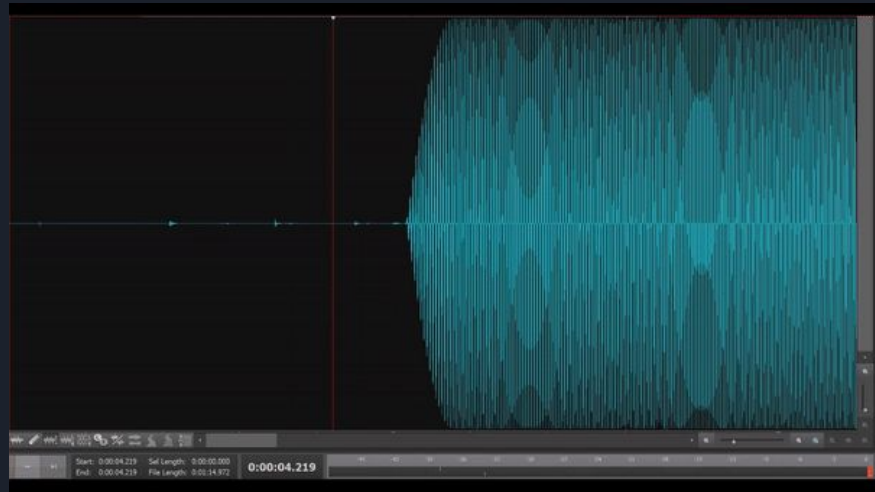
Speaking at 30°
from zero point



Speaking at 45°
from zero point

Additional Testing

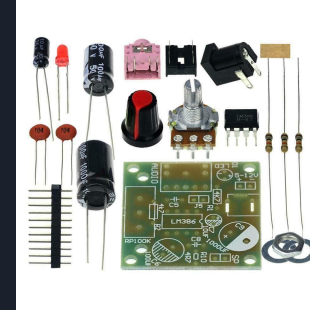
- Frequency capture range:
Goal (80 to 260 Hz)
Achieved (50-10kHz)
- Decibel capture:
Goal (as low as 54 dB)
Achieved (as low as 42.1dB)



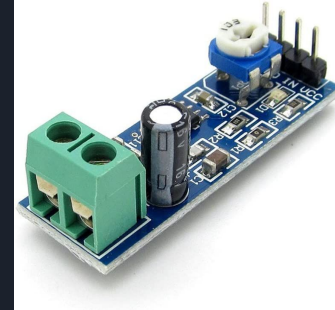
Affordability - DIY Inspiration

Part #	Description	Manufacturer	Vendor	Quantity	Cost/ Unit	Total Cost
LGDBHG21	Rechargeable Battery	LG Chem	18650 Battery Store	1	\$5.99	\$5.99
RK-0500500	Micro-USB Charger (x6)	DZS Elec	Amazon	1	\$1.165	\$6.99
MT3608	Voltage Regulator (x10)	WOWOONE	Amazon	1	\$0.995	\$9.95
-	On/Off Switch (x10)	VQVAAQ	Amazon	1	\$0.698	\$6.98
YXM04	Mini Cardioid Condenser Microphone	Bietrun	Amazon	1	\$23.63	\$23.63
COM-11996	Momentary Button	Sparkfun	Sparkfun	1	\$0.95	\$0.95
GR-US-145	Battery Capacity Indicator (x2)	DAOKI	Amazon	1	\$2.995	\$5.99
2914	Audio Plug Terminal Block	-	Adafruit	1	\$2.50	\$2.50
2915	Audio Jack Terminal Block	-	Adafruit	1	\$2.50	\$2.50
LM386	Mini Power/Audio Amplifier Board/Volume Adjustable Control (x2)	Acxico	Amazon	1	\$3.595	\$7.19
Total					\$45	\$72.31

DIY Assembly



Preassembled



Alternative Power Supply





Conclusions

- Amplification via a dial to a resistive potentiometer works properly and efficiently. Allows for distance capture and audio amplification without damaging the user's ears.
- Slight buzzing noise from first amplifier can increase dramatically across the second amplifier. Finding the buzz frequency can lead to filtering.
- The hefty design size was made more open for displaying the circuits in a way that represented the flow of our block diagram. This can be scaled much thinner to attract the appeal of being a portable device.



Future Work

- Remove buzzing noise with RC filtering at the right frequency found using an oscilloscope
- Incorporate AA batteries as the power supply.
 - This is easier for the typical consumer to obtain and is much cheaper.
 - Their battery capacity ranges from 2000-3000mAh
 - Also come in a rechargeable form.
- Find a more affordable condenser microphone and create our own PCB for the “microphone power circuit” to bring the total cost down.



Sources

[1] *Asha.org*. [Online]. Available:

<https://www.asha.org/uploadedFiles/Consensus-Paper-From-Hearing-Care-Associations.pdf>. [Accessed: 04-Dec-2020].

[2] “Voice Level at Distance,” *Engineeringtoolbox.com*. [Online]. Available:

https://www.engineeringtoolbox.com/voice-level-d_938.html. [Accessed: 04-Dec-2020].

[3] “What is the frequency range of human speech?,” *Reference.com*, 04-Aug-2015. [Online].

Available:<https://www.reference.com/science/frequency-range-human-speech-3edae27f8c397c65>.
[Accessed: 03-Dec-2020].

[4] “Harmful Noise Levels,” *Healthlinkbc.ca*. [Online]. Available:

<https://www.healthlinkbc.ca/health-topics/tf4173>. [Accessed: 04-Dec-2020].



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QUESTIONS?

THANKS FOR VIEWING