RONArmor

Team 31:
Aditya Gupta, Moriah Gau, Shana Milby

Introduction

- Safe, reusable, and affordable facial shield for daily use during COVID-19

- An enhanced shield that doesn't restrict your voice and alerts users to maintain safe social distance

Objective

- Comfortable, reusable, and versatile
- Reinforces social distancing guidelines with an alerting system
- Ensures improved communication through audio amplification

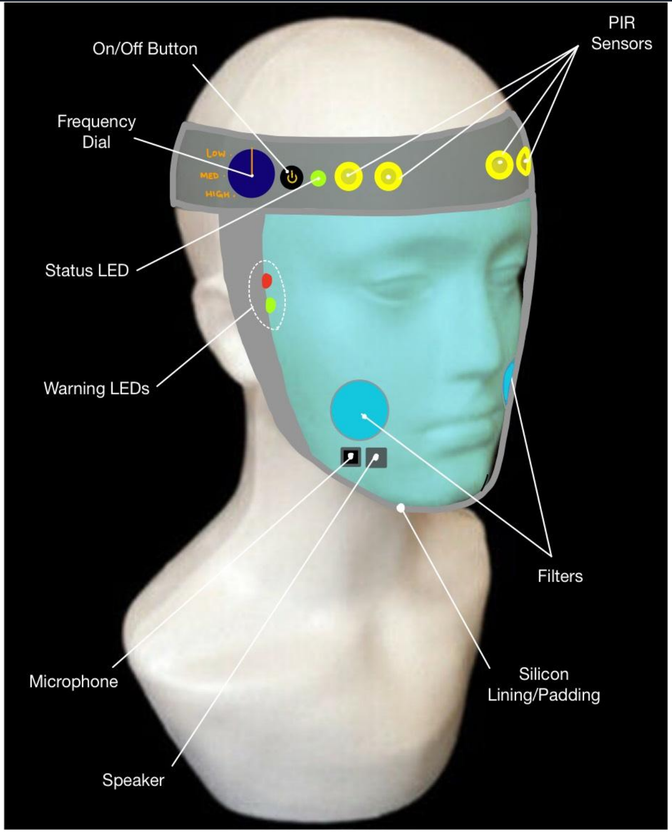
Original Design : High-Level Requirements

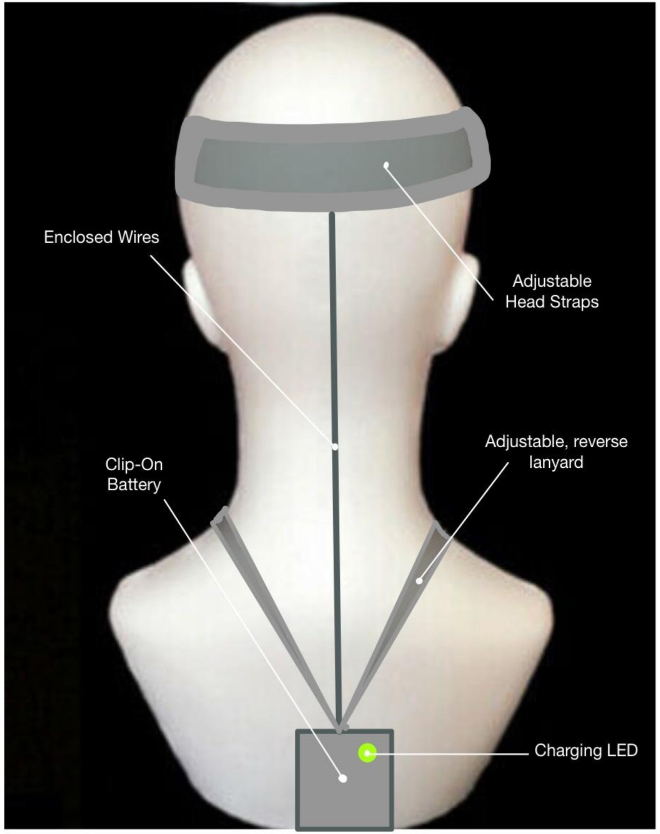
1. Audio is properly amplified and can be modulated between three pitches (low, medium, high) or remain unmodulated.

2. Accurately assesses and notifies the user whether people are standing six feet away.

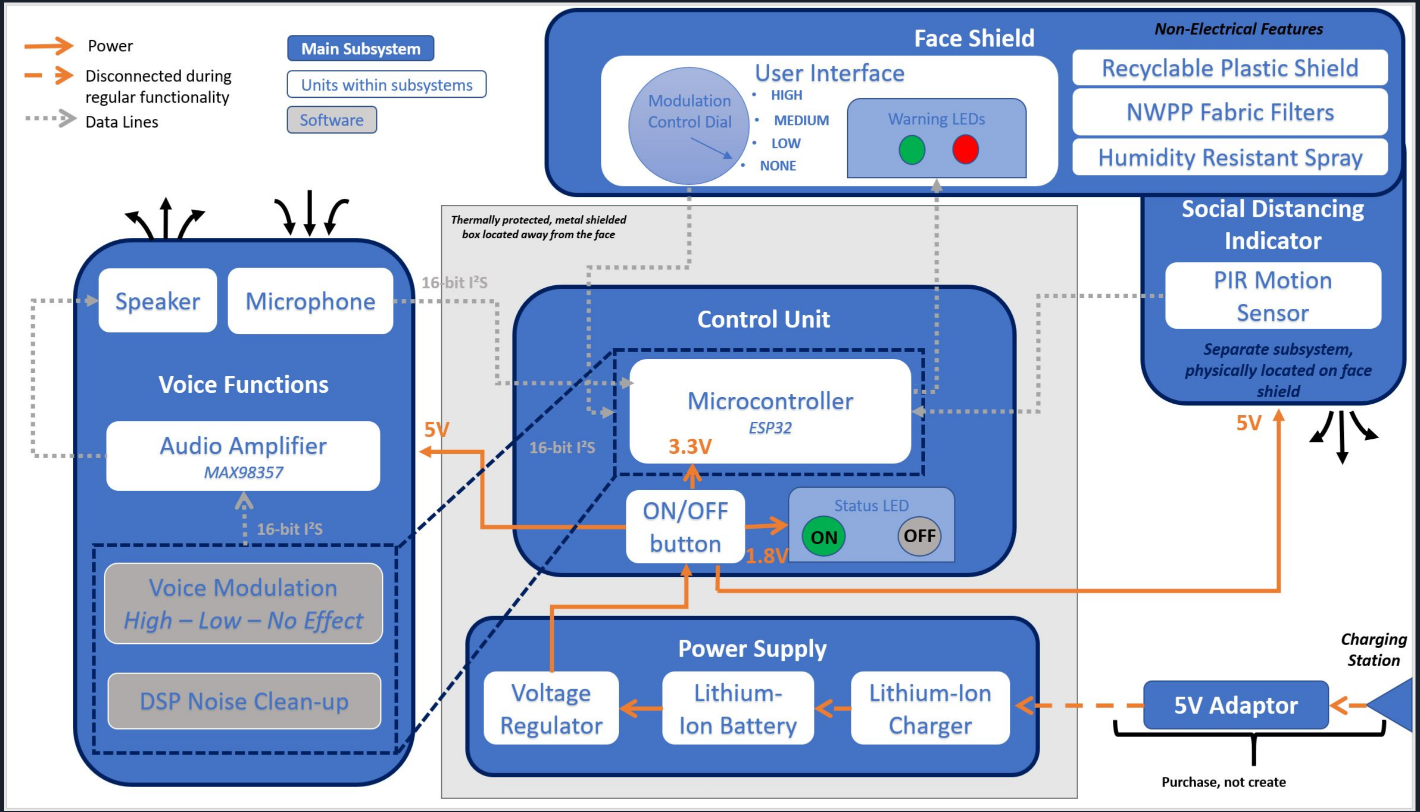
3. Prevents components near the face from shorting, overheating, and other dangerous risks by maintaining a low amperage of less than 2 mA.

Original Design : Physical Design





Original Design: Block Diagram



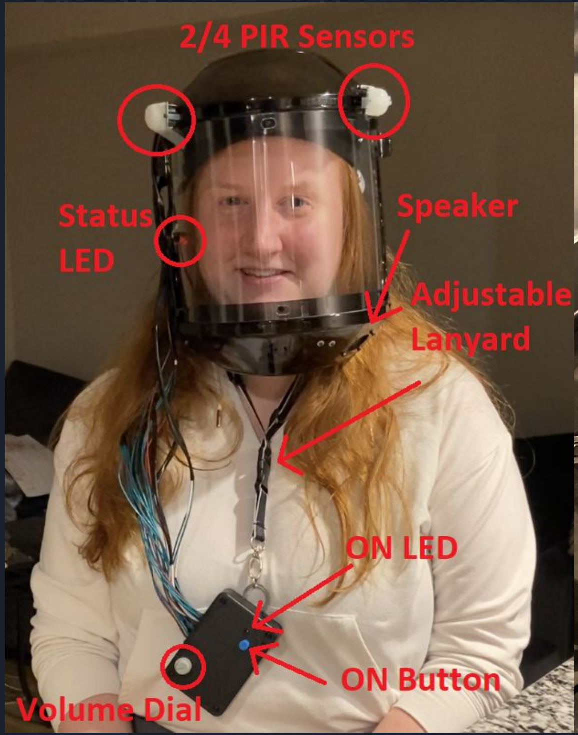
Final Product : High Level Requirements

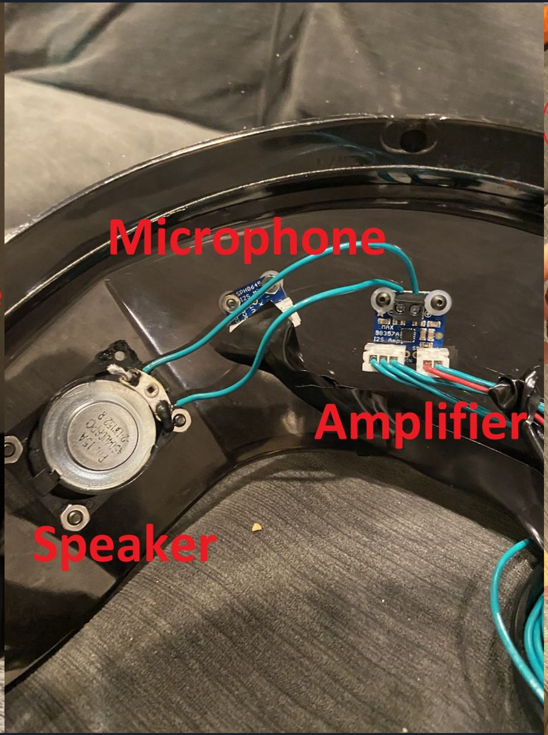
1. Audio is properly amplified and can be modulated between three volumes (whisper, conversational, raised).

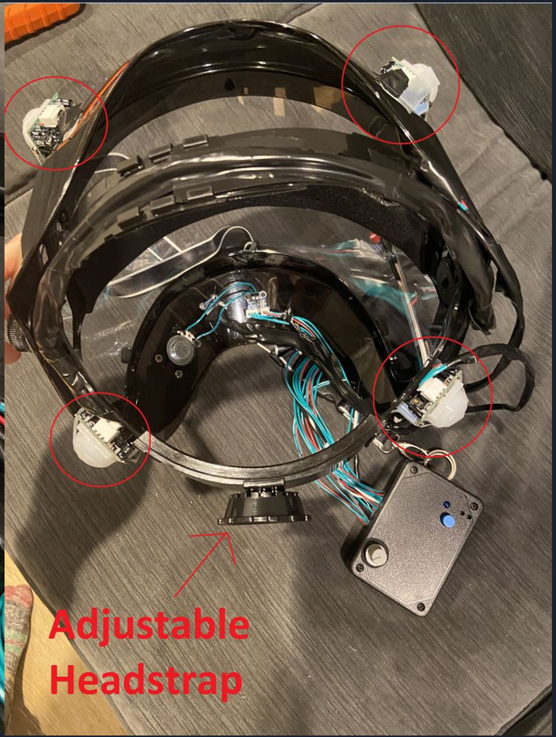
2. Accurately assesses and notifies the user when someone is standing within a 6-6.5ft distance.

3. Components located near the face will avoid shorting, overheating, or exposing the user to dangerous amperage levels (~2mA).

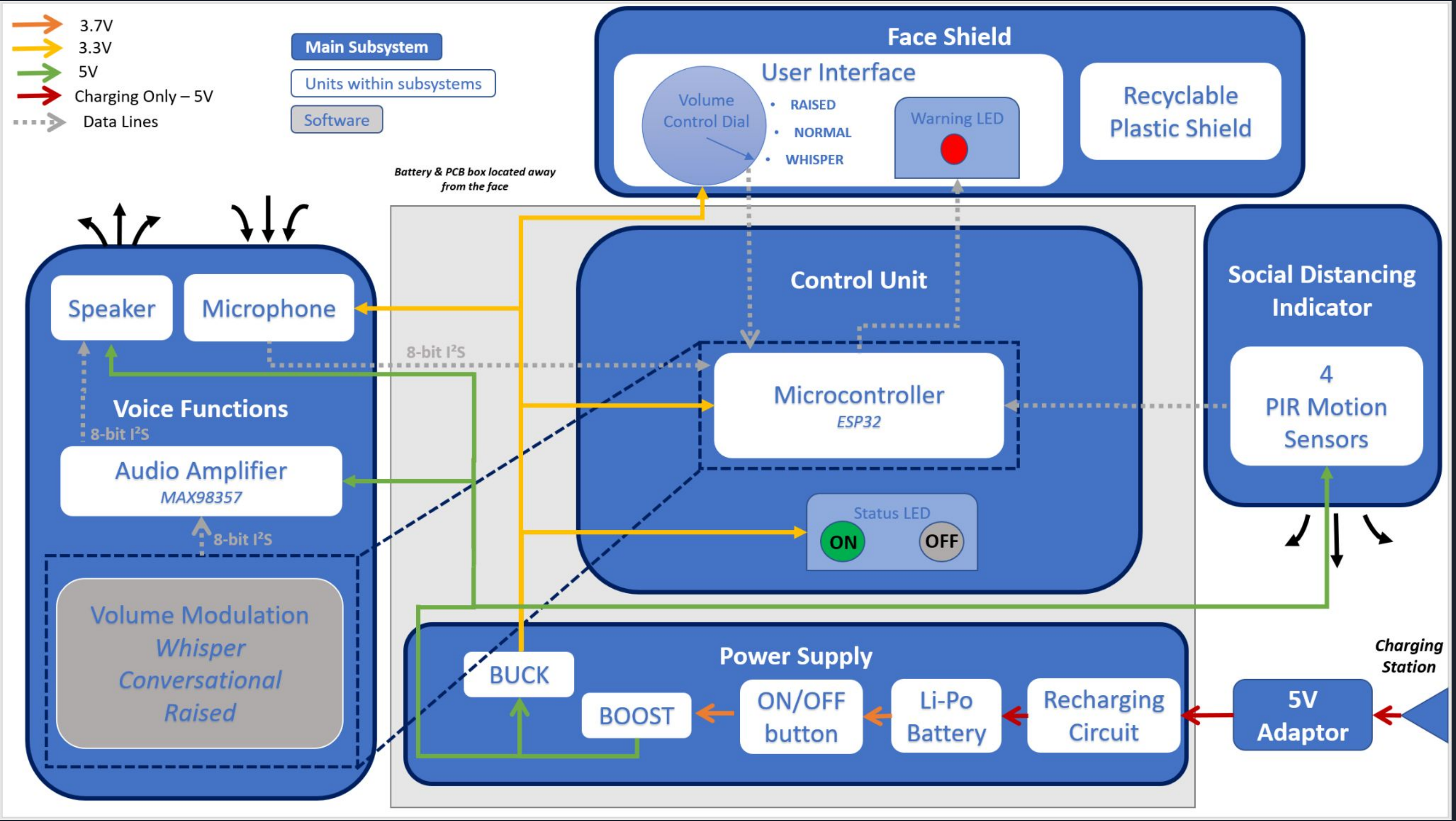
Final Product : Physical Design





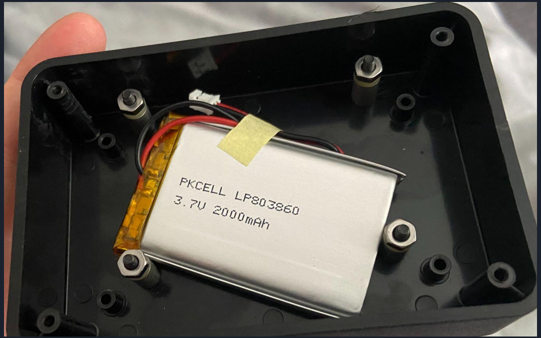


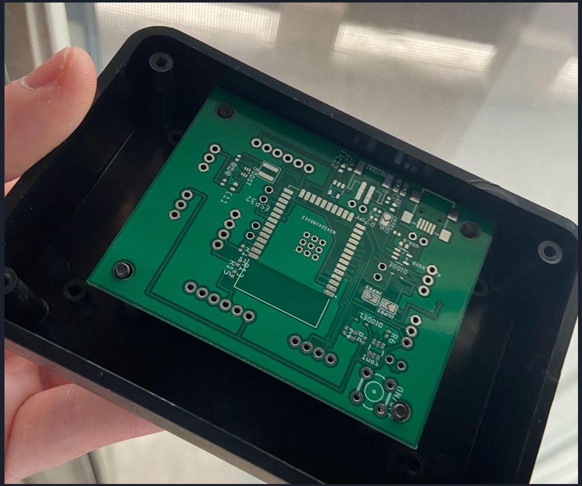
Final Product : Block Diagram

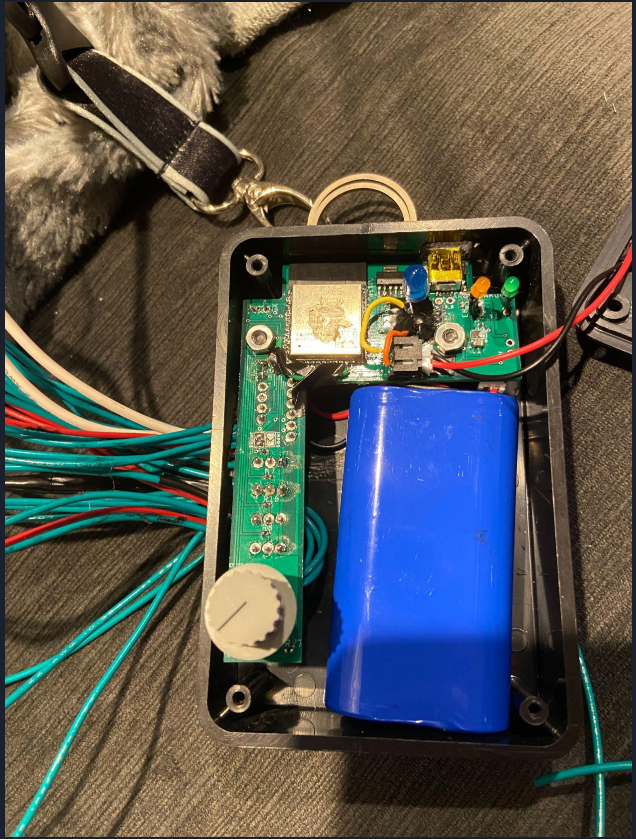


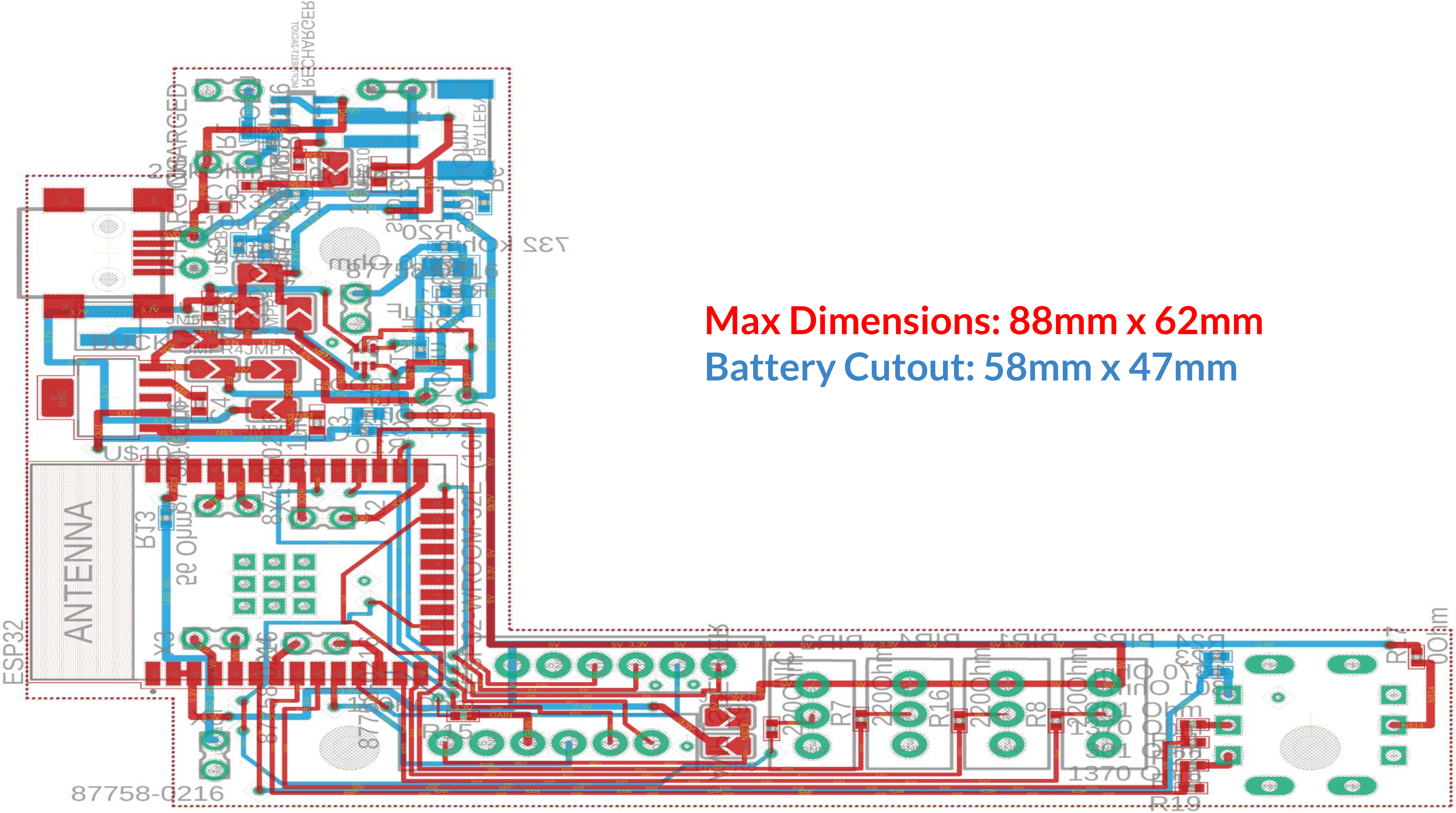
Power

- **Design Considerations:**
  - Large battery, small battery box
- **Battery Requirements:**
  - Supports > 1.5 A constant current
  - Battery box can be reasonably worn
  - Reasonable capacity
  - Cost Efficient









Max Dimensions: 88mm x 62mm

Battery Cutout: 58mm x 47mm

Power : Requirements & Verification

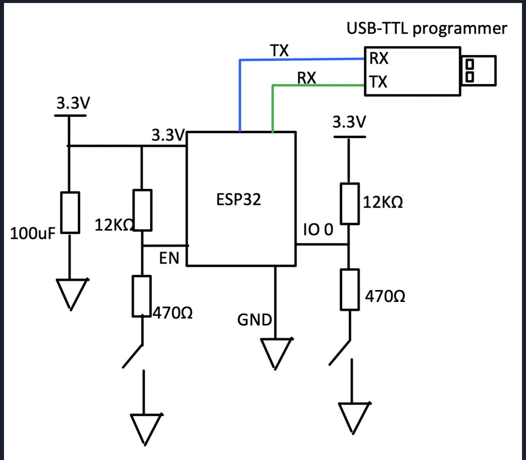
Requirement	Verification
5V regulator receives at least 3V and outputs at least 1.46A from the battery.	1.) Use DMM to measure V_{in} on boost. 2.) Verify V_{in} = 3.7 - 4 V 3.) Verify V_{out} current is > 1.46 A
3.3V regulator receives at least 5V and 0.66A from the boost.	1.) Use DMM to measure V_{in} on buck. 2.) Verify V_{in} = 3.3 V ± 5%. 3.) Verify V_{out} current is > 0.66 A
5V loads receive 5V	1.) Use DMM to measure V_{in} on each PIR sensor 2.) Verify V_{in} = 5V ± 5%. 3.) Use DMM to measure V_{in} on amplifier 4.) Verify V_{in} =5V ± 5%.
3.3 load receive 3.3V	1.) Use DMM to measure V_{in} on microcontroller 2.) Verify V_{in} = 3.3V ± 5%. 3.) Use DMM to measure V_{in} on microphone 4.) Verify V_{in} =3.3V ± 5%.

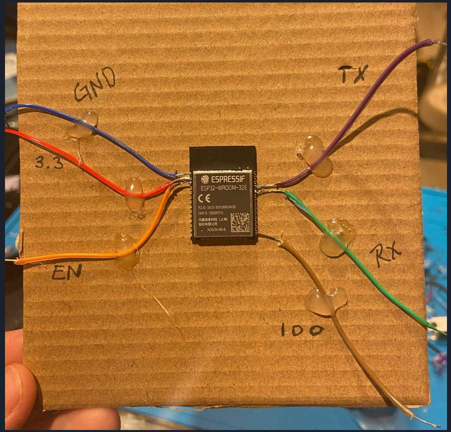
Control Unit

- **Design Considerations:**
  - Switched from Micropython → Arduino (C/C++)
  - Dual Core

- **Microcontroller: ESP32**
  - Controls the voice functions and the social distancing indicator subsystems
  - Loading Circuit Schematic (on the right)

- **Software**
  - *Algorithm for social distancing indicator*
  - *Algorithm for Voice functions*

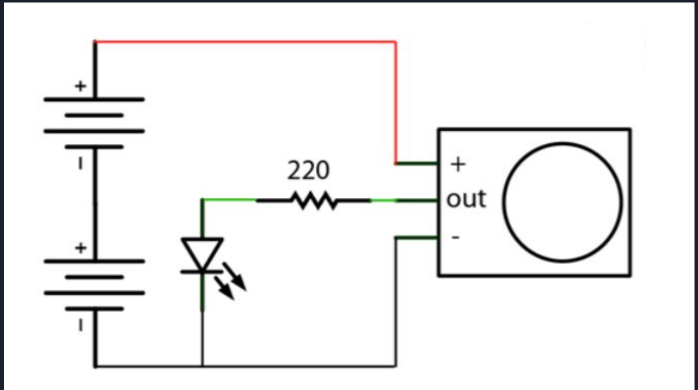




Social Distancing Indicator

- **Design Considerations:**
  - Ultrasonic vs PIR

- **4 - Passive Infrared Sensor (PIR):**
  - Full detection range of 360º
  - Releases a HIGH signal (3.3V) when human motion exists at a distance of <=6-6.5ft
  - Testing Circuit (on the right) - calibrate the sensitivity of the sensors:



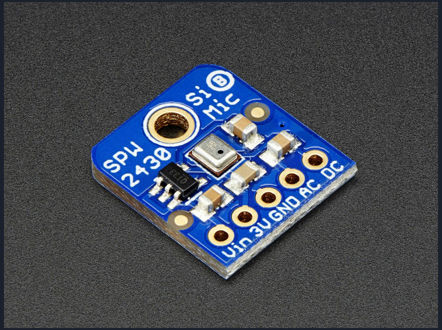
Social Distancing Indicator : Requirements & Verification

Requirements	Verification
Sensitivity of each PIR is set at 6-6.5ft. The DIGI. OUT is HIGH whenever motion is within the range.	1.) Build the testing circuit 2.) Pace at a distance 6-6.5 ft away in front of the sensor 3.) Connect the sensor's DIGI. OUT to a voltmeter 4.) Adjust the trimpot of the sensor until the voltmeter reads 3.3 V.

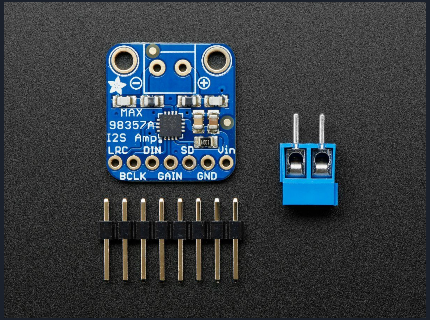
Social Distancing Indicator : DEMO

Voice Functions

- Design Considerations:
  - Voice modulation vs. Voice amplification
  - Digital vs analog sound
- Digital MEMS microphone and Digital Amplifier
  - I2S protocol for sound
- Voice Amplification:
  - Manipulating digital data in buffer based on knob input
  - Able to verify it on software side by manipulating the buffer
  - Unsuccessful with knob



Mems Microphone



I2S Digital amplifier

Voice Functions : Requirements & Verification

Requirements	Verification
Speaker projects clear audio at the three volumes	1.) Speak into the microphone 2.) Confirm that the volume of the voice projected through the speaker can be heard 3.) Repeat for different volumes.

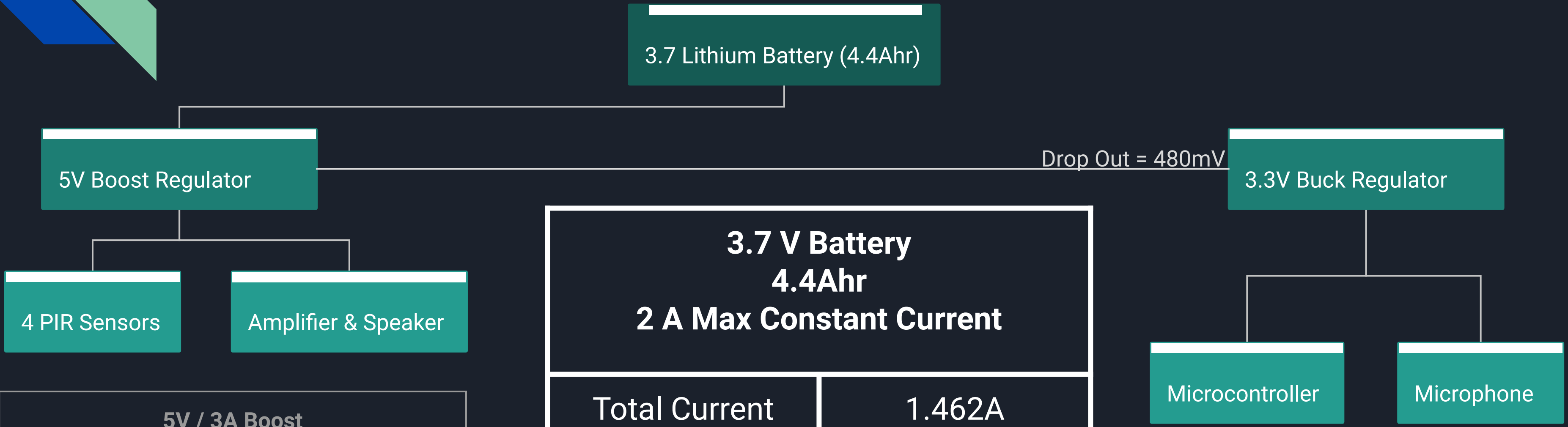
Face Shield

- **Design Considerations:**
    - Form-fitting w/ silicon lining → covers the entire face, extends to the back
    - Dial: Frequency Modulation → Volume Modulation
- **Power Button**
- **Warning LEDs**
- **Volume Modulation Dial**
    - whisper, conversational, raised

Face Shield : Requirements & Verification

Requirements	Verification
Entirety of the printed circuit board and the power supply is not exposed and away from the face.	1.) Position the PCB as well as the battery inside of the enclosure 2.) Confirm that enclosure closes and is safely away from the face.

Functional Tests - Power



5V / 3A Boost	
4 PIR Sensors	41.35mA
Amplifier & Speaker	760mA
3.3V Buck	660.62mA

Total = 1.462 A < 3A

3.7 V Battery 4.4Ahr 2 A Max Constant Current	
Total Current Draw	1.462A constant current
Battery Life	$\frac{4.4Ahr}{1.462A}$ = 3 hours

3.3V / 1A Buck	
Microcontroller	660mA
Microphone	620μA

Total = 660.62mA < 1A

Functional Tests

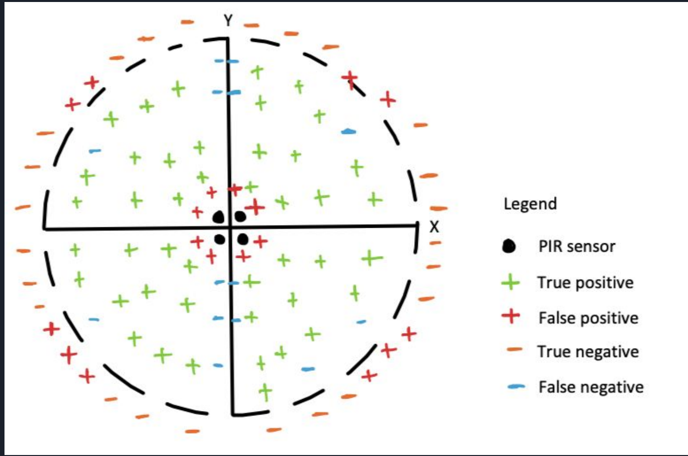
- PIR False Positives
  - Confusion Matrix
  - Shows total number of True/False positives/negatives

- Setup
  - User at the center with 4 PIR sensors on the face shield
  - Radius of 6-6.5 ff

- Results:
  - Success rate [(True positive+True Negative)/(Total)]: 68%
  - 4-5 false positives/quadrant
  - Potential blindspot: along Y-axis

	Positive	Negative	Total
True	44	24	68
False	18	14	32
Total	62	38	100

Confusion Matrix



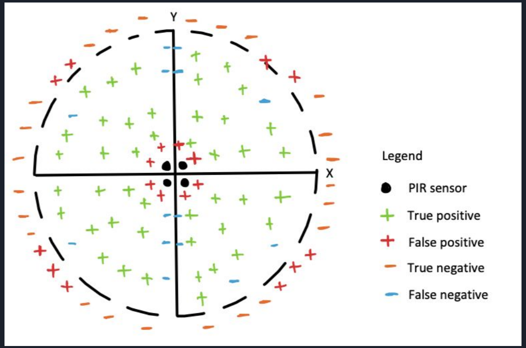
Testing Setup Schematic for PIR Sensors

Additional Testing

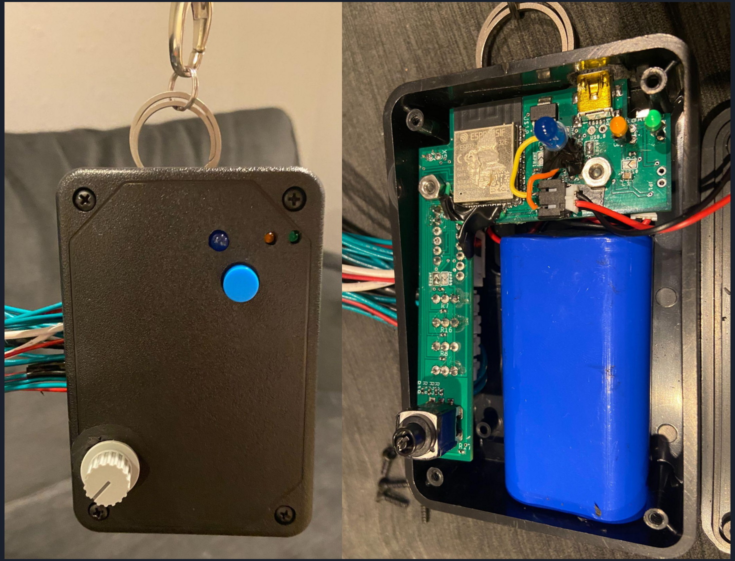
- **Control Unit:**
  - Connect and blink a LED to confirm successful uploads and the functionality of the dual cores

- **Sound Functions:**
  - Tested the i2s interface by running various audio files
  - Ran scripts for testing frequency modulation
  - *Microphone:*
    - Used Serial Plotter to initially confirm that the component is reading/responding correctly

Successes



- PIR sensors trigger correct 68% of the time
- Microphone amplifies voice
- Compact & wearable design
- Dual Core Implementation



Failures

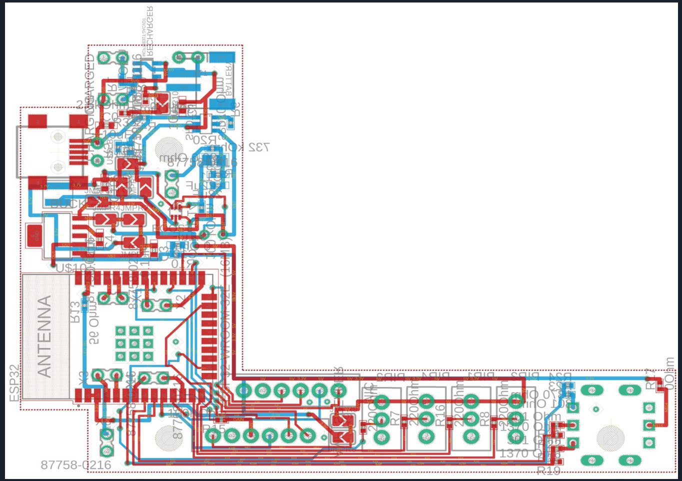
- **Micropython:**
  - Difficulty with the i2s driver/tools, lacking documentation

- **Frequency Modulation:**
  - More complex than expected especially in real-time
    - Granular synthesis, phase vocoder, and pitch shifting
  - Generated modulated sound, but w/o sustaining the duration of the original audio.
  - More practical for both our design /purpose

- **Volume Modulation:**
  - Dial is unable to adjust the volume levels

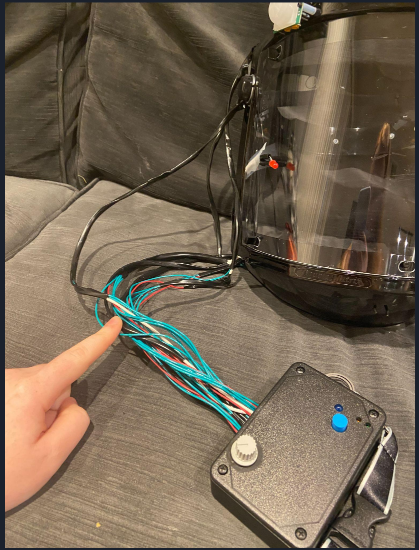
What We Learned

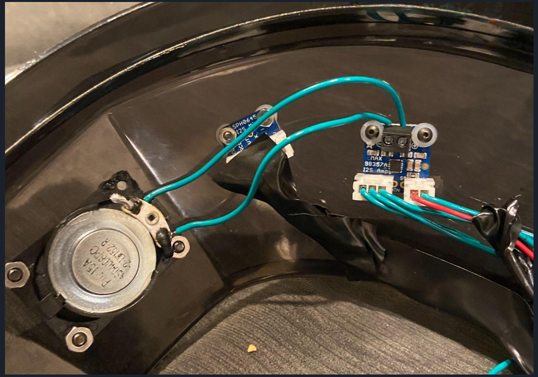
- How make a compact PCB
- Frequency modulation is *complex*
- Portable device are very limited by power/cost



Future Considerations

- Cable management
- Weight
- Battery cost/capacity
- PIR motion sensitivity and accuracy
  - PIR response to user motion
- Water-resistance for microphone, speaker and amplifier





Question?