Department of Electronic and Telecommunication Engineering

University of Moratuwa

EN-2160 Electronic Design Realization

Project Report

Name	**Index**
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Acknowledgment

I am very pleasure to submit this report of my project on the Electronic design realization module. I would like to express my heartfelt appreciation to the individuals who played a vital role in enhancing my understanding of this field prior to delving into theoretical concepts.

First and foremost, I extend my sincere gratitude to Dr. Jayathu Samarawickrama and Prof. J.A.K.S. Jayasinghe, the lecturers of the Electronic design realization module, as well as all the senior and junior lecturers who guided me throughout this project. I would also like to acknowledge the lab assistants who provided insightful guidance on lab instruments and offered their assistance in various ways to ensure the successful completion of my project.

I would also like to extend my sincere appreciation to Prof. J.A.K.S. Jayasinghe and Dr. Jayathu Samarawickrama, who imparted their expertise through invaluable lectures, teaching us how professional engineers operate. Their teachings covered a wide range of areas, including analysis, production planning, final product packaging, and marketing planning, providing us with a comprehensive understanding of the process involved in delivering a final product.

Additionally, I would like to express my gratitude to my fellow batch mates who played a significant role in my project's success. Their assistance and ideas in product designing were invaluable, and I deeply appreciate their unwavering support and contributions.

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Abstract

This report presents the development and evaluation of an air quality monitoring device capable of measuring carbon dioxide (CO_2) levels, temperature, and humidity. With the growing concern for indoor air quality and its impact on human health and comfort, the need for accurate and reliable monitoring devices has become paramount.

The project aimed to design a compact and portable device that could provide real-time measurements of CO_2 concentration, temperature, and humidity in various indoor environments. The device incorporates state-of-the-art sensors and utilizes wireless communication technology to transmit data to a user-friendly interface, allowing users to monitor air quality parameters conveniently.

The report details the design process, including the selection and integration of appropriate sensors, the hardware and software implementation, and the calibration and validation procedures. The device's performance was evaluated through extensive testing in controlled environments, comparing its measurements against reference instruments to ensure accuracy and reliability. Results demonstrate that the developed air quality monitoring device effectively captures and reports CO_2 levels, temperature, and humidity in real-time, providing users with valuable insights into indoor air quality conditions. The device's compact size, portability, and user-friendly interface make it suitable for a wide range of applications, including homes, offices, schools, and public spaces.

In conclusion, this project successfully addresses the need for an efficient and affordable air quality monitoring solution. The developed device offers a practical tool for individuals and organizations to monitor and optimize indoor air quality, contributing to healthier and more comfortable living and working environments.

Introduction

Product Goal

In a world increasingly focused on environmental health and well-being, the development of an air quality monitoring device stands as a pivotal advancement. With the growing awareness of indoor air pollution's impact on human health, such a device becomes a crucial tool in safeguarding occupants' well-being within various indoor environments. By providing real-time measurements of key parameters like carbon dioxide levels, temperature, and humidity, this innovative device empowers individuals and institutions to actively assess and improve their indoor air quality. Its potential to foster smart and sustainable living environments further underscores its importance. With the ability to collect valuable data, support research initiatives, and influence policy development, the air quality monitoring device is not just a technological feat, but a catalyst for positive change, encouraging greener practices and promoting healthier living conditions for everyone.

Problem Definition

Air pollution has become a major environmental concern, with adverse effects on human health, ecosystems, and climate. In indoor environments, pollutants such as carbon dioxide, volatile organic compounds (VOCs), particulate matter, and other harmful substances can accumulate and pose health risks to occupants. Poor indoor air quality has been linked to respiratory problems, allergies, asthma, and even more severe health conditions.

Additionally, outdoor air pollution, caused by emissions from vehicles, industries, and other sources, affects the air we breathe in urban areas and beyond. Exposure to high levels of pollutants like fine particulate matter (PM2.5) and nitrogen dioxide (NO_2) can lead to a range of health issues, including respiratory and cardiovascular diseases. By developing an air quality monitoring device, researchers, policymakers, and individuals gain access to real-time data on air quality, enabling them to better understand and address the problem of air pollution. The device empowers people to make informed decisions about their activities, such as adjusting ventilation, avoiding peak pollution times, or taking other measures to reduce exposure to pollutants.

Furthermore, the data collected by these monitoring devices can contribute to research on air pollution's impact, help evaluate the effectiveness of air quality regulations, and guide the development of more targeted and efficient pollution control strategies. the main problem that the air quality monitoring device seeks to solve is the need for accurate and accessible information about air pollution. By providing real-time measurements and insights into air quality, the device aims to mitigate health risks, raise awareness, and promote sustainable practices to improve the overall air quality and well-being of individuals and communities.

Product Details (Air Quality Monitoring Device)

Specifications

- Operating temperature - 0 °C to 70 °C
- Rechargeable and Compact Size Charging - micro-USB interface with 500mAh battery
- 1.34" inch LED display
- CO_2 detection range - 100ppm to 10000ppm
- CO_2 detection Sensitivity - 5ppm
- CO_2 Accuracy - ± 30ppm
- Humidity detection range - 20 - 90% RH
- Humidity detection Sensitivity - 1%RH
- Humidity Accuracy - ± 5%RH
- Temperature detection Range - 0 °C to 50 °C
- Temperature detection Sensitivity - 1 °C
- Temperature Accuracy - ± 1 °C
- Size - width = 4.5 cm, length = 8 cm, height = 6 cm

Extra Features

- This device is small and lightweight so you can place it anywhere in your room.
- This product is not affected by any power cuts as the device has a rechargeable battery.
- As an additional implementation for this product for dust-rich countries near the equator, we add a dust sensor to detect the dust concentration in the environment.

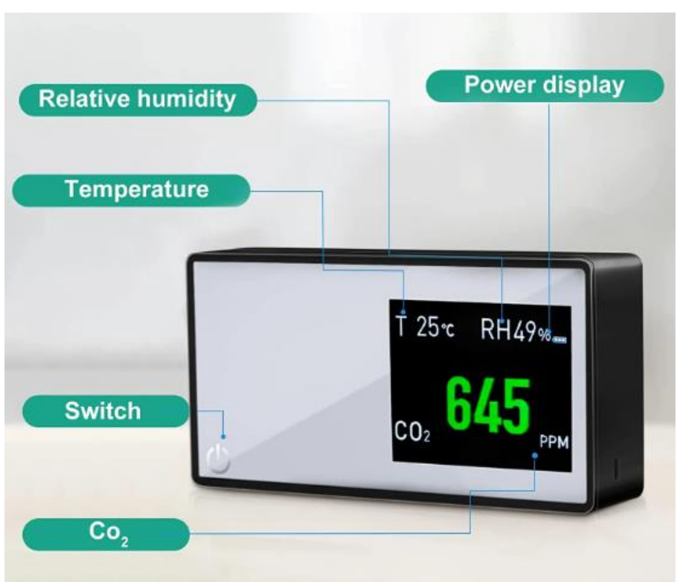
Main Components and Modules

- Atmega328P IC
- MQ135 Air Quality Sensor
- DHT11 temperature and humidity Sensor
- Optical Dust sensor
- TP4056 Charging Module
- MT3608 step-up boost converter
- 1.34” OLED Display
- 500 mAh rechargeable battery

Same Products in the Market

There are several products available in the market related to air quality monitoring devices. These devices come in various forms, from compact indoor monitors to portable handheld devices and even smart home integrated solutions. But That products have some constraints, and they are very expensive.

There are some products that measure CO_2 Concentration, temperature, and Humidity such thing that devices do not tell the overall idea of the air quality. That means when considering CO2, humidity, and temperature parameters the device should tell the user whether air quality is good or bad. Some devices do not tell that. Also, some devices are made without recharging and using replaceable alkaline batteries. It is not always compatible with a display because it consumes power all the time and drains the power from the battery. Therefore, the user needs to replace the batteries frequently. These are some products in the market.



This device real-time measures the CO2 concentration, temperature, and Humidity. But the device is too big relative to the display and there is unnecessary blank space in front of the device. Also, it measures the CO2 concentrations, and it displays the ppm value to the user. Users are not familiar with ppm values, and they need the overall air quality measurement. It is a failure of this device. In the international market, the price of this type of air quality monitor is USD 35$. It is a high price for this type of device.

This is another product on the international market. It also measures the CO2 concentration, temperature, Humidity such things.

This device has a user-friendly interface but when considering the functionality this device operates by replaceable alkaline batteries. It is not environment-friendly and cost-effective for the user.

Therefore, a lot of product in the international market has some constraints and there is a small number of products that fulfill the user's needs, on the other hand, most of the time they are very complicated and difficult to operate by an ordinary person. Therefore, I thought of designing a new product, integrating and modifying the available products and concepts.

Project aim

The primary aim of developing an air quality monitoring device is to create a cutting-edge solution that effectively measures and monitors crucial air quality parameters in indoor environments. With the growing concern over air pollution and its impact on human health and the environment, the project seeks to address this pressing issue by providing accurate, real-time data to individuals, businesses, and institutions. The device aims to ensure the accurate measurement of key air quality parameters, including carbon dioxide (CO2) levels, temperature, and humidity. This accuracy is paramount in providing reliable information that users can trust when making decisions related to their health and well-being.

In a world where rapid changes in air quality can occur due to various factors, having access to up-to-date information becomes indispensable. By enabling users to access real-time data on pollutant levels and environmental conditions, the device empowers them to take immediate actions to mitigate potential risks and optimize their living and working spaces.

By combining accurate data collection, real-time monitoring, and user-friendliness, the project aspires to contribute to a healthier and more sustainable world. The air quality monitoring device aims to play a pivotal role in raising awareness about air pollution, empowering individuals to make informed choices, and facilitating the implementation of effective measures to improve air quality for generations to come.

Project Objectives

The air quality monitoring device, incorporating the MQ135 gas sensor, DHT11 humidity and temperature sensor, ATmega328P microcontroller, and OLED display, operates on a well-defined working principle to accurately measure and display air quality parameters. Each component plays a crucial role in the process, culminating in a comprehensive air quality monitoring solution.

At the heart of the device is the MQ135 gas sensor, specifically designed to detect various air pollutants, such as VOCs and ammonia. As the air interacts with the sensor, its resistance undergœs changes proportional to the concentration of the target gas. This alteration in resistance generates an analog voltage signal, which the ATmega328P microcontroller interprets for further processing. Supplementing the gas sensor's data is the DHT11 humidity and temperature sensor. Employing a digital interface, the DHT11 communicates the current environmental temperature and humidity readings to the ATmega328P. These two vital parameters contribute to a holistic understanding of the air quality and its potential effects on human health.

Serving as the central processing unit, the ATmega328P analyzes the analog and digital data received from both sensors. By leveraging its onboard Analog-to-Digital Converter (ADC), the microcontroller converts the MQ135's analog voltage signal into digital values. Concurrently, it interprets the DHT11's digital readings, executing necessary calculations and calibrations to derive meaningful air quality values.

The culmination of data processing is the OLED display, which acts as the primary interface for users to interact with the device. Through seamless communication with the ATmega328P, the OLED presents the real-time air quality data in a visually appealing and easily interpretable format. The OLED ensures users can readily comprehend the current air quality status.

The air quality monitoring device operates continuously, repeatedly sampling the air quality and updating the displayed data. With this continuous monitoring capability, users can observe fluctuations in air quality over time, empowering them to identify patterns and make informed decisions to optimize indoor air conditions or avoid outdoor pollution. By combining gas sensing, temperature and humidity measurements, data processing, and user-friendly visualization, this device serves as a valuable tool in enhancing awareness and promoting healthier living environments.

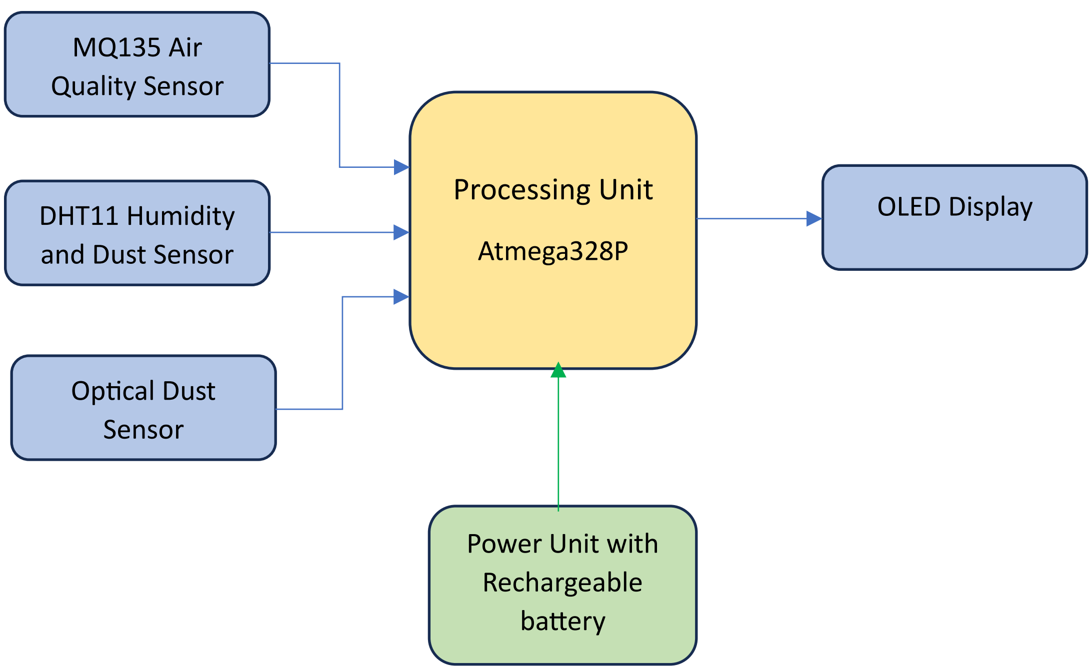
Design Procedure

The product aims to design the project with high functionality and a user-friendly interface. The product measures the carbon dioxide gas and ammonia gas concentrations ppm values and gives the overall quality of the air by considering those parameters. And it gives the real-time temperature and humidity in the environment. The product is consistent with a rechargeable battery and the battery power lasts longer than a day. The product is easy to operate, with no need to calibrate after starting up, it can work and detect automatically.

In the conceptual design stage, I designed the block diagrams of the project and hand sketches of the enclosure design. I consider three block diagrams that show different functionalities and different methods to implement the project and hand sketches of the enclosure shows the different types of enclosure that I can design for this project.

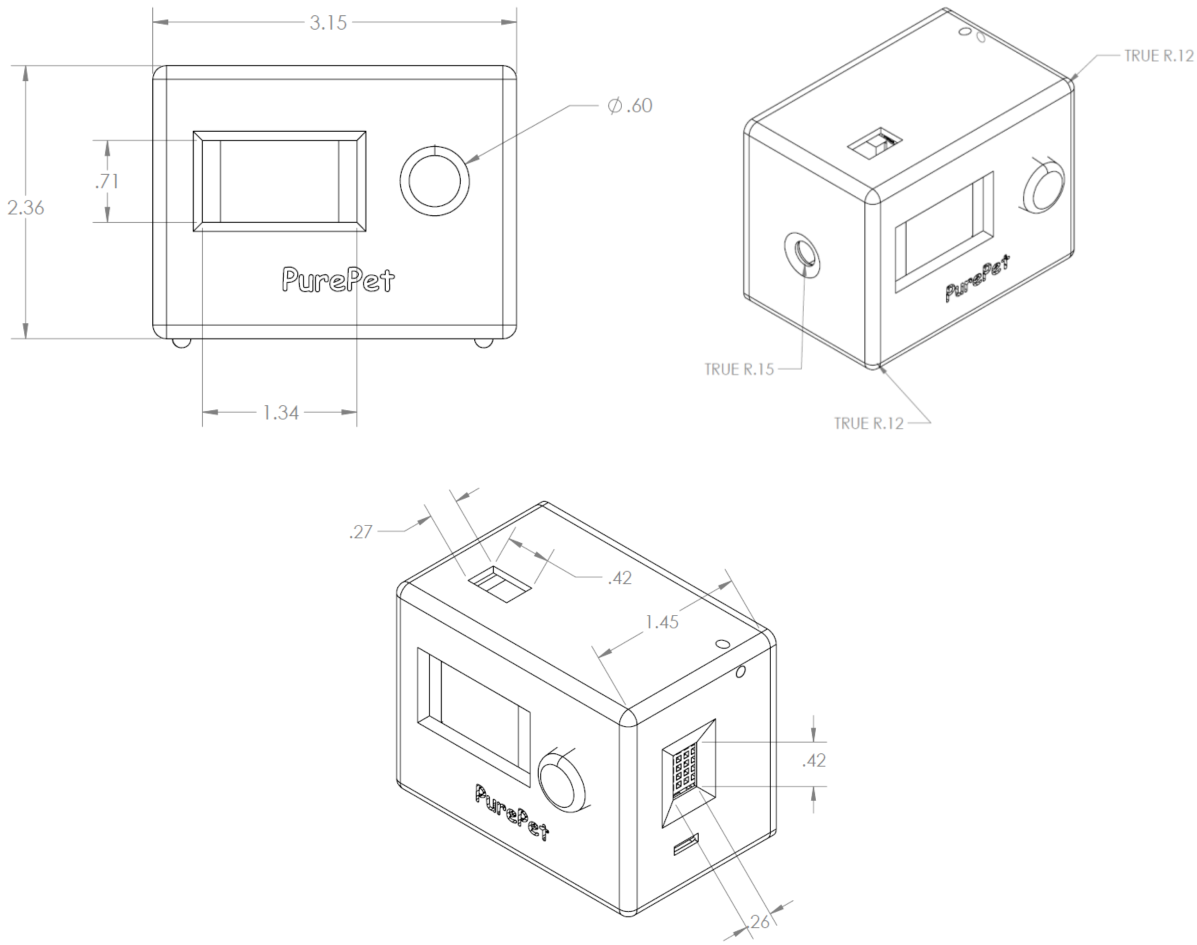
Block diagrams of the functionality

The following block diagram of the functionality is the conceptual design related to my air quality monitoring device project.



Enclosure Sketches

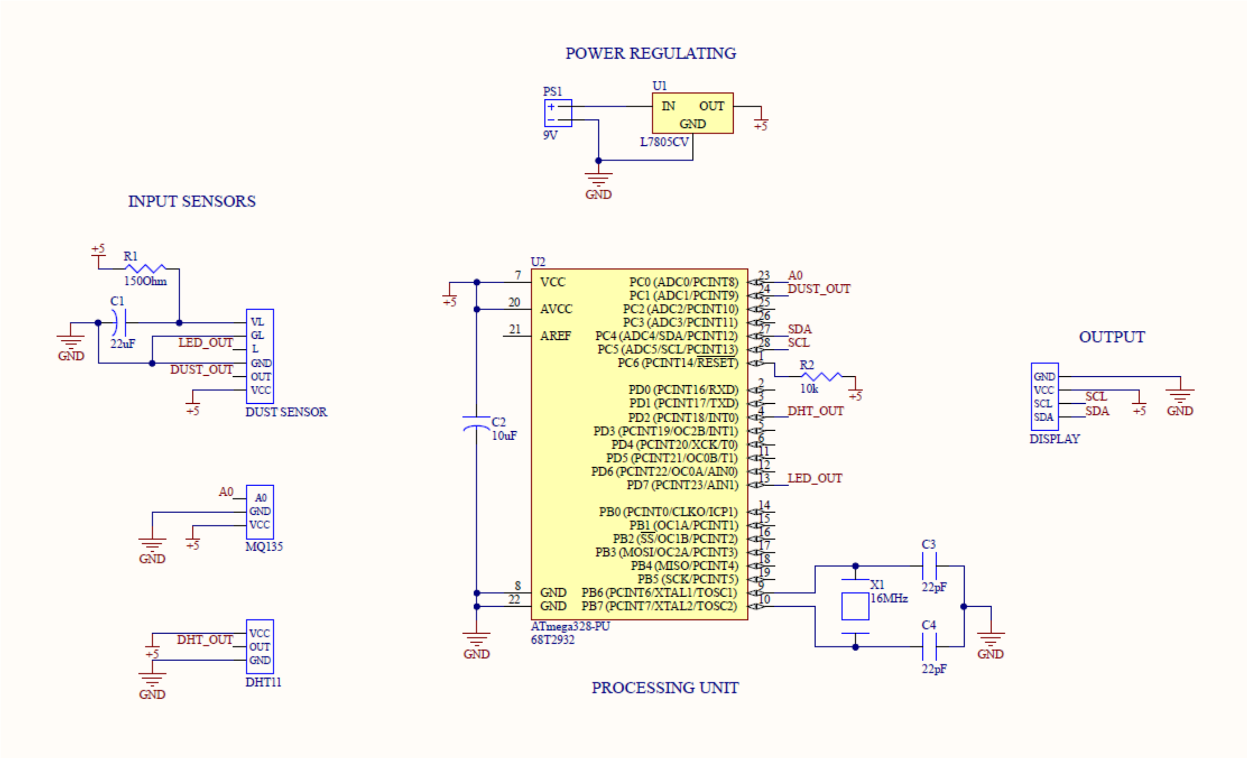
The following sketch of the enclosure is the conceptual design related to my air quality monitoring device project.



Circuit Design Procedure

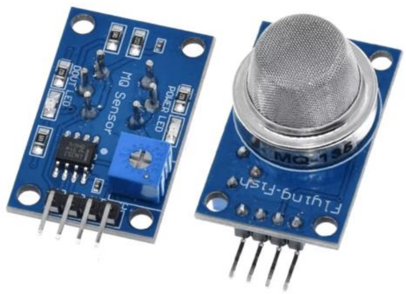
After deciding on the block diagram of the product, I designed the Schematic design and PCB design using Altium design software and PCB imported from JLC PCB in China.

Schematic Diagram



Input Sensors

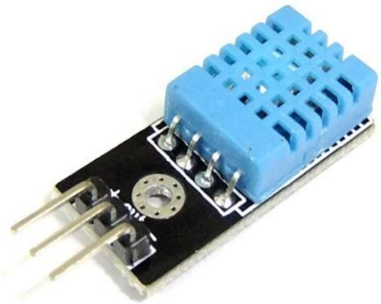
1) MQ135 Air Quality Sensor



The MQ135 air quality sensor plays a critical role in the air quality monitoring device mentioned above. Its primary use is to measure the concentration of carbon dioxide (CO_2) in the air, a significant indicator of indoor and outdoor air quality. By detecting CO_2 levels, the MQ135 sensor provides valuable information about the presence of pollutants and the overall air pollution in the environment.

The device uses the MQ135 sensor's output, which is an analog voltage signal proportional to the CO_2 concentration, and feeds it to the ATmega328P microcontroller. The microcontroller processes this signal using its onboard Analog-to-Digital Converter (ADC) to obtain digital values representing CO_2 levels.

2) DHT11 Temperature sensor



The DHT11 sensor serves a crucial role by measuring the ambient temperature and humidity levels in the environment. While the MQ135 sensor primarily detects carbon dioxide (CO2) levels, the DHT11 sensor complements the device's capabilities by providing additional essential parameters related to air quality. By incorporating the DHT11 sensor into the device, it enables a more comprehensive assessment of the indoor or outdoor air quality. Temperature and humidity are significant factors that can influence human comfort and health. High humidity levels can lead to a stuffy and uncomfortable environment, while low humidity may cause dryness and respiratory discomfort. Monitoring temperature is essential for maintaining comfortable living and working conditions, especially in extreme weather conditions.

The DHT11 sensor communicates with the ATmega328P microcontroller using a digital interface, providing real-time temperature and humidity readings. The microcontroller processes this data along with the CO2 concentration data from the MQ135 sensor.

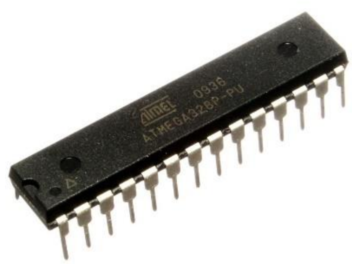
3) Optical dust Sensor

The optical dust sensor is a valuable addition that provides essential information about particulate matter (PM) levels in the air. Optical dust sensors are designed to detect and quantify the concentration of fine particles suspended in the atmosphere. By incorporating an optical dust sensor into the air quality monitoring device, it expands the range of pollutants being measured. While the MQ135 sensor focuses on CO2 levels and the DHT11 sensor measures temperature and humidity, the optical dust sensor complements these measurements by detecting and quantifying airborne particulates.

Particulate matter, especially fine particles with a diameter of 2.5 micrometers (PM2.5) or smaller, can have significant health implications when inhaled. These particles can penetrate deep into the respiratory system and potentially cause respiratory and cardiovascular problems. Monitoring PM2.5 levels is crucial in assessing air quality and its potential impact on human health.

The optical dust sensor operates by emitting a light source, and when particles pass through the beam of light, they scatter the light. The sensor then measures the scattered light, and the data is processed to determine the concentration of particulate matter in the air. Integrating an optical dust sensor with the ATmega328P microcontroller allows users to access real-time PM2.5 data along with CO_2 levels, temperature, and humidity readings. This comprehensive air quality data enables individuals to gain insights into the presence of airborne particulates and make informed decisions to safeguard their health and well-being.

Processing Unit



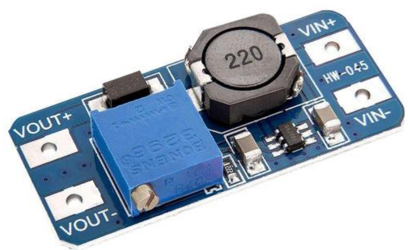
Atmega328P, The processing unit of the air quality monitoring device operates as the central brain, orchestrating the interaction with the connected sensors to provide accurate and comprehensive air quality measurements. The first step involves data acquisition from the MQ135 gas sensor, which generates an analog voltage signal representing the concentration of carbon dioxide (CO_2) in the air. The ATmega328P utilizes its onboard Analog-to-Digital Converter (ADC) to convert this analog data into digital values, enabling precise CO_2 level readings.

In tandem with the MQ135, the ATmega328P communicates with the DHT11 humidity and temperature sensor through digital protocols. By requesting and receiving temperature and humidity readings, the microcontroller obtains crucial environmental data. Digital communication ensures seamless and accurate transmission of sensor data to the microcontroller, contributing to reliable air quality measurements. Following data acquisition, the processing unit undertakes data processing and calibration. Through calibration algorithms, the microcontroller refines the raw sensor readings, compensating for sensor inaccuracies and variations in the surrounding environment. This calibration process ensures the accuracy and reliability of the air quality measurements, fostering confidence in the device's data output.

Once the data is processed and calibrated, the ATmega328P conducts real-time analysis of the air quality parameters. It continuously monitors the current CO2 levels, temperature, humidity, and, if applicable, PM2.5 concentrations in the environment. Comparing these readings with pre-defined thresholds, the microcontroller can detect any deviations or potential air quality issues, providing users with timely alerts and notifications. Interfacing with the user interface, specifically the OLED display, the processing unit formats the processed air quality data into a user-friendly format. This information is then displayed on the OLED screen, presenting real-time numerical values to convey the current air quality status at a glance. Users can effortlessly interpret the displayed data, enabling them to make informed decisions and take appropriate actions based on the air quality readings.

Power Unit

TP4056 Charging Module



Step up Boost Converter

Rechargeable Battery

The power unit of the air quality monitoring device project incorporates a 3.7V rechargeable lithium-ion battery as its primary power source. This battery is chosen for its high energy density and ability to provide a stable power supply to the device. To ensure the efficient charging of the battery, a TP4056 charging module is integrated into the power unit. The TP4056 module facilitates safe and controlled charging, preventing overcharging and protecting the battery from potential damage. To meet the power requirements of the device's components, including the ATmega328P microcontroller, sensors (such as MQ135, DHT11, and optional optical dust sensor), and the OLED display, a step-up boost converter is employed. This boost converter efficiently increases the battery's voltage from 3.7V to the required 5V, providing a stable and regulated power supply to the entire system.

The power unit's configuration allows for a portable and self-sustaining air quality monitoring device. The 3.7V rechargeable battery ensures mobility, enabling users to monitor air quality in various locations without the need for a continuous external power source. Moreover, the TP4056 charging module ensures safe battery charging, preventing potential hazards associated with overcharging and prolonging the battery's lifespan.

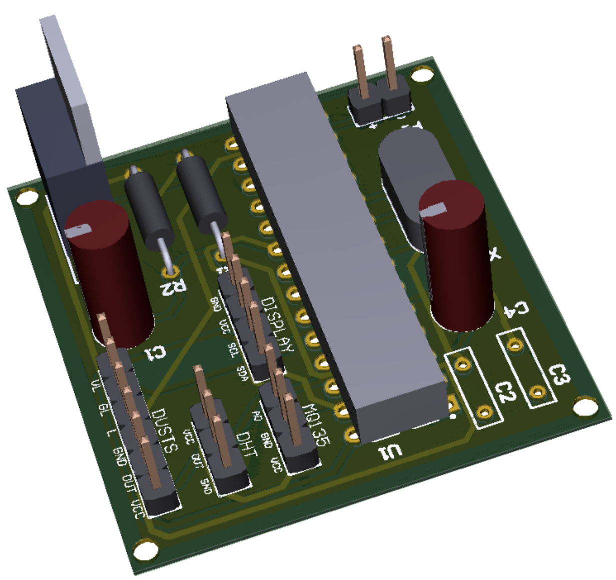
The step-up boost converter plays a crucial role in providing the necessary voltage to power the device's components. By efficiently converting the battery's voltage to the required 5V, it ensures optimal performance and reliable operation of the microcontroller, sensors, and OLED display.

Output OLED Display

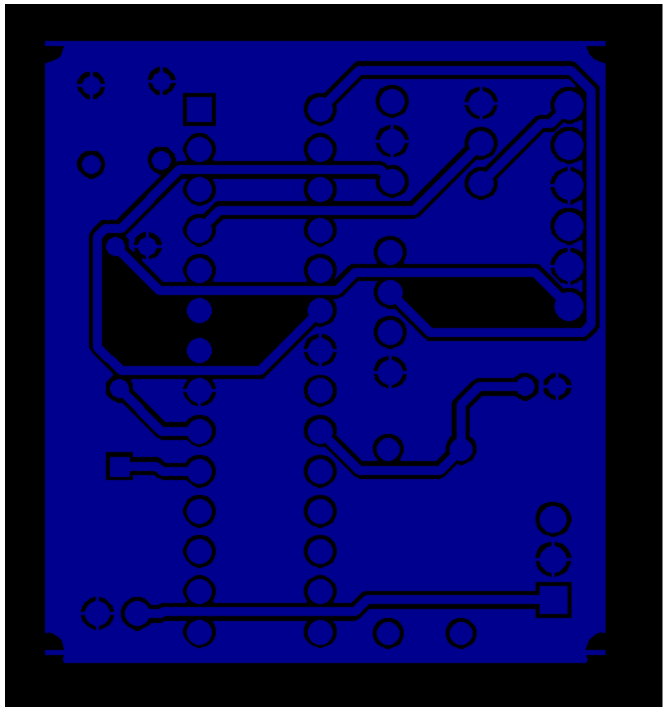
The OLED (Organic Light Emitting Diode) display serves as the user interface in the air quality monitoring device project. Its primary use is to visualize real-time air quality data and provide users with immediate feedback on environmental conditions. The inclusion of the OLED display offers several important benefits. Real-Time Data Presentation: The OLED display allows users to see the current air quality readings instantly. The device continuously updates and shows the CO2 levels, temperature, humidity, and, if applicable, PM2.5 concentrations, enabling users to assess the air quality in real time.

PCB Layouts

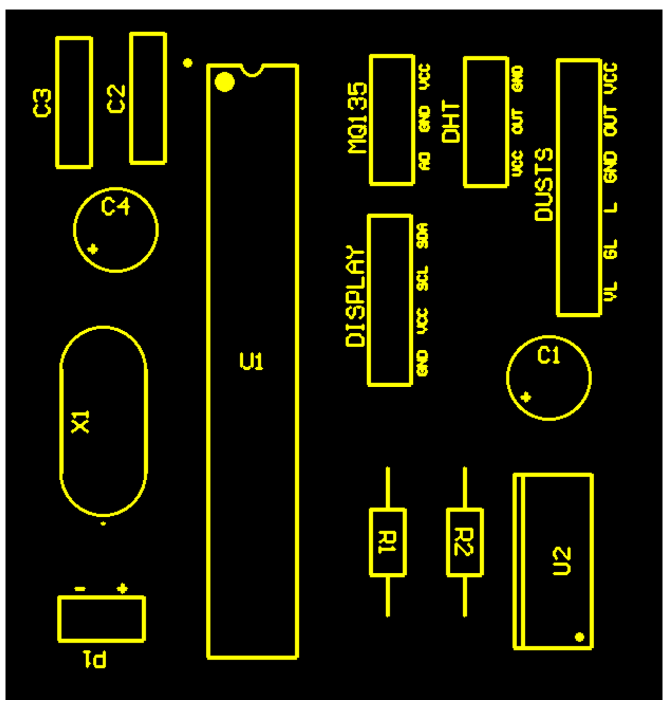
1) **3D model of PCB**



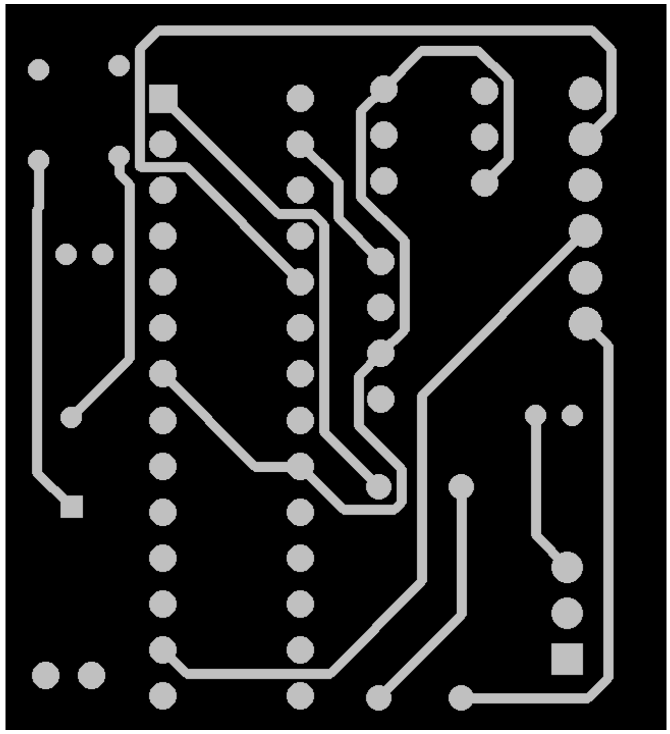
2) Gerber File Outputs



Copper Signal Bottom Gerber File

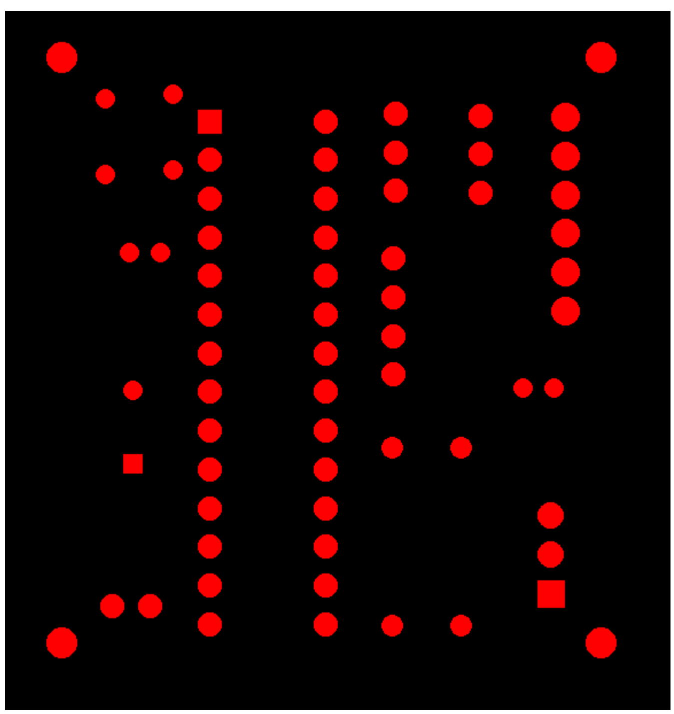


Top assembly Gerber File



Copper Signal Top Gerber

3) NC drill file Output



Bill of Materials (BOM)

Generated BOM by Altium designer

Component list

Bill of Materials for Project [AirQualityMonitor.PrjPcb] (No PCB Document Selected)

Source Data From: AirQualityMonitor.PrjPcb
Project: AirQualityMonitor.PrjPcb
Variant: None

Report Date: 4/23/2023 10:38 AM
Print Date: 23-Apr-23 10:50:06 AM

Contact:
AK Anuradha
anuradhaak.20@uom.lk
GitHub - https://github.com/askanuradha

EDR Project

#	Category	Manufacturer 1	Manufacturer Part Number 1	Footprint	Description	Quantity	Supplier 1	Supplier Part Number 1	Supplier Order Qty 1	Supplier Stock 1	Supplier Unit Price 1	Supplier Subtotal 1	Supplier Currency 1
1	Microcontrollers	Microchip	ATMEGA328PU	28P3	8-bit AVR Microcontroller, 32KB Flash, 1KB EEPROM, 2KB SRAM, 28-pin PDIP, Industrial Grade (-40°C to 85°C)	1	Avnet	68T2932	1	398	2.61	2.61	USD
2	Voltage Regulators	STMicroelectronics	L7805CV	TO220	Positive Voltage Regulator, 5V, 3-Pin TO-220	1	Digi-Key	497-1443-5-ND	1	41281	0.69	0.69	USD
3	Through-Hole Resistors	Ohmite	OC1K151E-TR	RESI	Res 150 Ohm 10% 1.2W Axial	1	Mouser	588-OC1K151E-TR	1	1000	4.62	4.62	USD
4	Sensors	SparkFun	SEN-17049	MQ135	Smoke Sensor - MQ-2	1	Digi-Key	1568-SEN-17049-ND	1	46	5.50	5.50	USD
5	Aluminum Electrolytic Capacitors	Rubycon	450BXC10MEFC10X20	10uF	BXC Series 450 V 10 µF 10x20mm Aluminum Electrolytic Capacitor	1	Digi-Key	1189-1894-ND	1	253692	0.71	0.71	USD
6	Aluminum Electrolytic Capacitors	Rubycon	450BXW22MEFR12.5X20	10uF	Cap Aluminum 22uF 450V 20% (12.5 X 20mm) Radial Aluminum Cylindrical Can 5mm 280mA 10000 hr 105°C Bulk	1	Digi-Key	1189-2936-ND	1	99001	1.59	1.59	USD
7	Batteries and Accessories	Adafruit Industries	1578	POWER	Lithium Ion Polymer Battery - 3.7v 500mAh	1	Digi-Key	1528-1841-ND	1	826	7.95	7.95	USD
8	Crystals and Oscillators	Diodes	GB1600032	GB1600032	Crystal 16MHz ±30ppm (Tol) ±30ppm (Stability) 30pF FUND 40Ohm 2-Pin Thru-Hole Bag	1	Digi-Key	GB1600032-ND	1	533	0.52	0.52	USD
9	LCD, OLED, Graphic Displays	Adafruit Industries	938	DISPLAY	Monochrome 1.3 128x64 OLED graphic display - STEMMA QT / Qwiic	1	Digi-Key	1528-1512-ND	1	36	19.95	19.95	USD
10	Mica Capacitors	Cornell Dubilier	CD5EC220JO3F	22pF	Capacitor; Mica; Cap 22pF; Tol 5%; Radial Miniature DIPped; Vol-Rtg 300VDC; LS 3.0mm	2	Digi-Key	338-2650-ND	2	978	3.82	7.64	USD
11	Sensors	Socle Technology	GP2Y1010AU0F	DUSTS	GP2Y1010AU0F Series 5.5 V 10 mA Compact Optical Dust Sensor (46 X 30 X 17.6 mm)	1	Digi-Key	1855-1012-ND	1	2206	12.37	12.37	USD
12	Sensors	DFRobot	DFR0067	DHT	Temperature Humidity Sensor, Arduino Rohs Compliant: Yes	1	Digi-Key	1738-1089-ND	1	16	7.90	7.90	USD
13	Through-Hole Resistors	Stackpole Electronics	CF14JT10K0	RESI	Res Carbon Film 10K Ohm 5% 0.25W(1/4W) - 500ppm/±to 0p|	1	Digi-Key	CF14JT10K0CT-ND	1	4110	0.10	0.10	USD
						14			14			72.15	

Approved

Notes

1 pcs: **Total** **72.15 USD**
Price for 1pcs 72.15 USD

BOM with different modules not connected to the PCB

Part	Quantity	Supplier	Unit Price (USD)	Sub Total (USD)
Atmega328P IC	1	Avnet	2.61	2.61
L7805CV Regulator	1	Digi-Key	0.69	0.69
150 Ohm resistor	1	Mouser	4.62	4.62
MQ135 Air quality sensor	1	Digi-Key	5.50	5.50
10uF capacitor	1	Digi-Key	0.71	0.71
22uF capacitor	1	Digi-Key	1.59	1.59
500mAh Li-ion Battery	1	Digi-Key	7.95	7.95
16MHz Oscillator	1	Digi-Key	0.52	0.52
1.34” OLED display	1	Digi-Key	19.95	19.95
22pF capacitor	2	Digi-Key	3.82	3.82
Optical Dust sensor	1	Digi-Key	12.37	12.37
DHT11 sensor	1	Digi-Key	7.90	7.90
10K resistor	1	Digi-Key	0.10	0.10
MT3608 step-up booster	1	Pololu	24.95	24.95

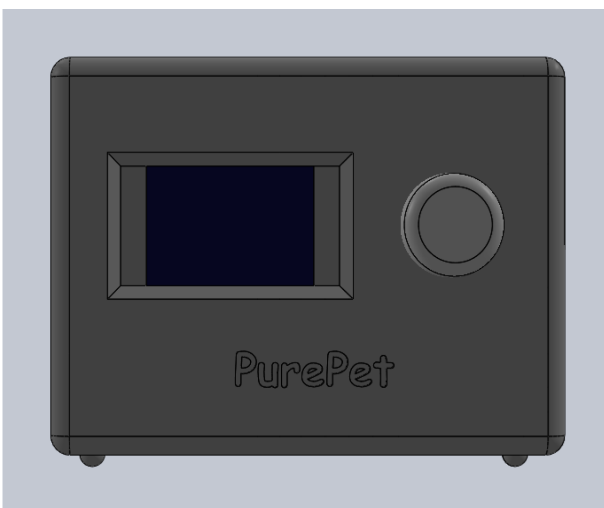
TP4056 Charging module	1	Mouser	5.90	5.90

Total = 103 USD

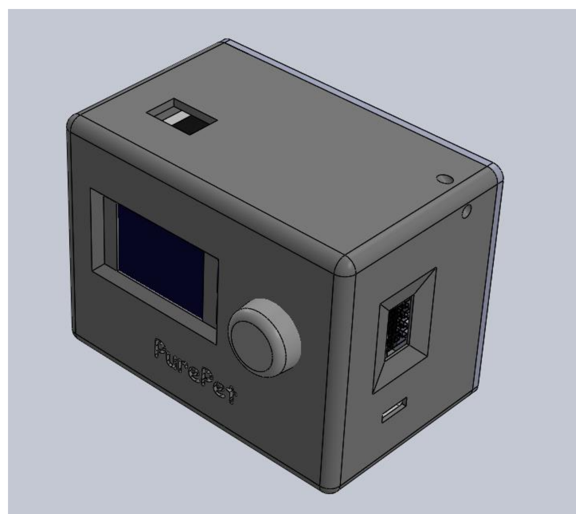
Enclosure Design Procedure

In the conceptual design stage, I drew the hand sketches of the enclosure and then considered the performance matrices of each enclosure design hand sketch and selected the below design. In the preliminary design stage, I planned to design the interior of the enclosure with proper dimensions. Then after these all stages, I made the solid works part files, assembly files, and mold design files.

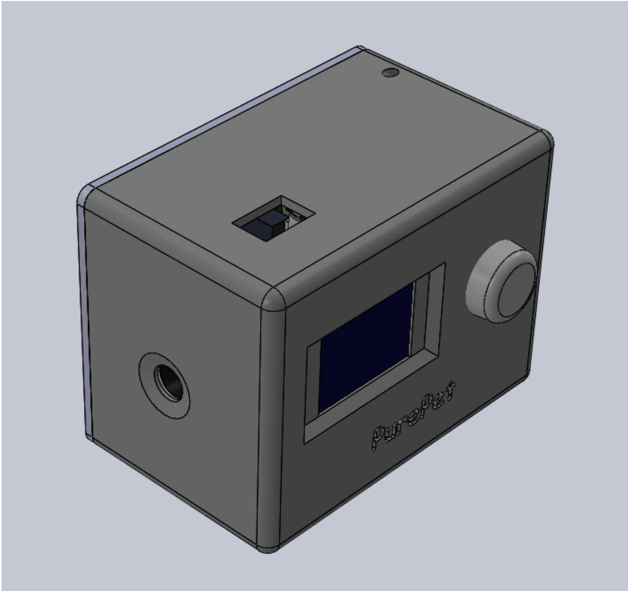
Collapsed view of Solidworks assembly file



Front View



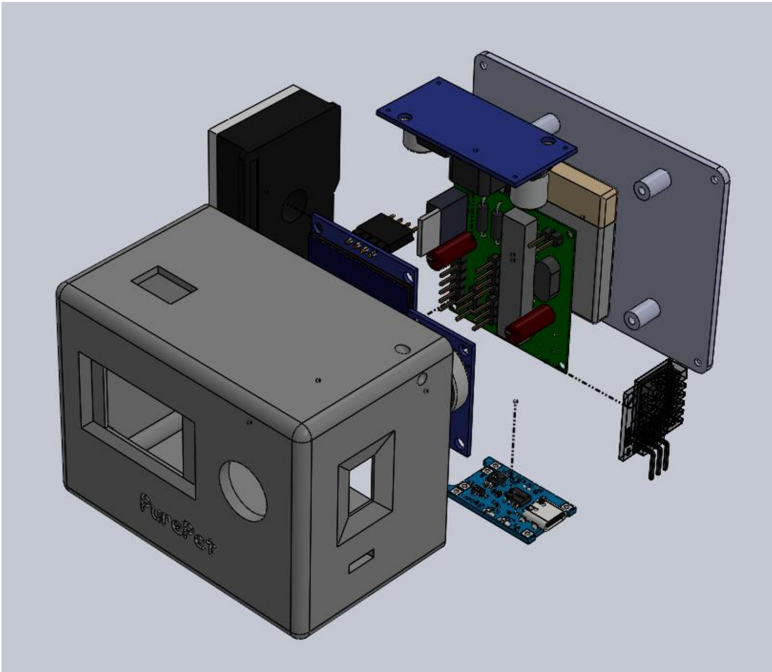
Isometric View

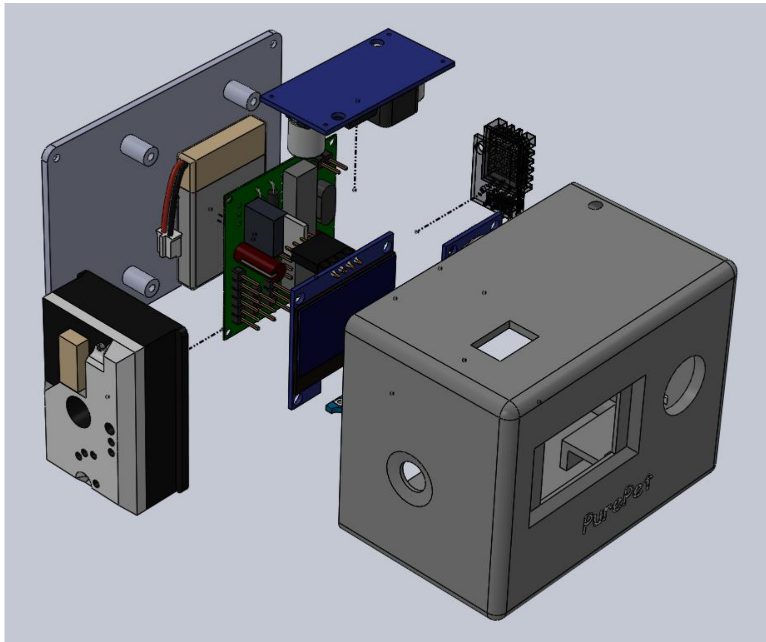


Isometric View 2

There are two parts to the Solidworks assembly file. The upper part contains all the components carriers other than the battery and PCB. The below part is a flat part and these two parts are connected through the 2 mm screws.

Exploded view of Solidworks assembly file





The above screenshots show the exploded view of the project and it contains all the modules that we need to build the project. The gray color parts are the enclosure and we need to design it using 3D printing or molding.

Assembly Procedure

The following instructions are used for the assembly of the sensors, PCB, battery, and Enclosure.

1. Prepare the Enclosure Parts: Start by laying out the two parts of the enclosure. Ensure that all holes and cutouts for the sensors, display, and PCB are aligned correctly.

2. Mount the Sensors and Display: Place the MQ135, DHT11, and optional optical dust sensor onto their designated positions on the enclosure. Secure each sensor in place using 2mm nuts. Next, position the OLED display on the PCB, aligning it with the appropriate cutout on the enclosure part. Fasten the display in place using 2mm nuts.

3. Secure the PCB: Carefully place the PCB inside the below part of the enclosure. Align the mounting holes on the PCB with those on the enclosure part. Use 2mm nuts to firmly attach the PCB to the enclosure.

4. Connect Wires: The sensors and the display require wiring connections, carefully route and connect the cables to the JST ports. Ensure that the connections are secure and well-organized to avoid any interference with the other components.

5. Additional Checks: Double-check all connections, sensor positions, and display alignment. Ensure that the two parts of the enclosure are tightly secured with the 2mm nuts to avoid any potential movement.

6. Power Source: The project uses a rechargeable 3.7V lithium-ion battery, insert it into the designated slot in the latter enclosure. Connect the battery to the TP4056 charging module for charging and power management.

7. Testing: Before closing the enclosure completely, power on the device and perform thorough testing to verify that all components are functioning correctly. Test the sensors, display, and microcontroller to ensure they are providing accurate air quality readings.

8. Secure the Enclosure: Once satisfied with the functionality and accuracy of the device, securely fasten the remaining 2mm nuts to fully close the two-part enclosure. Make sure there are no gaps that might compromise the device's integrity.

9. Final Inspection: Perform a final inspection to check for any loose connections, wires, or components. Verify that the device is fully functional and ready for use.

Testing the product

- When the device checks the stage, we can check temperature readings by increasing the temperature to some known level and check if it shows the correct value.
- In The humidity-checking stage, we can put the product in an environment with a known humidity level and check the product shows the same level of humidity level.
- In the air quality checking stage, the product should measure the CO2 level and smoke level, then it shows the overall air quality on the display. When we put the product near a flame we can see the product shows air quality is bad because of the increasing CO2 level and smoke particles in the environment
- The dust detection checking stage, the sensors in the product detect the dust and when the dust concentration gœs high, it shows the air quality is bad. When we try to put the product in a particles-rich area (powder-rich area) it shows the air quality is poor or bad because of the dustiness.
- Overall checking stage, we can put the product in a clean air environment and see is it show the air quality is good.

Arduino Code for the Project

```
#include <SPI.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include  <Adafruit_SSD1306.h>
#include <Fonts/FreeSans9pt7b.h>
#include <Fonts/FreeMonoOblique9pt7b.h>
#include "MQ135.h"
#include  <DHT.h>
#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define  SCREEN_HEIGHT 64 // OLED display height, in pixels

#define OLED_RESET     4  // Reset pin # (or -1 if sharing Arduino
reset pin)
Adafruit_SSD1306 display(SCREEN_WIDTH,  SCREEN_HEIGHT, &Wire,
OLED_RESET);

#define sensor    A0
#define DHTPIN  2          // Digital pin 2
#define DHTTYPE DHT11     // DHT 11

int gasLevel  = 0;         //int variable for gas level
String quality ="";
DHT dht(DHTPIN,  DHTTYPE);
MQ135 gasSensor = MQ135(A0);


int measurePin = A1; //Connect dust sensor to Arduino A1 pin
int ledPower = 7;   //Connect 3 led driver pins of dust sensor to
Arduino D7

int samplingTime = 280;
int deltaTime = 40;
int sleepTime = 9680;

float voMeasured = 0;
float calcVoltage = 0;
float dustDensity = 0;
```

```
void dustSensor() {
  float ppm = gasSensor.getPPM();
  digitalWrite(ledPower,LOW); // power on the LED
  delayMicroseconds(samplingTime);

  voMeasured = analogRead(measurePin); // read the dust value

  delayMicroseconds(deltaTime);
  digitalWrite(ledPower,HIGH); // turn the LED off
  delayMicroseconds(sleepTime);

  // 0 - 5V mapped to 0 - 1023 integer values
  // recover voltage
  calcVoltage = voMeasured * (5.0 / 1024.0);

  // linear eqaution taken from
http://www.howmuchsnow.com/arduino/airquality/
  // Chris Nafis (c) 2012
  dustDensity = 170 * calcVoltage - 0.1;

  display.setTextColor(WHITE);
  display.setTextSize(1);
  display.setFont();
  display.setCursor(0, 43);
  display.println("Dust :");
  display.setCursor(40, 43);
  display.println(dustDensity);
  display.setCursor(74, 43);
  display.println("ppm");
  display.setCursor(0,  56);
  display.println("CO2  :");
  display.setCursor(40, 56);
  display.println(ppm);
  display.setCursor(74, 56);
  display.println("ppm");
}

void sendSensor()
{
  float h = dht.readHumidity();
  float t = dht.readTemperature();
```

```
  if (isnan(h) || isnan(t)) {
  Serial.println("Failed  to read from DHT sensor!");
    return;
  }
  display.setTextColor(WHITE);
  display.setTextSize(1);
  display.setFont();
  display.setCursor(0, 43);
  display.println("Temp  :");
  display.setCursor(50, 43);
  display.println(t);
  display.setCursor(84, 43);
  display.println("C");
  display.setCursor(0,  56);
  display.println("RH    :");
  display.setCursor(50, 56);
  display.println(h);
  display.setCursor(84, 56);
  display.println("%");
}

void air_sensor()
{
  gasLevel = analogRead(sensor);

  if(gasLevel<181){
    quality = "  GOOD!";
  }
  else if (gasLevel >181 && gasLevel<225){
    quality =  "  Poor!";
  }
  else if (gasLevel >225 && gasLevel<300){
    quality  = "Very bad!";
  }
    else if (gasLevel >300 && gasLevel<350){
    quality  = "ur dead!";
  }
    else{
    quality = " Toxic";
}

  display.setTextColor(WHITE);
```

```
  display.setTextSize(1);
  display.setCursor(1,5);
  display.setFont();
  display.println("Air Quality:");
  display.setTextSize(1);
  display.setCursor(20,23);
  display.setFont(&FreeMonoOblique9pt7b);
  display.println(quality);
}

void setup() {
  Serial.begin(9600);
  pinMode(sensor,INPUT);
  dht.begin();
  if(!display.begin(SSD1306_SWITCHCAPVCC, 0x3D)) { // Address  0x3D
for 128x64
    Serial.println(F("SSD1306 allocation failed"));
}
  display.clearDisplay();
  display.setTextColor(WHITE);

  display.setTextSize(2);
  display.setCursor(50, 0);
  display.println("Air");
  display.setTextSize(1);
  display.setCursor(23, 20);
  display.println("Qulaity monitor");
  display.display();
  delay(1200);
  display.clearDisplay();

  display.setTextSize(2);
  display.setCursor(50, 20);
  display.println("EDR");
  display.display();
  delay(1000);
  display.clearDisplay();
}

void loop() {
  display.clearDisplay();
  air_sensor();
```

```
  sendSensor();
  display.display();
  delay(3000);
  display.clearDisplay();
  air_sensor();
  dustSensor();
  display.display();
  delay(3000);
}
```

References

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