ECE 445: RONArmor

Design Document Check

Team # 31
Aditya Gupta, Moriah Gau, Shana Milby

TA: Andrew Chen
Professor: Rakesh Kumar

1. Introduction

1.1. **Objective**:

Since the end of year 2019, the world has been stuck under vicious cycles of a global pandemic and non-stop quarantine where we are responsible not only for our own well-being, but also for the health and safety of those around us. Throughout this entire process, we’ve been told three things: mask up, stay 6 feet apart, and wash your hands. So we thought, why not design a safe, reusable, and affordable facial shield that reinforces the social distancing process and possesses communication-friendly features? While initially everyone struggled to keep up with the supply of masks and settled for whatever they could get their hands on, now we can design new masks that offer proper safety, freedom of expression, comfort and utility.

RONArmor will be a form-fitting, protective facial shield constructed with recyclable plastic that reassures the safety of users by enforcing social distancing guidelines through sensors and ensuring improved and entertaining communication through audio amplification and modulation. We look forward to producing a product that will aid people in moving beyond a conventional mask to express themselves better and in a safer manner.

1.2. **Background**:

COVID19 has left the world scrambling for economic stability, social justice, vaccines, and face masks. Daily, frontline workers must gear up with the proper protective equipment and it has led to a shortage of N95 masks throughout the US [1]. As face masks have become normalized and a required necessity, enormous amounts of plastic waste have been generated throughout the world [2]. Furthermore, a common recurring issue that comes along with the enforcement of face coverings is difficulty with communication, specifically with the transmission and reception of speech. Companies like Razer and their Project Hazel have proposed to solve this issue with a mask that possesses voice amplifying technology in addition to a UV Sterilizer charging case for repetitive use [3]. However, it still remains a concept as the product is yet to be officially introduced in the marketplace [4]. Moreover, its ample amount of high-tech and smart features will most likely require longer production time as well as higher cost. Both of these factors pose obstacles for countries and their people who are struggling to fulfill their essential duties on a daily basis. We want to create an effective product that can combat these issues so that everyone can easily, affordably, and comfortably attempt to regain some normalcy to their everyday lives while ensuring the safety of themselves and their communities.

2. High Level Requirements

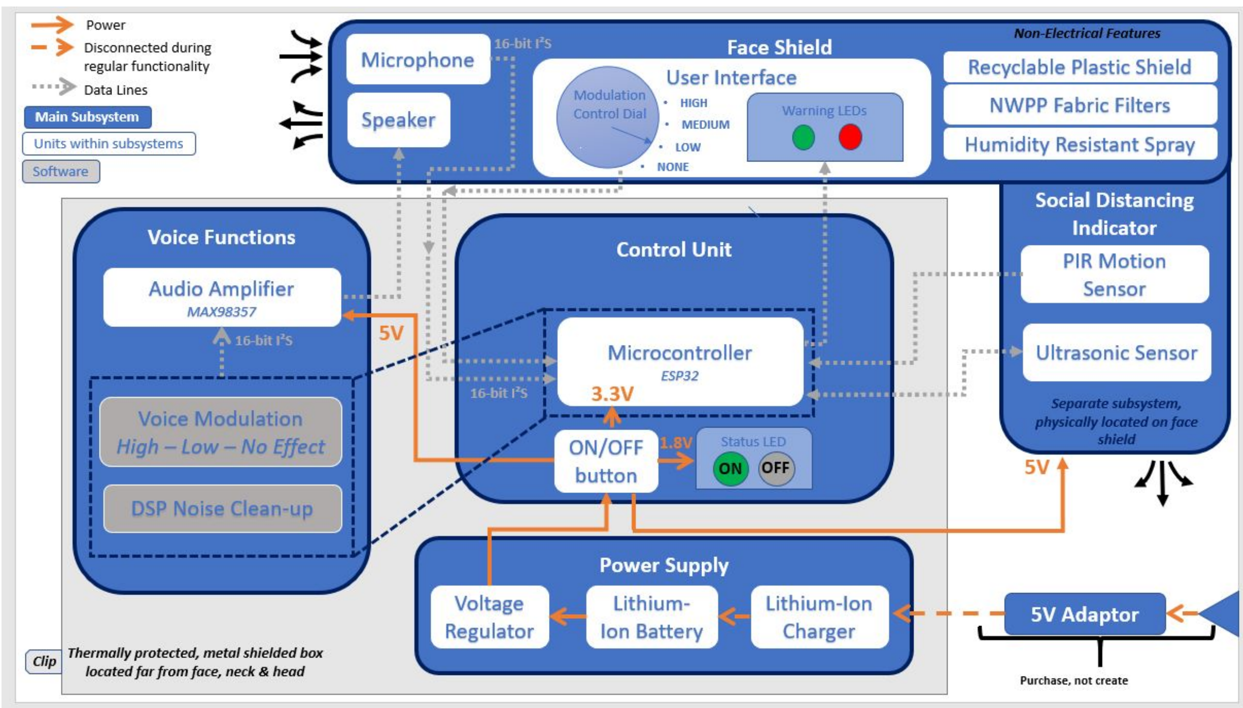
Mainly three requirements:

i) Audio is properly amplified and can be modulated between three pitches (low, medium, high) or left to the user's natural tone.

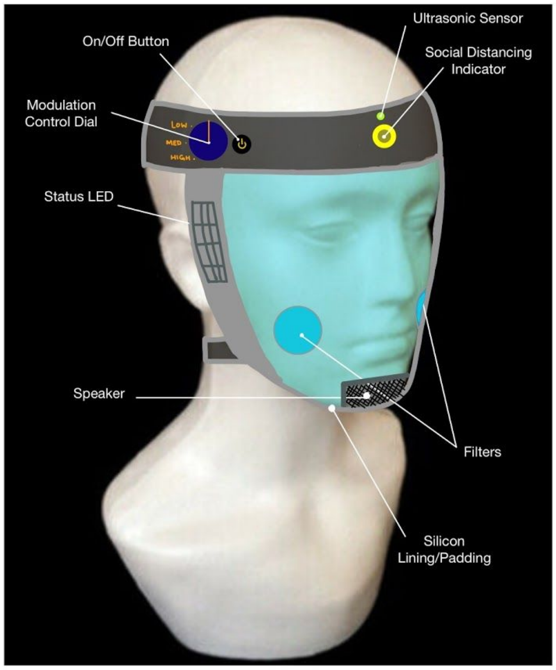
ii) Accurately assesses and notifies the user whether people are standing six feet away.

iii) Components near the face will avoid shorting, overheating, and other dangerous risks by maintaining a low amperage of less than 2 mA.

3. Block Diagram



4. Physical Design



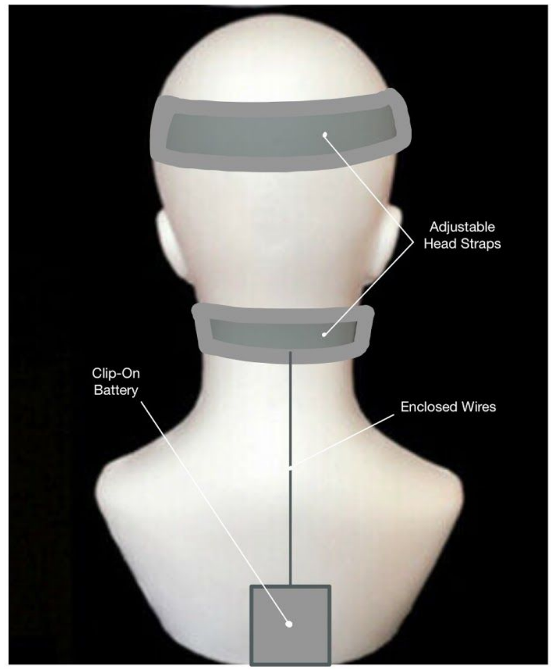


Figure 2: Physical Design

5. Requirements and Verification Table

5.1. Power Supply

5.1.1. Sufficient power supplied to all subsystems.

5.1.2. Isolates the battery and enforces voltage and current regulation according to each subsystem.

5.2. Voice Functions

5.2.1. Microphone receives speech

5.2.2. Speaker outputs modified speech

5.3. Social Distancing Indicator

5.3.1. PIR sensor detects people and sends signal to the microcontroller

5.3.2. Ultrasonic sensor receives detection signal from microcontroller from the PIR sensor and determines the distance of the detected person to the user

Verification Table:

Requirements	Verification
1.) PIR sensor module: Needs to be powered at 5V. It is a combined module with trimpots for sensitivity and delay adjustment. Module	1.a.) A simple breadboard circuit as shown in Figure 3 can be used to test a PIR sensor. We can use a 5V DC input from a function generator. 1.b) If the PIR sensor's DIG. OUT is high the Led should light up. 1.c) We can test for variable distance range by

comes with a decoder board to output a DIG. OUT of 3.3V. 2.) HC-SR04 Ultrasonic sensor. It uses a 5V DC In. Trigger should occur only when the PIR sensor activates i.e. when the OUT from PIR is high. Echo signal is sent to the microprocessor.	adjusting the sensitivity trimpot on the sensor. 2.a) Use a simple breadboard circuit similar to Figure 3 to test the signal outputs. Power it using a 5V DC input. 2b.) Confirm that the LED should turn on in the "visual" range of the sensor when the Echo signal is high (5V). 2c.) Test at various distances by varying the distance of the hand from the sensor and repeat steps.

5.4. Control Unit

5.4.1. Software accurately calculates distance by processing signals from social distancing indicator as well as modulates speech according to user input

5.4.2. Signals from voice functions are processed using software for a) amplification b) modulation

Verification Table:

Requirements	Verification
1.) Needs to be powered at 3.3V as the I/O pins are not 5V tolerant. I/O pins are needed to control the other components so it is crucial that 3.3V is maintained	1a.) Power the microcontroller with a voltage regulated lithium ion battery pack. 1b.) Connect the voltage inputs of the microcontroller to a multimeter and confirm a voltage reading of 3.3V is being powered to the system.
2.) Receives a high signal from the PIR sensor's DIG. OUT (3.3V). When this occurs, the ultrasonic sensor's echo signal goes high (5V).	2a.) Connect microcontroller to computer and power the sensors 2b.) Have a human walk within and beyond 6ft 2c.) Use a multimeter to confirm the PIR sensor's output voltage as well as the ultrasonic sensor's echo signal in respect to the distance of the human's position.

5.5. Face Shield/User Interface

5.5.1. Buttons and Dials function allow user to control modulation and ON/OFF states
5.5.2. Microphone mounted near the mouth, speaker on the outside
5.5.3. LED's light up according to the determined distance of people near user
5.5.4. Has a separated, isolated battery pack, away from the user's head

6. Plots

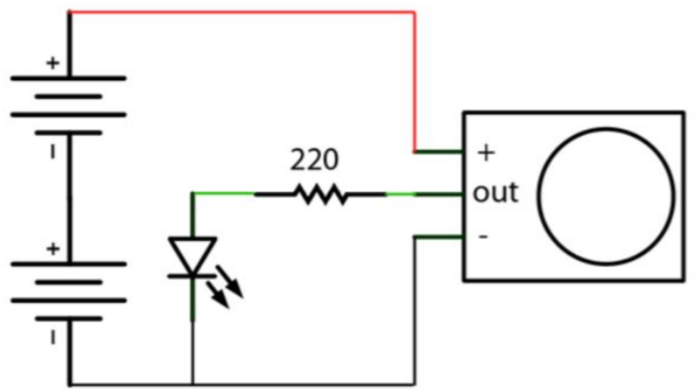


Figure 3: PIR Sensor Testing Circuit [16]

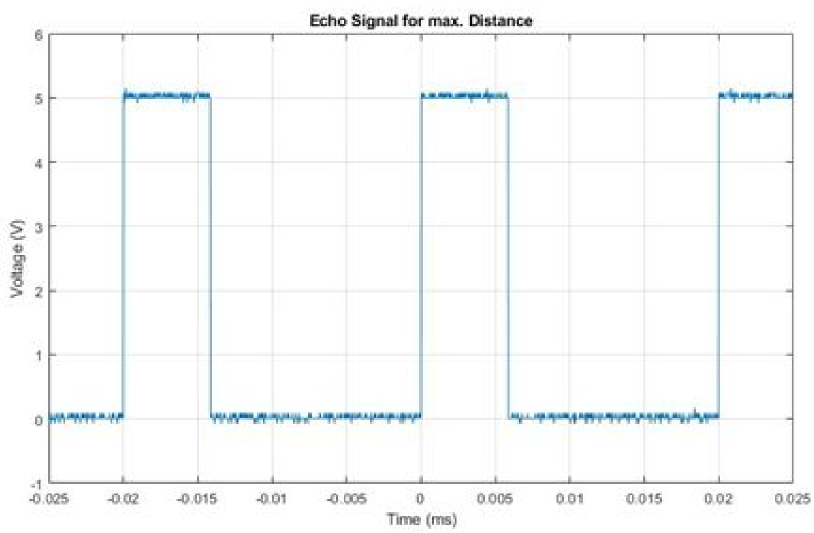


Figure 4: An example of Oscilloscope testing of echo signal of Ultrasonic sensor

7. Tolerance Analysis

The Control Unit is going to be the most crucial part of the project. The Control Unit is responsible for handling the data communication between voice functions and social distancing modules. As is highlighted in the control flow and design sections, most of the data processing is going to be done using the microcontroller. Thus, maintaining the required power for the microcontroller will be crucial. Further, it is crucial that all the connections from the GPIO pins are correctly connected, lest it lead to incorrect transfer of data and thus wrong computation.

The first part to ensuring correct data transfer will be the correctness of an event trigger. In our case an event trigger is when a person is within 6ft distance. Our selection of the PIR sensor is based on this fact as well. The PIR sensor range should be capped at about 2m to maintain as much accuracy as possible. The PIR sensor has a digital out signal as high when it is triggered. This should be used as a trigger for the Ultrasonic sensor to accurately determine the distance. PIR sensor helps us detect if a human walked into our surrounding and ultrasonic sensor helps distinguish the distance. (Some errors may creep in due to interferences between a person and the sensor.) Based on the distance, we will trigger the led (red - too close, yellow - moderate, green - comfortable).

Calculation of distance from Echo signal: distance (in cm) = duration of echo signal/58.2

8. Safety and Ethics

The main concern we are focused on as we begin to develop RonaAmor is the potential safety hazard that lithium-ion batteries present. This hazard cannot be completely eliminated due to the necessity of a high energy density, portable power supply for our facial shield. Nevertheless, we are committed to upholding the IEEE standard of prioritizing “the safety, health, and welfare of the public [by striving] to comply with ethical design and sustainable development practices” [13]. In doing so we will center our attention on taking the necessary precautions to ensure the longevity of our facial masks and the safety of the community members who will be wearing them.

Lithium-ion batteries have been known to cause fires, explosions, and other harmful accidents. Studies have shown that these accidents are largely caused by poor electrical designs such as short circuits, overcharging batteries and exposure to temperatures beyond their thermal rating [14]. In order to reduce these risk factors, we will integrate an appropriate charge management controller into our power supply subsystem. A good contender for a power management IC (PMIC) is Microchip Technology’s MCP73831/2 linear charge management controller. Once this PMIC has reached its Charge Complete mode (meaning the average charge current has diminished below an established percentage of the programmed charge current), the MCP73831/2 will latch off the charge current to prevent overcharging the battery. Furthermore, this PMIC is also designed to suspend charge if the die temperature exceeds 150°C and will not resume charging until the die has cooled to 10°C [15].

Another precaution that RonaAmor takes in order to prevent the harm of its users is the isolation of the battery pack from the user’s face, neck and head. Our design allows for the battery recharging circuit, the battery itself, and much of the supplemental circuitry to be located inside a thermally protective box fashioned to clip onto the users’ clothing a safe distance away from the facial shield itself. In this way we are both preventing electrical accidents, as well as preparing for the worst case scenario. Overall all the engineers on this project are committed to the IEEE standard “to seek, accept, and offer honest criticism of technical work [and] to acknowledge and correct errors” as we launch this new and exciting product that we hope will provide some relief in the midsts of this global pandemic [13].

9. Citations

[1] J. Parkinson, “Coronavirus: Disposable masks 'causing enormous plastic waste',” *BBC News*, 13-Sep-2020. [Online]. Available: https://www.bbc.com/news/uk-politics-54057799. [Accessed: 17-Feb-2021].

[2] Y. Noguchi, “Why N95 Masks Are Still In Short Supply In The U.S.,” *NPR*, 27-Jan-2021. [Online]. Available: https://www.npr.org/sections/health-shots/2021/01/27/960336778/why-n95-masks-are-still-in-short-supply-in-the-u-s. [Accessed: 17-Feb-2021].

[3] “The World's Smartest Mask - Project Hazel,” *Razer*, 2021. [Online]. Available: https://www.razer.com/concepts/razer-project-hazel. [Accessed: 17-Feb-2021].

[4] J. Finn, “Why Razer's Project Hazel Mask Has No Release Date,” *ScreenRant*, 05-Feb-2021. [Online]. Available: https://screenrant.com/razer-project-hazel-smart-mask-release-date-pricing-concept-explained/. [Accessed: 17-Feb-2021].

[5] A. Rowe, “Safe Workplace Touching Temperatures,” *Safety Action*, 30-Jan-2020. [Online]. Available: https://www.safetyaction.com.au/blog/safe-workplace-touching-temperatures. [Accessed: 17-Feb-2021].

[6] ESP32 Technical Reference Manual, V 4.3, Espressif Systems, 2020. [Online]. Available: esp32_technical_reference_manual_en.pdf. [Accessed: 18-Feb-2021].

[7] “Push Button Switches,” *Carling Technologies*. [Online]. Available: https://www.carlingtech.com/push-button-switches. [Accessed: 17-Feb-2021].

[8] J. Nielsen , “Response Time Limits,” *Nielsen Norman Group*, 01-Jan-1993. [Online]. Available: https://www.nngroup.com/articles/response-times-3-important-limits/. [Accessed: 17-Feb-2021].

[9] Staff, “Ensuring safety in LED lighting,” *Electronics Weekly*, 08-Nov-2012. [Online]. Available: https://www.electronicsweekly.com/news/products/led/ensuring-safety-in-led-lighting-2012-11/. [Accessed: 17-Feb-2021].

[10] HiLetgo, “Pyroelectric Infrared Radial Sensor,” AM312 datasheet, [Online]. Available: http://www.image.micros.com.pl/_dane_techniczne_auto/cz%20am312.pdf

[11] “I2S Sound Tutorial for ESP32,” *DiyIOt*, 2020. [Online]. Available:

https://diyi0t.com/i2s-sound-tutorial-for-esp32/. [Accessed: 17-Feb-2021].

[12] J. Albano, “Monitoring Latency (How Low Can You Go?),” *Ask.Audio*, 06-Aug-2017. [Online]. Available:
https://ask.audio/articles/monitoring-latency-how-low-can-you-go#:~:text=But%20in%20most%20situations%2C%20moderate,and%20reliable%20recording%20and%20playback. [Accessed: 18-Feb-2021].

[13] "IEEE Code of Ethics,” *IEEE*, 2021. [Online]. Available:
https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 17- Feb- 2021].

[14] J. Back and J. Hughes, “Lithium Battery Safety,” *Environmental Health & Safety*, Apr-2018. [Online]. Available: https://www.ehs.washington.edu/system/files/resources/lithium-battery-safety.pdf. [Accessed: 18-Feb-2021].

[15] Microchip Technology, “Miniature Single-Cell, Fully Integrated Li-Ion, Li-Polymer Charge Management Controllers,” MCP73831/2 datasheet, [Online]. Available:
https://ww1.microchip.com/downloads/en/DeviceDoc/MCP73831-Family-Data-Sheet-DS20001984H.pdf

[16] https://learn.adafruit.com/pir-passive-infrared-proximity-motion-sensor/testing-a-pir