Department of Electronic and Telecommunication Engineering

University of Moratuwa

Final Report - Sound Level Monitoring System

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This report is submitted as a partial fulfillment of the module

EN2160 – Electronic Design Realization

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Content

1. Introduction

- Among the major types of pollution happening in the world such as water pollution and air pollution, sound pollution is getting a special attention in the society.
- Sound pollution is becoming a major concern in urban areas where there are high traffic conditions, in factories where there are large machines that generate noise and in work sites which involves using explosives a lot.
- With these promising issues, people tend to check the sound pollution level in their living area on a periodical manner and they tend to keep a track on past the sound pollution levels in the area currently.

2. Product Identification

- There are products already available in the market that can detect the sound level in a specific place.
- Examples of such devices can be found using the following links.
    - https://www.amazon.com/noise-detector/s?k=noise+detector
    - https://www.aliexpress.com/w/wholesale-automotive-noise-detector.html
    - https://www.renkeer.com/noise-detectors-for-industrial-pollution/ '

- But they cannot keep a record either on the location or the past data.
- Considering the above-mentioned factors, it was decided to build a sound level monitoring device that can monitor and display the sound quality and level in a specific location and the data is directly stored in a database for further analysis.
- The device will be an IoT device as well.
- The level of sound will be displayed on a screen so the user can see the amount of sound pollution in decibels.
- It will further indicate whether the sound pollution level is low, intermediate, or high.
- It will be a portable device which can carried easily so the user does not need any extra space to pack the device.

3. Specifications of the Product

- The primary and foremost objective of this device revolves around its paramount capability to measure the prevailing sound level accurately and precisely within a designated area. Subsequently, this crucial acoustic data is meticulously stored in an extensive and comprehensive database, paving the way for exhaustive and in-depth analysis in the subsequent stages.

- Utilizing cutting-edge technology, the device employs a sound sensor to diligently gauge the acoustic intensity, precisely quantifying it in decibels (dB). This valuable information is then seamlessly portrayed on a highly convenient LCD display, thereby facilitating a comprehensive understanding of the prevailing sound pollution level in the environment.

- Users of this ingeniously designed device are presented with the invaluable privilege of effortlessly perceiving the sound level through the highly user-friendly display. Furthermore, they are granted unhindered access to an easily accessible ON/OFF switch, thereby empowering them with absolute control overpowering the device as they see fit.

- To ensure optimal functionality, the device warrants a steadfast 5V power supply to effectively power up its intricate modules. Nevertheless, users are afforded the liberty to swap out drained batteries with utmost ease, thus ensuring a continuous and seamless operation of the device without any interruptions.

4. Extra Features That Are Included

- Along with the sound pollution level in dB being displayed in the LCD display, it will also be pushing the readings to an IoT platform, and a graph will be plotted over time to see the sound level in that specific location.
- It will indicate whether the sound level in the area is quiet, medium, high, or high risk in the display.
- As the IoT platform, Blynk IoT platform will be used, and it is accessible to anyone around the world.

5. Simulation

- Before implementing the solution, the functionality of the circuit proposed for the product was simulated and verified.
- The platform used was Wokwi online simulator.
- Wokwi Arduino simulator is a great online tool for simulating projects that use a development board. The app supports various popular development boards and MCUs such as the Arduino UNO, the Raspberry Pi Pico, the ESP32, and the ATTiny85.
- Therefore, during the simulation instead of using the ESP32-WROOM32D microcontroller, ESP32 Development board was used because the microcontroller alone was not available in the simulation platform.
- During the simulation, the microphone module that was proposed to be used for the product was not available.
- A microphone module captures sound in the environment and outputs a voltage signal which is proportional to the sound level.
- Therefore, the functionality of the microphone module was simulated using a potentiometer.
- The Wi-Fi connection and the things associated with Blynk application was not simulated and they were tested during the breadboard implementation of the proposed circuit.

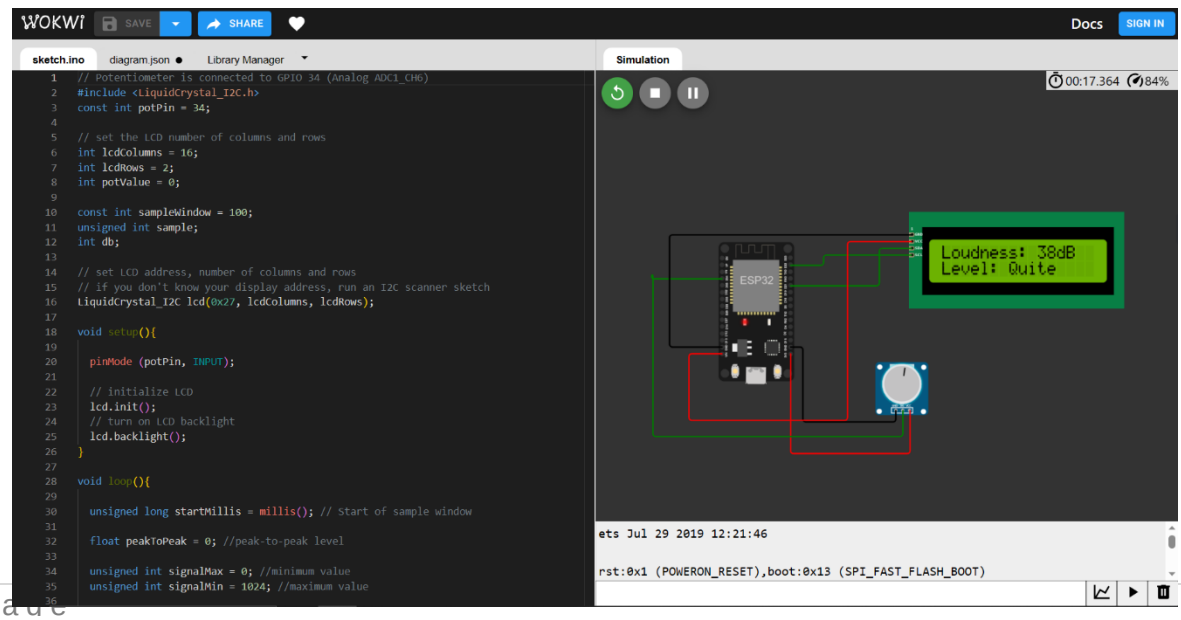


Figure 1

- Link for the simulation - [EDR_Sound_Level_Detection_System_V2 - Wokwi ESP32, STM32, Arduino Simulator]

- Sketch used during the simulation is as follows.

```
// Potentiometer is connected to GPIO 34 (Analog ADC1_CH6)
#include <LiquidCrystal_I2C.h>
const int potPin = 34;

// set the LCD number of columns and rows
int lcdColumns = 16;
int lcdRows = 2;
int potValue = 0;

const int sampleWindow = 100;
unsigned int sample;
int db;

// set LCD address, number of columns and rows
// if you don't know your display address, run an I2C scanner sketch
LiquidCrystal_I2C lcd(0x27, lcdColumns, lcdRows);

void setup(){

  pinMode (potPin, INPUT);

  // initialize LCD
  lcd.init();
  // turn on LCD backlight
  lcd.backlight();
}

void loop(){

  unsigned long startMillis = millis(); // Start of sample window

  float peakToPeak = 0; //peak-to-peak level

  unsigned int signalMax = 0; //minimum value
  unsigned int signalMin = 1024; //maximum value

  // collect data for 50 mS
  while (millis() - startMillis < sampleWindow)
  {

    sample = analogRead(potPin); //get reading from microphone

    if (sample < 1024) // toss out spurious readings
    {
      if (sample > signalMax)
      {
```

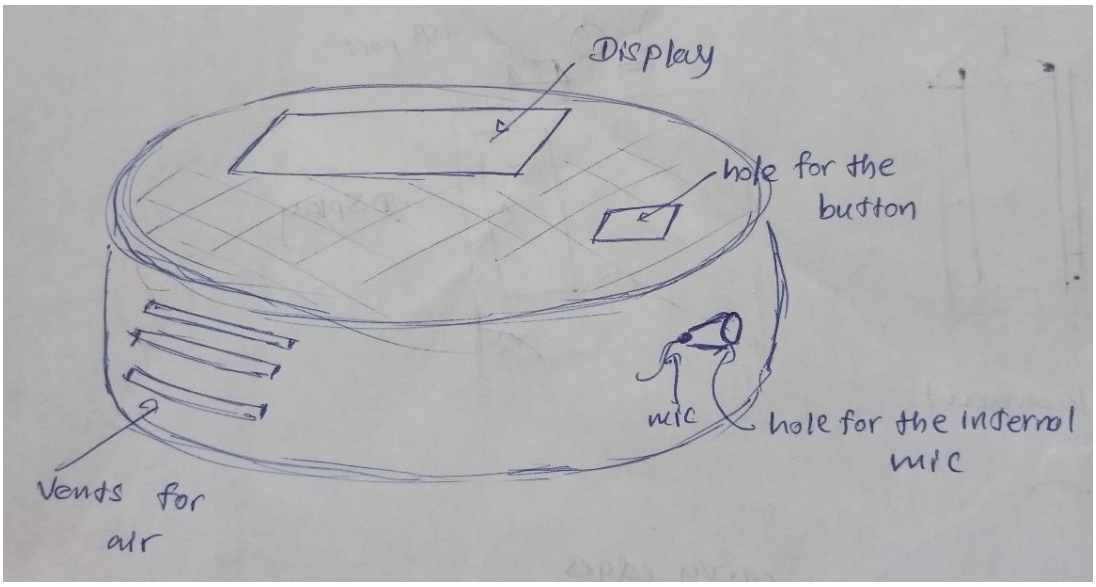
```
        signalMax = sample; // save just the max levels
      }
      else if (sample < signalMin)
      {
        signalMin = sample; // save just the min levels
      }
    }
  }

  peakToPeak = signalMax - signalMin; // max - min = peak-peak amplitude

  Serial.println(peakToPeak);

  db = map(peakToPeak, 50, 4000, 49.5, 90); //calibrate for deciBels

  lcd.setCursor(0, 0);
  lcd.print("Loudness: ");
  lcd.print(db);
  lcd.print("dB");

  if (db <= 40)
  {
    lcd.setCursor(0, 1);
    lcd.print("Level: Quite");
  }
  else if (db > 40 && db < 55)
  {
    lcd.setCursor(0, 1);
    lcd.print("Level: Moderate");
  }
  else if (db >= 55)
  {
    lcd.setCursor(0, 1);
    lcd.print("Level: High");
  }
  delay(600);
  lcd.clear();
}
```

6. Conceptual Designs of the Product

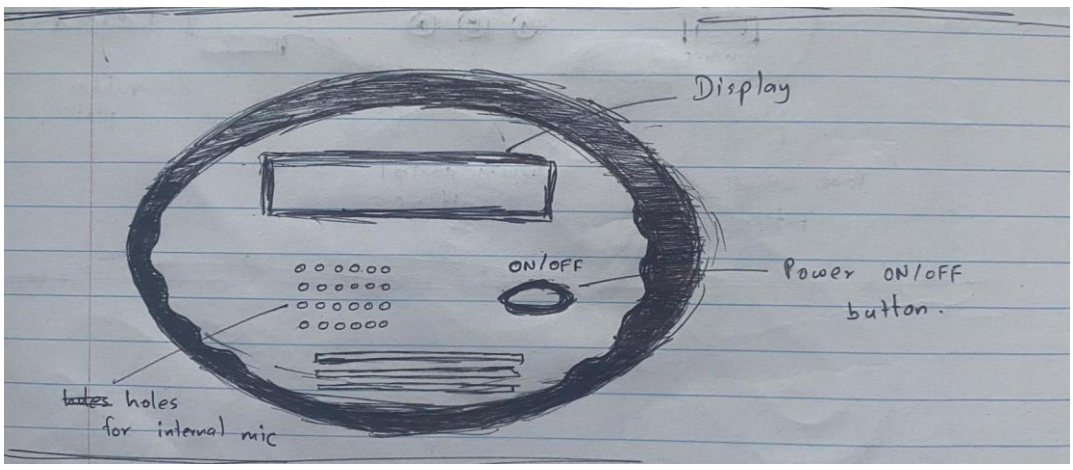
- In the conceptual design cycle of designing concepts and making prototypes, different circuits, enclosures, and functional parts (If available) are considered by brainstorming ideas among the members of the design team.
- Then those ideas are combined to make a complete solution to the problem which is addressed.
- The underlying ideas are then grouped and using hand sketches those ideas are presented to get the optimal solution.

- Conceptual Designs Drawn
    - After having many brainstorming sessions, the following conceptual designs were developed for the sound level monitoring system.

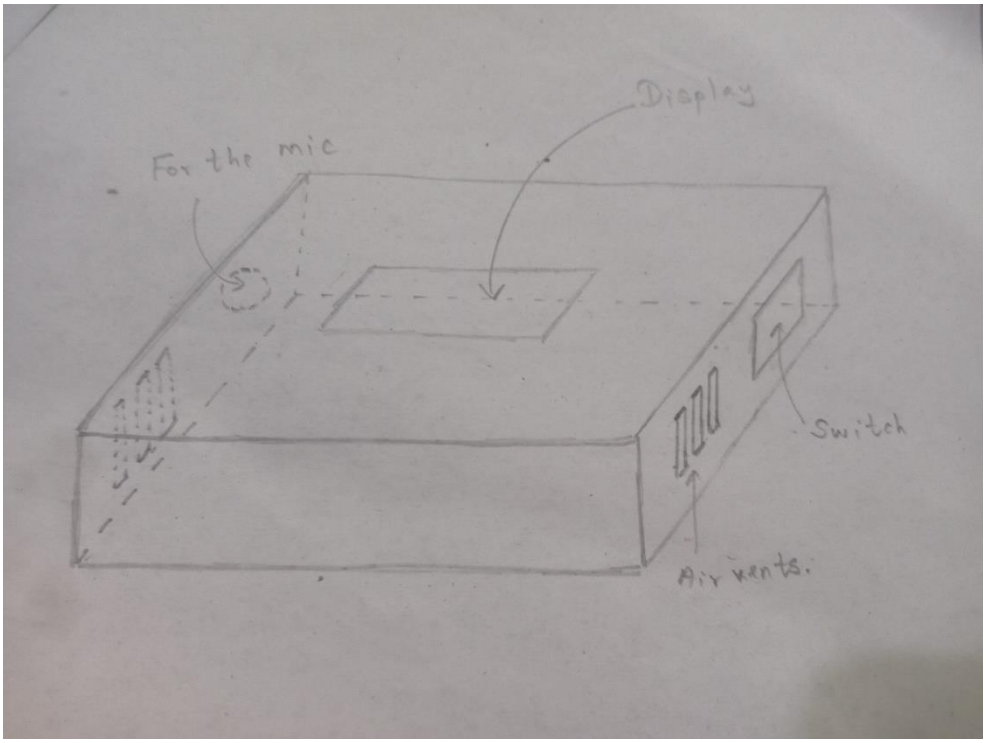
a) Design - 1 (Inspired from Amazon ALEXA)

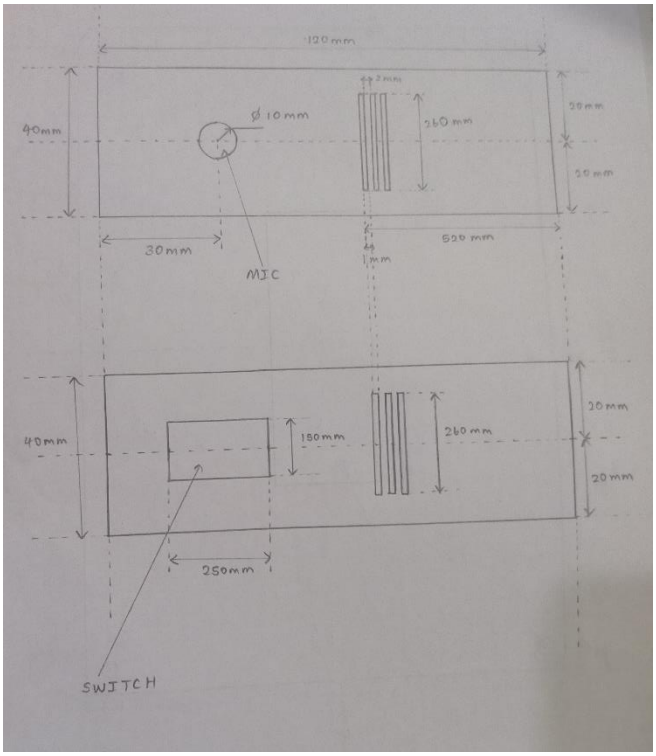


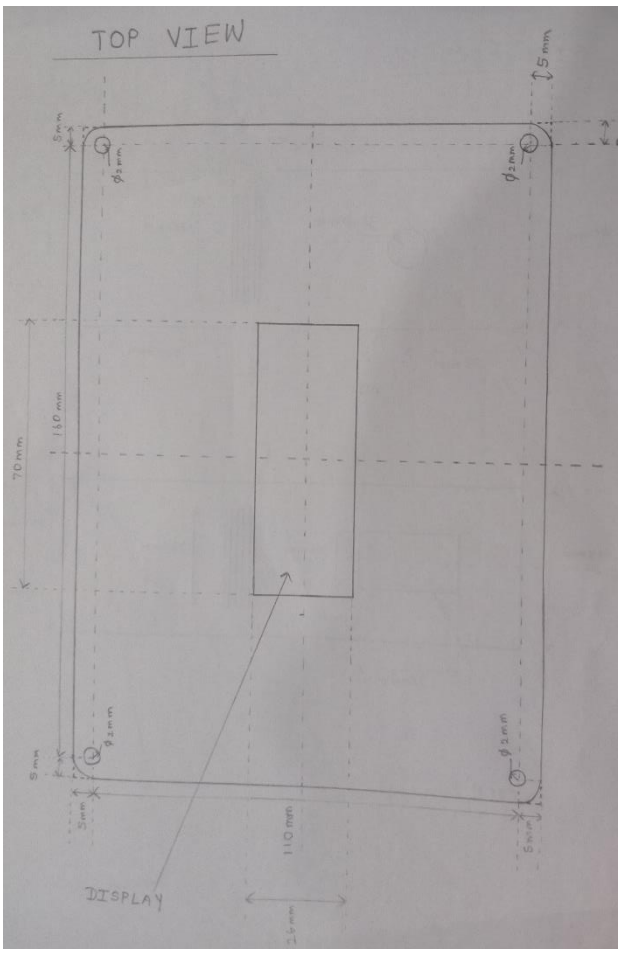
b) Design - 2 (Handheld type design)



c) Design - 3 (Wall mount design)

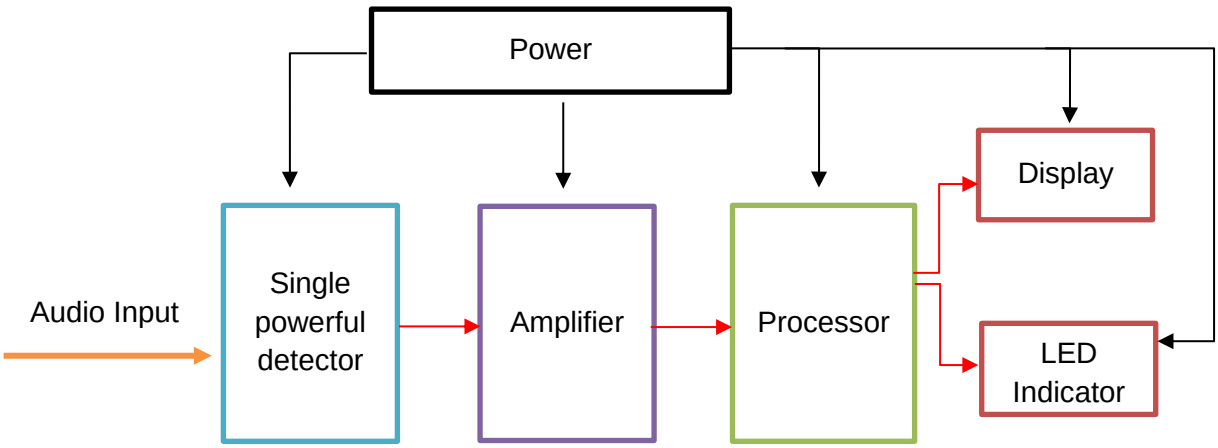




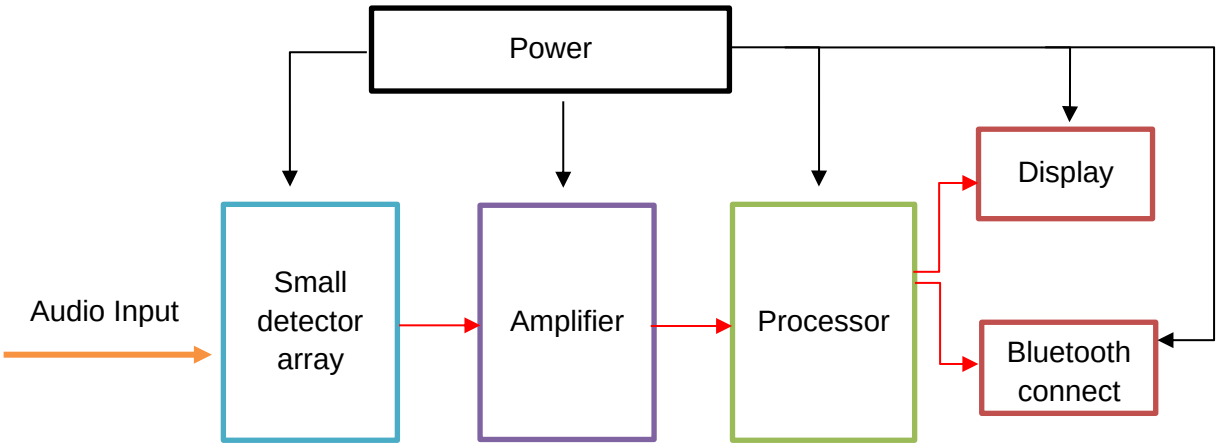


- Block Diagrams Drawn by Peers

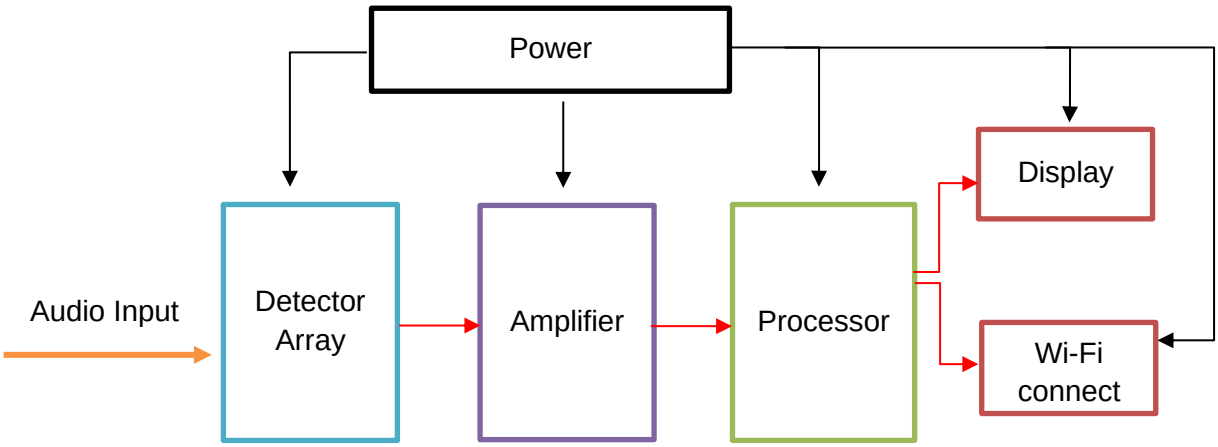
a) Block Diagram - 1



b) Block Diagram - 2

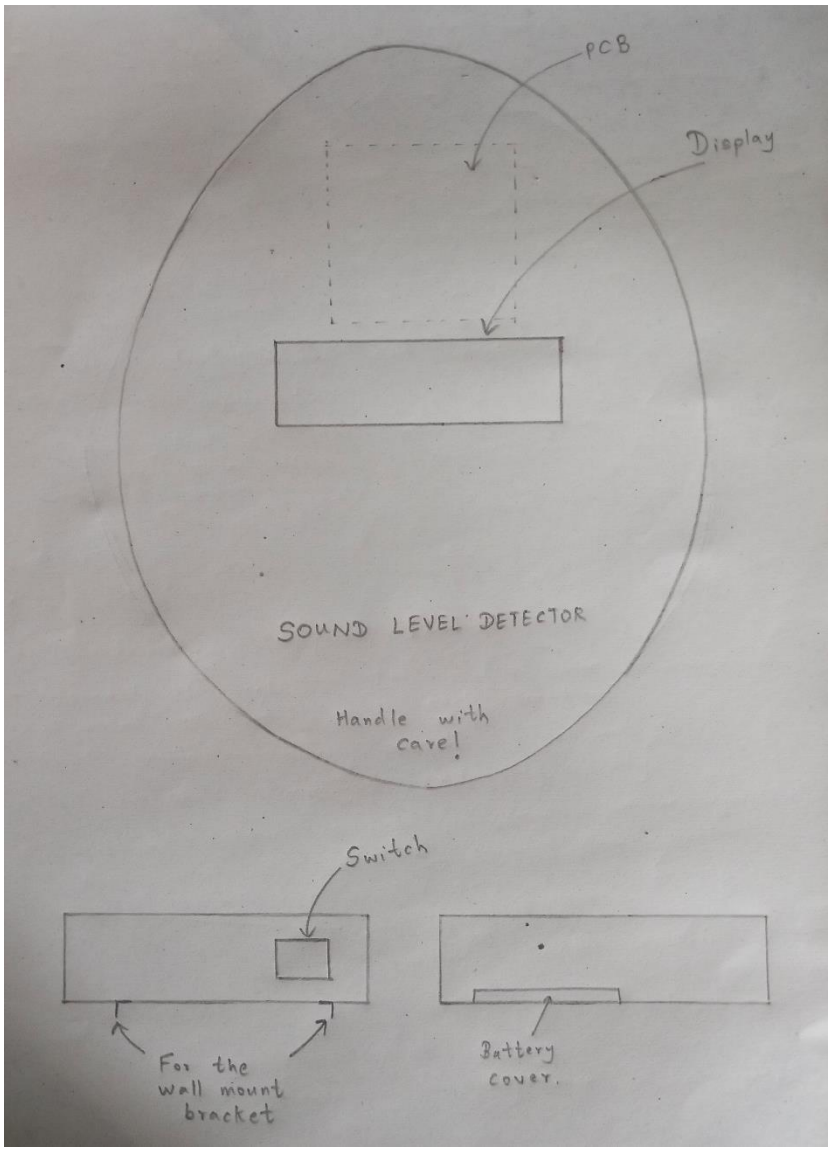


c) Block Diagram - 3

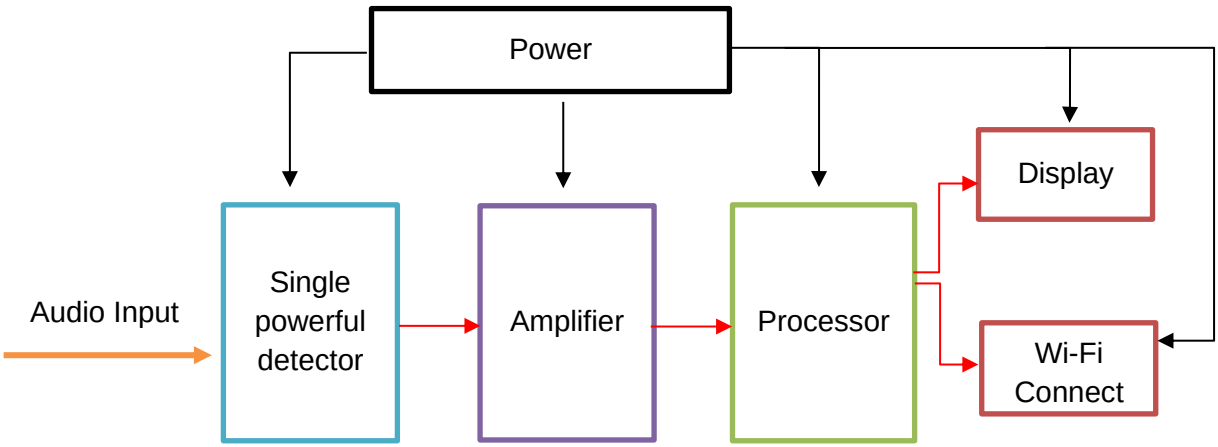


7. User Centred Design

- Sketch



- Block diagram



8. Evaluation Matrices

- For the conceptual designs

No.	Criterion	Design - 1 (Inspired from Amazon ALEXA)	Design - 2 (Handheld Type Design)	Design - 3 (Wall Mount Type Design)	Design - 4 (User Centred Design)
1	Portability	0	10	0	0
2	Simplicity	9	4	8	7
3	Repairability	8	8	8	8
4	Manufacturability	7	7	7	7
5	Indoor use	10	8	10	10
6	Outdoor use	0	4	9	0
7	User friendliness	5	3	8	6
8	Aesthetic view	5	4	3	5
9	Competitiveness with existing products	6	3	8	8
10	Eco friendliness	6	6	6	6
	Total Marks	56	57	69	57

- Features added and removed in each design

Criterion	Design - 1 (Inspired from Amazon ALEXA)	Design - 2 (Handheld Type Design)	Design - 3 (Wall Mount Type Design)	Design - 4 (User Centred Design)
Added features	• Indoor use • Simplicity	• Portability • Indoor use	• Both indoor and outdoor use	• Indoor use • Competitiveness with existing products
Removed features	• Outdoor use	• Simplicity	• Portability	• Portability • Outdoor use

- For the block diagrams

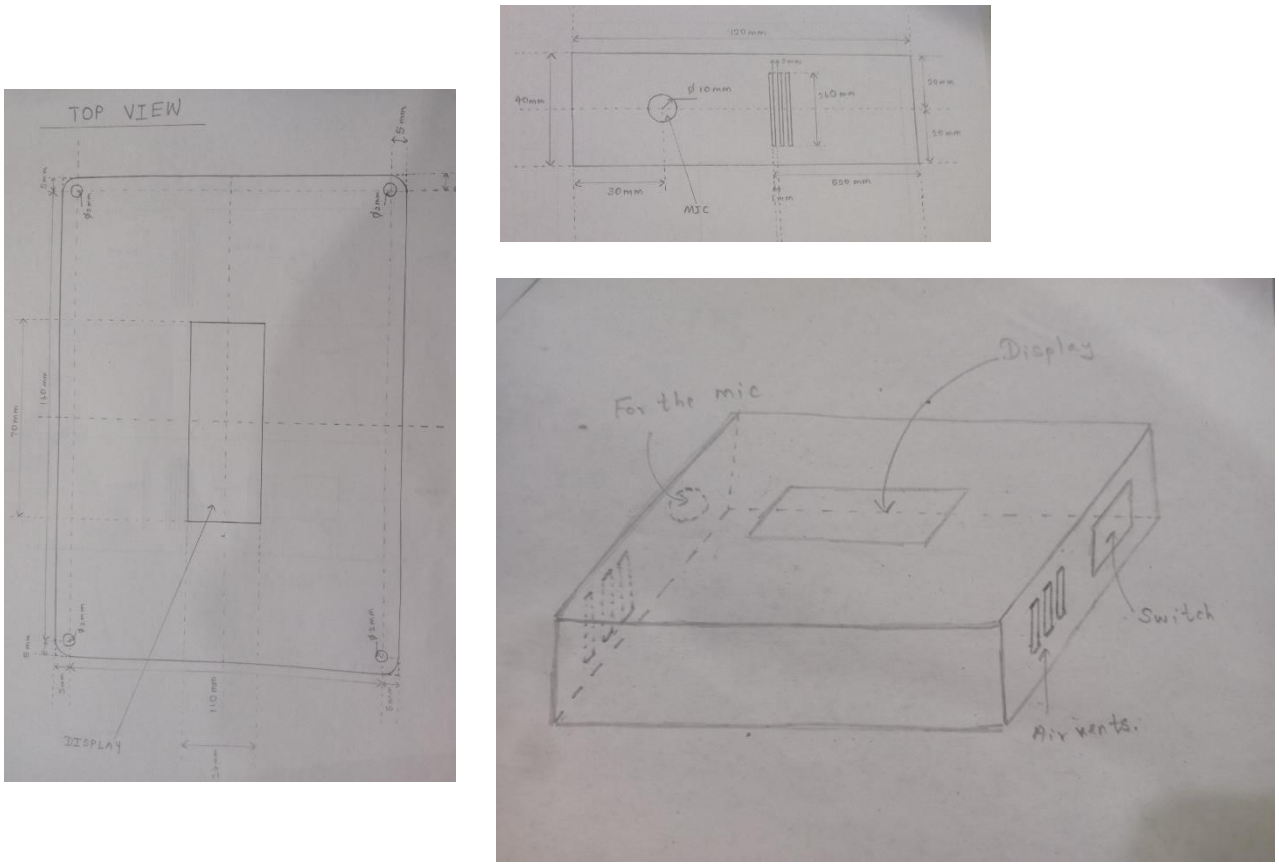
No.	Criterion	Block Diagram - 1	Block Diagram - 2	Block Diagram - 3	Block Diagram - 4 (User Centred Design)
1	Battery life	8	6	6	6
2	Simplicity	6	6	5	5
3	Repairability	5	5	5	5
4	Manufacturability	6	6	6	6
5	Indoor/Outdoor use	5	3	5	5
6	User friendliness	4	7	8	6
7	Response time	6	7	7	7
8	Reliability	4	6	8	8
9	Accuracy	5	6	6	5
10	Range	4	8	7	6
	Total Marks	53	60	63	59

- Features added and removed in each block diagram

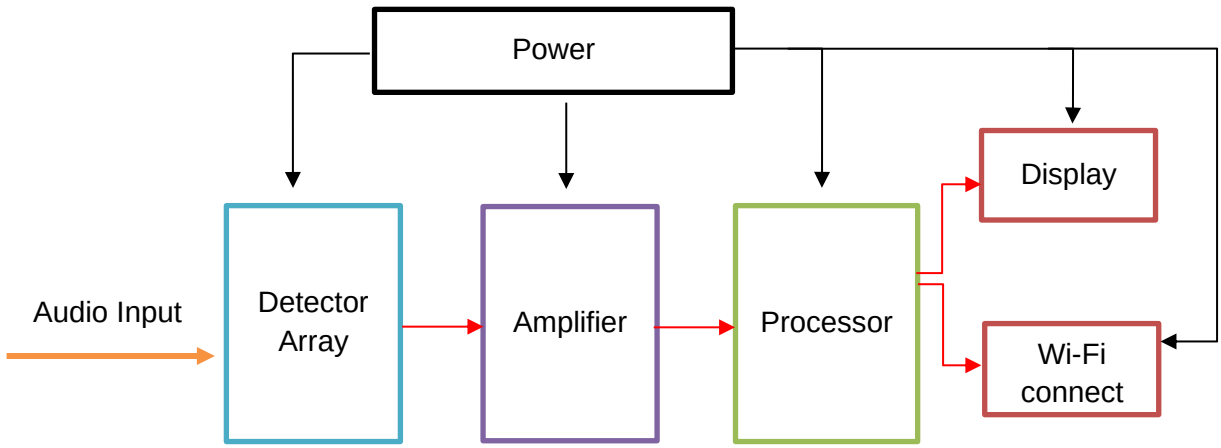
Criterion	Block Diagram - 1	Block Diagram - 2	Block Diagram - 3	Block Diagram - 4 (User Centred Design)
Added features	• Only one powerful detector to detect sound	• A detection array instead of a single detector for sound detection	• A detection array instead of a single detector for sound detection	• A detection array instead of a single detector for sound detection
Removed features	• No Wi-Fi or Bluetooth connection can be enabled.	• No Wi-Fi connection can be enabled.	• No Bluetooth connection can be enabled.	• No Bluetooth connection can be enabled.

9. Selected Design for the Product

i. Conceptual design - Design - 3 (Wall mount design)

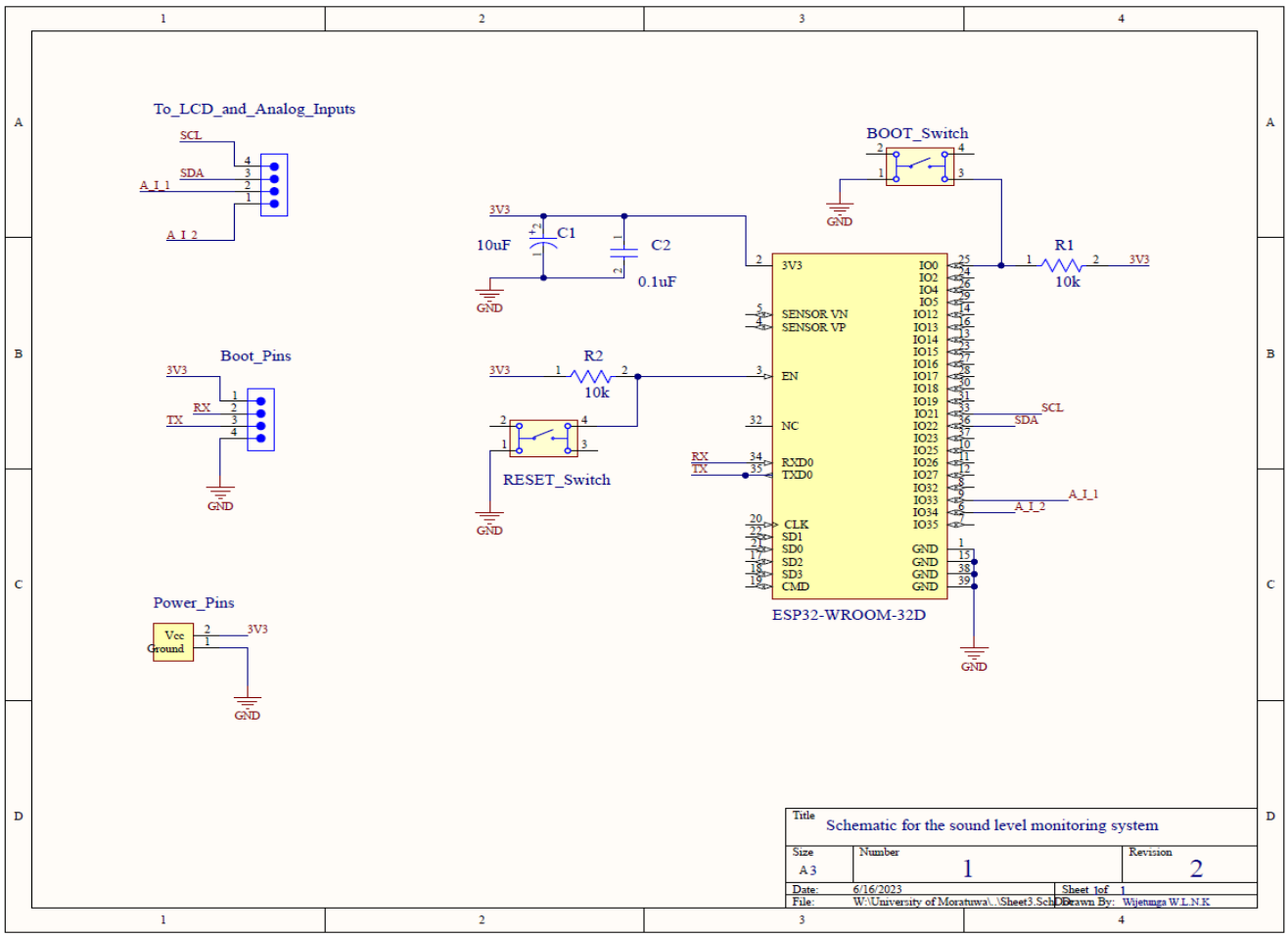


ii. Block diagram - Block diagram - 3

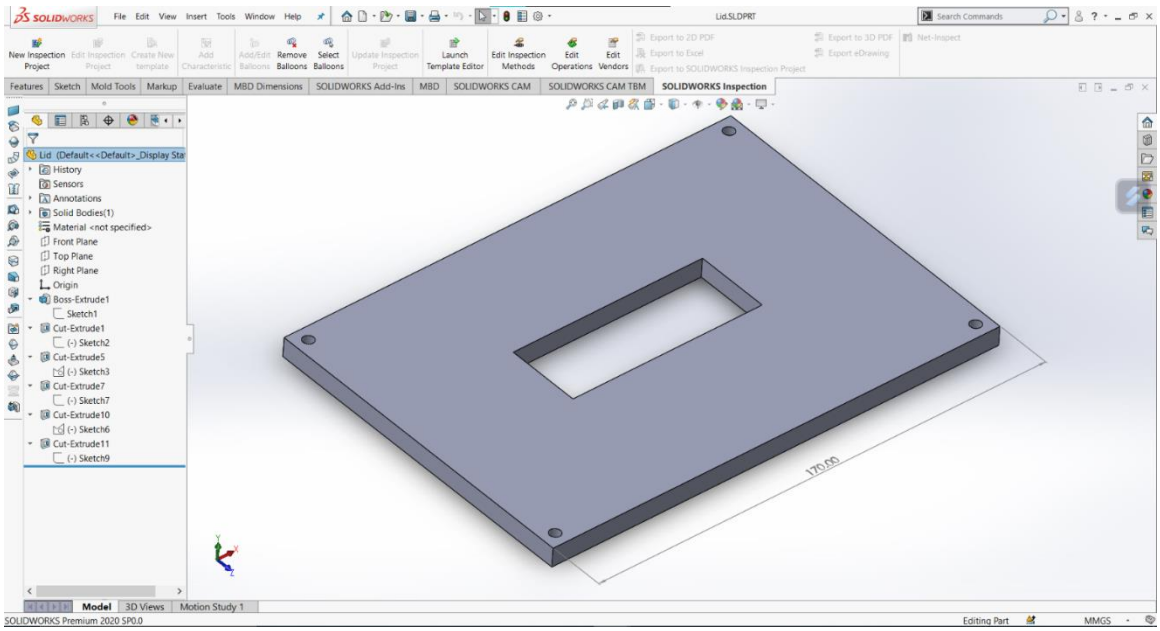


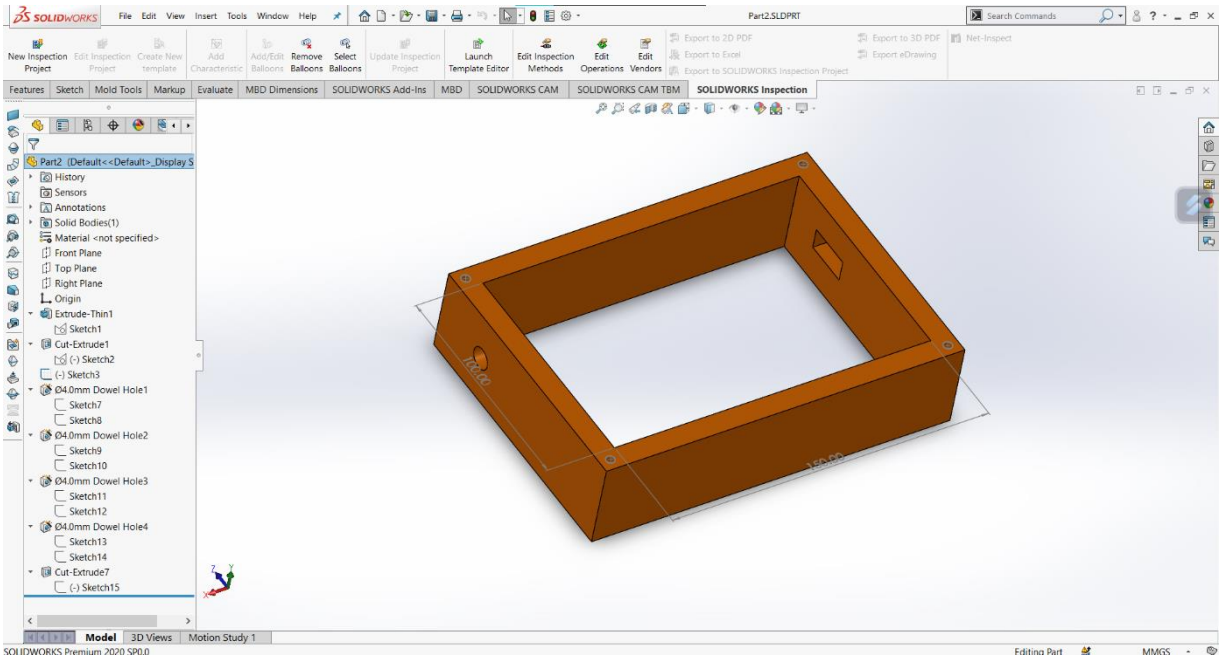
10.Implemented Designs of the Product

a. Schematic of the Implemented Design



b. Enclosure Design of the Implemented Design

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Sensors
Annotations
Solid Bodies(1)
Material <not specified>
Front Plane
Top Plane
Right Plane
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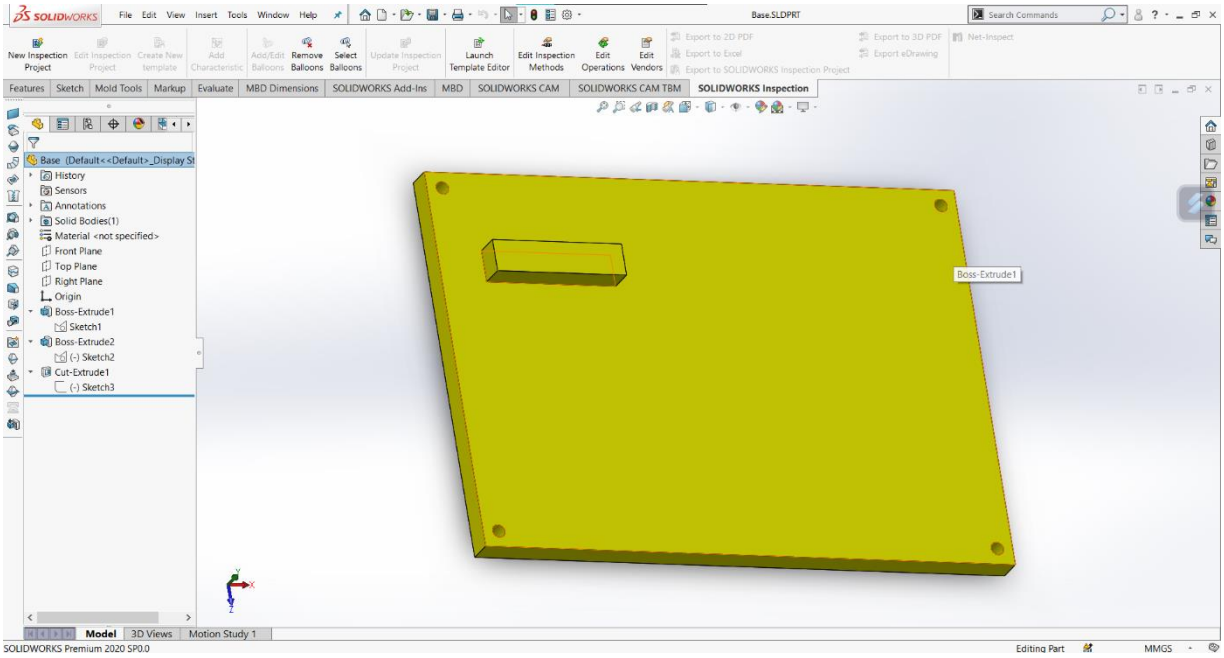
Sketch1
Cut-Extrude1
(-) Sketch2
(-) Sketch3
Ø4.0mm Dowel Hole1
Sketch7
Sketch8
Ø4.0mm Dowel Hole2
Sketch9
Sketch10
Ø4.0mm Dowel Hole3
Sketch11
Sketch12
Ø4.0mm Dowel Hole4
Sketch13
Sketch14
Cut-Extrude7
(-) Sketch15
Model
3D Views
Motion Study 1
SOLIDWORKS Premium 2020 SP0.0
Editing Part
MMGS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Annotations
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Top Plane
Right Plane
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Boss-Extrude1
Sketch1
Boss-Extrude2
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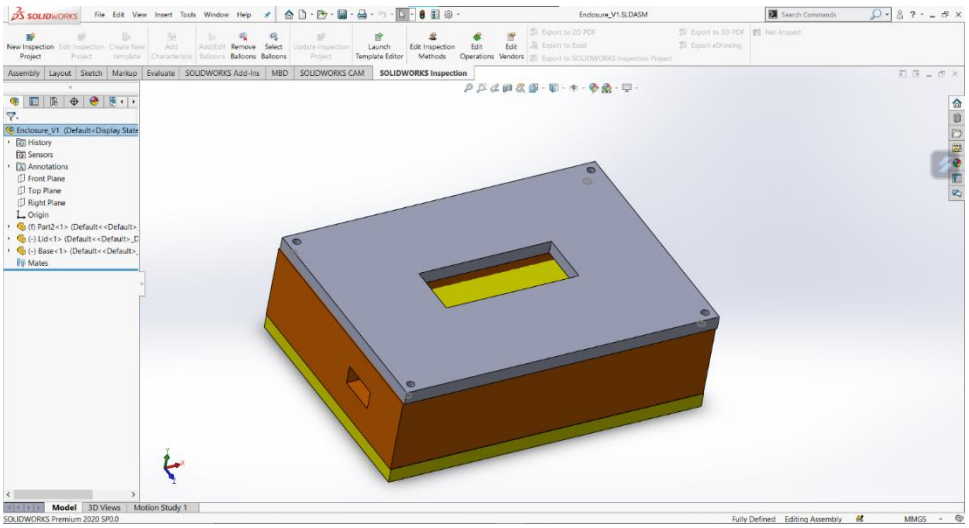
Cut-Extrude1
(-) Sketch3
Boss-Extrude1
Model
3D Views
Motion Study 1
SOLIDWORKS Premium 2020 SP0.0
Editing Part
MMGS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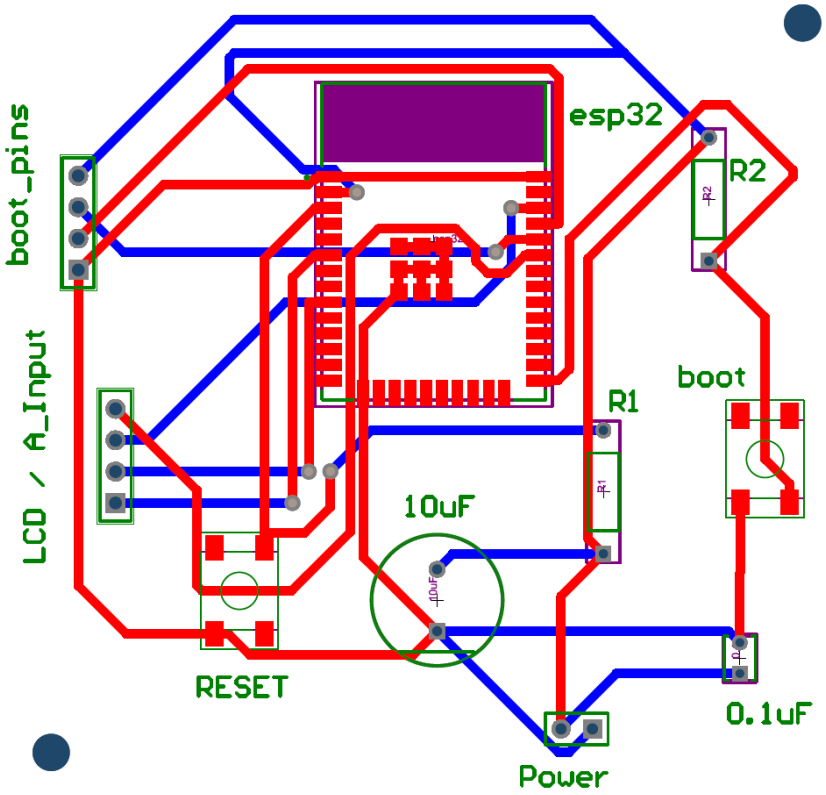
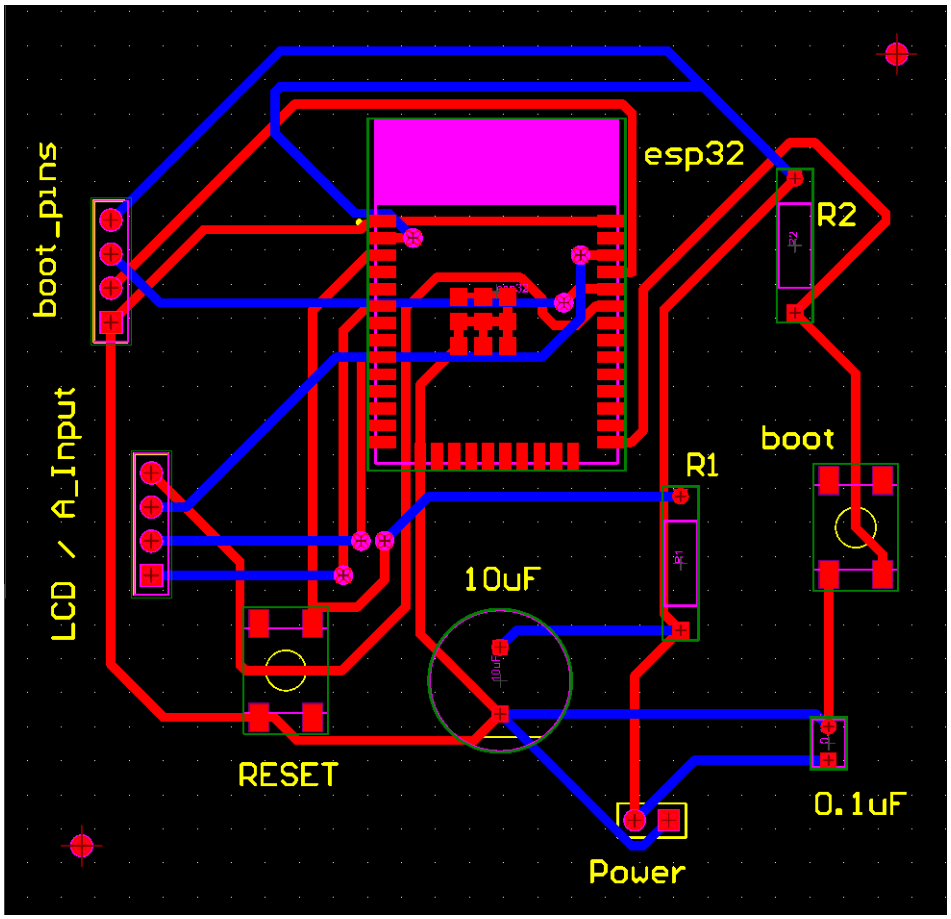
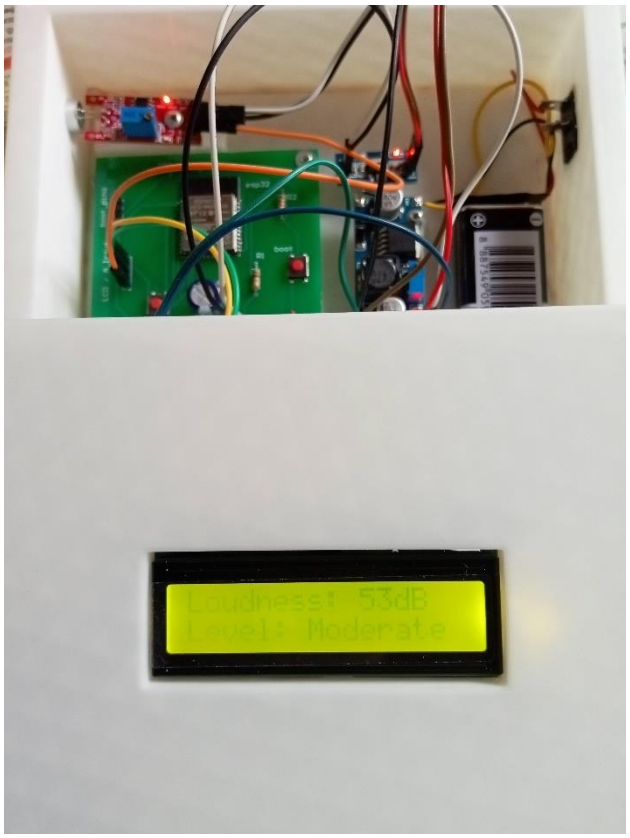
History
Sensors
Annotations
Front Plane
Top Plane
Right Plane
Origin
Mates
Model
3D Views
Motion Study 1
SOLIDWORKS Premium 2020 SP0.0
Fully Defined
Editing Assembly
MMGS

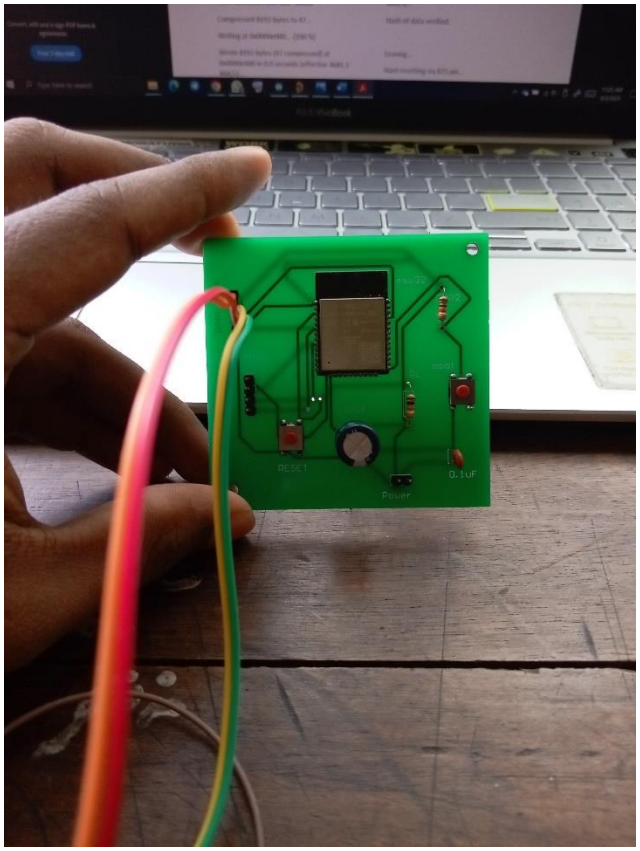
c. PCB Design and Gerber Files

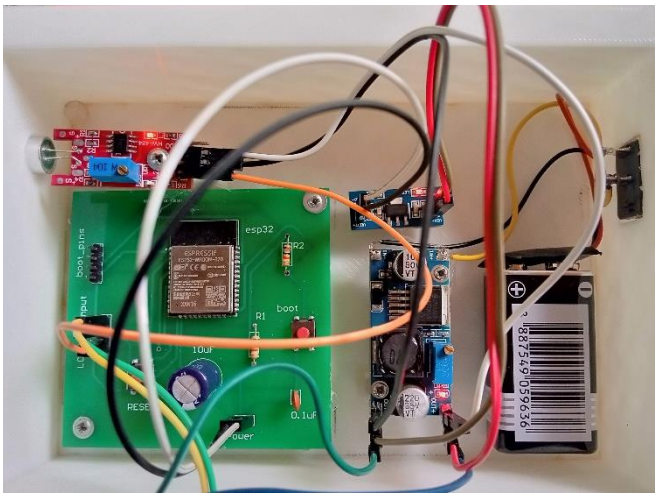




11.First Prototype







12.Problems and Improvements of the Implemented Design

a. Problems/Improvements identified/proposed during the mid-evaluation

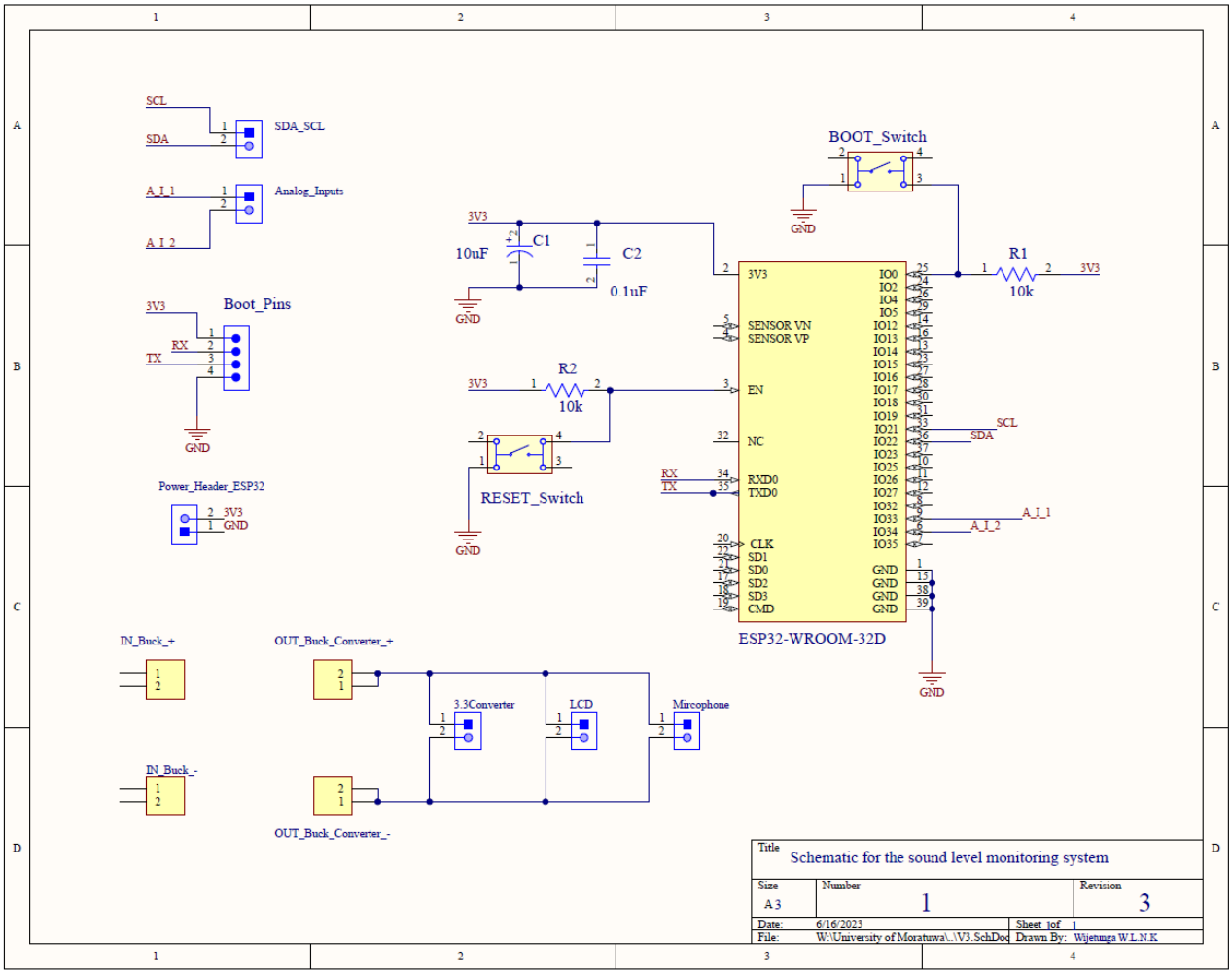
i. The initial rendition of the product's enclosure design featured a rather simplistic and utilitarian box-shaped configuration.
ii. Following the invaluable feedback received during the mid-evaluation stage, it became evident that the design lacked visual appeal, with its unattractive aesthetics failing to impress.
iii. Subsequently, in response to the constructive critique, the enclosure design underwent a complete overhaul, incorporating elegant curves and fillets to infuse it with a more captivating and alluring appearance.
iv. A thorough examination of the PCB revealed the possibility of optimizing its layout by strategically integrating the power supply modules within the board itself. The rationale behind this suggestion was twofold: not only would it free up precious space inside the enclosure, but it would also lead to a reduction in the number of interconnecting wires, streamlining the overall design and enhancing its efficiency.

b. Problems/Improvements identified/proposed by users.

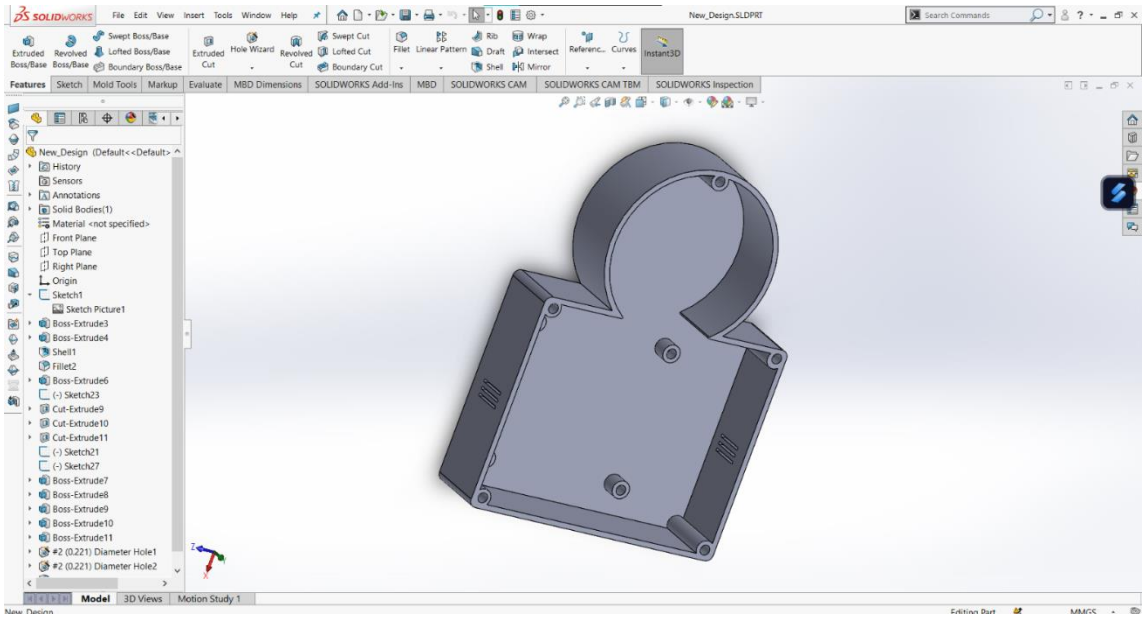
i. In response to the valuable feedback received during the mid-evaluation, proactive measures were taken to revamp the product's appearance. To explore various visually striking options, a series of conceptual designs were meticulously sketched, aiming to identify an alluring and captivating look for the device.
ii. The idea of adding Bluetooth connection to the device in addition to the Wi-Fi connectivity was suggested by one pf the group members. The justification for this was sometimes it is easy to use and implement Bluetooth connectivity rather than using Wi-Fi specially in a smaller physical area.
iii. The users' delight knew no bounds upon learning that the device had evolved into a full-fledged Internet of Things (IoT) device, significantly expanding its functionality and potential use cases.
iv. The overwhelming consensus among users was the pressing need to integrate Bluetooth connectivity into the device, echoing the sentiment put forth by their colleagues, thereby solidifying its status as a versatile and user-friendly product.
v. As a result of constructive criticism from users, there was a strong recommendation to diligently enhance and refine the product's design, which was deemed unappealing. This feedback served as a driving force behind the pursuit of a visually captivating and aesthetically pleasing appearance for the device.

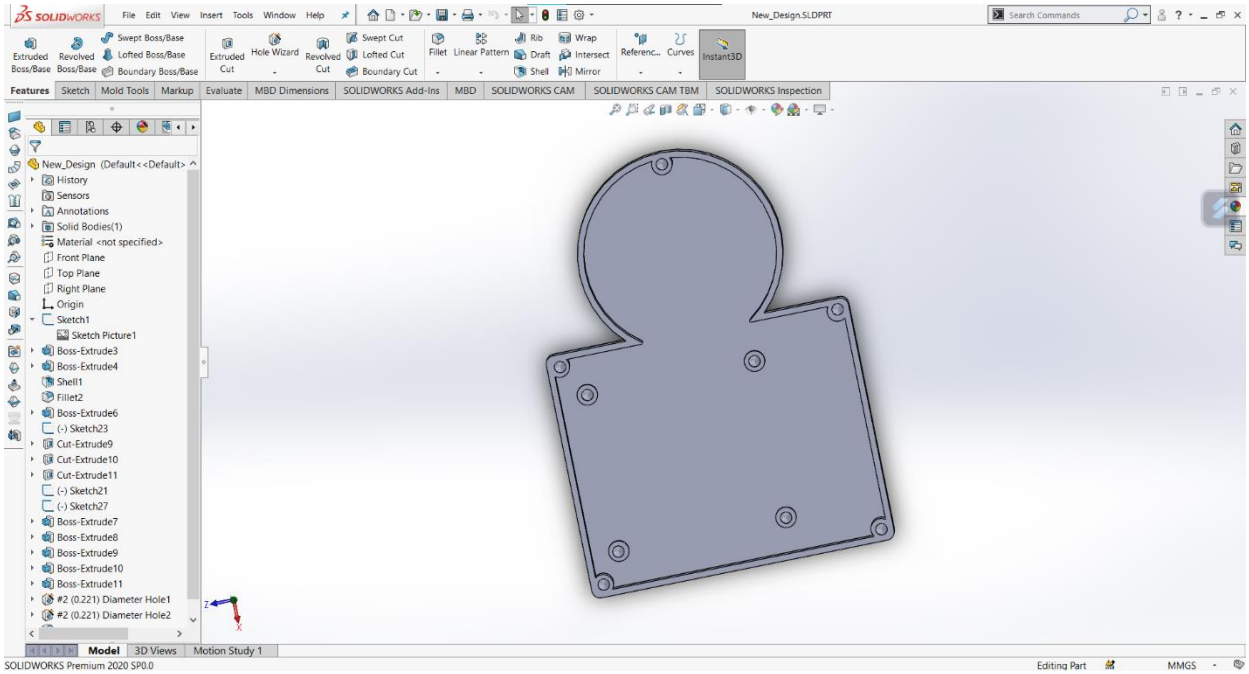
13.Improved Design

a. Schematic of the Improved Design



b. Enclosure Design of the Improved Design

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Search Commands
Extruded Boss/Base
Revolved Boss/Base
Swept Boss/Base
Lofted Boss/Base
Boundary Boss/Base
Extruded Cut
Hole Wizard
Revolved Cut
Swept Cut
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Boundary Cut
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Shell
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Intersect
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Sensors
Annotations
Solid Bodies(1)
Material <not specified>
Front Plane
Top Plane
Right Plane
Origin
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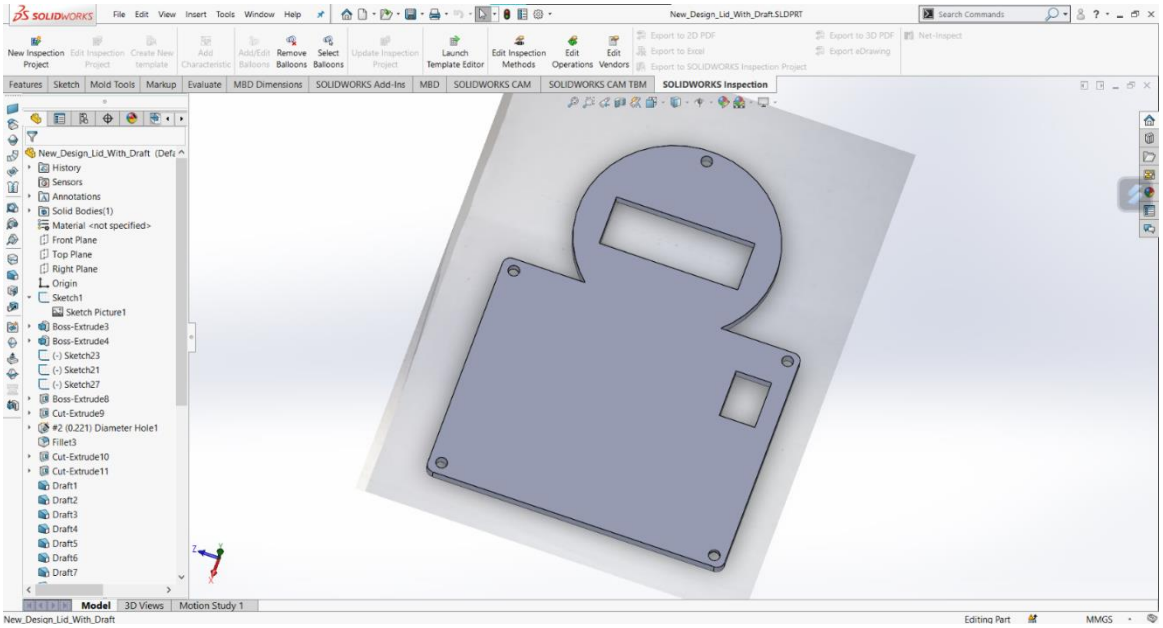
Sketch Picture1
Boss-Extrude3
Boss-Extrude4
Shell1
Fillet2
Boss-Extrude6
(-) Sketch23
Cut-Extrude9
Cut-Extrude10
Cut-Extrude11
(-) Sketch21
(-) Sketch27
Boss-Extrude7
Boss-Extrude8
Boss-Extrude9
Boss-Extrude10
Boss-Extrude11
#2 (0.221) Diameter Hole1
#2 (0.221) Diameter Hole2
Model 3D Views Motion Study 1
SOLIDWORKS Premium 2020 SP0.0
Editing Part
MMGS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Search Commands
New Inspection Project
Edit Inspection Project
Create New template
Add Characteristic
Add/Edit Balloons
Remove Balloons
Select Balloons
Update Inspection Project
Launch Template Editor
Edit Inspection Methods
Edit Operations
Edit Vendors
Export to 2D PDF
Export to Excel
Export to SOLIDWORKS Inspection Project
Export to 3D PDF
Export eDrawing
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Features Sketch Mold Tools Markup Evaluate MBD Dimensions SOLIDWORKS Add-Ins MBD SOLIDWORKS CAM SOLIDWORKS CAM TBM SOLIDWORKS Inspection
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History
Sensors
Annotations
Solid Bodies(1)
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Front Plane
Top Plane
Right Plane
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(-) Sketch21
(-) Sketch27
Boss-Extrude8
Cut-Extrude9
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Fillet3
Cut-Extrude10
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Draft3
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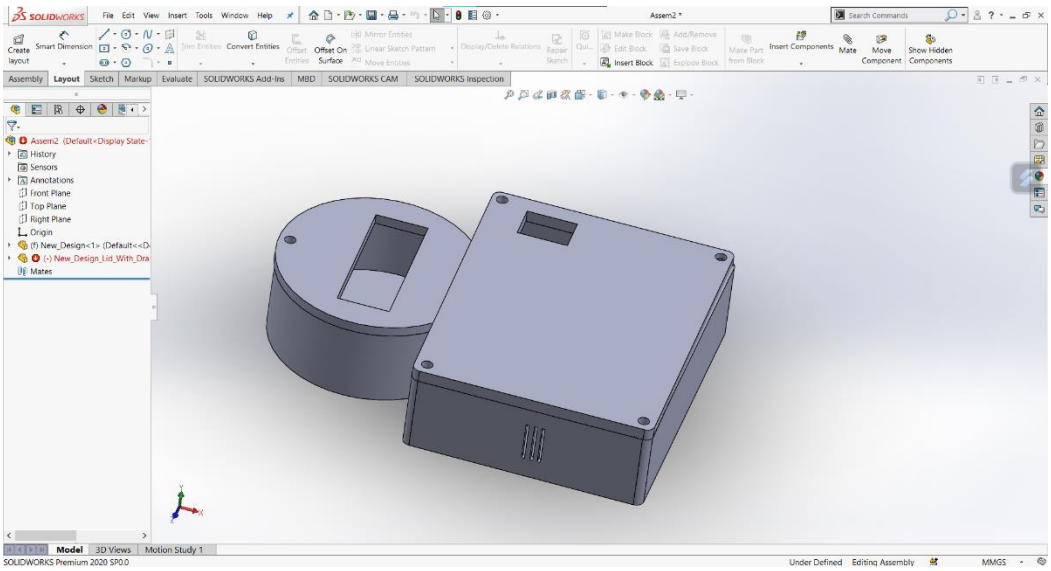
Draft5
Draft6
Draft7
Model 3D Views Motion Study 1
New_Design_Lid_With_Draft
Editing Part
MMGS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Search Commands
Create layout
Smart Dimension
Trim Entities
Convert Entities
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Mirror Entities
Linear Sketch Pattern
Move Entities
Display/Delete Relations
Repair Sketch
Quick Snaps
Make Block
Edit Block
Insert Block
Add/Remove
Save Block
Explode Block
Make Part from Block
Insert Components
Mate
Move Component
Show Hidden Components
Assembly Layout Sketch Markup Evaluate SOLIDWORKS Add-Ins MBD SOLIDWORKS CAM SOLIDWORKS Inspection
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Model 3D Views Motion Study 1
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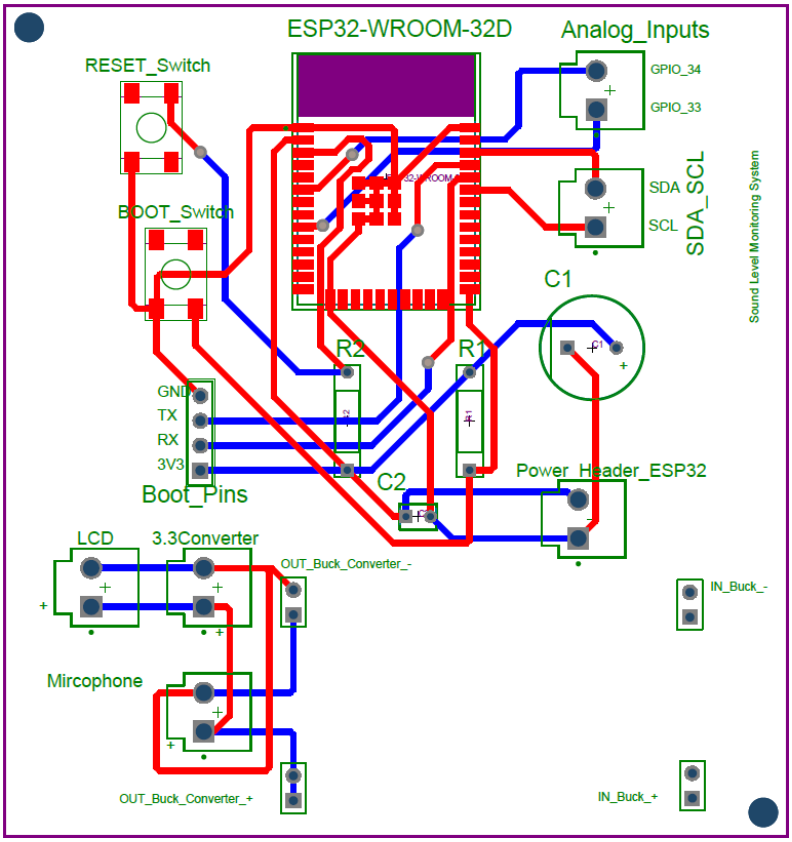
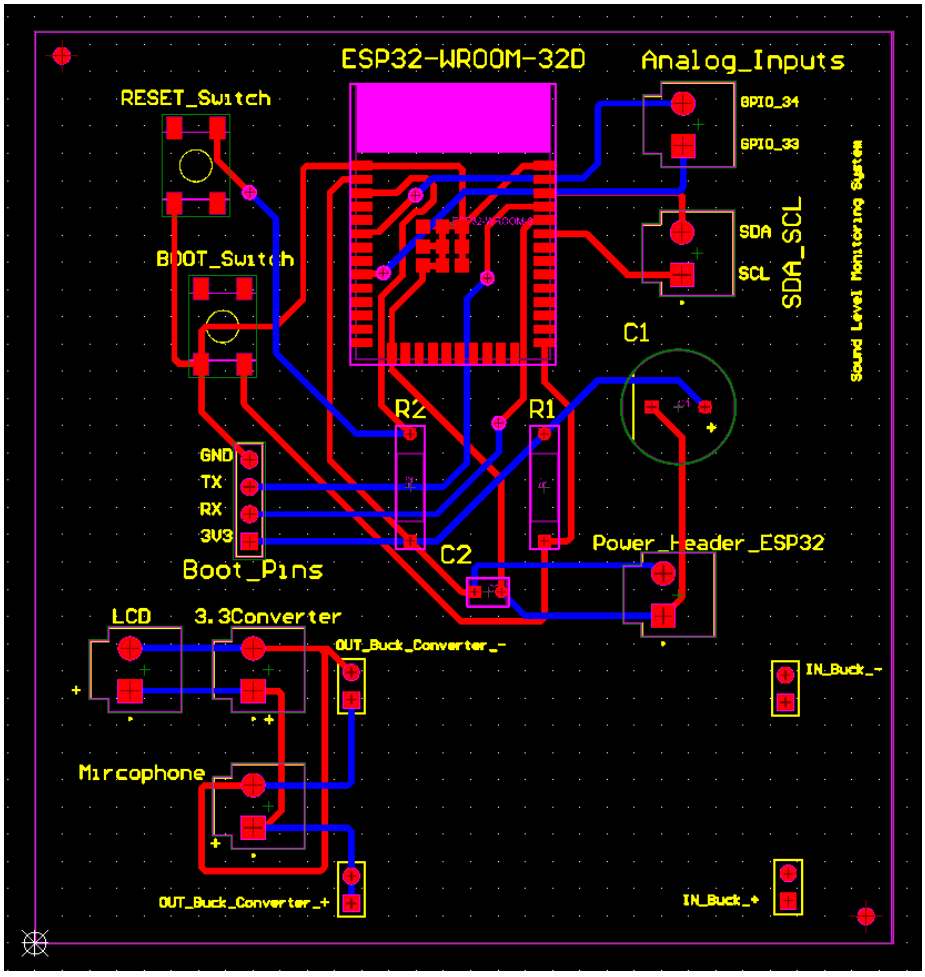
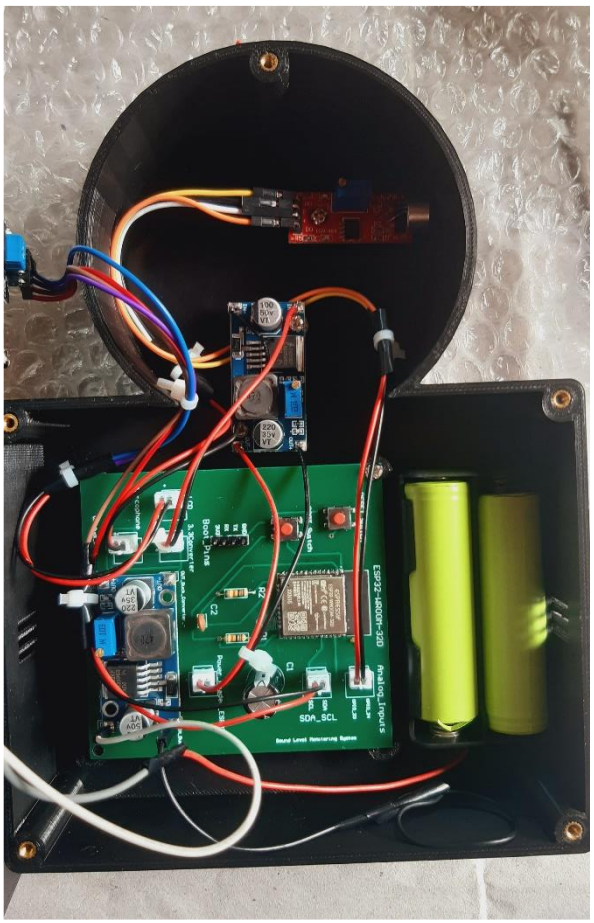
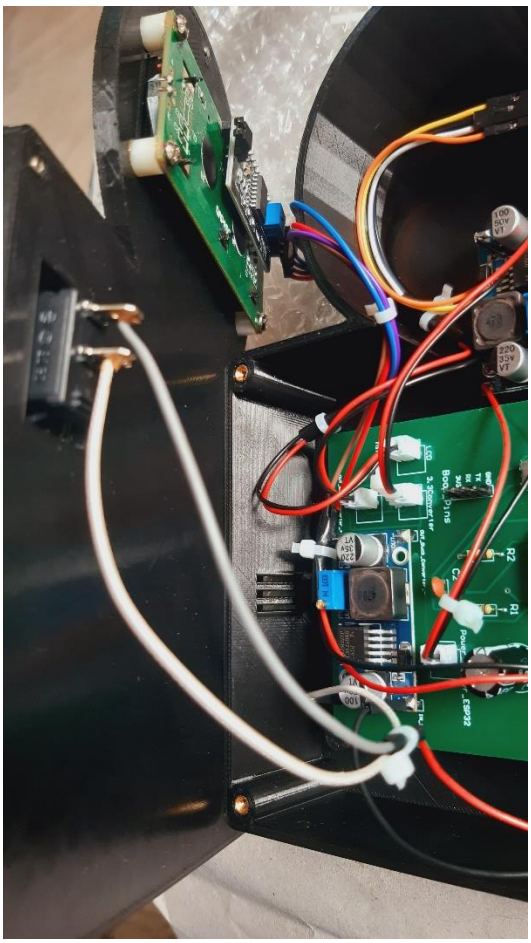
c. PCB design and Gerber Files





14.The Product After Improvements





- The sketch used for the ESP32 is as follows.

```
/* Fill-in information from Blynk Device Info here */
#define BLYNK_TEMPLATE_ID "TMPL6R8cIYZ6A"
#define BLYNK_TEMPLATE_NAME "Quickstart Template"
#define BLYNK_AUTH_TOKEN "DKvORhrPqRP_jFrWe91_ADIEHiUbJ54X"

/* Comment this out to disable prints and save space */
#define BLYNK_PRINT Serial

// Potentiometer is connected to GPIO 34 (Analog ADC1_CH6)
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#include <LiquidCrystal_I2C.h>

//Wifi connection
const char* ssid = "Namina_Wijetunga";
const char* password = "Iamthebest1ever@";
int WiFiStatus;
String Get_WiFiStatus(int Status){
    switch(Status){
        case WL_IDLE_STATUS:
        return "WL_IDLE_STATUS";
        case WL_SCAN_COMPLETED:
        return "WL_SCAN_COMPLETED";
        case WL_NO_SSID_AVAIL:
        return "WL_NO_SSID_AVAIL";
        case WL_CONNECT_FAILED:
        return "WL_CONNECT_FAILED";
        case WL_CONNECTION_LOST:
        return "WL_CONNECTION_LOST";
        case WL_CONNECTED:
        return "WL_CONNECTED";
        case WL_DISCONNECTED:
        return "WL_DISCONNECTED";
    }
}

const int potPin = 34;

// set the LCD number of columns and rows
int lcdColumns = 16;
int lcdRows = 2;
int potValue = 0;

const int sampleWindow = 50;
unsigned int sample;
int db;

// set LCD address, number of columns and rows
```

```
// if you don't know your display address, run an I2C scanner sketch
LiquidCrystal_I2C lcd(0x27, lcdColumns, lcdRows);

BlynkTimer timer;

// This function is called every time the Virtual Pin 5 state changes
BLYNK_WRITE(V5)
{
  int pinValue = param.asInt();
  Blynk.virtualWrite(V5, pinValue);
}

// This function is called every time the device is connected to the Blynk.Cloud
BLYNK_CONNECTED()
{
  // Change Web Link Button message to "Congratulations!"
  Blynk.setProperty(V3, "offImageUrl", "https://static-
image.nyc3.cdn.digitaloceanspaces.com/general/fte/congratulations.png");
  Blynk.setProperty(V3, "onImageUrl",  "https://static-
image.nyc3.cdn.digitaloceanspaces.com/general/fte/congratulations_pressed.png");
  Blynk.setProperty(V3, "url", "https://docs.blynk.io/en/getting-started/what-do-i-need-to-
blynk/how-quickstart-device-was-made");
}

// This function sends device's uptime every second to Virtual Pin 2.
void myTimerEvent()
{
  // You can send any value at any time.
  // Please don't send more that 10 values per second.
  Blynk.virtualWrite(V2, millis() / 1000);
  Blynk.virtualWrite(V5, db);
}

void setup(){

  pinMode (potPin, INPUT);
  // initialize LCD
  lcd.init();
  // turn on LCD backlight
  lcd.backlight();

  //Serial.begin(115200);
  lcd.setCursor(0, 0);
  lcd.println("Welcome");
  lcd.clear();

  WiFi.begin(ssid, password);
  WiFiStatus = WiFi.status();
    while(WiFiStatus != WL_CONNECTED){
    delay(250);
    WiFiStatus = WiFi.status();
```

```
    //lcd.println(Get_WiFiStatus(WiFiStatus));
    //lcd.clear();
    }
  //lcd.clear();
  //lcd.setCursor(0, 0);
  //lcd.print("WiFi Enabled");
  //lcd.clear();

  lcd.setCursor(0, 0);
  lcd.print("Welcome");
  lcd.setCursor(0, 1);
  lcd.print(WiFi.localIP());
  delay(500);

  lcd.clear();
  //Conneting to the Blynk IoT Server
  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, password);
  // You can also specify server:
  //Blynk.begin(BLYNK_AUTH_TOKEN, ssid, password, "blynk.cloud", 80);
  //Blynk.begin(BLYNK_AUTH_TOKEN, ssid, password, IPAddress(192,168,1,100), 8080);

  // Setup a function to be called every second
  timer.setInterval(1000L, myTimerEvent);
}

void loop(){

  Blynk.run();
  timer.run();

  unsigned long startMillis = millis(); // Start of sample window

  float peakToPeak = 0; //peak-to-peak level

  unsigned int signalMax = 0; //minimum value
  unsigned int signalMin = 1024; //maximum value

  // collect data for 50 mS
  while (millis() - startMillis < sampleWindow)
  {

    sample = analogRead(potPin); //get reading from microphone

    if (sample < 1024) // toss out spurious readings
    {
      if (sample > signalMax)
      {
        signalMax = sample; // save just the max levels
      }
      else if (sample < signalMin)
      {
```

```
      signalMin = sample; // save just the min levels
    }
  }
}

peakToPeak = signalMax - signalMin; // max - min = peak-peak amplitude

//Serial.println(peakToPeak);

db = map(peakToPeak, 20, 400, 30, 75); //calibrate for deciBels

lcd.setCursor(0, 0);
lcd.print("Loudness: ");
lcd.print(db);
lcd.print("dB");

if (db <= 40)
{
  lcd.setCursor(0, 1);
  lcd.print("Level: Quite");
}
else if (db > 40 && db < 60)
{
  lcd.setCursor(0, 1);
  lcd.print("Level: Moderate");
}
else if (db >= 60)
{
  lcd.setCursor(0, 1);
  lcd.print("Level: High");
}
delay(600);
lcd.clear();
}
```

- Here, as the IoT platform, Blynk is used and by downloading the Blynk IoT app from Android Play store of Apple Appstore, it can be configured to receive data from the device.
- In the app, the device uptime, real time sound level and the sound level variation over time is shown.

15.Any Instructions for Assembly

- It is recommended to use the following sensor models for accurate measurement of sound and displaying its level.
    i. Microphone module - Voice Sound Detection Mic Sensor Module
    ii. Buck converter - LM2596S 3-40V to 1.5-35V 4A DC to DC Adjustable Step-Down Buck Module

- When removing the lid for battery replacement, careful with the wires which are connected to the LCD display. They may get disconnected if handled carelessly.

16.How to Test for Functionality

- Here are the steps to test for functionality of the sound level monitoring device.

    i. Switch on the device. Then the LCD display will be switched on.
    ii. Wait for 2-3 seconds and the following items will be displayed on the LCD.

This means that the device is connected to the Wi-Fi network and its IP address is displayed.

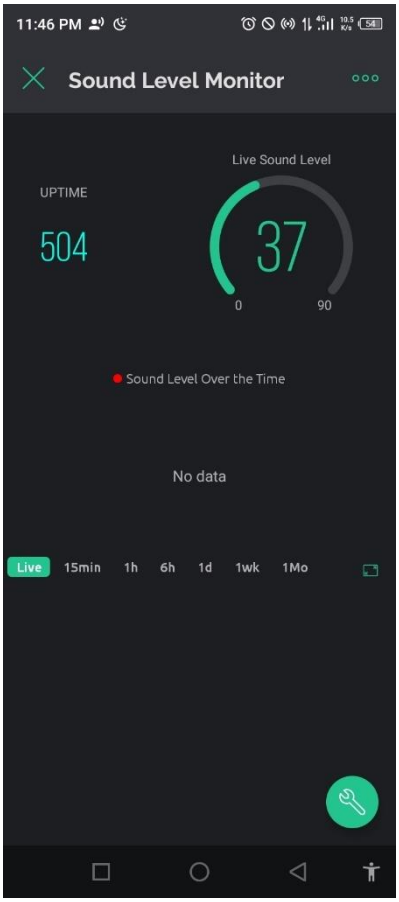
Note: If this is not displayed for more than 10 seconds, switch off the device and again switch on and wait. If that doesn't work, change the batteries to new ones and switch on the device.

iii. Again wait 2-3 seconds and then the sound level and the intensity will be displayed on the LCD screen as follows.

This means that the device is connected to the Blynk server and data is uploaded to the server so it can be accessed through the Blynk app which is installed in the smart phone of the user.

Note: If this is not displayed for more than 10 seconds, switch off the device and repeat step (i).

iv. Open Blynk IoT app in the smart phone and select the sound level monitor to see the real time data coming from the device.



Before Receiving Data

When Receiving Data

v. It is recommended to keep the device switched on all times except during the following occasions.

1. When the location of monitoring is going to be changed.
2. When batteries are about to be drained out.

17.Bill of Materials

Comment	Description	Designator	Quantity	Supplier
TSW-104-08-L-S	0.025" SQ Post Header, Through-hole, Vertical, -55 to 125 degC, 2.54 mm Pitch, 4-Pin, Male, RoHS	Boot_Pins	1	TronicLK
RCER71H104K0DBH03A	Cap Ceramic 100nF 50V X7R ±10% Radial 2.5mm +125°C Ammo Pack	C2	1	Digikey
MBB02070C1002FCT00	RES 10K OHM 0.6W 1% AXIAL	R1, R2	2	Digikey
Header 2	Header, 2-Pin	IN_Buck_-, IN_Buck_+, OUT_Buck_Converter_-, OUT_Buck_Converter_+	4	TronicLK
ESP32-WROOM-32D	WIFI MODULE 32MBITS SPI FLASH	ESP32-WROOM-32D	1	Digikey
EEUFC1A102	Aluminum Electrolytic Capacitors (Radial Lead Type) AEC-Q200 Qualified 1000uF ±20% 10V	C1	1	Digikey
B2P-VH(LF)(SN)	Male Header, Pitch 3.96 mm, 1 x 2 Position, Height 10.9 mm, Tail Length 3.7 mm, -25 to 85 degC, RoHS, Bulk	3.3Converter, Analog_Inputs, LCD, Mircophone, Power_Header_ESP32, SDA_SCL	6	TronicLK
4.30471E+11	WS-TASV SMD Tact Switch 6X6 mm	BOOT_Switch, RESET_Switch	2	Digikey
MD0220	Voice Sound Detection Mic Sensor Module		1	TronicLK
DM0002	1602 16x2 Yellow		1	TronicLK

	Backlight LCD Display			
MD0042	LM2596S 3-40V to 1.5-35V 4A DC to DC Adjustable Step-Down Buck Module		2	TronicLK

Appendix

GitHub Repository for the project - https://github.com/namiwijeuom/Sound-Level-Monitoring-System.git

References

[1] R. Verganti, "Research Summary - Design Driven Innovation," [Online]. Available: https://www.hbs.edu/faculty/Pages/item.aspx?research=7465. [Accessed 4 6 2023].

[2] Engineering Design Centre, Department of Engineering, University of Cambridge, "Inclusive Design Toolkit," [Online]. Available: http://www.inclusivedesigntoolkit.com/GS_overview/overview.html. [Accessed 3 6 2023].