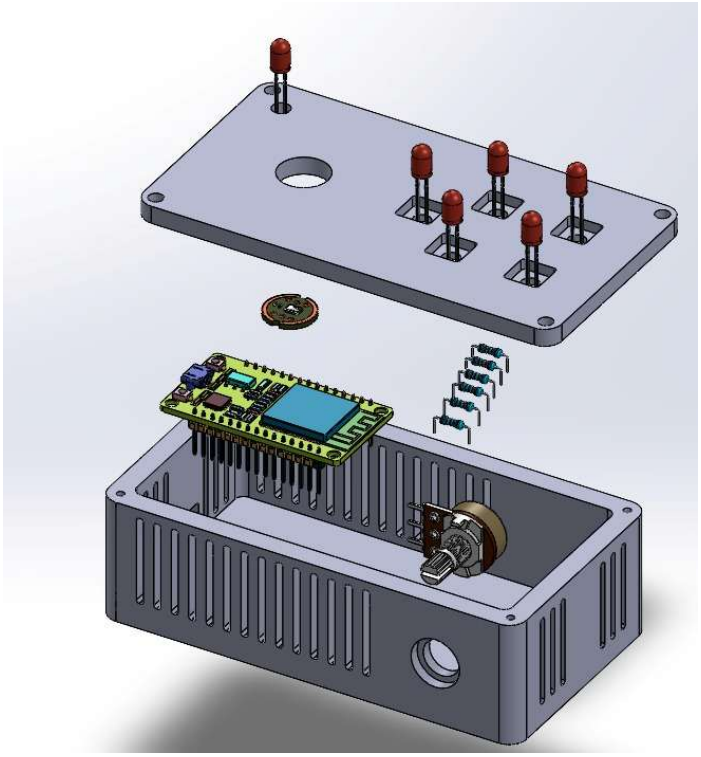
University of Puerto Rico

Mayagüez Campus

Department of Mechanical Engineering

Manufacturing Manual

Emergency Alert Recognition System (EARS)



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Overview:

This document describes the manufacturing process for The Emergency Recognition and Alert System (ERAS), a System that is meant to help deaf or hard of hearing drivers detect emergency sirens visually without relying on auditory senses. The system works by combining three main parts; (1) a sound sensor, (2) An embedded processor, meant to accurately detect emergency sirens, and (3) a visual alert. It outlines the materials, tools, and step-by-step procedures required to assemble the system. This manual is intended for students or technicians replicating the prototype.

Bill Of Materials (BOM):

Inserted below is a table that compiles all the necessary Components and Cost to create one unit of the product.

Table 1. Bill Of Materials

Part	Component	Component description	Quantity	Unit Cost (USD)	Total Cost (USD)	Supplier link
1	ESP32 Dev Board	ESP32-WROOM-32 WiFi + Bluetooth Development Board, 30-pin microcontroller module	1	$15.00	$15.00	Amazon / Espressif
2	INMP441	INMP441 I2S Omnidirectional MEMS microphone module for digital audio input	1	$3.00	$3.00	Amazon / Adafruit
3	5 mm LEDs	5 mm Red LED indicators, standard through-hole type	6	$0.10	$0.60	Amazon
4	220Ω Resistors	220 Ohm ±5% carbon film resistors, 1/4 W through-hole type	6	$0.02	$0.12	Amazon
5	Jumper Wires	Male-to-male Dupont jumper cables set for prototyping connections	One set	$5.00	$5.00	Amazon
6	Potentiometer	10 kΩ rotary potentiometer for adjustable sensitivity control	1	$1.00	$1.00	Amazon
7	On/Off Switch	SPST miniature rocker switch for device power control	1	$1.50	$1.50	Amazon

8	USB Cable	USB Type-C cable for ESP32 power and programming	1	$3.00	$3.00	Amazon
9	3D Printer Filament	PLA filament, 1.75 mm diameter, gray color, used for enclosure fabrication	~0.15 kg	$4.00	$4.00	Amazon / Hatchbox
10	Nylon Screws	For mounting and closing case	1	$9.99 (large quantity)	$9.99	Amazon
11	Double sided Adhesive	For more secure mounting	1	$3.99($0.40 per feet)	$3.99	Amazon
—	**Total**	—	—	—	$47.20	—

Inserted below are visual representations of parts:

Figure 1. *Part 5:* Jumper Wires

Figure 2. Part 7: On/Off switch

Figure 3. Part 8: UBS Cale

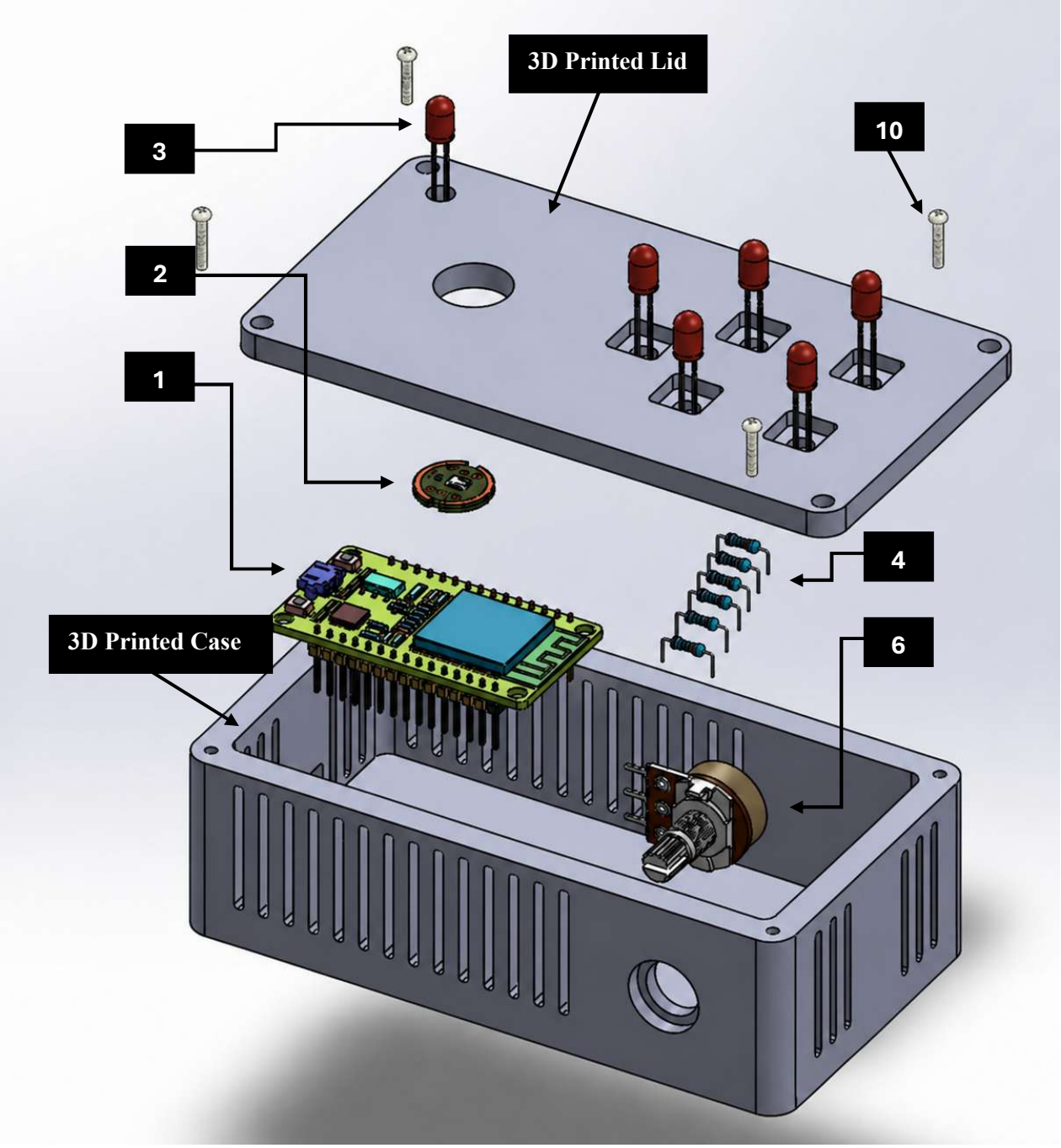


Figure 4. Parts 1, 2, 3, 4, and 6.

Tools And Equipment:

Table 2. Tools and equipment

Tool	Specification	Purpose
Soldering Iron	30–60 W temperature-controlled soldering iron with fine tip	Soldering electronic components
Solder Wire	60/40 rosin-core solder, 0.8 mm diameter	Electrical connections
Precision Screwdriver	Phillips #0 precision screwdriver	Assembly of enclosure screws
3D Printer	FDM 3D printer with PLA filament compatibility	Printing enclosure
Wire Cutter	Precision flush cutter	Trimming jumper wires and LED leads
Needle-Nose Pliers	Fine-tip pliers	Managing small components
Multimeter	Digital multimeter	Voltage and continuity testing
Computer with CAD software	Desktop or laptop computer capable of running SOLIDWORKS for 3D modeling and STL generation	Used for enclosure design, dimensional modeling, assembly visualization, and preparation of files for 3D printing

Manufacturing Process:

a. **5.1 Enclosure fabrication (3D printing):**
   i. Procedure:
      1. Open the provided CAD files in SolidWorks or export them as STL files. (STL files are posted in Google Drive. The STL file name is Case ESP.STL and Lid ESP.STL, Drive link: https://drive.google.com/drive/folders/1gf7Rs9Y4Bx1Tz5B0GRkFavQmsosql0H1?usp=sharing)
      2. Import STL files into Slicing Software.
      3. Configure printing settings:
         - Material: ASA
         - layer height: 0.2 mm.
         - Infill: 20 - 30%
      4. Generate G-code file.
      5. Print the enclosure and lid using a 3D printer.
      6. Allow parts to cool and remove any support material if used.

b. 5.3 Circuit assembly:

i. System is assembled on a breadboard for prototyping and testing.

ii. Procedure:

1. Connect the ESP32 power and ground, by connecting the 3V3 pin on the ESP32 to the 3.3 V power rail. Then connect one of the ESP32 GND pins to the ground rail (As shown in Figure 5)

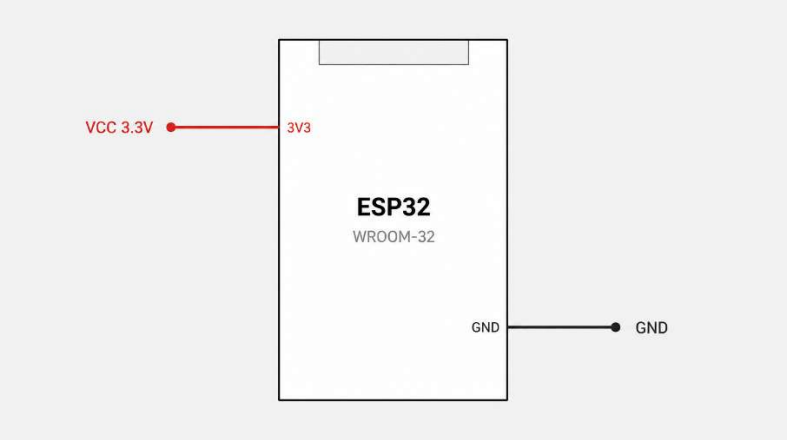


Figure 5. Circuit power and ground connection.

2. Connect the LEDs with their respective resistors. The LED connections are:
GPIO2 → R1 220 Ω → D1 → GND
GPIO4 → R2 220 Ω → D2 → GND
GPIO5 → R3 220 Ω → D3 → GND
GPIO18 → R4 220 Ω → D4 → GND
GPIO19 → R5 220 Ω → D5 → GND
GPIO21 → R6 220 Ω → D6 → GND
(As shown in Figure 6)

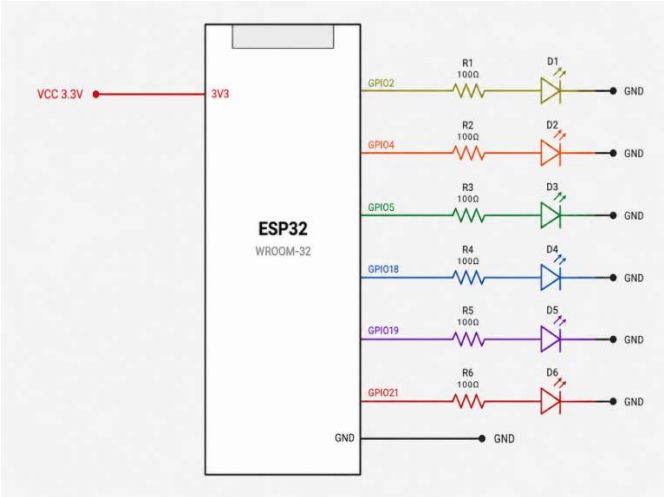


Figure 6. Circuit LED and Resistor connection.

3. Connect the INMP441 microphone to the ESP32. Connect the microphone **VDD** pin to **3.3 V** and the microphone **GND** pin and **L/R** pin to **GND**. Then connect the three I2S signal pins to the ESP32:
   WS → GPIO25
   SCK → GPIO26
   SD → GPIO34
   (As shown in Figure 7)

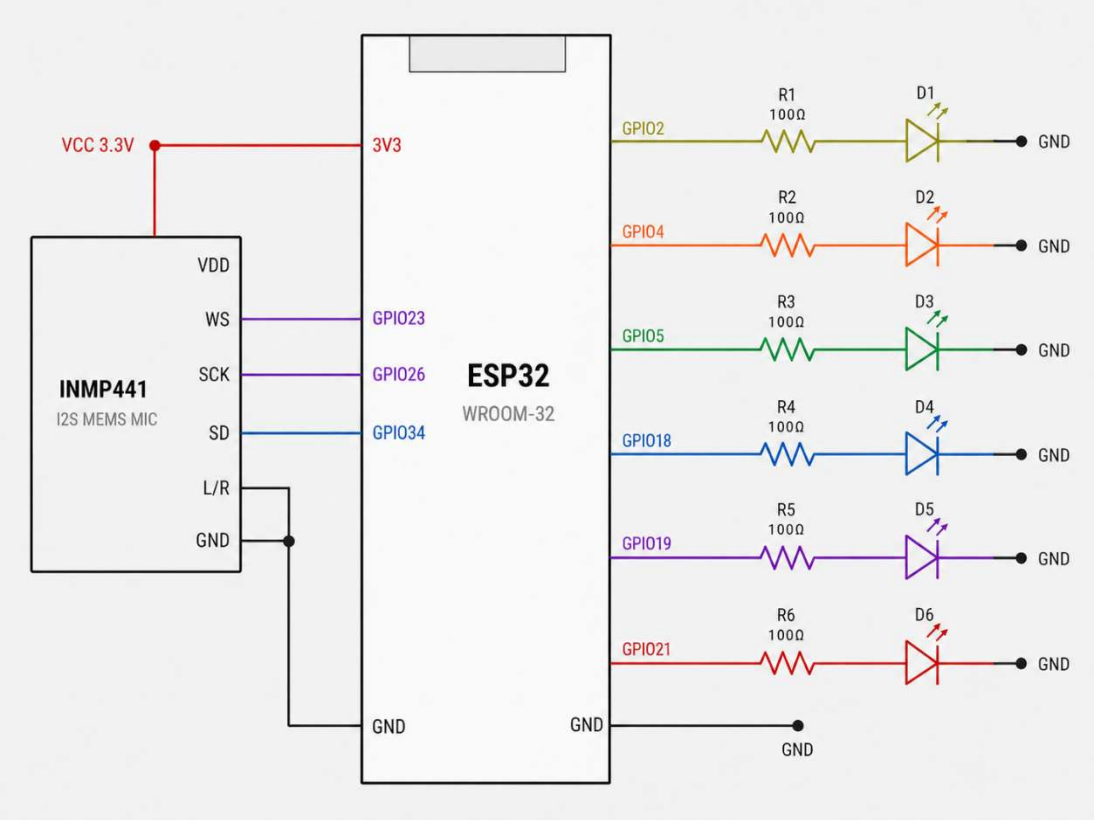


Figure 7. Circuit INMP441 Mic connection.

4. Connect the switch to the ESP32. Connect POS A and POS B of the switch to GPIO35 and GPIO35 respectively on the ESP32. Connect the switch COM terminal to one side of the 10 kΩ resistor R7, then connect the other side of R7 to GND. (As shown in Figure 8)

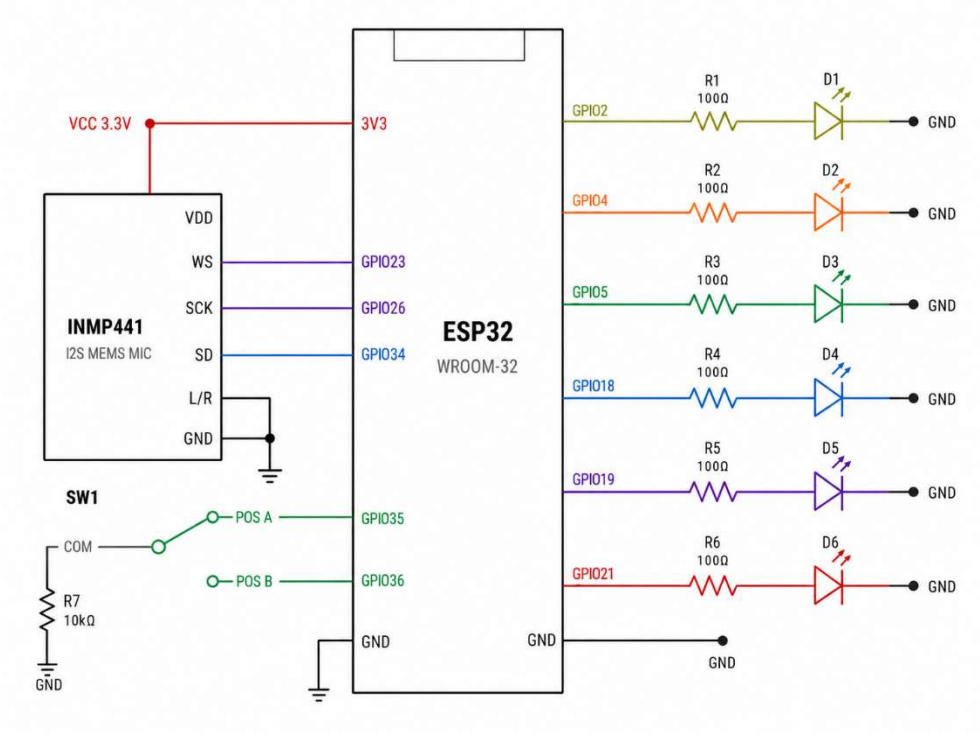


Figure 8. Circuit Switch on and off connection.

c. 5.5 Programming ESP32:

i. The ESP32 must be programmed with the siren detection algorithm.

ii. Procedure:

1. Connect ESP32 to a computer using USB cable. (As shown in figure 15)
2. Open the programming environment (e.g., Arduino IDE)
3. Load the siren detection code developed for the project.
4. Select the correct board and port. (As shown in Figure 9)

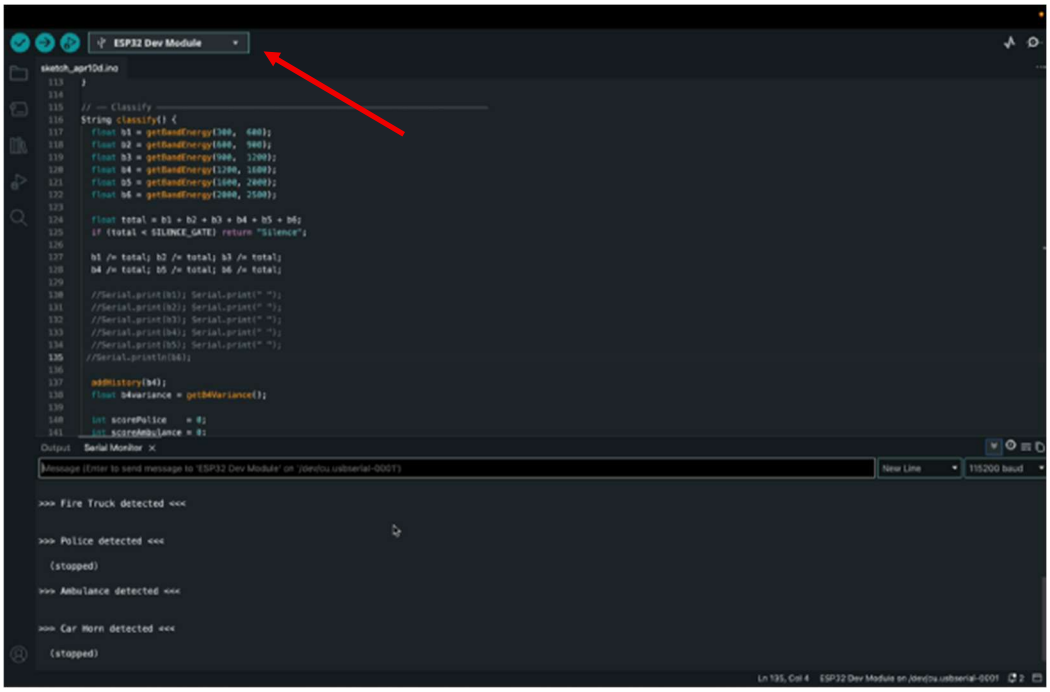


Figure 9. Check the correct board and port.

5. Upload the code to ESP32.

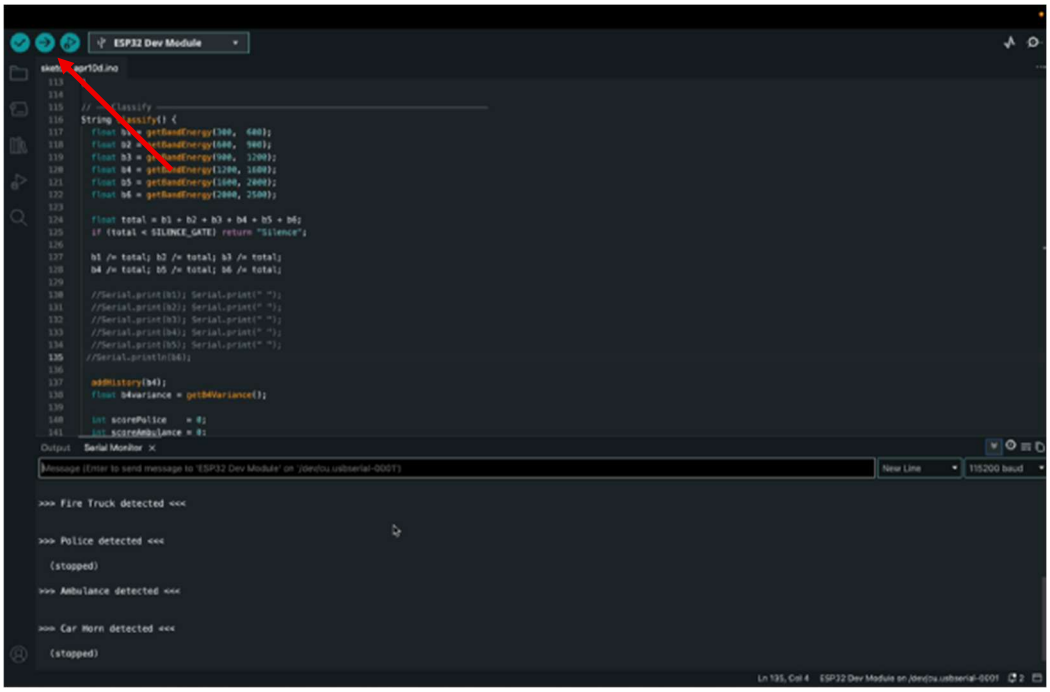


Figure 10. Check the correct board and port.

6. confirm successful upload via serial monitor or LED response.

d. 5.6 Final assembly into enclosure:

i. Once the circuit is verified, components are secured to the enclosure.

ii. Procedure:

1. Align four units of LED with the designated openings in the case.

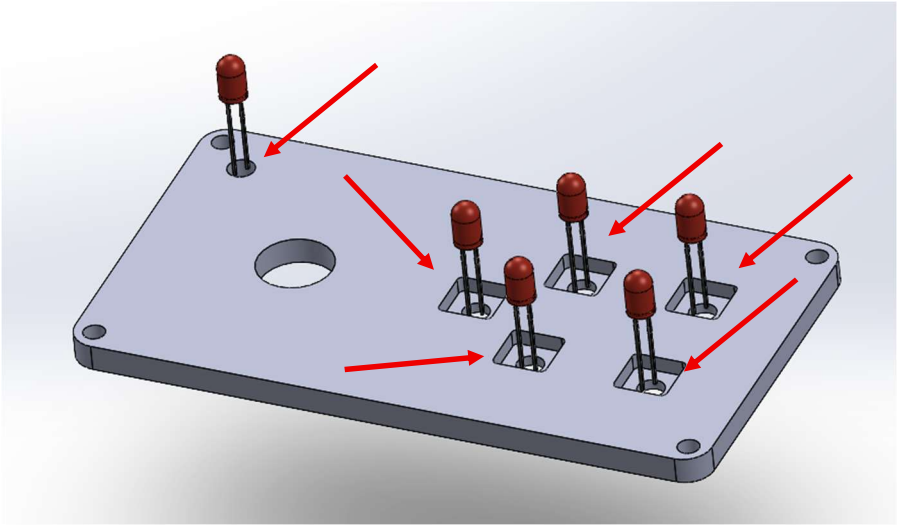


Figure 11. LED in their designated spots.

2. Secure components using screws.

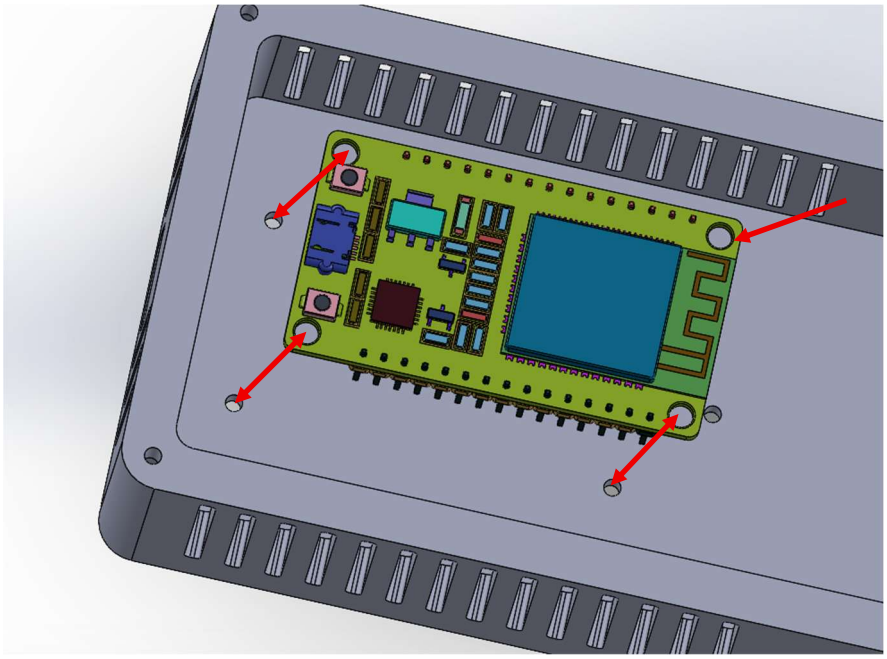


Figure 12. Secure components to case.

(for additional mounting safety a double-sided adhesive can be added under the ESP 32 Board)

3. Route USB cable and Potentiometer through the designated openings.

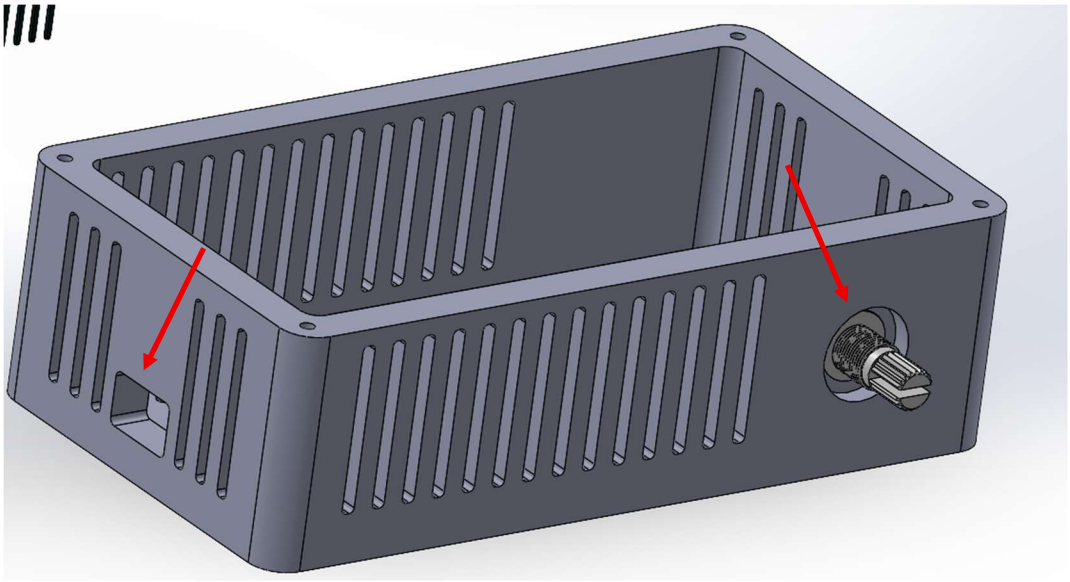


Figure 13. Potentiometer and USB designated spots.

4. Attach the enclosure lid and secure it.

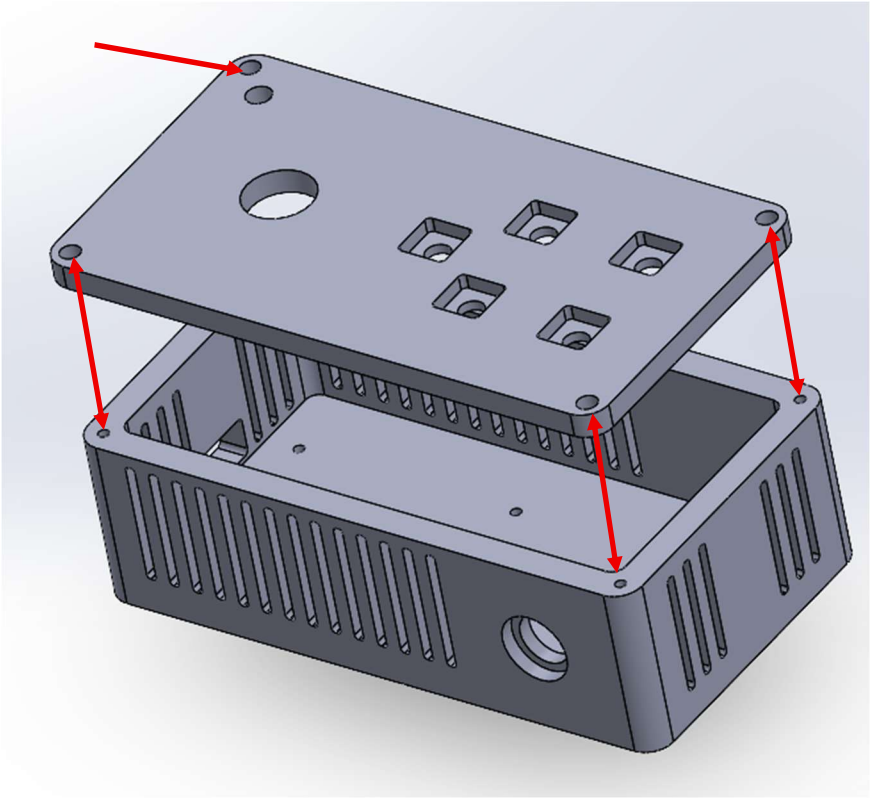


Figure 14. Case and Lid secured.

e. **5.7 System testing and verification:**

i. After assembly, the system must be assessed to ensure proper operation.

ii. Procedure:

1. Power on the system.

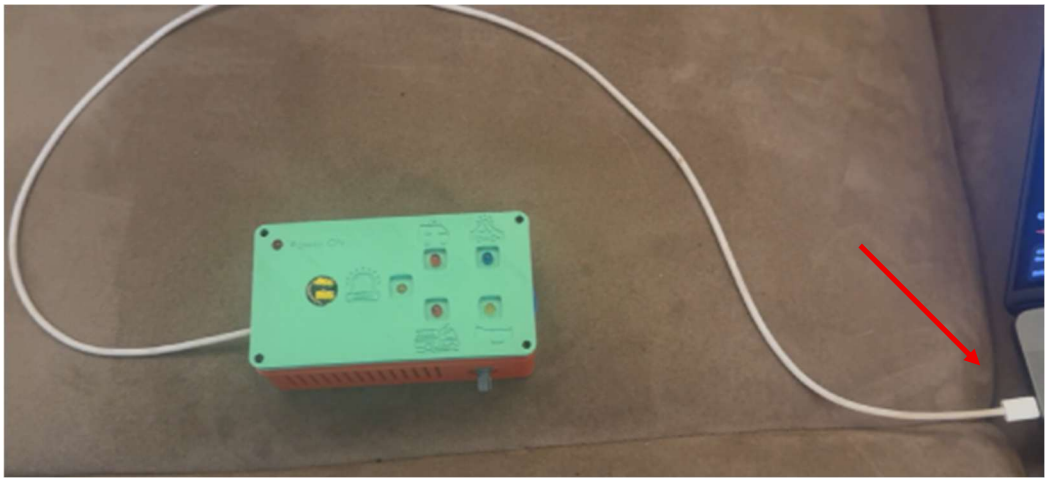


Figure 15. UBS connection to power on.

2. Confirm the power indicator LED is active (As Shown in Figure 4).

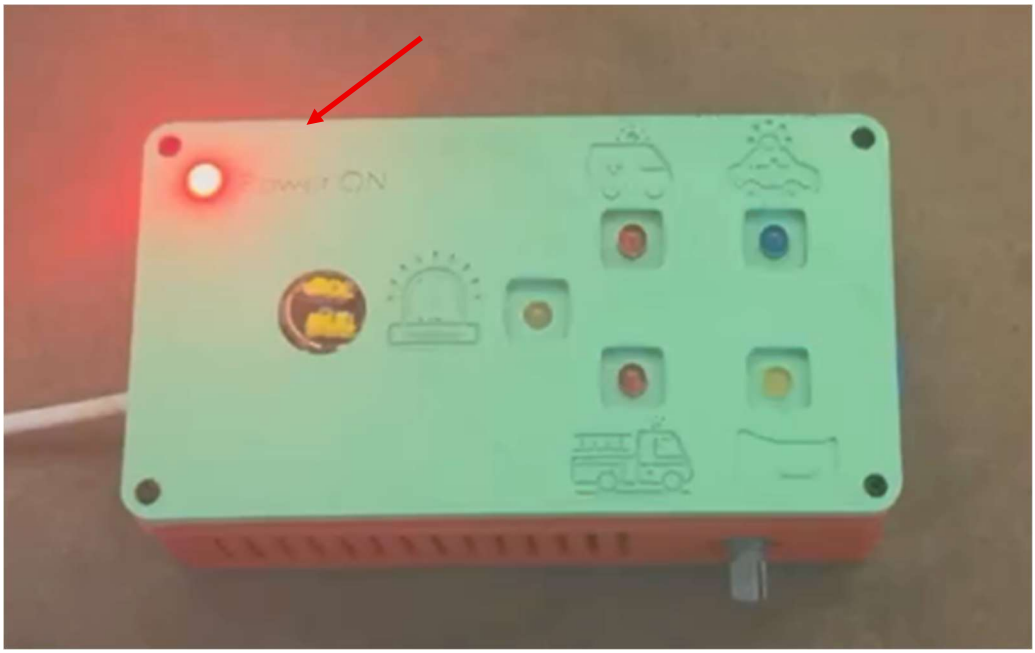


Figure 16. Power On LED.

3. Simulate emergency siren sounds.
4. Verify that the correct LED activates the detected siren type.

Figure 17. Police LED activated.

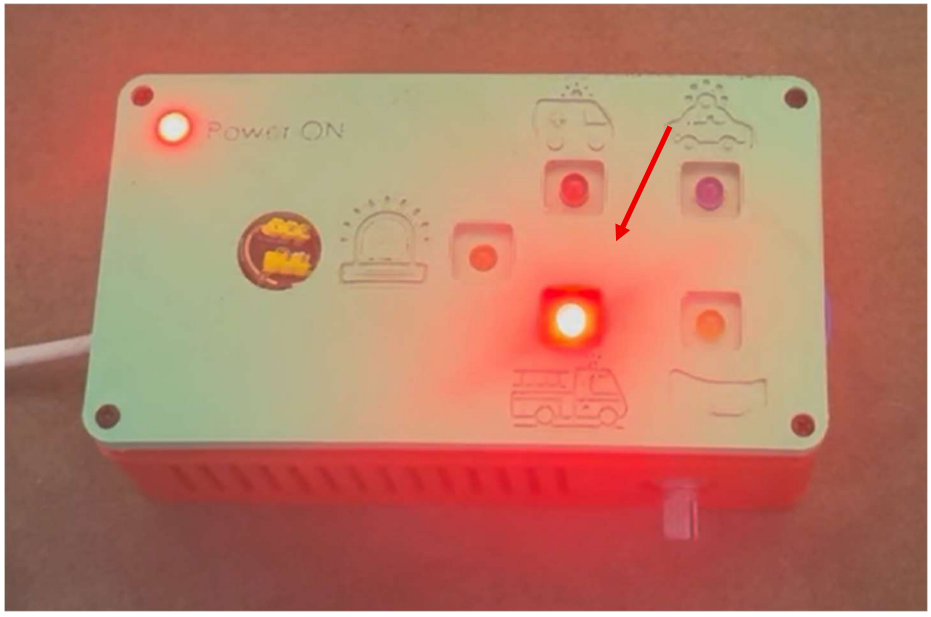


Figure 19. Firetruck LED activated.

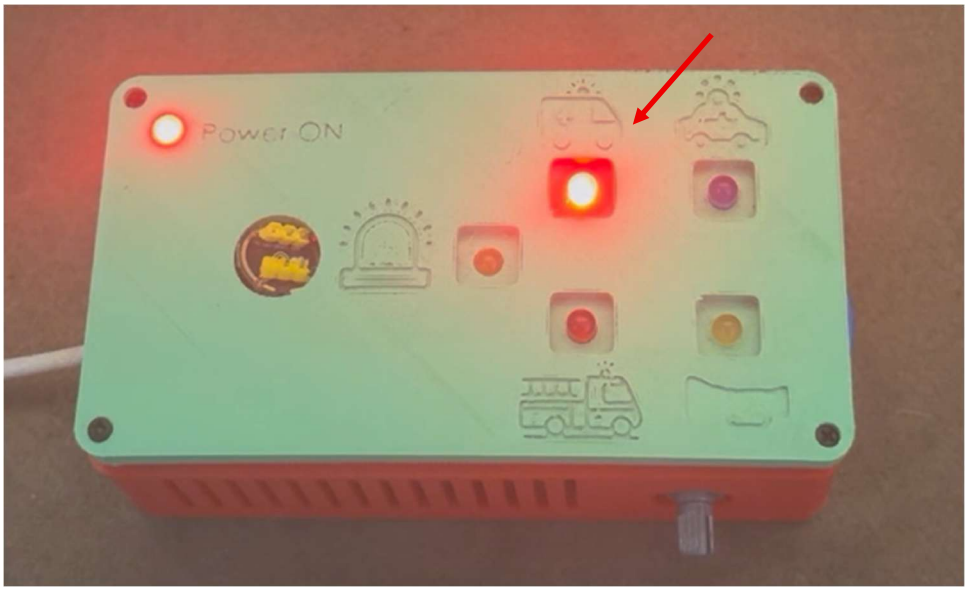


Figure 20. Ambulance LED activated.

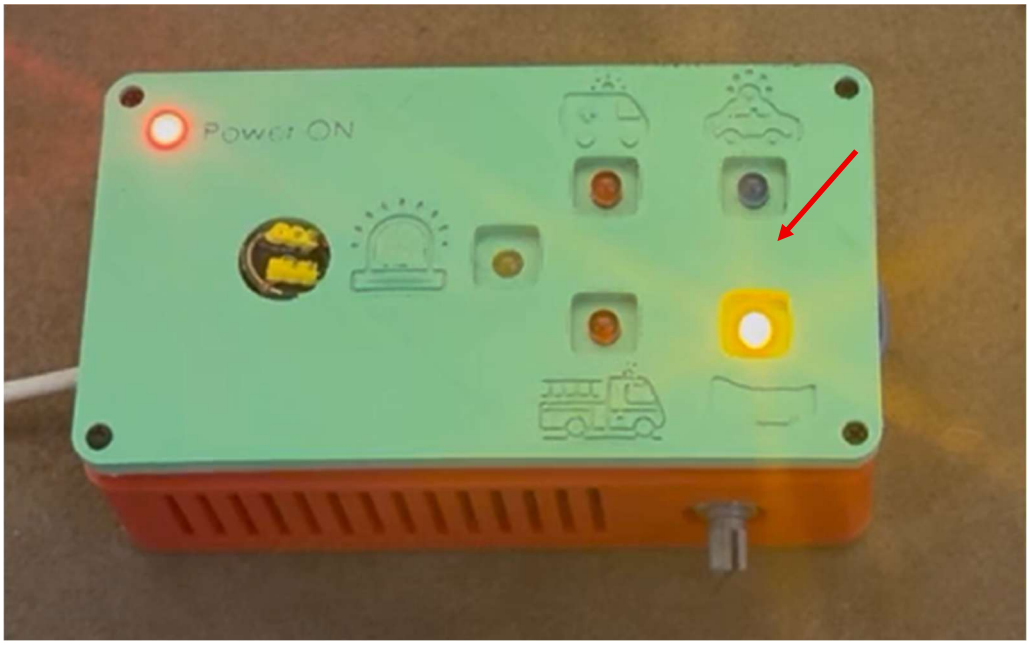


Figure 21. car horn LED activated.

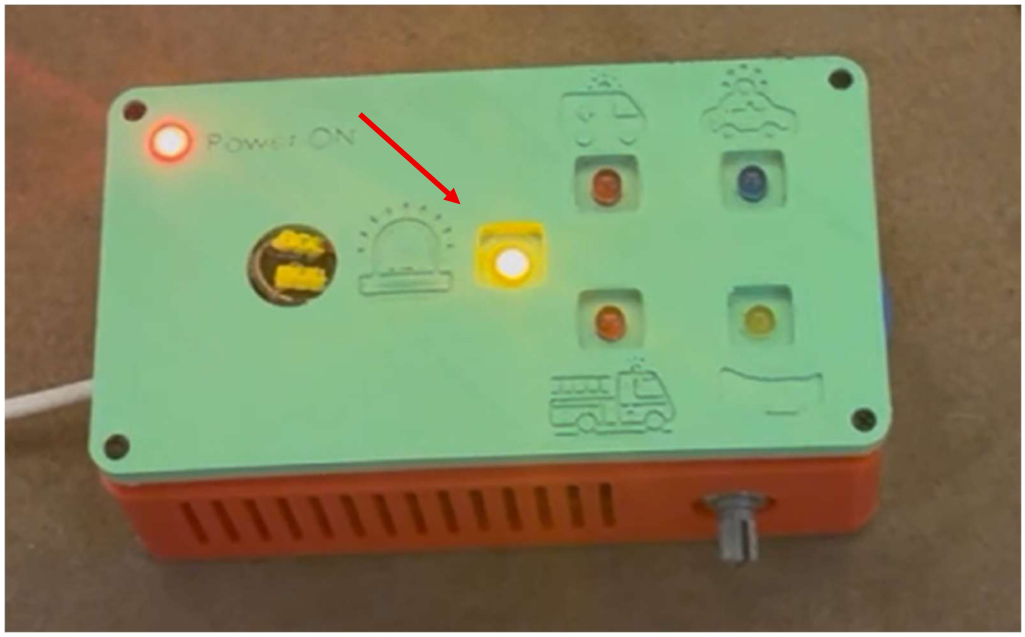


Figure 22. General alerts LED activated.

5. Check for consistent and accurate detection. (As shown in these demo videos: https://drive.google.com/drive/folders/1ojqiChXNrsIxEwL8xZR78jVgAruPesSh?usp=drive_link)

Quality Checks and Testing:

1. Power on the system and verify the power indicator LED is active (As Shown in Figure 4).
2. Verify the microphone sensor is capturing sound input correctly.
3. Simulate emergency siren sounds and confirm detection, by playback on recorded sirens of police cars, firetrucks, ambulances and finally multiple different car horns.
4. Verify that the correct LED activates for each detected siren type.
5. Ensure stable operation during continuous use.

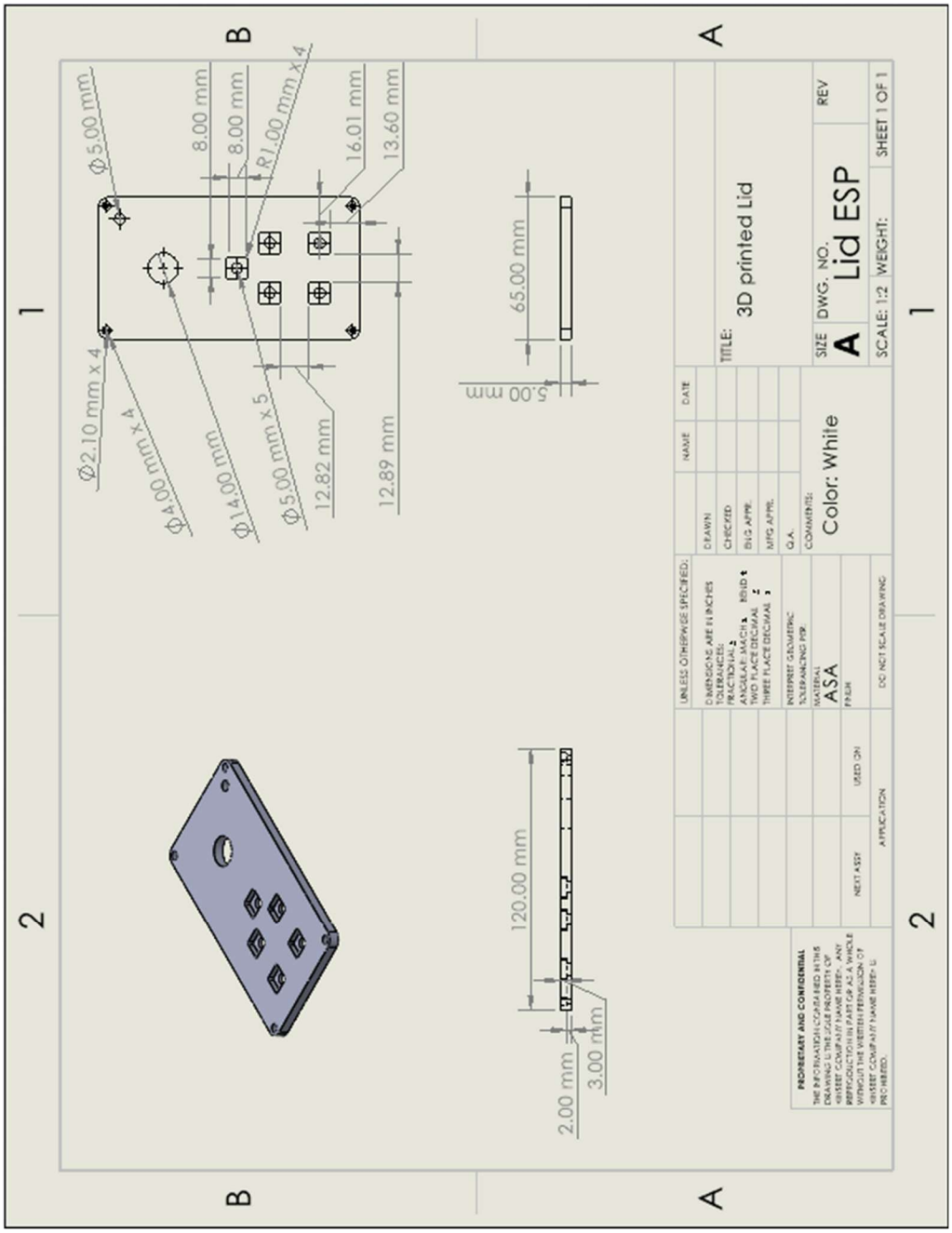
Safety Notes:

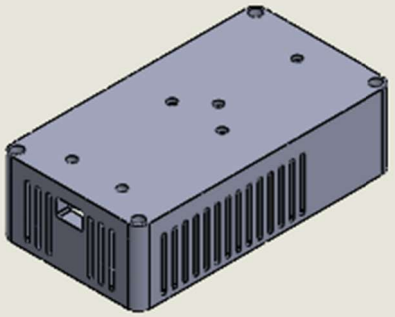
1. Avoid short circuits during assembly.
2. Do not touch hot soldering equipment.
3. Ensure correct voltage supply to all components.
4. Avoid exposing the system to moisture or excessive heat.

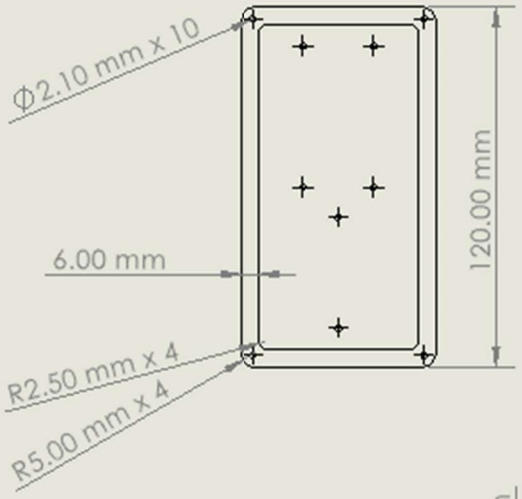
Appendix:

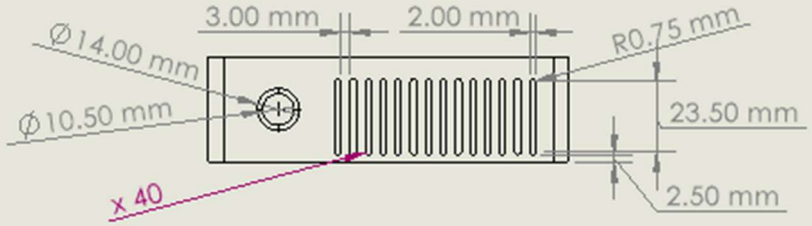
Engineering Drawings:

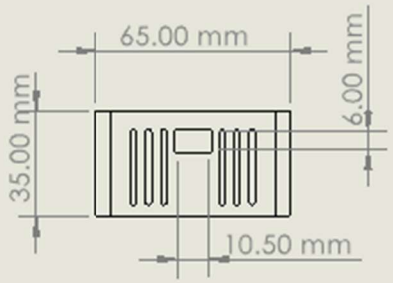
The enclosure was designed using SolidWorks. The files can be used for 3D printing.









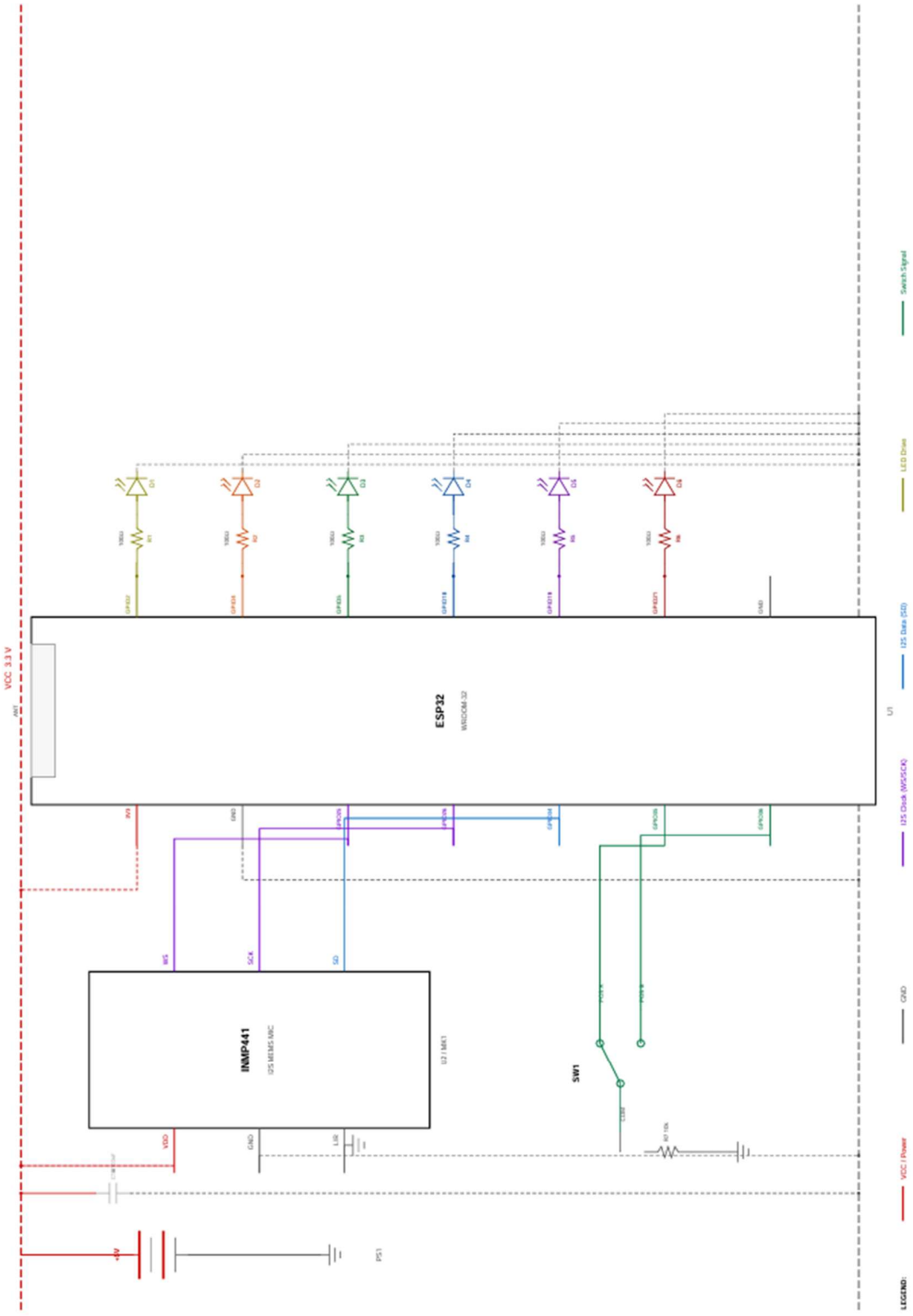


		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL ASA	COMMENTS: Color: White		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

TITLE: 3D Printed Case

SIZE	DWG. NO.	REV
A	Case ESP	
SCALE: 1:2	WEIGHT:	SHEET 1 OF 1

Engineering Circuit Drawing.



Component Links:

Part	Component	Links
1	ESP32 Dev Board	https://www.amazon.com/s?k=esp32&ref=nb_sb_noss
2	INMP441	https://www.amazon.com/s?k=INMP441+I2S+microphone
3	5 mm LEDs	https://www.amazon.com/s?k=5mm+red+LED
4	100Ω Resistors	https://www.amazon.com/s?k=100+ohm+resistor+1%2F4+watt
5	Jumper Wires	https://www.amazon.com/s?k=male+to+male+jumper+wires
6	Potentiometer	https://www.amazon.com/s?k=10k+rotary+potentiometer
7	On/Off Switch	https://www.amazon.com/s?k=SPST+mini+toggle+switch
8	USB Cable	https://www.amazon.com/s?k=USB-A+to+micro+USB+cable
9	Nylon Screws	https://www.amazon.com/dp/B0BYSHZ2TD?th=1
10	Mounting tape	https://www.amazon.com/Art3d-Double-Sided-Traceless-Removable-Reusable/dp/B09K58K13V?s=industrial