DESIGN A MONITORING SYSTEM TO MEASURE HEALTH HAZARDS THROUGH ROUTE MAPPING USING AIR AND WEATHER QUALITY

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A Final Year Design Project (FYDP) submitted to the Department of Electrical And Electronics Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering

Department of Electrical and Electronic Engineering
Brac University

August 2023

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August 2023

Declaration

It is hereby declared that

1. The Final Year Design Project (FYDP) submitted is my or our own original work while completing a degree at Brac University.
2. The Final Year Design Project (FYDP) does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project (FYDP) does not contain material that has been accepted or submitted for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all the main sources of help.

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Approval

The Final Year Design Project (FYDP) titled "DESIGN A MONITORING SYSTEM TO MEASURE HEALTH HAZARDS THROUGH ROUTE MAPPING USING AIR AND WEATHER QUALITY"
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Summer 2023 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Electrical and Electronic Engineering on August 26, 2023.

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Ethics Statement

The plagiarism index result of this report is 11%. The Similarity Check has been conducted Officially With the help of our supervisor.

Abstract/ Executive Summary

Health hazards resulting from air pollution have become a significant health concern around the world. This final-year design project report presents the development and implementation of air quality monitoring and mapping systems to measure health hazards and provide real-time data through route mapping based on air quality. The objective of this project is to design and develop a comprehensive monitoring and mapping system that integrates data from various sensors to assess health hazards along specific routes within the environment. We have designed a multisensor network that collects data on the contents of the air. The sensors will measure the temperature, humidity, ammonia, carbon dioxide, carbon monoxide, and particulate matter, or PM2.5, including the date, time, and exact position. And in addition to this, the data will be implemented on a map that will show different colors for different levels of pollution. This will make the users aware of the road situation, and as a result, they will be able to take proper precautions or take alternate routes to their destination. The monitoring and mapping system will make significant advancements in public health and environmental monitoring. It will empower its users to proactively protect their health by choosing safer routes based on real-time data. Moreover, this system will assist its stakeholders, such as city planners, in identifying areas with consistently poor air quality or high health hazards so that they can make improvements to such areas.

Keywords: Monitoring System, Air quality, Health hazards, Route mapping, Pollution.

Dedication

To the sources of our development, knowledge, and unflinching assistance, we dedicate this project to you, our beloved parents and teachers, with the utmost thanks and affection. Your unending support has been the wind beneath our wings, guiding us toward achievement and knowledge. You have been our beacon of greatness, leading us through every obstacle. We owe a debt of gratitude to our parents, whose selfless love and unwavering commitment helped mold us into the people we are today. Your unshakable faith in our abilities has given us the self-assurance to follow our ambitions without hesitation. Your sacrifices have strengthened our resolve to live up to your expectations. You are the masterminds behind shaping our minds with knowledge and fostering our curiosity, according to our instructors. Your kindness, wisdom, and enthusiasm for sharing information have made a lasting impression on our hearts and brains.

This effort is a monument to the virtues of patience, dedication, and the quest for knowledge that you have ingrained in us. We hope it adequately conveys how much we value the crucial role you've played in our lives.

Acknowledgement

We owe a debt of gratitude to Dr. Md. Mosaddequr Rahman, the head of our ATC panel and professor and chair of the department of electrical and electronic engineering at BRAC University, as well as to Mohaimenul Islam and Aldrin Nippon Bobby, lecturers in the same department, for aiding us with our design project from our senior year. Their advice has helped us go forward with the idea we have chosen. We are particularly grateful to Mohaimenul Islam, sir, for your assistance with the creation and operation of the system, data gathering, issue resolution, and several paperwork-related concerns. Relevant guidance turned out to be vital and crucial for the development of our project. Additionally, he was a comforting and understanding presence throughout the entire year. Our shoulders were lifted off a tremendous amount of stress, allowing us to operate more freely and effectively.

Last but not least, we want to express our sincere gratitude to our parents for helping us out financially and other times during our final year design project. Even though there were ups and downs along the way, our trust in our ATC members and the support from our parents helped us get to this point. We all worked very hard as a team to successfully complete this one-year project.

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1.1 Introduction

Air pollution is rising day by day, and health complications are increasing. As per the report of the WHO and IHME's Global Burden of Disease Study, air pollutants present in the air cause over 6 million deaths per year. These deaths are attributed to both indoor and outdoor pollution. Particularly in its capital city of Dhaka, which frequently ranks among the most polluted metropolitan places in the world, Bangladesh has suffered from continuously bad air quality. Rapid urbanization, industrial emissions, traffic pollution, and seasonal elements like crop burning and weather are the main causes of this issue. High concentrations of particulate matter, particularly PM2.5, pose serious health concerns to the general public and can cause respiratory ailments and other associated conditions. The promotion of cleaner energy sources, stronger emissions restrictions, and public awareness programs are just a few of the actions Bangladesh is taking to tackle air pollution, but making long-lasting changes in this heavily populated and developing country is still a difficult undertaking. In order for the public to readily learn about air quality and prevent health issues, it can be more useful and advantageous to develop a system that can inform us of the location and air quality of a given place. In order to do that, we created a system that analyzes air pollutants, displays their current location using GPS, and communicates with the server via GSM. Particulate matter (PM2.5), ammonia (NH_3), carbon dioxide (CO_2), carbon monoxide (CO), temperature, and humidity are just a few of the air pollutants that the planned monitoring system will be able to detect in real time using a network of strategically placed sensors. The sensors use cutting-edge sensing techniques to assure their position over a network and accurate readings across a wide range of pollution concentrations, including optical-based particle sensors, gas-specific sensors, GPS, and GSM.

1.1.1 Problem Statement

Dhaka is one of the cities in Bangladesh that has experienced rapid economic growth. Industrial advancement plays a crucial role in this. The two most widely cited and regularly dated estimates for the death toll from air pollution come from the World Health Organization (WHO) and the IHME's Global Burden of Disease study. Their latest estimates are very close to each other; they estimate 7 million and 6.7 million deaths per year, respectively [5]. These deaths are attributed to both indoor and outdoor pollution, which, as explained below, stems from both man-made and natural sources of air pollution. But the outcome is air pollution, which is a major issue for a country like Bangladesh. Air pollution is a global risk factor for sickness and death. Additionally, the degree of ambient air quality as well as the air quality in homes and workplaces becomes a crucial component of projected deaths. In Dhaka city, approximately 23,300 people live per Km^2. And the amount of pollution that occurs is appalling [11]. There have been several research studies across different cities in Bangladesh that investigated the air quality and showed that air pollution mainly contains nitrogen dioxide (NO2), sulfur dioxide (SO), carbon monoxide (CO), ozone (O), and carbon dioxide (CO2). But there is another particle making the air harmful, which is PM2.5. It is fine particulate matter, which is an air pollutant that is a concern for people's health when levels in the air are high. According to studies, a healthy level of PM2.5 is 12 g/m3 or less, with little to no harm from exposure. The air is deemed harmful if the quantity reaches or exceeds 35 g/m3 over the course of a 24-hour period and can be problematic for people who already have breathing conditions like asthma. PM2.5 concentrations in Dhaka are currently 14 times the WHO annual air quality guideline value. Because of these compounds, people have suffered, and around 19,000 deaths occurred in Dhaka in 2021. Dhaka's annual average PM2.5 value for 2019 was 83.3 g/m3, placing it in the category of "unhealthy" air quality, which is defined as having a PM2.5 reading between 55.5 and 150.4 g/m3 [8]. With readings significantly higher than the annual average, such as January's record high of 181.8 g/m3, which placed it in the "extremely unhealthy" range (150.5 to 250.4 g/m3), this grade is indicating that the air quality is actually unhealthy to breathe. According to the U.S Air Quality Index Categories, a chart of PM concentration in Dhaka city is given below. [13]

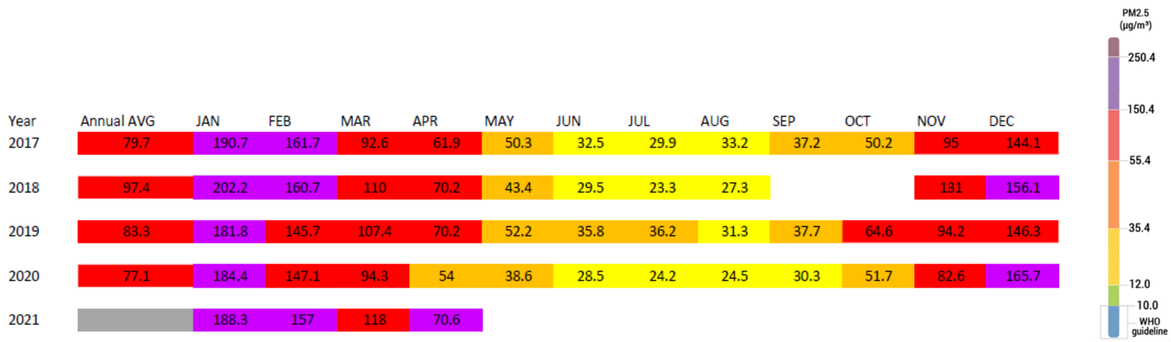


Figure 1.1: Average annual and monthly PM2.5 concentrations in Dhaka, color-coded by the U.S. Air Quality Index.

In Dhaka city, there are many offices and educational institutions where officers and students go. And they often take the same route to get to their destination. But due to severe air pollution, they suffer different types of breathing problems that can be lethal if not treated well. The annual report on air quality can give some information, but that would not be much of a convenience for their daily lives.

[3][4][7]To observe the daily behavior of the air quality, a portable monitoring device would be significant, as it would collect the data from the transit routes and make a map of the routes that he or she had taken [6]. In the current state of the country, maintaining a healthy life has become a key point. This device will monitor and take data, send it to cloud storage, and store it. Then a mapping system will take the data of each route that has been taken and implement it in a mapping system [2].

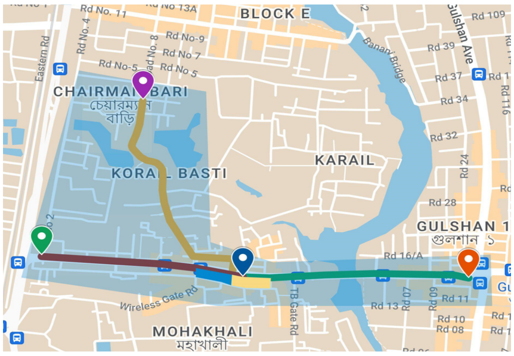


Figure 1. 2: Data collection path

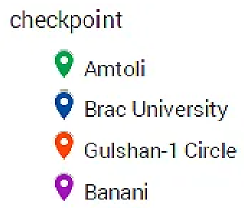


Figure 1.3: Checkpoints

In this project, the device will collect data for mapping the routes using customizable software. But if we want to implement it on a large scale directly through satellite, then it can be a game changer as it will automatically embed the data in the map and people can easily access it. Also, it will be convenient for them to just see the air quality for different times and dates before getting out, like when they see the map for traffic jams and take the fastest route to their destination.

1.1.2 Background Study

Previously, we encountered a problem with the air quality. For this problem, the solution is to make a device that will measure the air quality and be incorporated into a mapping system. In this phase, we have designed multiple approaches that meet the requirements and objectives of the problem's solution. For this initial stage, a brief knowledge base is needed so that we can understand and design multiple approaches. Articles, literature reviews, and journals are ideal sources to get an appropriate understanding of the design and further analysis.

Before proceeding to device development, it is important to implement circuit simulation to ensure whether the electronic designs will perform as expected or not, and to do so, we will be utilizing the electronics circuit simulation software to check whether the design models of different parameters of electronics components are used to replicate the performance and behavior of the circuit. Since we are developing an air quality monitoring and mapping system that will measure the air pollutants present in the air and implement them on a map, it is important to do the simulation first.

For simulation, there are several simulation tools on the market. As for our design, the most appropriate simulation software is MATLAB, Proteus, Autodesk Eagle, and CircuitLab. Which simulation software is suitable for performing analysis for all the design approaches that must be sorted out first. Then, to run the software, basic skills and knowledge are needed. From our research and learning, we learned that it is a complete development platform, from product concept to design completion. We also need to make sure that essential tools, libraries, and components are present or not for this development phase.

Figure 1.4: Proteus, Eagle, MATLab, and CircuitLab (simulation software)

For the 3D design part, there are several design programs present. To find the appropriate design software for that, we need to gather information on how to design the solution and whether it will be user-friendly. For design, Blender, AutoCAD, AutoDesk MAYA, and TinkerCAD are more useful than the other 3D design software. As this part is new to us, the first task is to gather knowledge and skills about these design tools.

Then comes the mapping part. For manual mapping, there are several websites and applications available on the internet. And also from our research, we learned that Scribble Maps, which is a mapping tool that allows users to map locations, draw on maps, annotate maps, export to various file types, share maps, and more, is much more user-friendly and easier to use. And if we want to do an automatic mapping system that will show the collected data automatically in the mapping system, GIS mapping with QGIS is also an option for streaming real-time data. It can also create a heatmap with the data that is connected to the map in the QGIS system. Similar to QGIS, ARCGIS and EsriGIS are also present to perform a similar kind of operation. But to show the real-time data in the map, we need to build our own algorithm so that the components the device measures will be converted to AQI, and that will be shown in the map, which will take time to develop. As part of our project, we will try to implement it with a physical map with all the measurements shown on the map. For that, the Google Map, which is very easy to use and basic, can be linked with the collected data. So for this part, a set of information is needed to choose the perfect mapping system software.

Figure 1.5: scribble maps

Figure 1.6: Google Maps

Figure 1.7: QGIS

And in the last phase, we will gather the materials and other necessary components that are relevant to the project to design the optimum solution.

1.1.3 Literature Gap

Systems for measuring air quality are crucial tools that are employed globally to control air pollution levels, safeguard public health, and provide information for environmental laws. These systems typically consist of a carefully placed network of sensors and monitoring stations in urban centers, industrial areas, and rural areas. They monitor a number of air pollutants, such as particulate matter (PM2.5 and PM10), carbon monoxide (CO), sulfur dioxide (SO2), etc. Thanks to the real-time data gathered from these sensors that is relayed to centralized databases, citizens may stay informed about the state of the air quality conditions and take necessary actions, such as limiting outdoor activities on days with poor air quality.

The sophistication and scope of air quality monitoring systems vary globally. Developed nations with vast and well-established networks of monitoring stations, such as the United States, Canada, and European countries, provide comprehensive and current information on air quality. On the contrary, some developing countries might only have infrastructure for monitoring, making it difficult to correctly measure and manage air pollution. Nevertheless, there has been a drive for better air quality monitoring on a worldwide scale recently as a result of heightened awareness of the dangers that air pollution poses to human health. International organizations like WHO have set air quality guidelines and are trying to encourage nations to invest in this field and reduce pollution levels, making air pollution monitoring a vital component.

But after going through research papers, we have encountered a lack of focus on providing this facility at all income levels. In most Asian countries, where a significant portion of the population is from lower- to middle-income families, they cannot afford it. The private companies that make air quality monitoring devices only focus on their perspective. Also, we have seen that very little research has been conducted about integrating the air quality measurements into the mapping system. Which still needs to be on sight.

1.1.4 Relevance to current and future Industry

Due to their ability to solve urgent environmental issues and improve public health, air quality monitoring systems coupled with route mapping technology hold substantial importance for both existing and future businesses. In many metropolitan areas nowadays, air pollution is becoming a bigger concern and is a factor in a number of health issues. When used in conjunction with route planning, real-time air quality monitoring devices may offer both consumers and businesses useful information. Commuters have access to the most recent information on the state of the air along their preferred routes, enabling them to make well-informed choices regarding their daily travel arrangements, such as selecting cleaner air routes or altering their timetables. Route mapping must incorporate air quality monitoring for sectors dependent on mobility, such as logistics and delivery services. It helps them plan their journeys more effectively while minimizing exposure to polluted regions, minimizing vehicle wear and tear, and enhancing driver health. Additionally, these systems may be used by companies that operate in regions with strict emissions rules to guarantee compliance and lower possible fines.

These devices will play an even bigger role in the future as worries about climate change and air quality continue to grow. Governments and regulatory agencies are anticipated to enact higher emission requirements, necessitating the adoption of greener transportation techniques by companies. A proactive strategy to fulfill these changing needs while also lessening the carbon impact of transportation operations is air quality monitoring using route mapping. Additionally, as autonomous cars proliferate, including current air quality data in their navigation systems can assist these vehicles in selecting the safest and cleanest routes, thus enhancing the sustainability of transportation networks.

In summary, the way that businesses and individuals navigate and address air pollution concerns is about to be revolutionized by the integration of route mapping and air quality monitoring technologies. They position the industry for a cleaner, more sustainable future in addition to providing immediate benefits like better commutes and more effective transportation. These solutions will be essential tools for companies trying to remain ahead of the curve and contribute to a greener, healthier world as environmental concerns and legislation continue to change.

1.2 Objectives, Requirements, specifications, and constants

As the world leaps toward the industrial revolution, many countries, like Bangladesh, are facing the problem of air pollution and have been noted as some of the most populated cities in the world. That general mass is suffering from various diseases that happen to be fatal for them and even sometimes lead to death. To reduce that, we are going to develop a system that will show the level of air pollutants in a specific location. By doing so, an individual will be able to identify which route he or she should take for safer travel. And as the rates of death from air pollutants increase, it will decrease, ensuring that one adjusts their lifestyles by avoiding routes that are polluted.

1.2.1. Objectives

- To make an air quality monitoring device that will be portable.
- Collection of data from a specific area at a specific time.
- Storing the collected data on a website
- Implement the collected data into a customizable mapping system.
- Making a map of the air quality in that specific area or transit route

1.2.2 Functional and Nonfunctional Requirements

Functional Requirements:

Functional requirements are needed to achieve the project objective.

- **Portability:** This device can be carried from one place to another with ease.
- **Location:** Around 1–2 km (roads to cover: Brac University to Titumir College, Brac University to Gulshan 1 Circle, and Gulshan 1 Circle to DCC Market) for testing the device in a real-life scenario.
- **Particulate Matter ($PM_{2□.5}$ and PM_{10}):** This subsystem should be able to detect particulate matter in the air.
- **Gas Sensors:** This subsystem will detect gases such as NH3, PM2.5, CO2, and CO2 in the atmosphere or air.
- **Power Supply:** It should have low power consumption for a long period of time.
- **Remote Accessibility:** This should send all the collected data from the device to the website portal.
- **Location tracking:** Location will be shown via GPS module
- **Data Processing System:** This will act as the CPU to control all the subsystems.

<u>Non-Functional Requirements:</u>
Non-functional requirements are only for ease of usage purposes.

- **Size and Weight:** The device must be compact for carrying and also be light in weight.
- **Color:** The device can be any color, as there are no standards for this. But for cost-effectiveness, white will be ideal.
- **Outer Layer:** This should protect the device from external damage.

1.2.2 Specifications

TABLE 1.1: Component specifications of our designed prototype

System	Subsystem Requirements	Components	Specifications
Air Quality Monitoring System and PM detection	Microcontroller	Node MCU (ESP WROOM-32)	● **Microcontroller:** ESP Wroom32 ● **Operating Voltage:** 2.2–3.6 V ● **Digital I/O Pins:** 39 ● **Analog input Pins:** 4 (pins 36, 39, 34 and 35) ● Single- or Dual-Core 32-bit LX6 Microprocessor with clock frequency of up to 240 MHz. ● **SRAM:** 520 KB ● **WiFi:** 802.11 b/g/n Wi-Fi connectivity with speeds up to 150 Mbps ● **ADC/DAC:** Up to 18 channels of 12-bit SAR ADC and 2 channels of 8-bit DAC ● **Pins GPIO:** 34 Programmable GPIOs ● **Serial Connectivity:** 4 x SPI, 2 x I2C, 2 x I2S, 3 x UART ● 1 Host controller for SD/SDIO/MMC and 1 Slave controller for SDIO/SPI ● Motor PWM and up to 16 channels of LED PWM.
	Particulate Matter (PM) detection	GP2Y1010AU0F	● **Operating Voltage:** 3.3V–7V ● **Output Voltage:** 0-4.2V ● **Operating Current:** 11mA (ort.) to 20mA (maks.)

			Size: 46mm x 30mm x 17.6mm **Particle Measurement Range: Up to 500 µg/m³** **Working Temperature: -**10°C to 60°C
Gas Detection	Carbon Dioxide(CO_2)	MQ-135 Gas Sensor	**Operating Voltage:** +5V **Analog Output Voltage:** 0-5V **Digital Output voltage:** 0–5 V (TTL Logic) **Size:** 35mm x 22mm x 23mm (length x width x height) **Power consumption:** 150 mA **Detection:** NH_3, NOx, CO_2, Alcohol, Benzene, Smoke
	Carbon Monoxide(CO)	MQ-7 Gas Sensor	**Operating Voltage:** 5V **Range:** 10–1000 ppm **Sensitivity:** ≥ 3% **Detection:** CO **Power Consumption:** 150 mA
	Ammonia(NH_3)	MQ-135 Gas Sensor	**Operating Voltage:** +5V **Analog Output Voltage:** 0-5V **Digital Output voltage:** 0–5 V (TTL Logic) **Size:** 35mm x 22mm x 23mm (length x width x height) **Power consumption:** 150 mA **Detection:** NH_3, NOx, CO_2, Alcohol, Benzene, Smoke
Temperature and Humidity	Temperature and Humidity sensors	DHT-11	**Working Voltage:** 3.3-5V **Temperature Measurement Range:** 0–60 ° C **Humidity measurement range:** 20–90% RH **Response Time:** less than 5 seconds **Weight:** 0.6 g

Internet Connectivity	Sim networkConnectivity	Sim800L	• **Quad-Band:** 850/900/1800/1900 MHz • **Supply Voltage:** 3.4V ~ 4.4V • **Support:** 3.0V to 5.0V logic level • **Size:** 23mm x 35mm x 5.6mm • **Power Consumption:** 1mA in sleep mode • **GPRS multi-slot class 12 connectivity:** GPRS multi-slot class 12 connectivity: • **Controlled by AT Command:** 3GPP TS 27.007, 27.005, and SIMCOM enhanced AT Commands • **SIM card socket:** microSIM (bottom side) • **Antenna connector:** IPX • **Status signaling:** LED • **Working temperature range:** -40 to 85 ° C
Map	Location Tracking	GPS module Neo-6M	• **Receiver Type:** 50 channels, GPS L1 (1575.42 MHz) • **Horizontal Position Accuracy:** 2.5m • **Navigation Update Rate:** 1 HZ (5 Hz maximum) • **Capture Time: Cool start:** 27s Hot start: 1s • **Navigation Sensitivity:** -161dBm • **Communication Protocol:** NMEA, UBX Binary, RTCM • **Serial Baud Rate:** 4800–230400 (default 9600) • **Operating Temperature:** -40°C to 85°C • **Operating Voltage:** 2.7V ~ 3.6V • **Operating Current:** 45mA • **TXD/RXD Impedence:** 510Ω
	Mapping Software	Google My maps	• **Create Custom Map** • **Symbology interface** • **Basemaps** • **Layer Styling**

1.2.3 Technical and Non-technical considerations and constraints in design process

Technical Considerations:

- To ensure proper power supply to the device, the battery must be capable of supplying power for a very long time, as the device should be outdoors and will be collecting data for a long period of time.
- The microcontroller that will control all the sensors and other components should be suitable for giving all the instructions that are needed.
- The sensor that would be used for the measurement of the air pollutants must be available and should have good accuracy. Also, it should not consume more power, be easily replaced if damaged, and be biodegradable.
- The device server will show the amount of pollutants as well as the exact location of the device, and from that, it will be integrated into a custom map that will provide information.

Non-technical consideration:

- The size of the device will depend on whether it will be stationary at a specific point or whether it will be installed in a vehicle. The main purpose is to make it compact.
- The data will be recorded for a specific time and area, as it is not possible to cover a very large area in very short period of time. We have also chosen some pinpoints to measure the air quality and integrate them into the map.
- The outer covering must be suitable for the device to withstand any kind of damage to the system and also protect it from the rain.

Constraints:

- Collecting data at a specific time and area.
- The power supply should be suitable for the portable device.
- Budget issues.
- Compact design.

1.2.4 Applicable compliance, standards, and codes

The applicable codes for designing a system are given below,

IEEE 1451:

Smart transducers are tools with the capacity to detect and transform physical occurrences into digital information. A comprehensive framework that offers a standard interface and communication protocol for these devices is the IEEE 1451 standard. With the help of this standard, various sensors and actuators may communicate data and control commands, and they can easily integrate into systems and networks. It sets standards for transducer electronic data sheets (TEDS) and supports a wide range of communication protocols, enabling automatic transducer identification and setup. As a result, it may be used for many different applications. Thanks in large part to IEEE 1451, the use of sensors and transducers is greatly simplified in a wide range of sectors, from industrial automation to environmental monitoring.

IEEE Standard C57.12.28-2005, 4.1. 2:

Titled “Enclosure Security,” 'Water Resistance' states: “The enclosure shall restrict the entry of water (other than flood water) in the enclosure so as not to impair the operation of the apparatus inside.”

The GoB revised the Environment Conservation Rules (1997) in 2005 via a statutory regulatory order (SRO no. 220) and set with further clarity the National Ambient Air Quality Standard (NAAQS)

TABLE 1.2: National Ambient Air Quality Standard (NAAQS) table

Pollutant	**Limit Value**	**Average Time**
CO	10 mg/m3 (9 ppm)	8 hours
	40 mg/m3 (35ppm)	1 hours
pb	0.5 µg/m3	Annual
NO_x	100 µg/m3 (0.0053 ppm)	Annual
PM_{10}	50 µg/m3	Annual
	150 µg/m3	24 hours
$PM_{2.5}$	15 µg/m3	Annual
	65 µg/m3	24 hours

O_3	235 µg/m3 (0.12 ppm)	1 hours
	157 µg/m3 (0.08 ppm)	8 hours
SO_2	365 µg/m3 (0.14 ppm)	24 hours

1.3 Systematic Overview/summary of the proposed project

Our project is to measure the air quality and implement it through a route mapping system. As Bangladesh is a developing country, most of the people are not aware of their own health, and because of a lack of knowledge about the bad air quality, the majority of the people suffer from various types of illnesses related to the bad air quality. Thillnessessses often lead to death if not taken seriously. The most affected are the particles in the air, which are dust, which are mainly the reason for different types of airborne diseases. These particles are bad for our health, and they can get into our lungs or even into brain cells and damage them for a long period of time. To make sure the general population is staying healthy and leading a healthy life, we have taken a step to at least make them aware of routes whithate not going to be good for their health. The air quality monitoring system will provide information on the air components and also show the route map of a specific area to determine whether it will be good or bad for an individual's health. Bangladesh is now moving towards many advancements, but the people in the country still do not know about the bad impacts of poor air quality. As described above, Bangladesh has one of the most polluted cities in the world, and that raises the questi:n, how do we get rid of this situation? The answer is to make the general public more aware of the situation and try to give them enough information so that they can decide what will be good for them as well as for the country. Furthermore, a device that can monitor air quality and also give location information is valuable to make cities like Dhaka less polluted. And one of the main purposes is to make it affordable for people.

1.4 Conclusion

Air pollution is not a new thing to describe, but the main issue is that people are not aware. A developing country like Bangladesh and a city like Dhaka are two of the most populated cities in the world. For that,something needs to be done. An air quality measuring device can be a solution. There are many private sectors using their own air quality monitoring stations to measure the air quality, but that is not related to the government of Bangladesh. And to buy something that is expensive, which can be made even cheaper can be a solution. And often the general people are not able to view it from their perspective as the private company owns the system. For this they can not get any type of information about the air quality. Is it bad or good. In short our project is all about making an air quality monitoring system that will measure the hazardous air pollutants and giving location will be implemented in a route mapping system.

Chapter 2: Project Design Approach [CO5, CO6]

2.1 Introduction

Bangladesh's air quality is of extreme concern because of a number of environmental concerns and urbanization. The population's health and wellbeing are impacted by the nation's regular bad air quality. For this reason, people are suffering from various diseases relating to bad air quality. Bangladesh's citizens are suffering greatly as a result of the persistent problem of poor air quality, especially in heavily crowded metropolitan areas like Dhaka. With an alarming rise in respiratory conditions including asthma, bronchitis, and chronic obstructive pulmonary disease (COPD), this severe air pollution issue has a number of grave repercussions. Stories of people straining to breathe, experiencing increased symptoms, and needing more frequent medical attention abound. Children in particular risk a bleak future since their lung development is hindered, which might result in lifelong health issues. The vulnerability of the elderly increases as they deal with deteriorating health and a worse quality of life. Beyond health, the pernicious effects also have an influence on everyday activities, outdoor pursuits, and general well-being.

Systems for monitoring air quality are essential for identifying and controlling air pollution. In order to assess different pollutants such as particulate matter, nitrogen dioxide, sulfur dioxide, ozone, carbon monoxide, and volatile organic compounds, these systems generally consist of a network of sensors that are strategically positioned in urban and industrial regions. For authorities to issue alarms and implement mitigation measures in reaction to poor air quality, real-time data from these sensors is essential. Additionally, the historical information gathered by these systems helps with research, public awareness campaigns, and policy formulation, ultimately leading to better air quality and public health.

People often take the same route to go to their designated destination without being concerned about how bad the air quality of that route might be and suffer from various diseases. To reduce that air quality monitoring system that gives relevant information about the air quality with the location, it will help the masses of people to take alternate routes not to get affected by diseases caused by bad air quality. This system will allow us to pinpoint the location, and by route mapping, it will give us information on which route is not fatal for our health.

2.2 Identify multiple design approach

All in all, we have selected three design approaches for our air quality monitoring using route maps. Following is a list of the three design approaches that have been chosen:

Design Approach 01:

Automatic air quality monitoring system using concentration method by collecting samples and data analysis. The design consists of a dust collector and PM sampling head that collect samples of air and analyze them. Then record it on a data storage device to view from a computer or laptop. And you can also get air quality information from a physical map of a particular area.

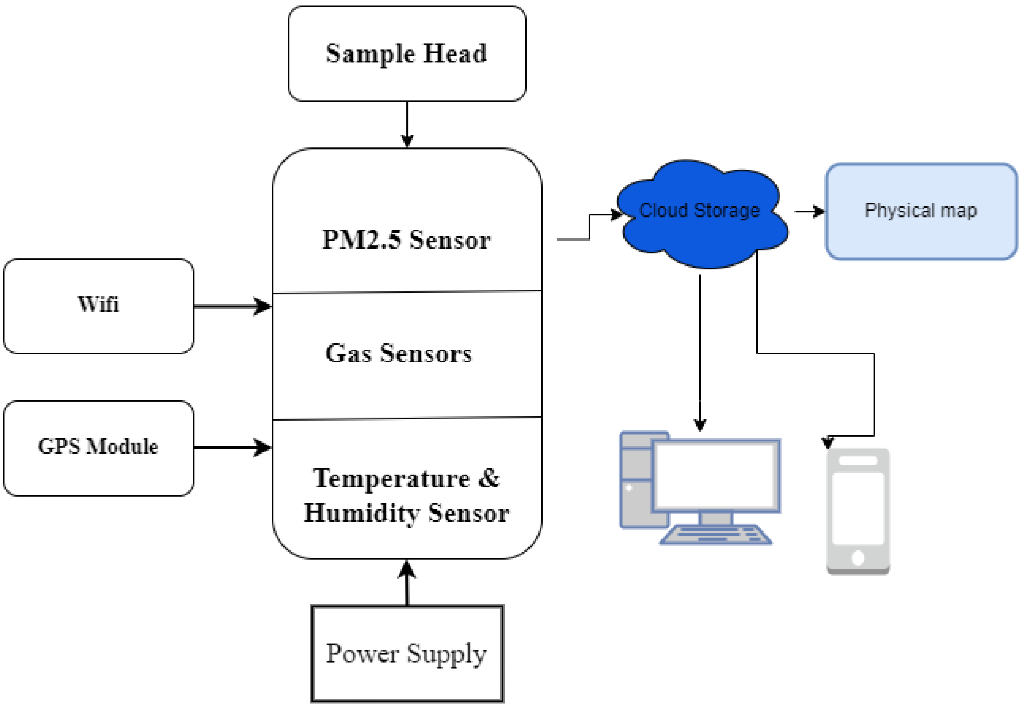


Figure 2.1: Block Diagram of Design Approach 01

In this design approach, the device is connected to a wifi network as it will be stationary, and the GPS module will show the location of the device and, at that point, the air quality measurements.

Design Approach 02:

Air quality monitoring involves collecting data through measuring particulate matter (PM2.5) and some air pollutants like CO_2, CO, NH_3, SO_2, etc., as well as the temperature and humidity meter. The design required a particulate matter (PM) and gas detector to measure the amount of PM and the harmful gases that exist in the air, as well as the temperature and humidity. Then the system will be connected to a cellular network as it will be outdoor and can be moved from one place to another. And lastly, the GPS will show the location. From there, the data will be sent to a data server where all the data is stored, and after that, it will be integrated into a custom mapping system.

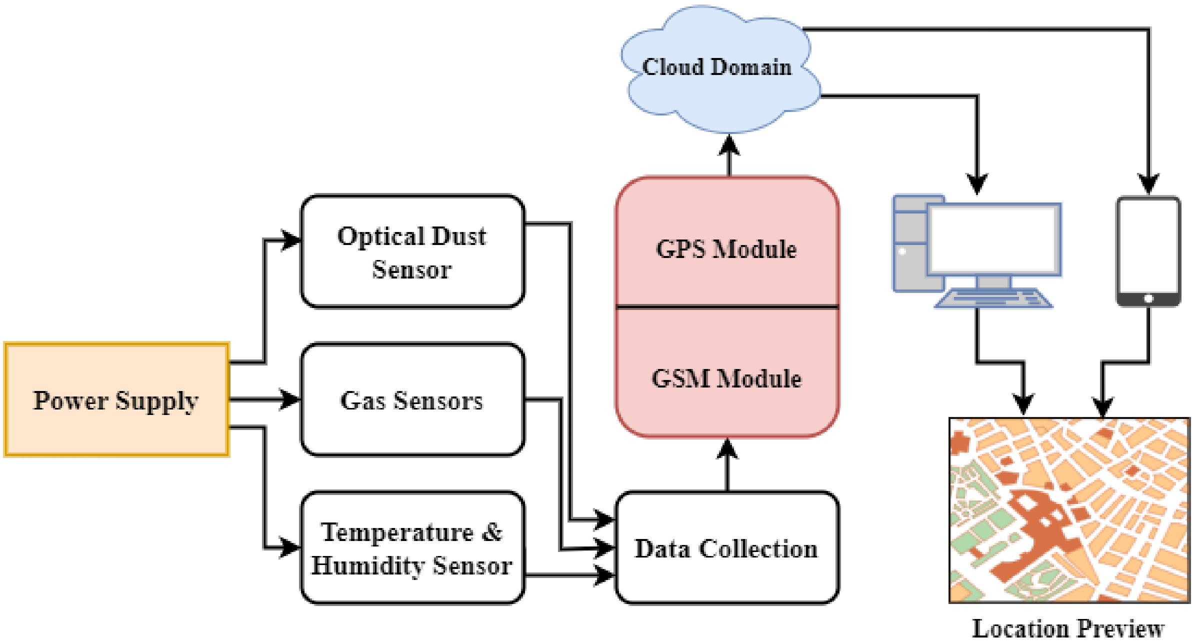


Figure 2.2: Block Diagram of Design Approach 02

This device can be moved from one place to another as it is compact in size, and it gives the accurate location of the device, which is going to be helpful to the mapping system.

Design Approach 03:

Measure the air quality using manual sampling of the air and the collection of data on the storage server. The system collects samples of air and takes them through an air filter that filters a specific air pollutant. After procuring and measuring the sample, collect the data, upload it to a storage server, and physically implement it in a thematic map that you can view from the storage.

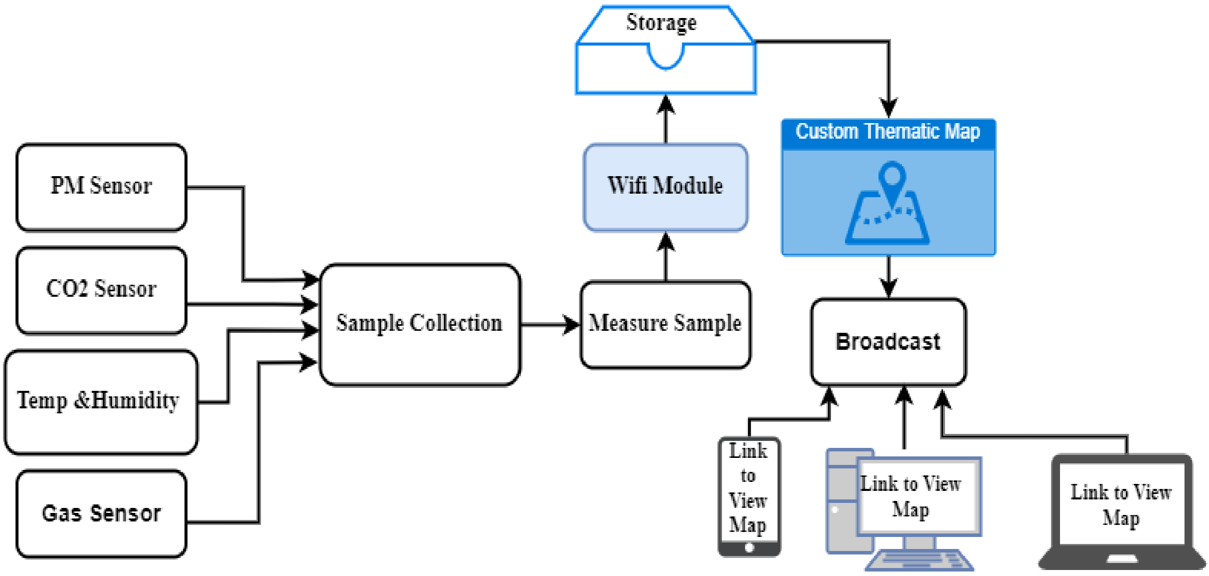


Figure 2.3: Block Diagram of Design Approach 03

This design approach will broadcast the annual, monthly, or weekly data into the custom thematic map from there, anyone can view it, but it will not give real-time data as it will be an approximation.

2.3 Describe multiple design approach

An elaborated overview of the three design approaches to measuring air quality through route mapping is described below:

I. Design Approach 01:

In this design approach 01 the air quality is measured through different sensors for different air pollutants. We all know that dust, also known as particulate matter, causes great damage to the lung as well as to the brain cells. More importantly, PM2.5 (Particulate matter 2.5) and PM10 (Particulate matter 10) are the most hazardous. Also, other elements are present in the air, which can be harmful if the level is higher than usual. This system will measure all these components, collect the data for storage, and then integrate all relevant data into the physical map.

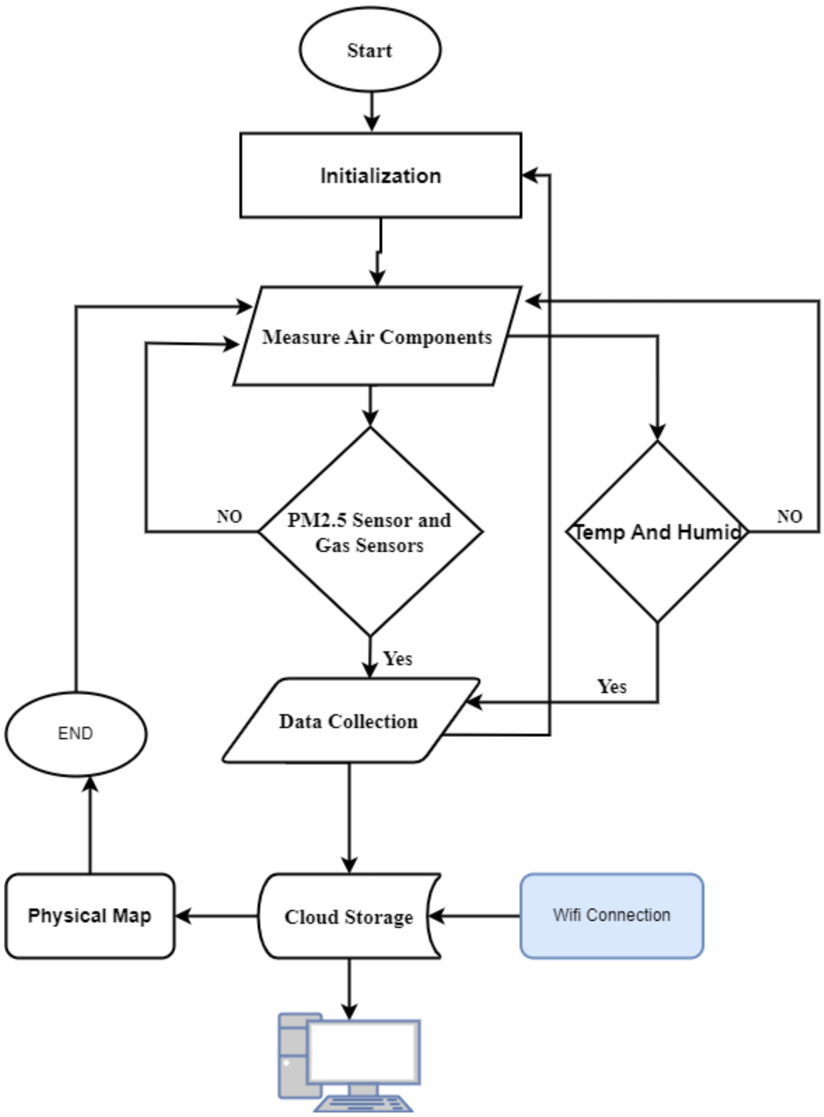


Figure 2.4: Flowchart of Design Approach 01

II. Design Approach 02:

In this design approach 02, the system is connected to a cellular network as it will not be stationary, and it will also be connected to the server where all the data will be stored and the location viewed with the help of a GPS module. The PM (Particulate matter) will be measured via an optical dust sensor as well as the other air components. The collected data will be implemented in the mapping system so that you can view it on any laptop, computer, or smartphone. A flowchart is given in the following for a better understanding of the design process:

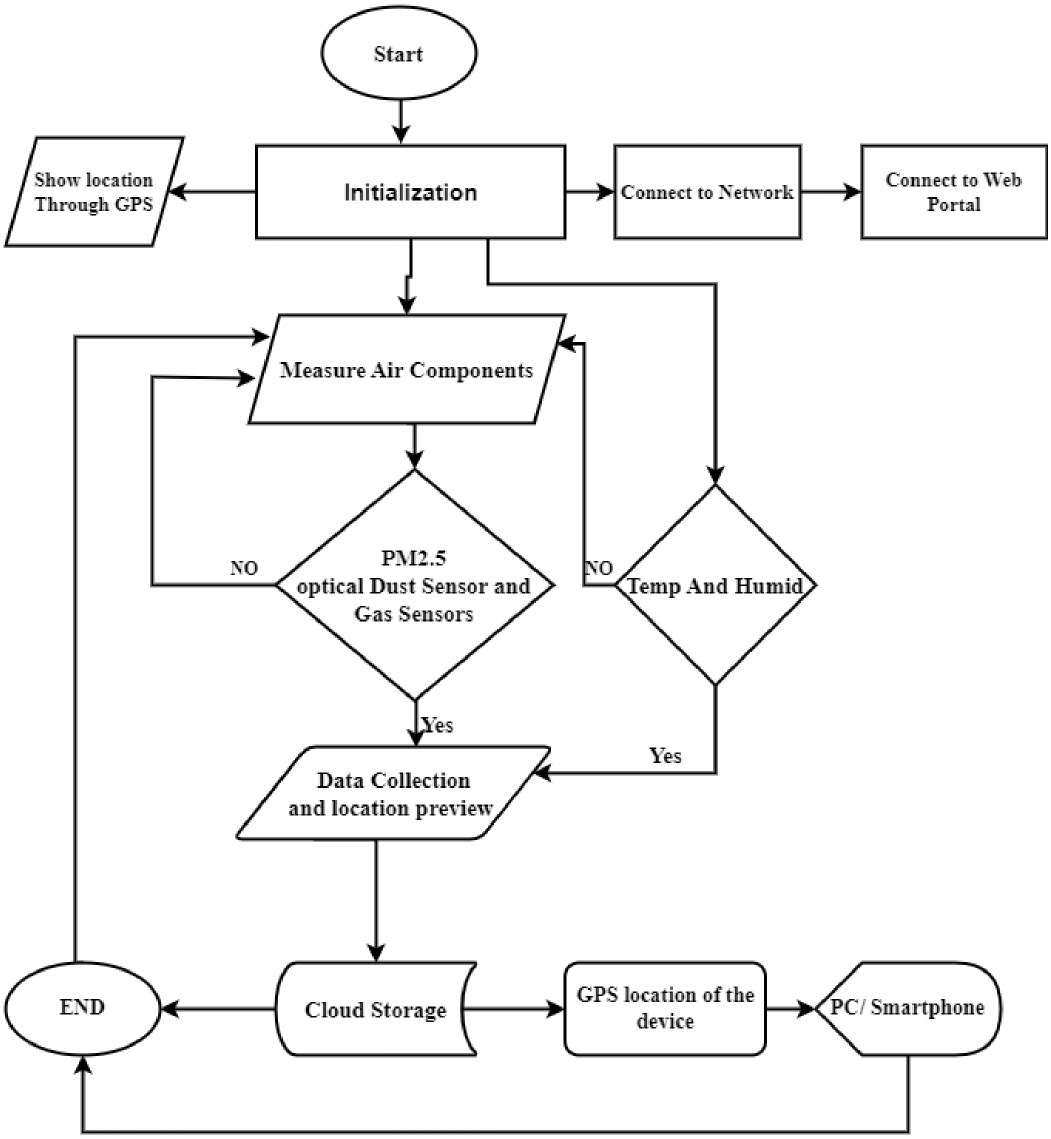


Figure 2.5: Flowchart of Design Approach 02

III. Design Approach 03:

This design approach 03 is simply a manual data collection of the hazardous air components. In this process, all the air pollutants are measured and stored in the data storage. The system is connected to wifi to send the measured data to the storage, and from there it will be implemented in the custom thematic map. More specifically, this system measures the air quality using manual sampling of the air and the collection of data on the storage server. The system collects samples of air and takes them through an air filter that filters a specific air pollutant. After procuring and measuring the sample, collect the data, upload it to a storage server, and physically implement it in a thematic map that you can view from the storage.

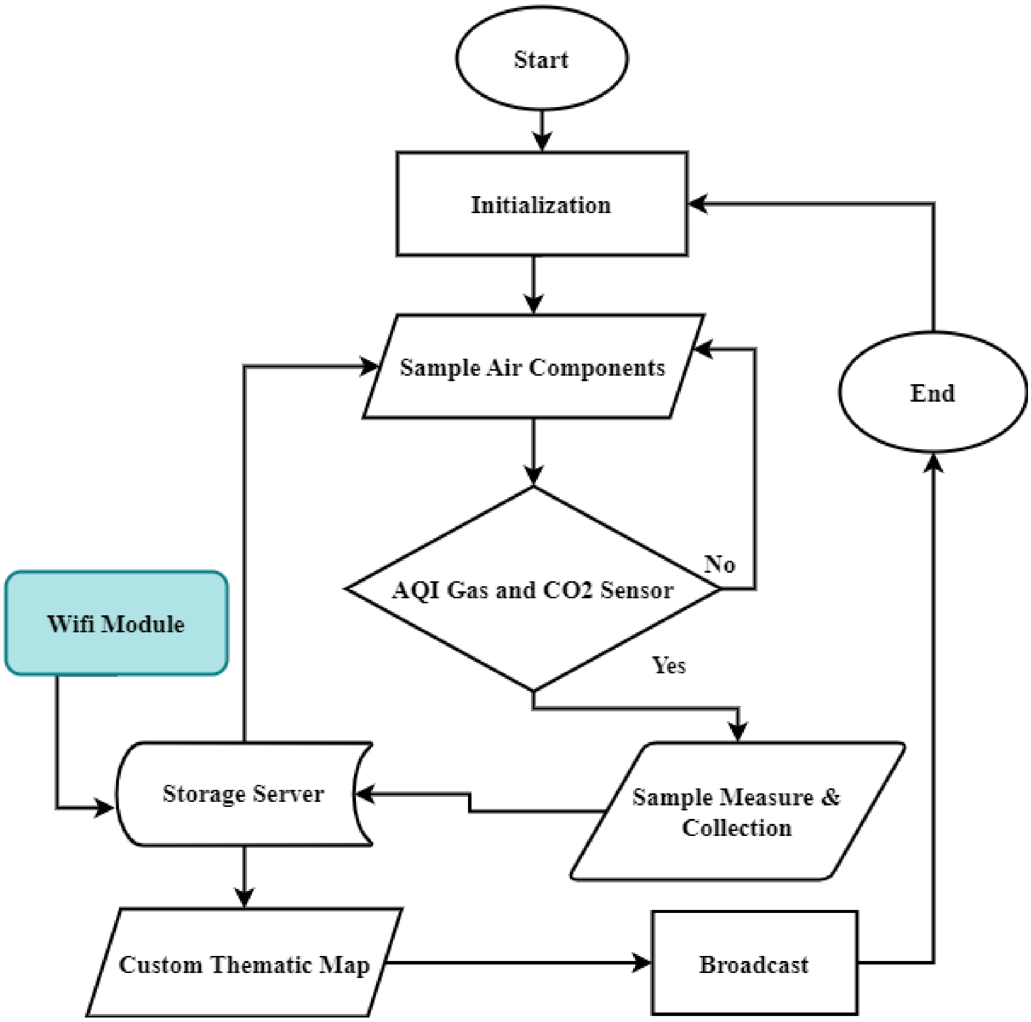


Figure 2.6: Flowchart of Design Approach 02

2.4 Analysis of multiple design approach

According to various criteria, such as requirement fulfillment, system cost, maintainability, etc., in particular according to different classifications that are thoroughly represented in the proceeding, the various design approaches for air quality monitoring systems have been further analyzed:

TABLE 2.1: Analysis on multiple design approaches of the system

Multiple design Approach	Design Approach 01:	Design Approach 02:	Design Approach 03:
Fulfilling Requirements	CO_2, CO measurement, and dust sensor with temperature and humidity	CO_2, CO, SO_2 measurement, and PM2.5 with temperature and humidity	CO_2, NH_3 sensors with temperature and humidity
Cost	Moderate	Low	Moderate
Usability/how easy it is to use and Weight	It takes a good amount of time to learn to use, but not for easy carrying	Very easy to use. Users can easily carry	It takes a little time to learn to use. Users can easily carry
Size	The size is a bit big	Compact	Compact
Maintainability	Complex and takes a good amount of time to troubleshooting.	Comparatively easy to troubleshooting.	Is easily maintained and takes less time to troubleshoot.
Data accuracy	Moderate	Moderate	Moderate

The key element in selecting multiple design approaches is to fulfill the requirements that are being approved. The design approaches can have good and bad parts, but aside from that, some limitations exist that do not fulfill the requirements. But the design approach that we have selected has almost all the requirements that we have picked according to the analysis. Moreover, the analysis has also been done under the abscess of cost. Which design approach cost less, and which one cost more. Also, the analysis has been done under the useability of the device. How easily consumers are able to operate the system and which one is less weighty and smaller in size. Many air quality monitoring devices are enormous in size, so that cannot be an option. Also, how easily an individual is able to maintain it and how much accuracy the design approach gives. The analysis has been done using all these criteria.

2.5 Conclusion

According to the World Health Organization (WHO), deaths have been recorded due to bad air quality nowadays, which is a very big concern. Most of the families have members who are elderly, diagnosed with lung diseases, or have breathing problems. The main reason is that the components in the air are much higher than average due to pollution. If an individual at least tries to avoid the polluted routes to go to their designated destination, it would reduce the chance of being affected by diseases caused by poor air quality. For this, our project gives good value by giving information as well as the route where bad air quality is present. For this project solution, we have come to a conclusion by selecting three design approaches, and among those, one has to be selected as the optimal solution for building the prototype. The project is about the health concerns of the general public against bad air quality and how to make their lives healthy and lessen the chance of getting affected by airborne diseases.

Chapter 3: Use of Modern Engineering and IT Tools [CO9]

3.1 Introduction

Before building the prototype of the project, we have to undergo some tests and find the optimum solution for the design among the three design approaches. For that, we have to do some simulation work to ensure the device will provide valuable data and relevant results. Moreover, which design gives a better result and has good accuracy. There are many softwares on the market which one one will be using depends on several categories, like its availability, if it is free or not, whether the interface of the software is complex or easy to handle, etc. For simulation purposes, there are several simulation software programs on the market. Bearing in mind the availability of the components in the library, we have to choose one we should be using. For simulation, use Proteus, Matlab, Autodesk Eagle, etc. After some research about these, we found out that Proteus is easy to use and almost has all the library contents that are necessary. And for the tentative 3D design, thousands of 3D design tools are present. But as we are very new to this, we have to choose a tool that is easy to use and has the features of a professional 3D tool. And lastly, for the mapping part, we have QGIS, ArcGIS, and Google My Maps. The GIS mapping is a very complex system and also not familiar to us, so we went with Google My Maps for the custom route mapping. And for the coding part, Arduino IDE is being used, as it is the most popular nowadays.

3.2 Select appropriate engineering and IT tools

This project is based on measuring the air components through route mapping. There are numerous softwares available that can be used as IT tools. But all are not that suitable or easy enough to work with, so a comparison is made to choose the best IT tools to simulate the design approaches.

For simulation, there are multiple softwares from which we have selected Proteus, as we are familiar with the interface and have used it previously. As for Matlab, which is also familiar to us, all the needed components for the simulation are not available in Matlab, and it is more complex in Matlab to simulate this type of simulation. And for Autodesk Eagle, it is more complex than Proteus and Matlab. Though it has all the components, those are not free to use one has to buy the library to use it in the simulation process. And for the circuit lab, it is very simple and easy to use, but it also has some limitations with the simulation process, as it is mainly for basic simulation. So considering all this, we think Proteus is a better choice for simulation. For 3D design purposes, tons of 3D design software is present on the market, but for affordability and ease of use.

All these softwares were picked by comparing them with one another in different categories, and the best one was chosen for achieving the proper outcome.

Table 3.1: Simulation software tools

Simulation Software Comparison				
Comparison	**MATLAB**	**Proteus**	**Eagle**	**CircuitLab**
Component/Sensor Library	Limited library. Add-ons are required.	Several libraries. Additional libraries can be added on.	Insufficient components in libraries, difficult to create or add libraries.	Some components may not be available, and the library is limited.
User Interface	User Friendly	User Friendly	User Friendly	User-Friendly and Simplicity
Simulation Tool Availability	Numerous tools for analysis.	Numerous tools for designing and simulation/ analysis.	Limited features in the free version.	Online tools are available
Usage	Testing/ Data visualization	Schematic/ Confirmation, For digital circuits	For printed circuit board designs.	Basic circuits
Microcontroller Library	Add-ons or extra packages are needed.	All kinds of microcontroller boards are available.	All kinds of microcontroller boards are available.	Some microcontrollers are missing.

Table 3.2: 3D design software for designing prototype

3D Design Software					
Comparison	**Blender**	**AutoCAD**	**TinkerCAD**	**AutoDesk Maya**	**Sketchup**
Software Type	Open source.	Paid service.	Open source.	Paid service.	Open source
Advanced Features	Up-to-date feature and easy customization	Has a lot of features	Few advanced features are accessible	Expansive amount of features	Up-to-date feature and easy customization with easy interface
Simplicity	Moderately easy to learn, user-friendly interface.	Difficult to learn, Training is required.	No training required, very easy to learn.	Moderately difficult to learn.	It is very easy to use, and the library is available online for better design. experience

File Types	Supports file formats.stl. gltf..obj..fbx. AVI and JPEG formats.	Limited file formats.	STL, OBJ, and SVG file formats are supported.	STL, OBJ, and SVG file formats are supported.	Supports file formats: SKP PDF, COLLADA (DAE), DWG/DXF, PNG, JPG · SKP, PNG, STL
Design Quality	Can provide high-quality image renders.	Realistic Producing images is difficult.	Average quality designs.	Industry-standard.	Can provide high-quality image rendering.

Table 3.3: Custom mapping software

Custom Mapping Software			
Comparison	**QGIS**	**ArcGIS**	**Google Map**
Software Type	Free and open source	Online subscriptions are needed.	Free and open source
Features	Vector analysis, raster analysis, sampling, geoprocessing, geometry, and database management tools	Basemap analysis, Data Hosting, Data Visualization, Geocoding and search	Manual route mapping, manual data implementation, checkpoints, and overlay data
User Friendly	Easy to use and less time needed to develop skills	Yes, but it requires some other skills and knowledge to perform.	Easy to use
Availability	Has almost all types of maps and can even add external source layers.	Some need to upload external files or data online, and some are paid.	A world map is included
Design Quality	Very precise design quality and can do 3D design maps as well.	Can perform good design, but documentation needs a considerable amount of memory and storage.	Though it cannot design 3D maps, it can create manual hand maps

3.3 Use of modern engineering and IT tools

In our project, we have used multiple modern engineering and IT tools to simulate the design approaches. Following the use of modern engineering and IT tools, they are briefly explained:

Proteus:

Through the Proteus software, we have simulated all three design approaches and checked whether they are working or not, giving us the values. For the design approaches, the simulation process was done seamlessly. All the simulations were done using the Arduiono Uno, but in the last final design, it was replaced with an ESP32 as the microcontroller because of its unavailability. And some changes have also been made on the side of analog sensors. All the design approaches are given as follows:

So, we have to design all three approaches to the proteus. For design approach 01, there are four sensors operating. The particulate matter sensor will measure PM2.5 as well as a temperature and humidity sensor with CO2 and CO measuring sensors. The whole thing is operated by an Arduino Uno. After collecting the values of components, they will be implemented in a physical map, which will then be distributed.

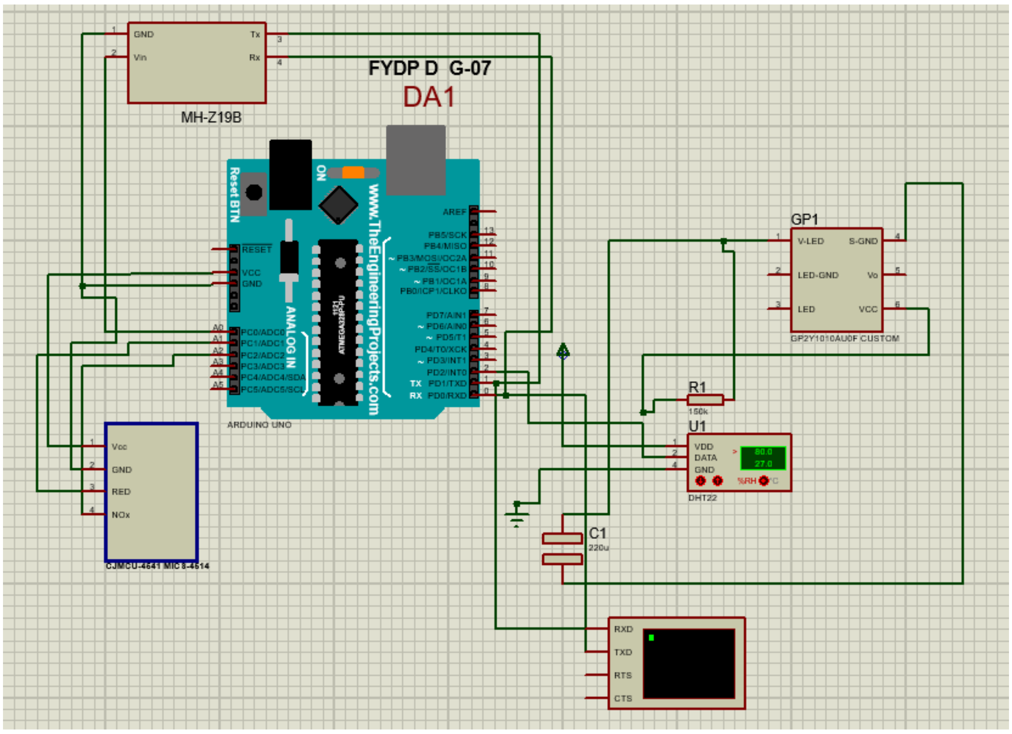


Figure 3.1: Design Approach 01 block diagram in proteus

In proteus design approach 01 is shown above.

Arduino IDE:

An essential software tool for programming and creating apps for Arduino boards and microcontrollers is the Arduino Integrated Development Environment (IDE). The open-source Arduino IDE provides a user-friendly interface for the creation, compilation, and uploading of code to Arduino boards. It makes the development process easier to understand for both novices and specialists. It has a code editor with tools for simpler, error-free coding, like syntax highlighting, auto-indentation, and code recommendations.

Figure 3.2: Arduino IDE coding software interface

The extensive library of pre-written code modules included with the Arduino IDE makes it easier to complete difficult tasks, including interacting with sensors or modules. By showing the data sent and received by the Arduino board in real-time, a built-in serial monitor aids with code debugging. Through the board manager, users can quickly add support for various Arduino boards and platforms. The IDE creates a binary file from the code and uploads it via USB or another interface to the Arduino board that is attached. The Arduino IDE is frequently employed in many different projects, such as robotics, home automation, sensor data recording, interactive art pieces, and educational initiatives, which are all examples of IoT (Internet of Things) applications. There is a vibrant online community for Arduino that consists of forums, websites, and social media pages. This community is a wonderful resource for Arduino aficionados since it gives support, shares projects, and offers troubleshooting assistance.

In conclusion, the Arduino IDE is a flexible and user-friendly platform that is essential for helping experts, amateurs, and makers realize their electrical creations. It is a mainstay in the field of microcontroller-based electronics due to its broad feature set, simplicity of use, and strong community support.

Google My Maps:

As for the part about the mapping system, we have selected a few mapping software programs that can be used in this project. But for some limitations and also for cost effectiveness, we have chosen Google My Maps as the route mapping. In this, we will be collecting the data that will be stored on the data server, and we will manually implement it in the map. And anyone who will have access can check the data. The main constraints of this are that, as we are building this prototype, the air quality monitoring system will be able to get values for specific areas and times. To upscale it in the future, we have to build our own network system where all can view it, the data will be automatically sent to the map, and the air quality level will be seen.

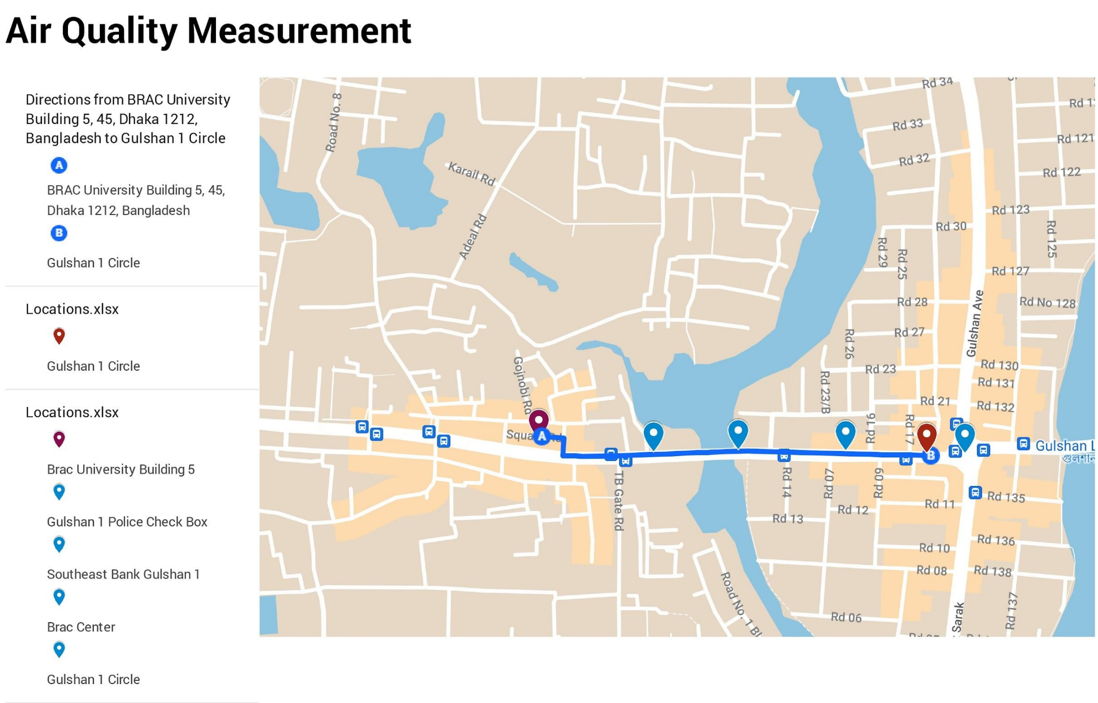


Figure 3.3: Google my maps and the location where the data will be taken from and route map will be done

On the map, we are trying to cover a specific route and pin the location. The time when we will measure the air quality will be a peak time when vehicle concentration is high and air pollution is also high at noon.

Sketchup:

The 3D design that we have done previously, which was our tentative design of the prototype, There are some changes due to some limitations in the design of the device. The tentative design that we have designed is given below:

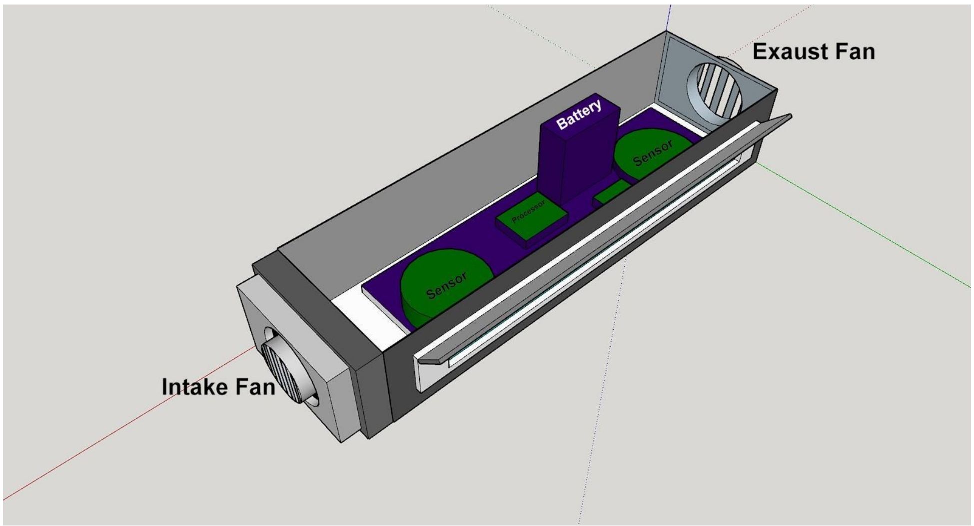


Figure 3.4: Tentative 3D design in Sketchup

3.4 Conclusion

Our project requires software where we can get all the needed information and components that will be used for the design approaches. We have selected software that is familiar and easy to use. And as for the data result, sensors are mainly analog, so the values can be determined by a potentiometer in the simulation process. All the design approaches have been tested for two test cases, as shown in the previous parts. And in Proteus, all the availability of parts makes it effortless to use it and do the simulation. And for the maps, GIS has some complications, so we shifted to Google My Maps. And for coding, we used the Arduino IDE, as it is more reliable, has all types of code libraries, and also has examples for test runs.

Chapter 4: Optimization of Multiple Designs and Finding the Optimal Solution [CO7]

4.1 Introduction

The project proposal serves as the foundation for the implementation of the project idea into a prototype. After the proposal is given, multiple designs are assigned, which will lead to the project's main idea. But which design is the optimum solution has to be determined, which is the main task. However, the question of which design approach may prove to be the most optimal can only be answered after every design has been thoroughly optimized. Thus, every possible design strategy for the project is examined. In our project, the main purpose is to get the optimum design by simulating the designs and checking whether the components are available or not, cost-efficient, replaceable, etc. After undergoing some research, we have come to the conclusion that a design approach has to be implemented in a real-life scenario.

4.2 Optimization of multiple design approach

The project concept has three main design approaches to be implemented. We had to undergo research to find the optimum solution that would be showcased as a prototype. In the research part, we have gone through simulations and operated new software to get to know it more deeply. We have used Proteus as the simulation process for all the design approaches and determined which one has the best possible outcome according to our project's main concept idea.

Through different analyses, we have been able to identify the best possible solution by some categories, such as fulfilling requirements, data accuracy, etc.

Fulfilling requirements:

The main requirement is that the device be able to detect and monitor the hazardous gases present in the air and provide information to the general public. Also, it will be a compact and portable device. The first design approach fulfills almost all the requirements, but the original design is that it will be stationary and mounted on a pole to measure the air quality outside and will have a specific detection range. The requirements must be fulfilled to extract the optimum design approach. Another requirement is that it send data with the location of the device so that it can be implemented in the manual route map.

Cost:

As the device will be for the general public or can be used in industrial areas, keeping that in mind, the device must be low-cost so that anyone can easily use it and the device can be within their reach. The components that will be used must be low-cost for easy replacement but also have good accuracy.

Usability:

It basically means how easily one can use the device. Usability is the term used to describe how simple and effective it is for users to interact with a system, product, or interface in order to accomplish their objectives. Users should be able to pick up a usable system quickly. Without considerable training, new users should be able to browse and utilize the product with ease. Users ought to be able to do activities swiftly and with little exertion. When users revisit a system after some time has passed, they should still be able to utilize it efficiently. It shouldn't need to be constantly reviewed and should be remembered. User error management and avoidance are factors in usability. User-friendly solutions should reduce the likelihood of mistakes and offer precise feedback when they do.

Size:

The size is a big issue as it will be compact, so the size will be as small as possible, as well as being able to be carried from one place to another.

Maintainability:

Maintainability is the capacity of a system or product to be readily updated, fixed, or modified with little effort and expense. A maintainable system is created and maintained in a way that makes quick troubleshooting, issue fixes, and upgrades possible. It makes it simpler for developers to comprehend, work on, and modify the system as necessary throughout its lifespan by utilizing clear and well-documented code, a modular architecture, and industry-standard standards. Reduced downtime, improved system dependability, and the continued viability and adaptability of a product are all dependent on maintainability.

In conclusion, maintainability is a proactive method of developing software and systems that takes into account the whole lifespan of a product. Developers may guarantee that systems are dependable, flexible, and cost-effective over time by following best practices in code quality, design, documentation, and testing. This lowers the total cost of ownership and maximizes the return on investment.

Data Accuracy:

The most important thing is which components will be chosen to measure the air quality and which will give us the best possible result. And for that, the sensor or the sub-system must have data accuracy. According to our research of the different sensors available on the market, we have picked a few and done a comparative comparison among them. Also, we have selected MQ-07 for the measurement of carbon monoxide, as there are sensors to measure CO, but they are not available and cost much more than the typical analog sensors.

Table 4.1: Particulate matter sensor comparison

Particulate Matter (PM): Dust Sensor			
Comparison	**PMS5003**	**GP2Y1010AU0F**	**SDS011**
Power Consumption	Moderate	Moderate	Moderate
Range	≥500µg/m3	500µg/m3	0 - 999.9 µg /m³
Cost	Medium	Low	High
Size	50 x 38 x 21 mm	46 x 30 x 17.6 mm	71x70x23 mm
Accuracy	High	Medium	High

Table 4.2: gas sensors comparison

Gas Sensors			
Comparison	**MH-Z19B**	**MQ135**	**MH-Z14A**
Power Consumption	Moderate	Moderate	Moderate
Range	0-2000 ppm	0-1000 ppm	0-1000 ppm
Cost	High	Low	High
Gasses Measure	CO2	CO2, SO2, NOx, NH3, Smoke, Benzene, Alcohol	CO2

Table 4.3: Temperature and Humidity sensor comparison

Temperature and Humidity			
Comparison	**DHT-11**	**DHT-22**	**RHT03**
Power Consumption	Moderate	Moderate	Moderate
Range(Temperature)	-20 to + 60℃	-40 to +125 ℃	-40 to +80℃
Range(Humidity)	5 – 95% RH	0 – 100%RH	0 – 100%RH
Cost	Low	Low	High

4.3 Identify optimal design approach

All the design approaches are being simulated through proteus. And for the familiar interface and having more knowledge about the software givs advantage to use it for simulating all the design approaches in one.

In the design approach 01 the system is measuring the air components with temperature and humidity.

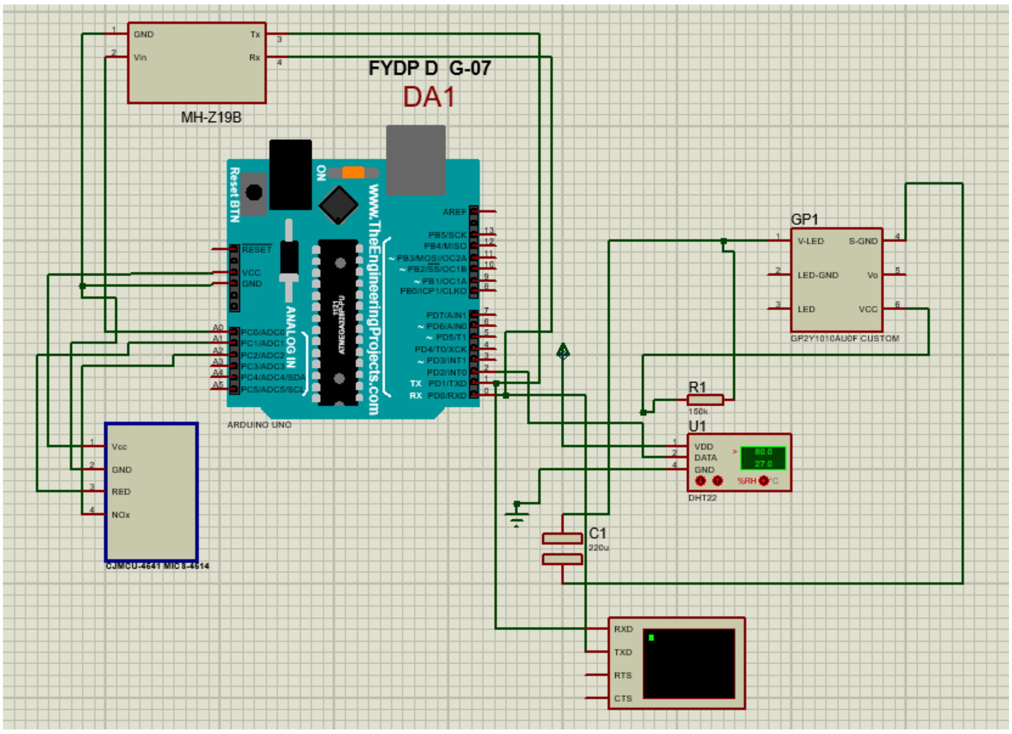


Figure 4.1: Design Approach 01 block diagram in proteus

Air quality monitor by collecting data through measuring particulate matter (PM) and CO_2, NH_3, CO with a temperature and humidity meter. The design required particulate matter (PM) and CO_2, NH_3, CO detectors to measure the amount of PM and the gas components that exists in the air as well as the temperature and humidity. Then it will be implemented in the custom mapping system where it will show the air quality in a specific route for a specific time.

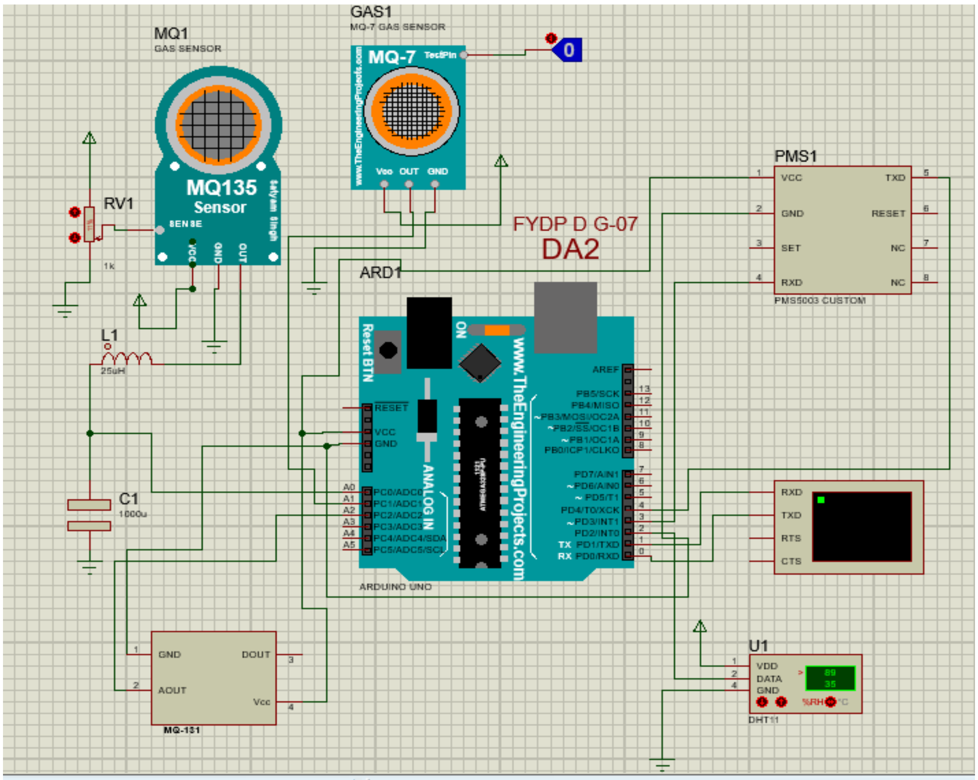


Figure 4.2: Design Approach 02 block diagram in proteus

Utilize manual air sampling and data collection on the storage server to determine the air quality. The device gathers air samples and passes them through an air filter that removes a particular air contaminant. Once the sample has been acquired and measured, gather the information, upload it to a storage server, and physically implement it in the thematic map. This information can then be viewed from storage.

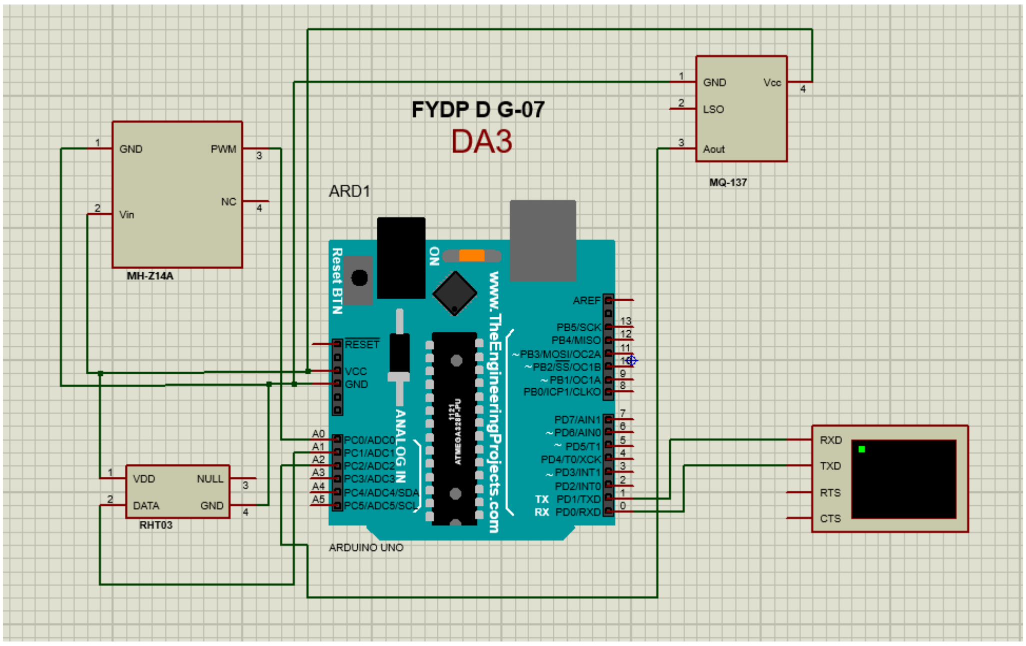


Figure 4.3: Design Approach 03 block diagram in proteus

For all the three simulations, as we have run two tests one for when the values of the sensors are low and another one is when it is high in measuring the air components.

From the above all approaches, we have selected the optimum design approach on the basis of various criteria like affordability, maintainability, manufacturability, etc., and from that, we have given scores in every criteria. The ideal project solution is discussed with the members of our group and the ATC panel member to determine the scores. Considering all other limitations, the weighted score defines which design approach will be suitable for making the prototype of the design.

TABLE 4.4: Weighted average score for optimum design approach

parameters	Assigned weight	Design Approach 01	Design Approach 02	Design Approach 03
Match Requirements	**25**	14	16	12
Affordability	**10**	6	7	7
Usability	**10**	6.5	6.5	6
Weight	**10**	5	7.5	7
Size	**10**	5	7	7
Manufacturability	**10**	7	8	7
Maintainability	**10**	8	9	9
Data accuracy	**15**	12	11.5	10
Total	**100**	**63.5**	**72.5**	**65**

We have prepared a weighted average chart to find the optimal design. In the chart, we have marked different categories with different scores, and according to that, we have marked all three design approaches. From the following chart, we have found that design approach 02 is the best solution.

4.4 Performance evaluation of developed solution

The performance of all the design approaches are being evaluated by testing for two cases.

The issued air quality monitoring design prototypes were created in Proteus, and data was collected in order to choose the best design. Various metrics have been used to assess the viability of various designs. The following examples show how the three design methods are simulated in Proteus and how the best design is chosen after weighing various factors:

I. Design approach 01 the simulation test are as follows:

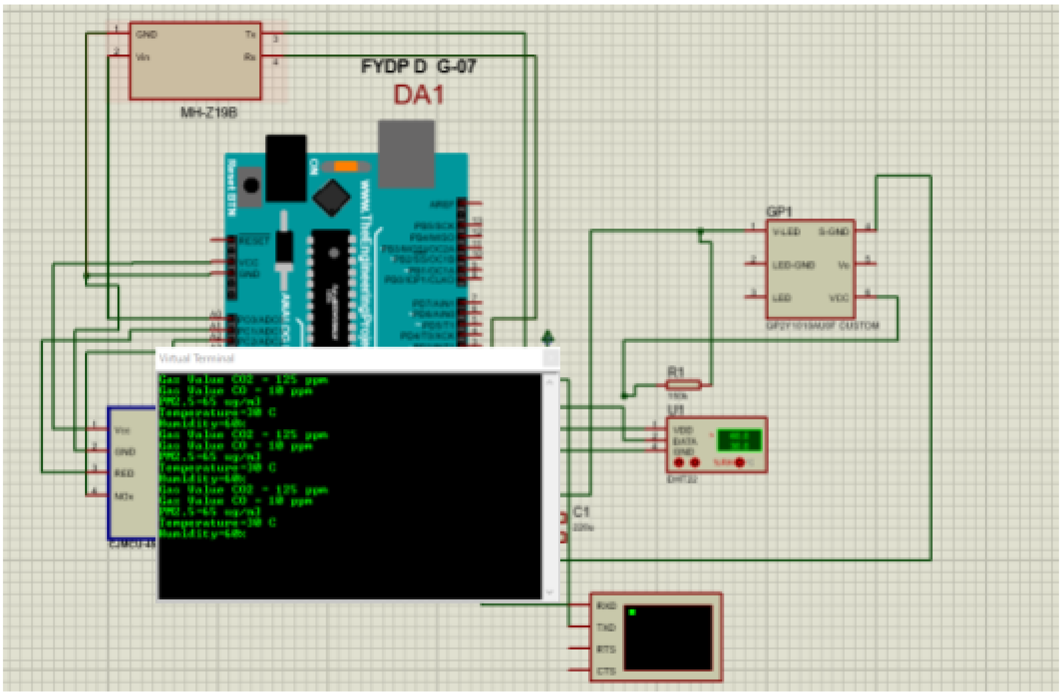


Figure 4.4: Design Approach 01 Test Case 01 Simulation

In this design, there are four sensors operating. The particulate matter sensor will measure PM2.5 as well as a temperature and humidity sensor with CO2 and CO measuring sensors. The whole thing is operated by an Arduino Uno. After collecting the values of components, they will be implemented in a physical map, which will then be distributed.

For the test case 01 in the virtual terminal, we are seeing the amount of gas components are low according to the standard amount of air quality. And the particulate matter is also low.

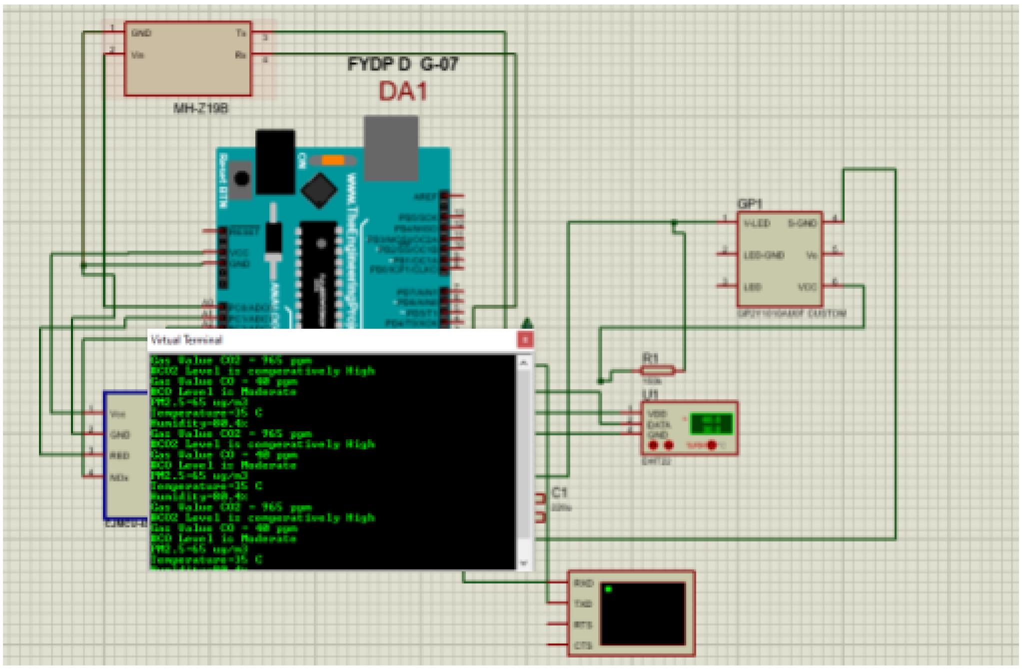


Figure 4.5: Design Approach 01 Test Case 02 Simulation

And for the test case 02, in the virtual terminal, we are seeing the amount of gas components is high according to the standard amount of air quality. And the particulate matter is also high. And it is also showing that the number of air components is high. After that, it will be placed on a custom physical map.

II. Design approach 02 the simulation test are as follows:

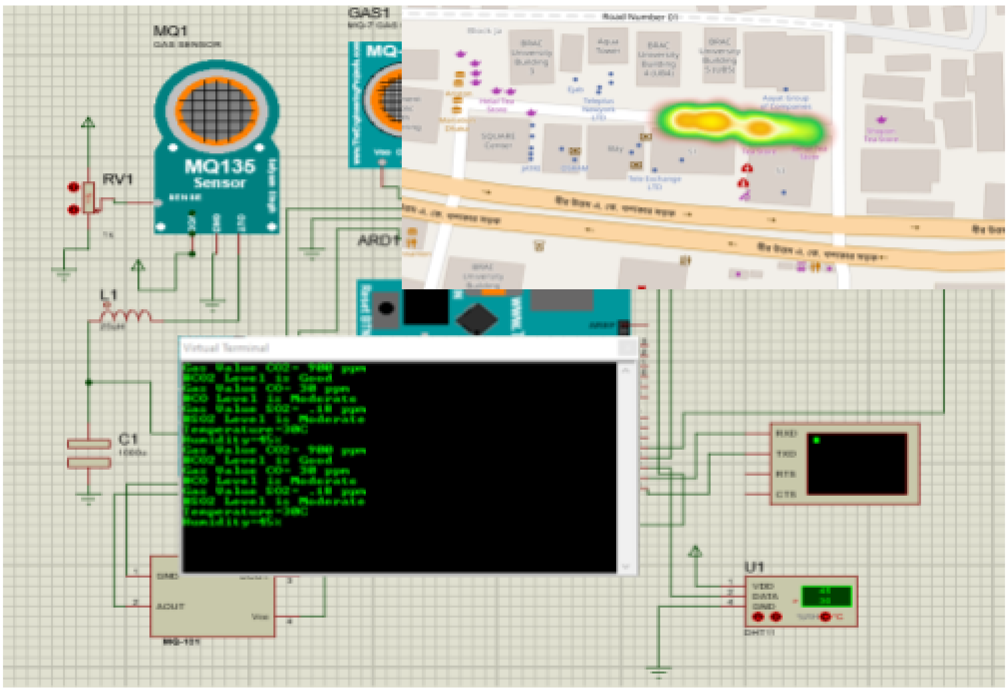


Figure 4.6: Design Approach 02 Test Case 01 Simulation

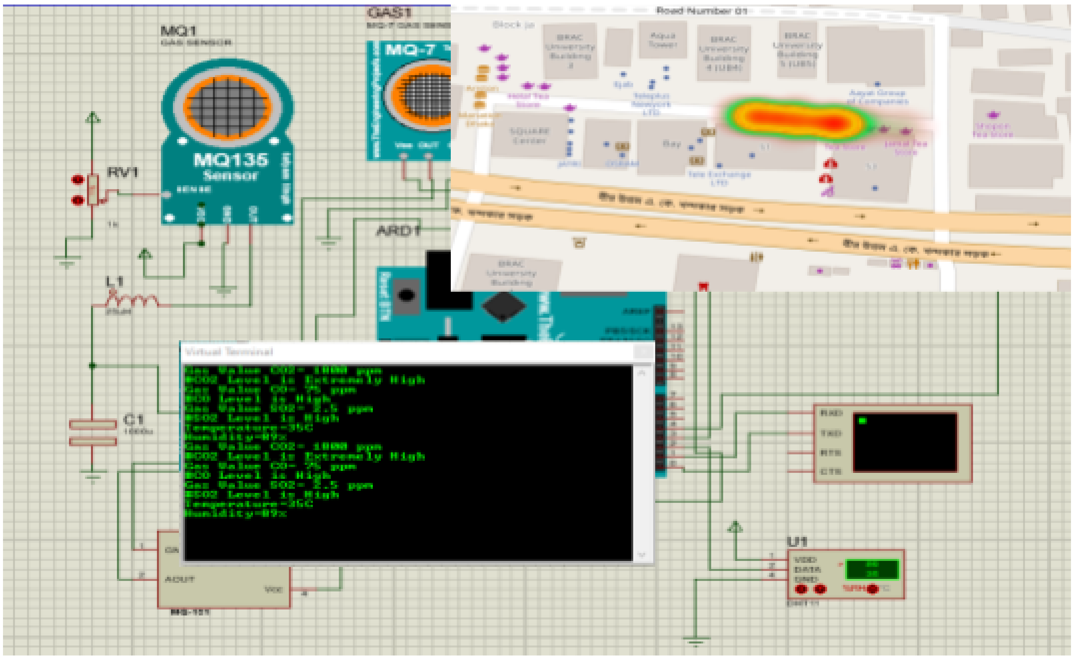


Figure 4.7: Design Approach 02 Test Case 02 Simulation

For the test case 01 in the virtual terminal, the amounts of CO2, CO and SO2 are measured and shown. Also, the particulate matter PM2.5 is measured. Here, we can see that the amount of air components is typically low as per the standard of air quality. And after collecting the data we will implement it in the map manually. The GIS mapping is done manually and the real time data of the air components has been implemented. And the heat map is also produced manually as the heatmap is optional cause the heat maps are produced in the GIS softwares are done weekly, monthly or annually. As well as the temperature and humidity are measured.

III. Design approach 03 the simulation test are as follows:

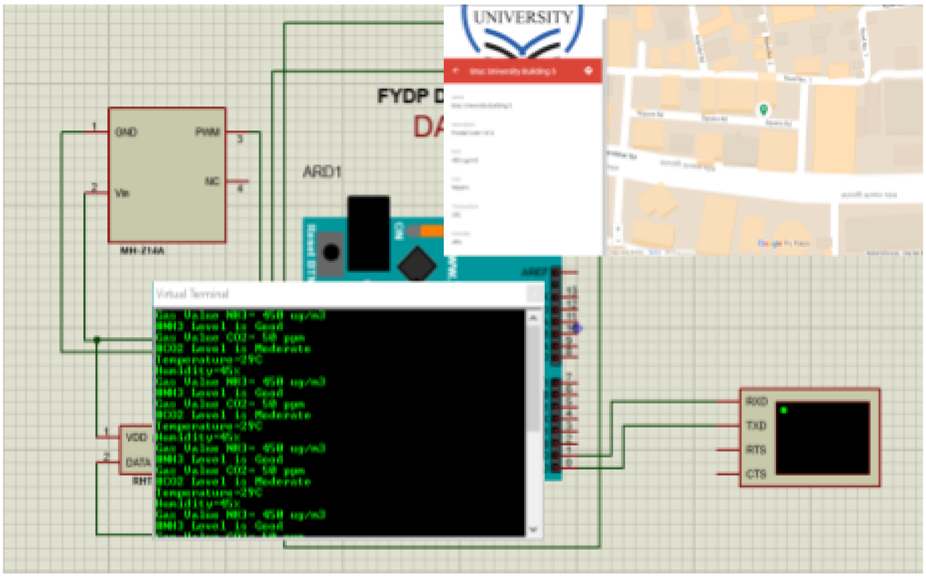


Figure 4.8: Design Approach 03 Test Case 01 Simulation

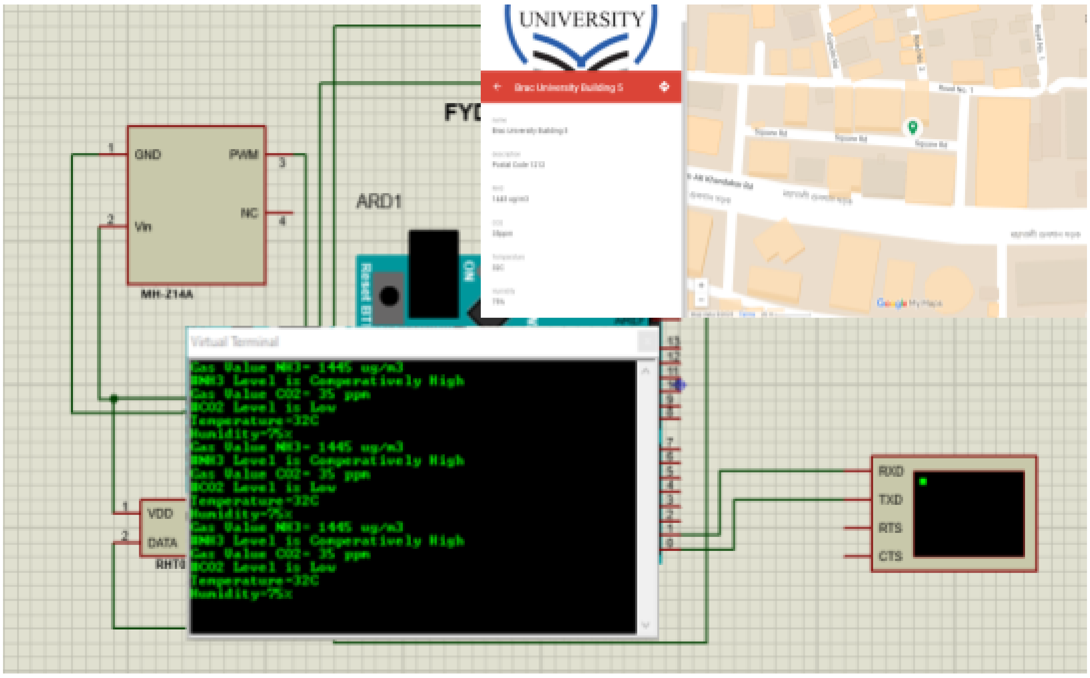


Figure 4.9: Design Approach 03 Test Case 02 Simulation

For the test case 01 the amount of NH3 and CO2 is low as per the national air quality standard. And also, it is shown what the amount of component is and what the temperature and humidity are. In the top right part, we can see that the custom thematic map done is Google Maps. And for the test case 02 the amount of NH3 and CO2 is low as per the national air quality standard. And also, it depends on how much the component is and the temperature and humidity. In the top right part, we can see that the custom thematic map is on Google Maps.

4.5 Conclusion

Our project has been designed in such a way that it emphasizes the concept of air quality monitoring system in a new way. The main objective of this project was to design such a system that can measure the air pollutants and also pinpoints the location of that device so that the data received from it can be integrated into the mapping system manually.

Through our research we came to know that there are several ways and several types of air quality monitoring systems in the present time. Many private companies are using their latest and advanced technologies to measure the air quality as well as public sectors. But they only tell how bad the air quality is. If a system that integrate the same data into the mapping system so that anyone can view it will try to avoid the route which has bad air quality and will take an alternate one.But before going to that we need to optimize all the design approaches that we have selected and from that only one design will be finalized made as the prototype. The final design will be analyzed through different categories to be the optimal solution. And also extensive analysis needs to be done for making it a prototype.

Chapter 5: Completion of Final Design and Validation [CO8]

5.1 Introduction

Following a more thorough comparison of the published design approaches, the hardware prototype for the optimized design of Design Approach 02 has been fabricated. On the hardware prototype, there have been some modifications. The software design is implemented in Proteus, and it is only for checking all the connections with the sensors and making sure all are working well. Before designing the PCB layout, we had to go through extensive research as it was new to us. And before integrating the PCB layout, we have to check whether the components are sending data to the website.
On the other hand, a hardware prototype system is used, and data is measured and sent in real time to a website where it can all be viewed and saved, as well as the location, from the same portal.
The system has undergone manual testing at a certain time and route. The proceedings include a thorough breakdown of the design development and evaluation.

5.2 Completion of final design

The project has been implemented through a hardware prototype. But we have also designed it later in the software, Proteus, for better understanding. A detailed explanation and analysis of the design are depicted below:

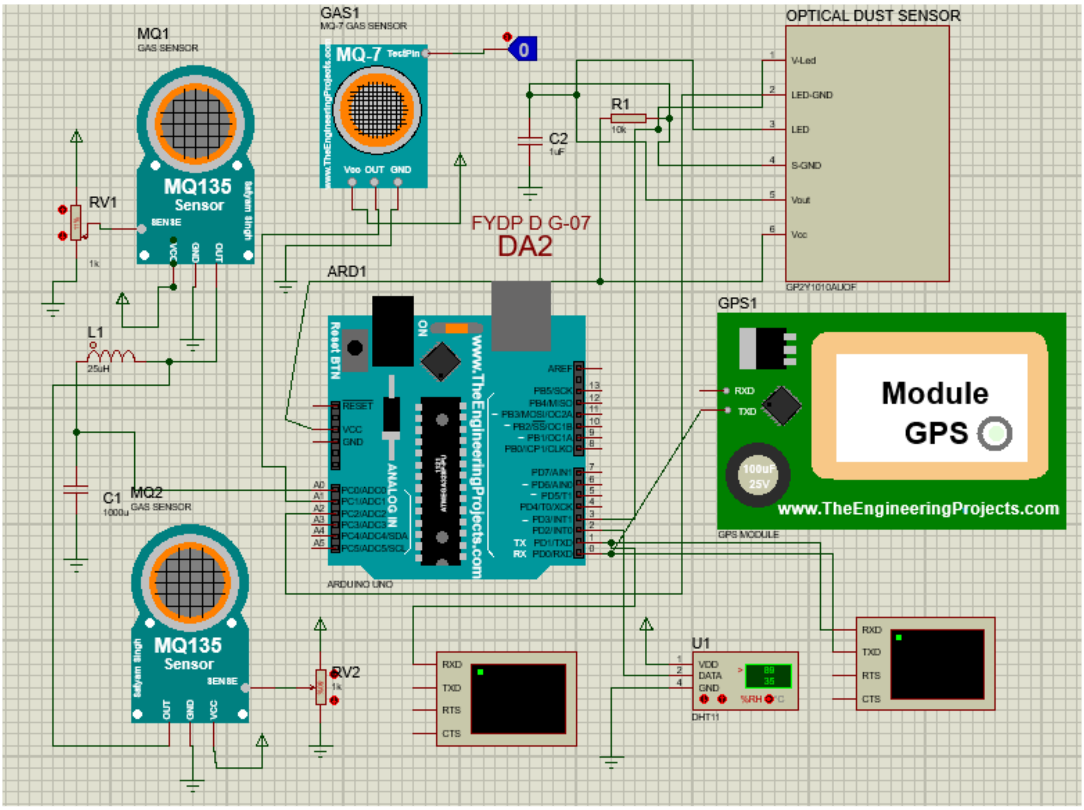


Figure 5.1: Optimum design Approach 02: Proteus design

In the optimized design approach, the sensors are selected based on their availability in the present market. For controlling all the components, we have chosen an ESP32 microcontroller. But in the design that has been done for the Proteus, for simplicity, we have used a different microcontroller. The connection varies from microcontroller to microcontroller; otherwise, the rest of things are almost the same. First, we decided to go with the built-in wifi in the ESP32 module, but as the device will be outside and can be moved, we used another GSM module for the cellular network. The particulate matter sensor was also changed because the module we had selected was not available.

Final Prototype Design

According to their respective purposes, the hardware prototype design implementation has been grouped into a single distinctive system. For your reference, the procedures are given below with a thorough explanation of each of the systems:

Figure 5.2: Final prototype design

The overall prototype has been shown above, as have all the connections with the power supply. As we developed our prototype design, the main idea of this project was to make the system compact so that it could easily be carried from one place to another. Keeping that in mind, we took the step to build a compact system. For that, we have to design a layout and implement it according to it.

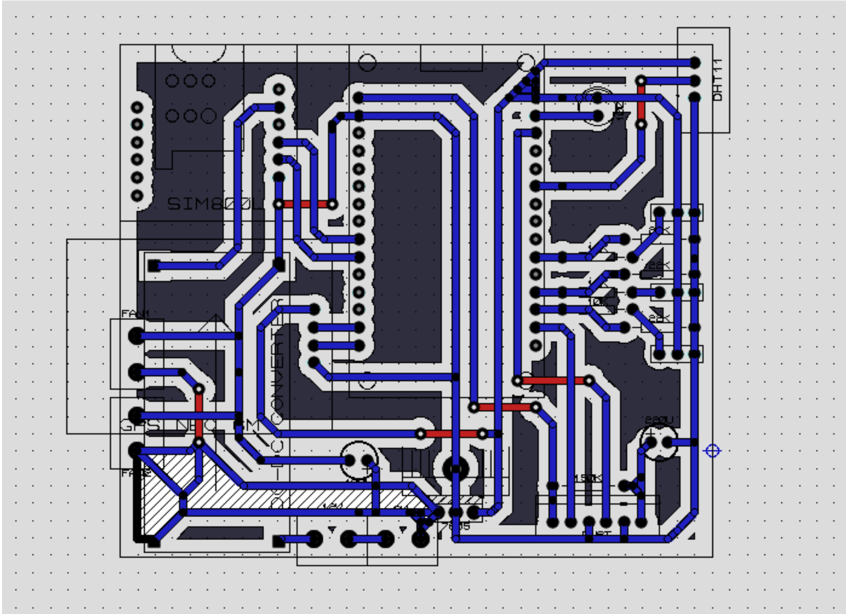


Figure 5.3: Final prototype design PCB layout

For designing the layout, we had to go through a lot of research as it was completely new to us. The PCB design layout was then soldered to the soldering board. Most of the main connections in the layout have been done on the backside. And the rest of the connections are overlaid.

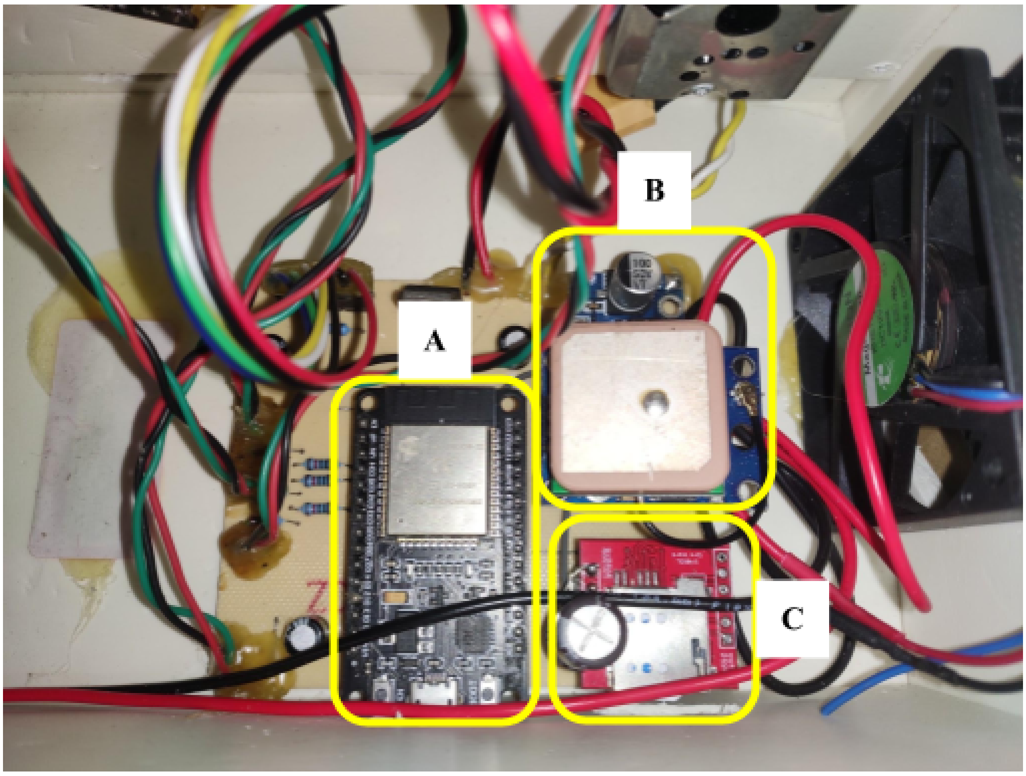


Figure 5.4: Final prototype design, main board design

If we see the system, we can see that everything is connected to the board and controlled by a microcontroller.

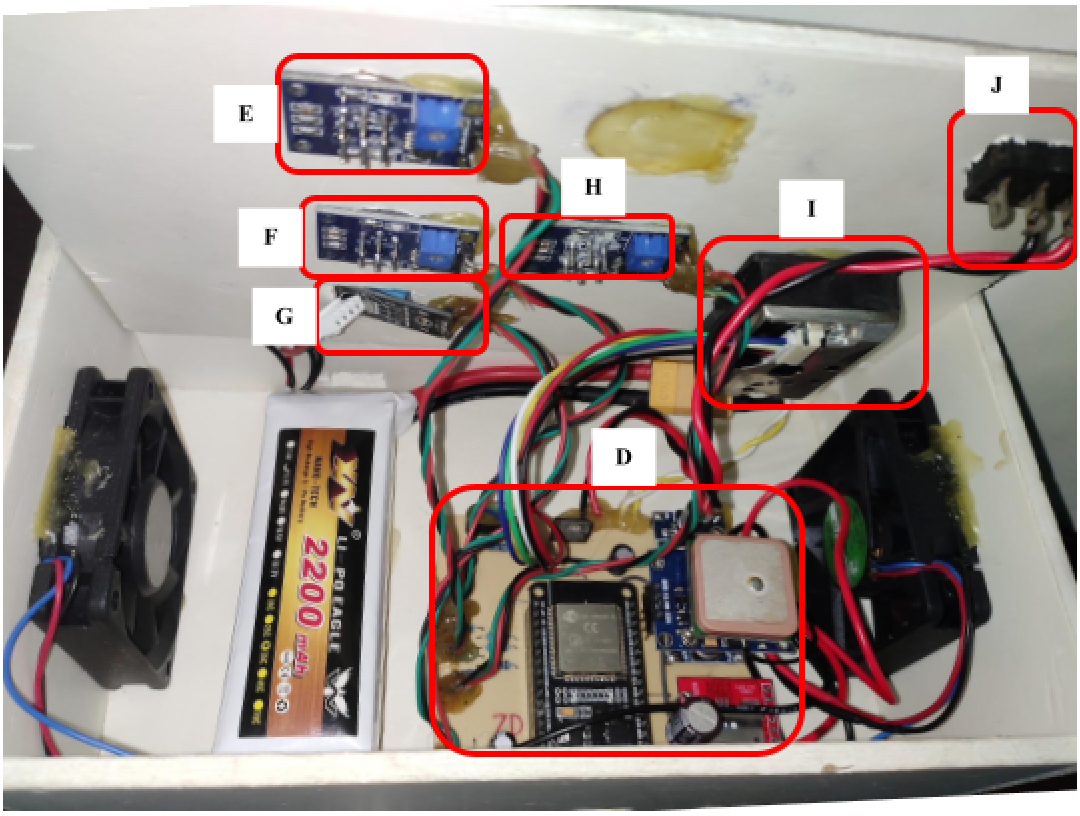


Figure 5.5: Final prototype design, main board and all the sensors

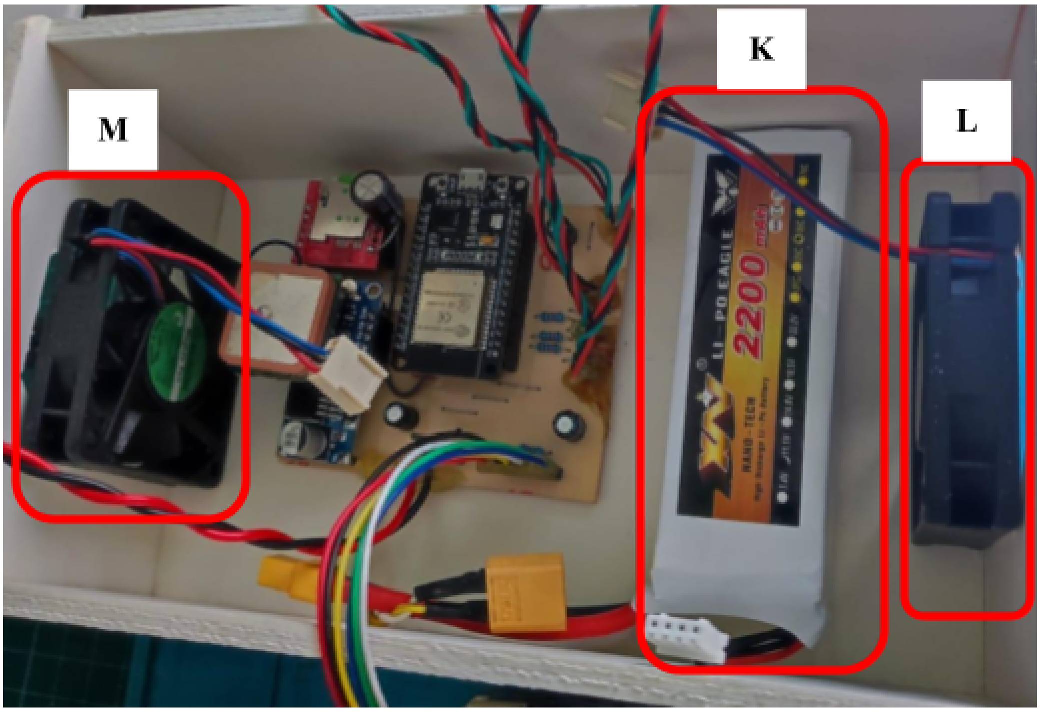


Figure 5.6: Final prototype design, power supply and fans

All the components that have been used in the system have been labeled alphabetically. The labeled components are described in the proceeding:

The main component to monitor air quality and send data via GSM with GPS location:

A. The microcontroller that has been used to control all the other components and send data to the web portal

B. The step-down voltage regulator and the GPS module have been integrated in the same position by soldering them to the board. The GPS module also has the antenna on the upper side, and below that are the system and voltage regulator.

C. For cellular networks, a GSM module is used.

The sensor to sense the air components and the connection to the main microcontroller:

D. The total system has been connected to one board, and all the necessary connections are done below it.

E. The marked sensor is the MQ-135 analog sensor, which is going to measure carbon dioxide (CO2).

F. This one is the MQ-7 analog sensor, which is going to sense carbon monoxide (CO).

G. Temperature and Humidity sensor DHT-11

H. Another MQ-135 analog sensor for sensing the hazardous level of ammonia (NH3)

I. The particulate matter sensor, or PM sensor, has been picked as the optical dust sensor (GP2Y1010AU0F).

J. A simple switch to start and stop the whole system.

Power supply and other parts:

K. The power supply is going to provide power for a long period of time.

L. Intake fan

M. Exhaust fan

5.3 Evaluate the solution to meet desired need

For the prototype design, we have uploaded the measured data from the sensors via a GSM module. The module validates the device's position and provides data to a network server that is publicly available online. The data is also recorded and stays on the server so that it can be viewed at any time. The GPs module shows the latitude and longitude as the location and shows it on the website. The data is recorded, and the parameters are temperature, humidity, CO2, NH3, CO, PM2.5, latitude, and longitude with a given time and date.

TABLE 5.1: Measured data of the air quality monitoring system extracted from the server

Date	Time	Temp.	Humidity	NH_3	CO_2	CO	PM2.5	Latitude	Longitude
22/08/2023	1:18:00 PM	34.7	78	4.19	180.65	19.35	4.52	23.746132	90.3651428
22/08/2023	1:18:30 PM	35.2	73	1.94	135.48	19.35	4.42	23.746141	90.3651352
22/08/2023	1:19:00 PM	35.6	73	0.65	129.03	19.35	6.06	23.74612	90.3651352
22/08/2023	1:19:30 PM	36.3	70	0.32	129.03	19.35	3.71	23.74613	90.3651352
22/08/2023	1:20:00 PM	36.8	81	0.65	129.03	19.35	5.84	23.746155	90.3651352
22/08/2023	1:20:30 PM	36.8	81	0	116.13	19.35	4.81	23.74613	90.3651428
22/08/2023	1:21:00 PM	36.3	69	0	109.68	19.35	4.45	23.746132	90.3651276
22/08/2023	1:21:35 PM	36.9	69	0	129.03	19.35	5.55	23.746145	90.3651276
22/08/2023	1:22:00 PM	36.9	68	0	129.03	19.35	4.61	23.746147	90.3650818
22/08/2023	1:22:30 PM	36.9	67	0	103.23	19.35	4.65	23.746126	90.3651352
22/08/2023	1:23:04 PM	36.8	81	0.97	129.03	22.58	4.65	23.746109	90.3651276
22/08/2023	1:23:30 PM	36.9	69	0.65	141.94	22.58	5.06	23.746109	90.3651276
22/08/2023	6:34:35 PM	31.8	87	24.84	380.65	38.71	4.61	0	0
22/08/2023	6:35:04 PM	31.8	88	7.42	206.45	25.81	4.26	0	0
22/08/2023	6:35:34 PM	31.8	90	4.84	180.65	25.81	5.03	0	0

22/08/2023	6:36:04 PM	31.8	90	4.19	187.1	25.81	3.9	0	0
22/08/2023	6:36:34 PM	31.8	90	3.55	180.65	25.81	4.42	0	0
22/08/2023	6:37:04 PM	31.8	90	4.19	212.9	32.26	4.71	0	0
22/08/2023	6:40:02 PM	31.8	90	6.77	232.26	16.13	4.65	0	0
22/08/2023	6:40:31 PM	32.2	86.5	4.19	193.55	22.58	4.26	0	0
22/08/2023	6:41:02 PM	32.3	89	3.87	180.65	22.58	3.77	0	0
22/08/2023	6:41:54 PM	32.3	87	3.55	187.1	25.81	4.06	0	0
22/08/2023	6:42:24 PM	32.2	86	4.19	219.35	35.48	4.65	0	0
22/08/2023	6:42:54 PM	32.2	86	5.48	258.06	38.71	5.29	0	0
22/08/2023	6:43:24 PM	32.3	90	4.19	212.9	29.03	4.87	0	0
22/08/2023	8:11:25 PM	31.8	86	15.16	303.23	25.81	4.94	0	0
22/08/2023	8:11:55 PM	31.3	87	4.84	174.19	22.58	4.71	23.746002	90.3653641
22/08/2023	8:12:25 PM	30.7	89	2.58	141.94	16.13	4.45	23.746174	90.3650665
22/08/2023	8:12:54 PM	30.2	90	2.58	154.84	19.35	3.77	23.746189	90.3650742
22/08/2023	8:13:28 PM	29.8	92	0.97	129.03	16.13	4.03	23.746201	90.3650436
22/08/2023	8:13:54 PM	29.8	92	2.26	154.84	19.35	4.61	23.746185	90.3650589
22/08/2023	8:14:25 PM	29.2	87	1.61	154.84	16.13	4.32	23.746109	90.3651276
22/08/2023	8:14:55 PM	29.8	93	1.61	161.29	22.58	4.1	23.746067	90.3649902
22/08/2023	8:15:28 PM	30.2	92	1.94	167.74	22.58	4.74	23.745991	90.3649979
22/08/2023	8:15:55 PM	30.8	92	2.58	180.65	22.58	3.84	23.745991	90.3649979

22/08/2023	8:16:25 PM	30.8	91	1.94	174.19	22.58	4.35	23.745991	90.3649979
22/08/2023	8:16:54 PM	31.3	91	1.94	174.19	22.58	4.71	23.745991	90.3649979
22/08/2023	8:17:25 PM	31.8	91	2.26	180.65	25.81	4.42	23.745991	90.3649979
22/08/2023	8:17:56 PM	31.8	91	2.26	174.19	25.81	4.48	23.745991	90.3649979
22/08/2023	8:18:25 PM	32.3	91	1.94	174.19	25.81	4.58	23.745991	90.3649979
22/08/2023	8:18:57 PM	32.3	90	2.26	174.19	22.58	4.81	23.745991	90.3649979
22/08/2023	8:19:24 PM	32.3	90	1.61	174.19	22.58	4.52	23.745991	90.3649979
22/08/2023	8:26:56 PM	32.8	87	4.84	206.45	22.58	3.97	0	0
22/08/2023	8:27:30 PM	32.8	87	3.55	174.19	22.58	4.77	0	0
22/08/2023	8:27:54 PM	33.3	86	2.9	174.19	22.58	3.9	0	0
22/08/2023	8:28:26 PM	33.3	86	2.58	180.65	22.58	4.65	0	0
23/08/2023	11:32:39 AM	35.6	71	43.87	412.9	48.39	4.81	0	0
23/08/2023	11:33:09 AM	35.6	69	9.35	180.65	25.81	5.13	0	0
23/08/2023	11:33:39 AM	36.3	70	4.84	135.48	22.58	4.58	0	0
23/08/2023	11:34:09 AM	36.3	70	3.55	129.03	16.13	4.42	0	0
23/08/2023	11:34:39 AM	36.3	70	3.55	154.84	29.03	4.52	0	0
23/08/2023	11:40:09 AM	35.2	70	0.65	129.03	19.35	4.65	0	0
23/08/2023	11:40:39 AM	35.6	71	1.29	129.03	19.35	4.29	0	0
23/08/2023	11:41:09 AM	36.3	69	1.94	161.29	19.35	5.16	0	0
23/08/2023	11:41:40 AM	36.3	68	1.94	161.29	19.35	5.16	0	0

23/08/2023	11:42:10 AM	35.6	69	1.94	129.03	16.13	4.26	0	0
23/08/2023	11:42:39 AM	35.6	69	2.9	154.84	16.13	4.45	0	0
23/08/2023	11:43:08 AM	35.2	70	2.26	135.48	16.13	4.77	0	0
23/08/2023	11:47:25 AM	35.6	69	5.16	212.9	22.58	4.87	0	0
23/08/2023	11:47:57 AM	36.3	69	2.58	148.39	19.35	5.19	23.74745	90.3730774
23/08/2023	11:48:25 AM	36.9	68	3.23	180.65	25.81	4.29	23.747448	90.3730469
23/08/2023	11:48:54 AM	36.2	81	1.94	148.39	25.81	5.39	23.747746	90.3729858
23/08/2023	11:49:28 AM	35.2	71	3.23	200	29.03	4.68	23.747879	90.3728256
23/08/2023	11:50:17 AM	35.2	73	2.26	154.84	19.35	5.1	23.747971	90.3725357
23/08/2023	11:50:35 AM	34.7	75	1.94	148.39	16.13	4.94	23.749027	90.3721771
23/08/2023	11:50:55 AM	34.7	75	1.94	148.39	16.13	4.94	23.749027	90.3721771
23/08/2023	11:51:26 AM	34.1	78	1.61	141.94	16.13	5.03	23.750195	90.3723831
23/08/2023	11:51:55 AM	33.8	78	1.94	148.39	16.13	3.74	23.750851	90.3733673
23/08/2023	11:52:24 AM	33.8	78	1.29	129.03	16.13	4.52	23.751303	90.3735428
23/08/2023	11:52:54 AM	33.3	78	1.29	109.68	12.9	5.16	23.751347	90.3741989
23/08/2023	11:53:25 AM	32.8	81	0.97	103.23	12.9	4.35	23.751461	90.3749542
23/08/2023	11:53:55 AM	32.8	83	2.26	180.65	16.13	4.9	23.75189	90.3755417

24/08/2023	3:56:34 PM	30.2	93	22.58	309.68	32.26	4.52	23.780317	90.4117661
24/08/2023	3:57:05 PM	30.2	92	16.13	270.97	25.81	4.9	23.780331	90.4118118
24/08/2023	3:57:38 PM	30.2	92	19.35	296.77	38.71	4.97	23.780401	90.4117889

24/08/2023	3:58:04 PM	30.2	92	12.9	258.06	32.26	4.65	23.780437	90.4117813
24/08/2023	3:58:36 PM	30.2	92	0	167.74	25.81	5.23	23.78051	90.412796
24/08/2023	3:59:13 PM	30.2	92	22.58	309.68	25.81	4.87	23.780443	90.4135132
24/08/2023	4:00:09 PM	30.2	92	12.9	258.06	32.26	4.9	23.78063	90.4133987
24/08/2023	4:00:36 PM	30.2	92	9.68	258.06	32.26	4.68	23.780394	90.413475
24/08/2023	4:01:12 PM	30.8	92	9.68	309.68	45.16	4.68	23.780411	90.4145508
24/08/2023	4:03:05 PM	30.2	91	6.45	245.16	25.81	4.81	23.780355	90.4157028
24/08/2023	4:03:47 PM	30.2	92.9	6.45	258.06	32.26	4.03	23.780287	90.4157028
24/08/2023	4:04:49 PM	30.8	91	3.23	258.06	25.81	4.68	23.780605	90.4159546
24/08/2023	4:05:40 PM	30.8	91	16.13	361.29	51.61	4.65	23.780954	90.4160309
24/08/2023	4:06:35 PM	30.8	90	19.35	322.58	32.26	4.52	23.780954	90.4160309
24/08/2023	4:07:05 PM	31.3	90	16.13	322.58	25.81	5.06	23.780954	90.4160309
24/08/2023	4:07:35 PM	31.3	91	100	774.19	103.23	5.13	23.780954	90.4160309
24/08/2023	4:08:06 PM	31.3	91	54.84	503.23	38.71	4.97	23.780954	90.4160309
24/08/2023	4:08:38 PM	31.8	90	29.03	374.19	32.26	4.77	23.780954	90.4160309
24/08/2023	4:10:19 PM	31.2	86.5	32.26	270.97	38.71	4.29	23.780954	90.4160309
24/08/2023	4:11:10 PM	31.8	91	16.13	322.58	32.26	4.19	23.780357	90.4157333
24/08/2023	4:12:23 PM	31.8	90	25.81	374.19	32.26	5.35	23.780357	90.4157333
24/08/2023	4:12:39 PM	31.8	90	19.35	322.58	32.26	4.87	23.780357	90.4157333
24/08/2023	4:13:41 PM	31.3	90	35.48	400	25.81	6.19	23.780357	90.4157333

24/08/2023	4:14:38 PM	31.3	90	35.48	400	25.81	6.19	23.780357	90.4157333
24/08/2023	4:15:15 PM	31.3	91	12.9	270.97	32.26	4.65	23.780357	90.4157333
24/08/2023	4:16:00 PM	30.8	91	0	206.45	25.81	5.26	23.780357	90.4157333
24/08/2023	4:16:40 PM	29.8	93	41.94	464.52	32.26	4.55	23.780357	90.4157333
24/08/2023	4:18:35 PM	30.2	92	38.71	400	45.16	4.71	23.780357	90.4157333
24/08/2023	4:19:04 PM	30.8	92	35.48	400	45.16	5.03	23.780357	90.4157333
24/08/2023	4:19:36 PM	30.8	92	32.26	361.29	38.71	4.42	23.780357	90.4157333
24/08/2023	4:20:04 PM	30.8	92	45.16	464.52	38.71	5.13	23.780357	90.4157333
24/08/2023	4:20:37 PM	30.8	92	90.32	645.16	51.61	5.1	23.780357	90.4157333
24/08/2023	4:21:13 PM	30.8	92	51.61	464.52	45.16	6.61	23.780357	90.4157333
24/08/2023	4:21:35 PM	31.3	92	38.71	387.1	38.71	3.61	23.780357	90.4157333
24/08/2023	4:22:10 PM	31.3	91	25.81	335.48	38.71	4.65	23.780357	90.4157333
24/08/2023	4:23:32 PM	31.8	91	25.81	361.29	45.16	5.42	23.780357	90.4157333
24/08/2023	4:24:07 PM	31.3	91	0	38.71	6.45	4.77	23.780357	90.4157333
24/08/2023	4:24:36 PM	30.8	91	67.74	554.84	51.61	5.03	23.780357	90.4157333
24/08/2023	4:25:11 PM	30.8	92	38.71	374.19	32.26	4.55	23.780357	90.4157333
24/08/2023	4:26:00 PM	30.8	91	16.13	296.77	32.26	4.55	23.780357	90.4157333
26/08/2023	10:26:13 AM	25.3	77	267.74	787.1	206.45	4.06	0	0
26/08/2023	10:26:41 AM	25.3	77	41.94	206.45	45.16	3.61	0	0
26/08/2023	10:27:12 AM	25.8	79	16.13	141.94	25.81	3.97	0	0

26/08/2023	10:27:41 AM	25.8	80	3.23	129.03	19.35	4.55	0	0
26/08/2023	11:03:43 AM	26.7	76	0	206.45	25.81	4.68	0	0
26/08/2023	11:04:12 AM	26.7	76	0	206.45	25.81	3.77	0	0
26/08/2023	11:04:41 AM	26.7	76	0	206.45	25.81	4.29	0	0
26/08/2023	11:05:11 AM	26.7	75	0	206.45	25.81	4.1	0	0

Before testing in the real scenario the sensors need to be calibrated according to the analog reading. Before integrating the sensors it needs to be preheated for the accurate result and then update the code for better accuracy. The analog sensors are tested outside and according to that result the calibration is done. And for the GPS module it only works outside so inside if the device is initiated there will be no latitude and longitude as it does not show any location indoors. That's why when we tested indoor or in the showcase it did not render any location in the website.

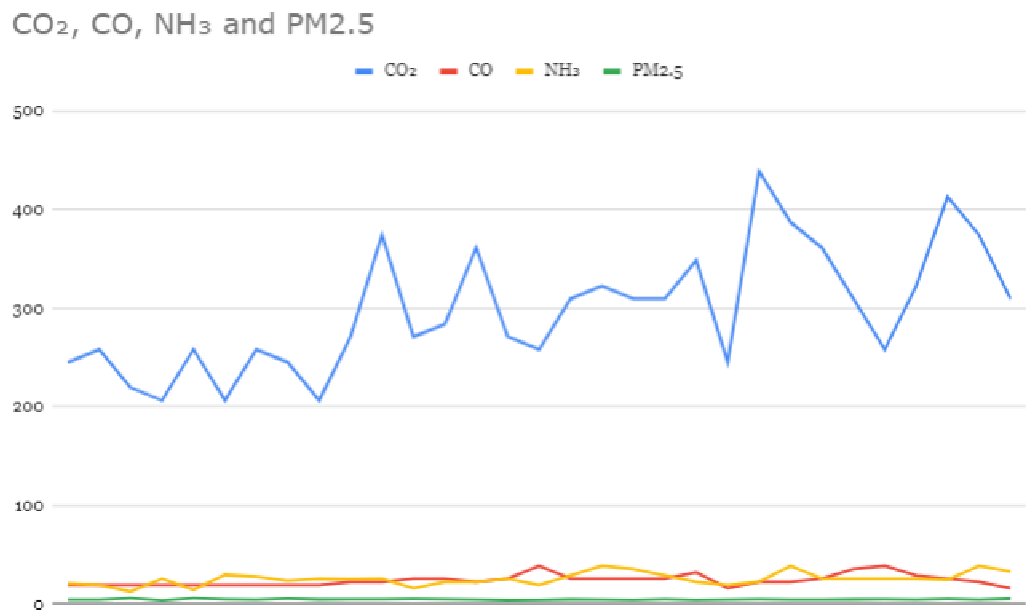


Figure 5.7: graph of different air components data

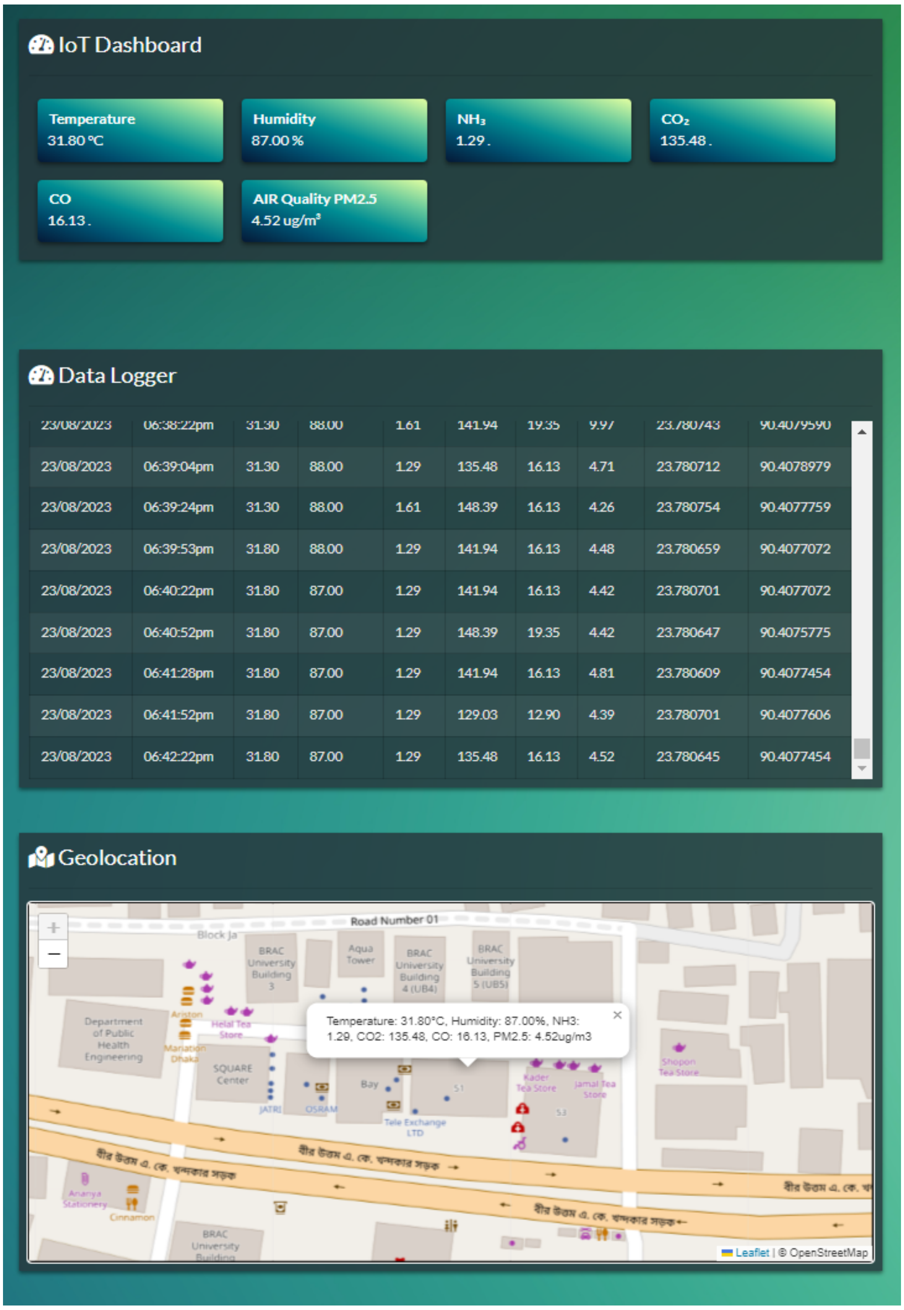


Figure 5.8: The IoT dashboard where all the data is stored and also shows the location.

SWOT Analysis of the prototype design:

With the use of a SWOT analysis, the completed hardware prototype design has been further assessed in order to identify its matching strengths, weaknesses, opportunities, and threats. Various factors have been taken into account during this procedure.

TABLE 5.2: SWOT analysis table of the prototype

	Beneficial	**Harmful**
Internal	**Strength-** • Innovatory attributes • Precise measuring • Low cost • Location via GPS • Data sent to the WEB portal	**Weakness-** • Not performed tests • Power wastage
External	**Opportunity-** • The design can be said new in air quality measuring system category • Provide valuable information about health safety to the public • Can improve public health in Bangladesh by air quality measuring with route mapping system	**Threats-** • Air quality is not given any significance in outdoor places • Public are not aware of air quality measuring devices so the market is small

5.4 Conclusion

It is obvious from the measured data and performance speculation that the design strategy adopted was successful in implementing several requirements. The air components that are harmful to human health have been assessed for the design. After examining the data and design development, we further explored the findings using a SWOT analysis to list its advantages, disadvantages, opportunities, and potential risks, and hence its overall performance.

Chapter 6: Impact Analysis and Project Sustainability. [CO3, CO4]

6.1 Introduction

Every project, when it is first presented, has its share of effects that simultaneously make it powerful and susceptible. When we examined our project, we divided its effects into a number of categories, including societal, health and safety, cultural, etc. These categories are all detailed in more depth in the segment below. To further explore the impact of our project, a SWOT analysis has also been carried out. Our project's innovative qualities, accurate measurement, and low power consumption are its strengths. The technology is cost-effective, dependable, and portable all at once.

6.2 Assess the impact of solution

Through the initialization of the system, we expect the following outcomes:

- The main objective is to make an air quality measuring device.
- The device should be compact or portable.
- We will be collecting data on specific areas, and we will be able to inform people about the weather quality of that particular area.
- Implement the data into mapping system software to generate a custom map;
- Consumers can get information about air quality.

Societal Impact:

By increasing public knowledge and responsibility for environmental health, an outdoor air quality monitoring system with route mapping capabilities has a substantial societal impact. With access to real-time information on air quality, it gives communities and people the freedom to decide for themselves on outdoor activities, commutes, and their own health. Additionally, the technology's openness fosters support for environmental and clean air policy campaigns. It emphasizes concerns of environmental justice and encourages social interaction and action to solve pollution hotspots by showing differences in air quality across communities and regions. Additionally, it helps preserve the health of vulnerable groups, such as individuals with respiratory disorders. Overall, such a system has transformative social effects that encourage civic participation, environmental responsibility, and the goal of cleaner, healthier communities.

Health and Safety Impact:

The device will also play a major role when it comes to health and safety, as we have mentioned above. Health and safety are greatly enhanced by an outdoor air quality monitoring system with route mapping capabilities. Such a technology gives people, communities, and authorities crucial information by continually measuring and charting data on air quality along certain routes. Early identification of air pollution hotspots is made possible by this, allowing individuals to avoid exposure to dangerous pollutants and make wise choices about their outdoor activities. Additionally, route mapping enables emergency responders to properly allocate resources and identify safe evacuation routes in the case of abrupt environmental crises or catastrophes. Overall, this technology improves safety by increasing readiness and responsiveness in the event of emergencies linked to air quality, while also promoting public health by limiting exposure to air contaminants.
Since our project will not only measure the air quality but also provide a map for the users to get the best route with the least pollution, it will definitely have an impact on their health as they can now avoid or take proper precautions while using those roads.

Cultural Impact:

Since the people of our country are very familiar with Google Maps and other related applications, it will not be very difficult for them to get used to the idea, and in fact, this will be very efficient and have a good cultural impact considering the recent times when people are very concerned regarding their health and surroundings. With the advancement of technology, people are becoming more concerned about a healthy lifestyle.

Following a SWOT analysis, the potential effects of an air quality monitoring system using route mapping are assessed.

TABLE 6.1: SWOT analysis table

	Beneficial	Harmful
Internal	**Strength-** ● Innovatory attributes ● Precise measuring ● Low power consumption ● Durable and portable ● Low cost	**Weakness-** ● Developing a separate mapping software ● For large scale manufacturing requires of initial investments ● Time period required to execute data in the map
External	**Opportunity-** ● The design can be said new in air quality measuring system category ● Provide valuable information about health safety to the public ● Can improve public health in Bangladesh by air quality measuring with mapping system	**Threats-** ● Air quality is not given any significance in outdoor places ● Public are not aware of air quality measuring devices so the market is small

I. Potential Strengths

The air quality monitoring system through route mapping possess several strengths that will be beneficial to the consumers. A developing country like Bangladesh, it has innovative attributes like the mapping part of this project is almost new to us. Very few other countries are still doing some research on it. The system gives the consumer precise measurements of the air pollutants as well as the current location of the device. A country like Bangladesh where power generation is not that stable yet here it can be operated through very low DC current also the cost of this will be suitable for the consumers. This monitoring device would be very much durable and as a compact size it can be carried from place to place.

II. Tentative Weakness

To elaborate on the possible weaknesses of the air quality monitoring system through route mapping, the most significant weakness is that we are currently integrating the data on a custom map. The synchronization with the real time data as well as creating a custom color categorized system is still not developed. The google mapping system though it uses a different kind of algorithm to locate the density of traffic. Another one is if the device needs to be manufactured in large scale we will be requiring initial investments and lastly a time period for executing the data in the custom mapping system.

III. Possible Opportunities

As Bangladesh is developing day by day the advancements might bring some modifications of the device that will lead us to build a more advanced air quality monitoring system which will do all the required tasks that are programmed for. Also it will provide valuable data and for the government for the public safety. And from that general mass will be able to improve their lifestyle by simply turning on the system.

IV. Tentative Threats

The most common issue is that people are still not aware of the effects of bad air quality. There are millions of people who are not literate and do not know what bad air quality can do to them. Therefore, providing awareness as well as general knowledge can bring them to light. Also still people do not pay any heed to the outdoor air quality. For example, if someone has a mask in their pocket they will hesitate to use it even though there is bad air quality. So it needs to be fixed by awarding them.

6.3 Evaluate the sustainability

The designed system should be sustainable in terms of economics and the environment. And we can expect the system to have a long life of approximately 3–5 years if proper guidelines and methods are followed. We also need to develop the system so that it can measure accurate values of air pollutants and have the fewest errors.

Economically:

The system that we are focused on designing with all the components for measurements must be expensive. But we are trying to develop the system so that the consumers and stakeholders can have the availability to obtain it. As the system is measuring harmful air pollutants, there are several methods to calculate them. The government has taken the initiative to install air quality measuring stations that can compute the air quality in a certain area. But that is only for research purposes, which are not that beneficial for the general public. But as we are focusing on the portable as well as consumer availability, the design system can be obtained by any common individual. This project will solve that problem, as it will be consumed by the public, and an air quality map will assure their health safety by guiding them.

Environmentally:

The system we are developing can be carried anywhere, so it should be made considering all the matters related to the environment. As it will be designed with different components, we need to make sure all of these are environmentally friendly. And as it will be portable, there will be a cover protecting the internal parts from being damaged, and the material should also have no impact on the environment. In the future, the system can be collaborated with by other companies, and for that, the design can be upgraded as per requirement. And make sure that it can modify taking environmental matters on account.

Social:

The system will be measuring air quality data of outside areas. The data will be collected and it will be implemented in a custom that will be accessible for all users. It will help to improve the lifestyles and lead to a healthy life. As the system will be generating a map any user will be acknowledged by the hazardous impacts of air pollutants. Thus ensuring health safety for the common people.

6.4 Conclusion

The extent to which a project is sustainable is a factor in determining its efficacy. It is not worthwhile to spend time, effort, and money on something that will not last for a long time. In the same way, we carefully examined our project to see how much sustainability it exhibited. Thankfully, ours is very sustainable in all three areas: socially, economically, and ecologically. This is due to the fact that it would have no negative environmental consequences of any kind. If it goes as planned this will be recognized and general people can lead a healthy life without any doubt.

Chapter 7: Engineering Project Management. [CO11, CO14]

7.1 Introduction

An individual cannot complete the labor required to turn a concept into a proposal, which is subsequently translated into a physical product. It always requires a collective effort from many brains to accomplish something that seems unattainable at first. It took a team to complete this technical job. However, planning and managing the team is crucial while working in a group. Execution conflicts are bound to arise without a good strategy, management, and team orientation, ultimately leading to the collapse of a project. Thus, we organized the tasks that were allocated and depicted them in a gantt chart that was sent to all of the group members. Throughout the project, this schedule was closely adhered to. But there still will be some ups and downs as we face in our real life, for this we may not have properly followed the project timeline but at least tried to finish all the tasks in the proper given time.

7.2 Define, plan and manage engineering project

Through the final year design project, the timeline is divided into three phases. For the first phase 400P, we have to select a complex engineering topic to work on. Then in phase two 400D we have to simulate all possible alternative designs and find an optimal solution to build as a prototype. And lastly for 400C we have vbuild the prototype of the optimal solution and test according to the instructions. And compare it with any resources.

Throughout the entire semester we have tried to maintain the timeline for getting the project proper outcome. All of the group members' tasks have been divided throughout the entire semester. Nevertheless, there still are some ups and downs but putting all of that aside we have moved forward and tried to finish timely. Also we have done meetings with our ATC members to get the feedback and work accordingly. Throughout the process we have maintained a logbook for all the meetings with the ATC member. And a proper gantt chart has been prepared to maintain the timeline.

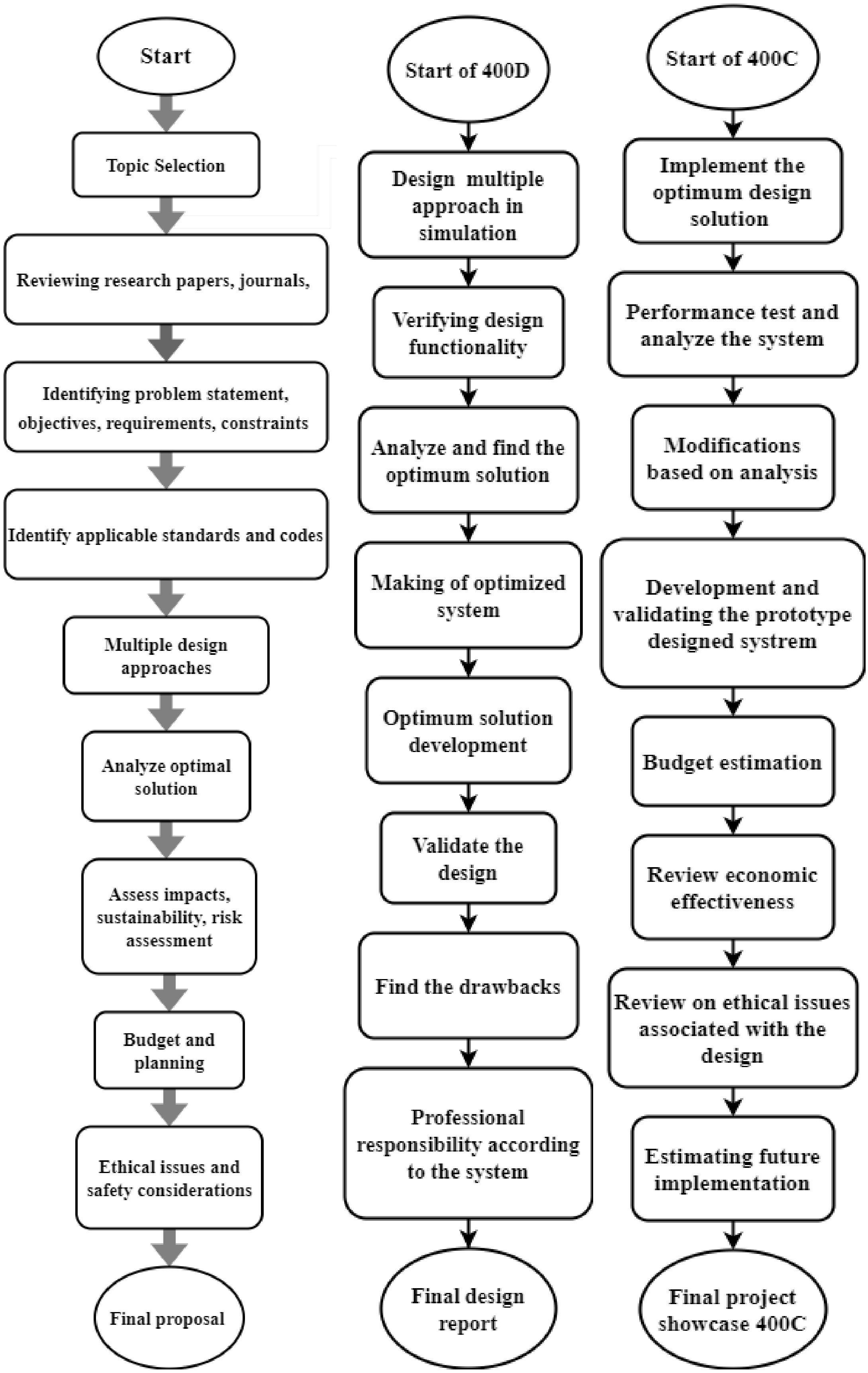
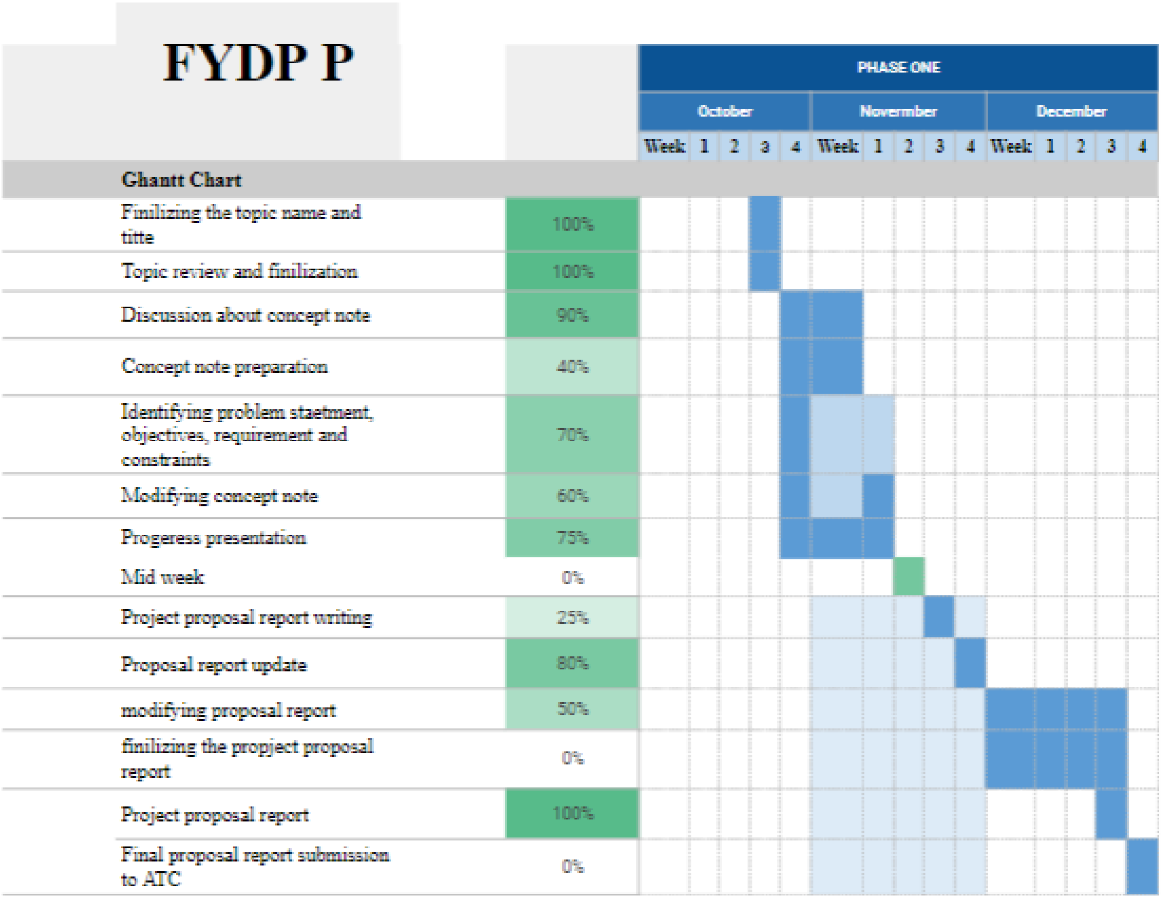


Figure 7.1: workflow of 400P, 400D, 400C

Gantt Chart:

TABLE 7.1: Tentative Gantt chart followed throughout the final year design project semesters



FYDP P

PHASE ONE: October (Week 1 2 3 4), Novermber (Week 1 2 3 4), December (Week 1 2 3 4)

Ghantt Chart	
Finilizing the topic name and titte	100%
Topic review and finilization	100%
Discussion about concept note	90%
Concept note preparation	40%
Identifying problem staetment, objectives, requirement and constraints	70%
Modifying concept note	60%
Progeress presentation	75%
Mid week	0%
Project proposal report writing	25%
Proposal report update	80%
modifying proposal report	50%
finilizing the propject proposal report	0%
Project proposal report	100%
Final proposal report submission to ATC	0%

According to the given gantt chart, the activities are divided among the group members. And after finishing a task, we tried to consult the ATC for their approval about the project report work.

For 400P, we first focused on picking a topic that meets all the requirements for a final-year design project. And will have to meet some criteria to be a complex engineering problem. After finalizing the topic, we move on according to the gantt chart, and after some extensive research, we find alternate design approaches for our topic. The gantt chart will span October, November, and December. And according to it, we are going to deliver all our tasks one by one. After selecting the alternate designs, we did some analysis based on economic, ethical, etc. And in the final week, we will write the report and submit it to ATC for feedback. Finally, after updating the report, we submitted it on time. A logbook was maintained to follow the proper plan and keep track of the progress.

TABLE 7.2: Tentative Gantt chart followed throughout the final year design project semesters

FYDP D		PHASE TWO											
		February				March				April			
		1	2	3	4	1	2	3	4	1	2	3	4
Ghantt Chart	Progress												
Background research	100%												
Device survey conducted	100%												
Prepare designs of multiple solutions	90%												
How to receive real time data from the device analysis	40%												
Finilizing appropriate it tools for varifying optimal solution	45%												
Analyze the best optimal solution	60%												
Designed 3D model for the device	50%												
Mid Break	0%												
Perform simulation for functional varification	25%												
Budget and real time mapping system analysis	90%												
Analysis impacts	100%												
Research on ethical considerastion	100%												
Perform risk management analysis and contingency plan	100%												
Draft design report prepare and mock presentation	70%												
Final design report update	85%												
Final presentation	100%												
Final design report submission to ATC	0%												

According to the plan, responsibilities were divided among group members, and they tried to consult with the ATC panel every week, if possible, about the project reports.
For 400D, we mainly focused on finding the optimal design approach for our project. In our Gantt chart for EEE400D, some tasks have been changed, and the timeline has also been slightly modified or delayed according to our semester schedule or the conflicting time or class schedule of our groupmates. The Gantt Chart will now span the months of February, March, and April. We have planned our project work time with the help of the Gantt chart. In the first few weeks, we have been going through a research background as well as starting to analyze the functional verifications of the design approaches. Then we focused on finding the optimal design from the multiple design solutions by doing a simulation for all three designs. And lastly, we did some research on expected outcomes and ethical considerations before submitting the final project report. A logbook was maintained to follow the proper plan and keep track of the progress.

TABLE 7.3: Tentative Gantt chart followed throughout the final year design project semesters

FYDP C	Progress	PHASE THREE											
		June				July				August			
		1	2	3	4	1	2	3	4	1	2	3	4
Selecting components	100%												
Testing Components	100%												
Designing the system	15%												
Testing the designed system	40%												
Further modification of the system	70%												
Calibrate the sensors	60%												
Progress Presentation	50%												
Finilizing the design	22%												
Update and finilize the budget	16%												
Mid week	0%												
Testing the designed prototype	100%												
Start taking data and prepare for showcase	75%												
Start writing report	0%												
Consultant with ATC for the report	25%												
Preparation for showcase	50%												
Project showcase	100%												
Updating the report	50%												
Rerport submission	0%												

According to the plan for 400C, the optimal design has been fulfilled by following the gantt chart guidelines.

For 400C, we have to design the optimal solution that we found previously and make a prototype. For this, we have decided to divide tasks among the group members and make sure all of us are following the timeline. As per the timeline, For designing the optimal solution, necessary components are needed and things that will be used for this After that, we have to make sure all things are working properly, as we have to integrate them all together to make a prototype. After finalizing the design, we now have to build it for the showcase. And along with that, we need to make sure one group member is working on the report. Finally, when building the prototype, we have to make sure it is working properly and meets all our requirements so that we can showcase it. And by following the timeline, after doing some analysis of the prototype and updating the report, we can timely submit it. A logbook was maintained to follow the proper plan and keep track of the progress.

7.3 Evaluate project progress

Following is a quick comparison of the development, together with the progress status and remarks, while keeping in mind the project's preliminary pre-arrangement timeframe and the actual workflow throughout the semester:

TABLE 7.4: Evaluation of the project progress

Date/Time	Tentative plan	Progress	Responsible	Progress Status
10/07/2023	Brief discussion of 1. Confirming optimal design 2. Plan the workflow	Brief discussion of 1. Confirmed optimal design 2. Plan the workflow	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 1: completed. Task 2: partially completed.
20/07/2023	1. Selecting proper components 2. Necessary instruments	1. Selected proper components and Necessary instruments	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 1: completed.
06/08/2023	Assembling the Components and Testing	1. Assembled the Components 2. Tested components	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 1: completed. Task 2: partially completed.
07/08/2023	1. Designing Systems	Designed the system	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 2: partially completed. Task 3: have not started yet
11/08/2023	Testing the system to match outcome and Preparation for progress presentation	Tested the system to match with outcome Preparation of progress presentation	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 2: partially completed.
15/08/2023	Brief discussion about 1. designing the prototype 2. testing all the components	Finished designing the prototype	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 1: completed.
26/08/2023	Showcasing the prototype	Showcase of the prototype	Md.Shadman Shahriar Adit Shams Yeamin Abu Shadad Mohammad Sayem Md.Asif Iqbal Roza	Task 1: completed.

7.4 Conclusion

The duties were first included in a timeline chart that was created. This was considered, accepted by all members, and then distributed. Following the timeline chart, the tasks stated in 400P were completed without difficulty. As a result, 400D performed the same process, and the gantt chart was given to all of the members. Everything proceeded methodically and smoothly, as intended, when it was followed. In order to obtain findings that are as good at 400 C, we are now repeating the identical situation.

Chapter 8: Economical Analysis. [CO12]

8.1 Introduction

Investors, clients, stakeholders, and everyone else pay attention when a project demonstrates that it is economically viable. Since it is highly improbable that anyone would want to waste time and resources on a project that would fail. Therefore, in order to ensure that a project concept is widely adopted, it must be profitable. When a project proposal is proposed, the implementation costs, necessary finance, and time period for realizing a return on investment must all be considered. It will need further investigation to prove the project's long-term sustainability. In our project of air quality monitoring system thorough route mapping the main idea is to promote the device through different sources to attract the stakeholders and to show how economically feasible the device is to the consumers. After having the tentative cost of the project, will attract a good amount of investors which will be needed in the future.

8.2 Economic analysis

The system that we are focused on designing, with all the components for measurements, must be expensive. But we are trying to develop the system so that consumers and stakeholders can have access to it. As the system is measuring harmful air pollutants, there are several methods to calculate them. The government has taken the initiative to install air quality measuring stations that can compute air quality in a certain area. But that is only for research purposes, which is not that beneficial for the general public. But as we are focusing on portable as well as consumer availability, the design system can be obtained by any common individual. This project will solve that problem as it will be consumed by the public, and an air quality map will assure their health and safety by guiding them. Furthermore, there are some private organizations who are trying to achieve the same goal and with the advancement of their technology they are leaping forward. As a matter of fact, the device that will be on the market for every consumer will not be able to use it as it will be very expensive. We can see in many countries there are air quality measuring devices installed outside their home or outside in large city scapes, but those come for a very expensive price. If we try to make it import the pricerates increases which may not be liked by the stakeholders. So to make it affordable also to make it accurate the device must meet the demands of the consumer's budget. For this decrease the cost may differ the result of the number of consumers.

8.3 Cost benefit analysis

The cost benefit analysis has been conducted in terms of designing the system before making the prototype of the air quality monitoring system through route mapping as well as the hardware prototype that has been developed. Cost benefit analysis mainly focuses on how much the system will cost and will it be beneficial to the consumers as the price of the device is fixed. So the analysis gives a brief understanding about the cost and will it be beneficial or not. The cost analysis from economic aspects is elaborated in the following:
The tentative budget of the optimum design before making it as a prototype. In these few components price tags were estimated as it was taken from different sources. The price even varies if it is mass produced in the factories because the raw materials will be in large numbers.

TABLE 8.1: Previously estimated budget for the project

Components		Quantity	Price(Tk.)
Micro-controller		1	850 - 1500/-
Battery		1	1000 - 1500/-
NH3 **NOx** **CO2**	Sensor	1	150 - 300/-
CO	Sensor	1	150 - 300/-
$PM_{2.5}$	Sensor	1	1500 - 3500/-
Humidity and temperature	Sensor	1	150 - 300/-
Wifi Module		1	350 - 500/-
PCB		1	150 - 250/-
Breadboard		1	100 - 150/-
Wires		20	50 - 100/-
Others			800 - 1500/-
		Total=	5250 -9600/-

In the previous budget we have mentioned all the necessary components that play a significant role for measuring the air quality and sending the calculated data to the server storage. Although there are many expensive air quality measuring sensors, all are not available in Bangladesh. It needs to be imported from abroad. As well as we decided to make it cost efficient for the consumers by keeping it low cost. Most of the analog sensors present in the market are available and some are not available. For the final prototype design we have considered many aspects by the means of availability of the sensors, and built the final design prototype.

Prototype:
The prototype that has been built the budget is given in the proceeding:

TABLE 8.2: Final costing of the proposed prototype of the project

EEE400C Spendings of Group-07 Summer-2023				
SI no.	**Components**	**Quantity**	**Cost Per Quantity(BDT)**	**Price BDT**
1.	ESP WROOM-32	1	400	**400**
2.	Sim800L	1	280	**280**
3.	Lipo Battery 12V 2200mAh	1	1500	**1500**
4.	Battery Balance Charger	1	350	**350**
5.	MQ-135	2	100	**200**
6.	MQ-07	1	100	**100**
7.	Switch	1	5	**5**
8.	GP2Y1010AU0F	1	735	**735**
9.	GPS Neo-6M	1	500	**500**
10.	DHT-11	1	150	**150**
11.	3.7V single cell battery	4	87.5	**350**
12.	Battery Holder	1	80	**80**
13.	LM2596 Step down voltage regulator	1	100	**100**
14.	Capacitor-100uF	1	20	**20**
15.	Resistor-10KΩ	3	6.67	**20**
16.	Resistor-22KΩ	3	6.67	**20**

17.	XT60 spark arrestor	1	70	**70**
18.	Soldering Wire(40-50 gm)	1	100	**100**
19.	Soldering board	1	150	**150**
20.	12V fan	2	80	**160**
21.	Female Header Connector	2	50	**100**
22.	Male Header Connector	2	50	**100**
23.	Wire		240	**240**
			Total	**5630 TK**

8.4 Evaluate economic and financial aspects

To evaluate the economic and the financial aspects we have to compare with the external resources that are available. The closest comparison we can make is with IQAir which is a Swedish company monitoring the air quality of Dhaka city 24/7 and their stations are situated in many parts of the city. They also have their own built outdoor monitoring system for households. Which measures the outdoor air quality and it sends it to the main server where they can measure the average AQI for 24 hours straight. But after doing the cost analysis all other consumers are not able to buy at the price rate at which the air monitoring system is being sold. The basic model of AirVisual outdoor costs around 50,000 Tk(BDT). And also it does not have any route mapping feature. By keeping that in mind for the availability of the consumers we are trying to make the prototype as low-cost as possible. The price has been put at around 5630 Tk (BDT) and it can be lessened if some modifications are done. And if the device is manufactured on a large scale the price of the single components will be lowered as the components will be purchased wholesale. Considering the consumer's economic state the product will be in reach of the consumers or stakeholders. And as for the financial aspect there are some criterias which should be kept in mind. If the device somehow damages it will be our concern to fix it and give proper service to the consumers. Additionally, if the device is being installed in vehicles in the future it will be under the cost of the vehicle as well. But talking about the financial aspects of the device cost which has been introduced is quite encouraging. And with more technical developments in this field, things can only get better.

8.5 Conclusion

The economic analysis is done in accordance with the idea of our project, which is an air quality monitoring system that is primarily focused on our nation, Bangladesh. The project's economic and financial components are crucial when seen from the standpoint of Bangladesh's populace. Less people would participate in and show interest in our initiative if it were not financially viable; conversely, the more economically viable the business, the greater the number of prospective customers. Unfortunately, the companies who provide the same types of system are not in reach of the normal consumers. keeping in mind, the device is being designed so that it can be easily used and also can be modified for future industry. Also the air quality monitoring systems that are present in the market are big in size. So considering the usability of the consumers we tried to make it as low cost as possible and a compact device which can be taken from one place to another.

Chapter 9: Ethics and Professional Responsibilities CO13, CO2

9.1 Introduction

The core values of project management ethics include preserving honesty, openness, and responsibility over the course of a project. It requires ethical behavior, open dialogue with stakeholders, responsible decision-making, respect for confidentiality, equality for all parties involved, adherence to laws and regulations, avoidance of conflicts of interest, sustainable practices, and a dedication to continuous improvement. The use of ethical norms in project management promotes trust, upholds reputation, and aids in the accomplishment of project goals. Also we never forgot to give credibility to the resources we gained knowledge and move forward with the goal of achieving an honest outcome of the project.

9.2 Identify ethical issues and professional responsibility

Designing a monitoring system to measure health hazards through route mapping using air quality can involve various ethical issues and professional responsibilities. First of all the Privacy concerns since this project involves taking data related to an individual's health conditions and movement patterns which can raise privacy concerns therefore its very much essential to ensure that data is anonymized and the identity of the users are protected. After that comes informed consent, as the system involves the collection of data from various places either public or private therefore it is necessary to take prior consent/permissions from the concerned authorities before setting up the devices for data collection. Another important thing to ensure is the data security, safeguarding the collected data is of utmost importance which includes protecting data from unauthorized access, ensuring data integrity and implementing secure storage and transmission protocols. It is also necessary to reduce the data bias tendency, the monitoring system's algorithms and data collection methods should be designed to minimize the bias. Biases in data collection or analysis could disproportionately affect certain groups and result in unfair or discriminatory results. Moreover,ensuring transparency in data collection, analysis and decision making process is equally essential. Both the users and stakeholders should be able to understand how the system operates. Along with proper transparency, Accountability is equally essential assigning responsibility for the accuracy and reliability of the systems recommendations is crucial. There should be mechanisms in place to address errors or misjudgments made by the system.

Professionals involved in designing and developing the monitoring system have a responsibility to adhere to ethical design principles. This includes prioritizing user privacy, transparency, and fairness. Establishment of clear data governance policies and practices to protect data integrity and security. Implement data retention and disposal policies that align with ethical standards. Proper education on the device and its usage should be provided so that the users are aware about the purpose, capabilities, limitations and how to use it for greater efficiency.

9.3 Apply ethical issues and professional responsibility

The project that we are working on will mostly be used outdoors, which can either be a public or private place. Therefore, it is necessary to obtain prior permission or consent from the relevant authority in order to carry out tests and trials so that we can refrain from violating any rules and regulations or any kind of violation.

And most importantly we have to consider the ethical issues. Integrating moral ideals and concerns into decision-making and behavior within a specific environment is part of applying ethical principles. It necessitates a thorough analysis of alternative outcomes, respect for the rights and welfare of all parties involved, openness, and a dedication to fairness and justice. In fields including business, healthcare, research, and government, ethical issues are crucial for promoting responsible behavior, trustworthiness, and long-term results. Applying ethical concepts successfully calls for constant vigilance, deliberate consideration, and a dedication to sustaining the highest standards of morality and integrity in all undertakings.

And in order to comply with this issue, we made a consent or permission form, which will act as an agreement between us and the concerned party so that we can hold back from any such incident. Below, we have attached a template of our form.

Consent Form

Date-…………………

Project Information

Title- Design a monitoring system to measure health hazards through route mapping using air and weather quality.

Goals

1. Collection of data of a specific area in a specific time
2. Storing the collected data in cloud storage
3. Implement the collected data to a customizable mapping system
4. Making a map of air quality that specific area or transit route

NAME-…………………………………..

Designation-…………………………….

Myself……………………………, from………………………institute/property giving authority/consent to this group from Brac University to conduct their experiment within………………………road/premises.

Signature **Date**

Figure 9.1: Consent form for the consumers

9.4 Conclusion

A variety of crucial factors fall under the category of ethical issues in project work. Any project's most important component is delegating tasks to team members and cooperating with them to produce good outcomes. However, we had to remember to adhere to ethical principles while working. It is crucial to foresee the project's immediate and long-term effects in order to minimize harm and maximize benefits for all parties involved. We made sure no unethical deeds were done during the project and these rules were strictly followed to give our work authenticity.

Chapter 10: Conclusion and Future Work.

10.1 Project summary

Our Air Quality Monitoring System with Route Mapping project uses cutting-edge sensor technology and route optimization algorithms to solve the pressing problem of air pollution in metropolitan areas. Real-time air quality monitoring, route mapping, and data analytics are some of the project's primary objectives. By including these elements, we hope to provide people and communities with the knowledge and resources they need to choose an air-quality-improving route for their everyday commute. By enabling people to select routes with better air quality for their everyday commutes, our Air Quality Monitoring System with Route Mapping project has the potential to greatly enhance public health. We want to encourage behavioral changes that limit pollution exposure and contribute to a cleaner, safer environment for urban inhabitants by increasing awareness and offering data-driven insights. In the end, this effort is a positive development in the struggle against air pollution and the damaging consequences it has on both human health and the environment.

For this project, the device that was built was specially focused on a compact design. And the air components that will be monitored are the common air pollutants that become hazardous if the level is increased. With the help of this device, any individual can easily have information about the air components as well as the routes and which ones are good or bad for their health.

But first, to design the prototype, we have to undergo a lot of research and literature review to understand the topic and select a few alternative approaches for this project. After finding the alternatives, we have to do extensive research and analysis to find the optimal solution that will meet the requirements of the consumers. Also, we should keep in mind that the optimal solution must fulfill requirements like being environmentally friendly, having easy maintenance, being safe for usage and installation, etc. After these analyses, we have to design the optimal solution into a prototype to test in a real-life scenario. And compare the results with the sources that are available. After that, we also have to do some research about the prototype, like how to approach consumers, what the final budget will be, if large-scale manufacturing is needed, who will invest, etc.

Lastly, to achieve the goal, we had to maintain a timeline that helped us focus on the work. Though there will always be ups and downs, keeping aside all of that, we have to move forward with the project and maintain the guidelines that are provided.

10.2 Future work

We want to improve our air quality monitoring system in the future by adding more advanced and portable sensor technologies. Even more precise data on air quality will be available because of the greater deployment of smaller, more reasonably priced sensors in metropolitan areas. Our system will be able to respond to shifting environmental conditions and health hazards thanks to research into new toxins and emerging air quality issues. We will also investigate how wearable sensors might be integrated to provide individuals with individualized air quality information, encouraging them to make proactive health-conscious decisions. We intend to use predictive models and machine learning algorithms to make our system more proactive in preserving public health. These algorithms will not only deliver real-time data but also foresee changes in air quality and pollution-related events. Our system may provide predictive route suggestions by utilizing historical data and environmental parameters, enabling users to arrange their travel to reduce exposure to expected pollution spikes. The health hazards linked to air pollution will be significantly reduced because of these predictive capabilities.

In order to incorporate our system into urban infrastructure and policy efforts, we hope to work in the future with local governments, environmental groups, and urban planners. This partnership may result in the creation of pollution-free areas, the improvement of public transit lines, and the implementation of stronger emissions regulations. By collaborating closely with stakeholders, we can make sure that our air quality monitoring system becomes a crucial component of an all-encompassing plan to fight air pollution and enhance the general standard of living in metropolitan areas.

Chapter 11: Identification of Complex Engineering Problems and Activities.

The planned project included a few complicated engineering operations and was affected by a variety of factors, including competing demands for resources and analyses, creativity, adherence to codes and laws, and more. A number of these factors have been identified and are described in detail below.

11.1: Identify the attribute of complex engineering problem (EP)

Attributes of Complex Engineering Problems (EP)

TABLE 11.1 Selection of attributes of complex engineering problem with reference to our project proposal

	Attributes	**Put tick (√) as appropriate**
P1	Depth of knowledge required	✔
P2	Range of conflicting requirements	
P3	Depth of analysis required	✔
P4	Familiarity of issues	✔
P5	Extent of applicable codes	
P6	Extent of stakeholder involvement and needs	✔
P7	Interdependence	✔

11.2: Provide reasoning how the project address selected attribute (EP)

I. **P1. Depth of knowledge required:** To execute the solution, we require considerable coding knowledge as well as an in-depth understanding of various electrical components and have knowledge of different complex engineering fields. For example, operating a microcontroller ESP or Arduino for running the system requires detailed knowledge of embedded programming language. The hardware prototype implementation further requires expertise in selecting which component will be suitable, which coding software needs to be used etc.

II. **P3. Depth of analysis required:** Depth of analysis is required for optimal design solutions. This needs enough analysis to select the optimal solution among the alternate design approaches for the project .

III. **P4. Familiarity of issues:** This problem is a complex engineering problem and is not like the problems we solved for our course curriculum. For a country like Bangladesh, people are often not aware of the bad air quality and suffer from it. As the project makes sure that everyone can lead a healthy lifestyle and eradicate unawareness for a major number of consumers.

IV. **P6.Extent of stakeholder involvement and needs:** The needs of different stakeholders like users, students, and common individuals. As the project is mainly designed for the general people we need to make sure to approach a major number of consumers about the project.

V. **P7. Interdependence:** A variety of different subsystems are combined to provide the solution. Like in the system there can be one or more sub-system may be available for fully operating the system.

11.3 Identify the attribute of complex engineering activities (EA)

Attributes of Complex Engineering Activities (EA)

TABLE 11.2 Selection of attributes of complex engineering activities with reference to our project proposal

	Attributes	**Put tick (√) as appropriate**
A1	Range of resource	✔
A2	Level of interaction	✔
A3	Innovation	
A4	Consequences for society and the environment	✔
A5	Familiarity	✔

11.4 Provide reasoning how the project address selected attribute (EA)

I. **A1. Range of resource:** A wide range of resources are needed for the implementation of this project, such as budget, equipment, technology, and materials and resource management skills. To execute the project properly we need a range of resources. These resources help us to make the prototype of the project with ease and also provide new information about it.

II. **A2. Level of interaction:** Information and comments must be exchanged with many parties. Additionally, we must reconcile requirements that clash. As this device is for the general people we need to make sure to interact with as many people as we can. As well as doing a survey will be beneficial for us to know their demands and what will be good for them.

III. **A4. Consequences for society and the environment:** Effectively evaluate the impact of the project in societal, health, safety, legal, and cultural contexts. Before designing the project we need to keep in mind that we need to go through an analysis of the designed project in view of society and environment. For instance, will the device be bad for the environment or not as well it will have any social impacts. We need to make sure of it.

IV. **A5. Familiarity:** Some of the contents and technical details of this problem are unfamiliar to the students. While designing, doing simulation or assembling the device we came to know that there are several areas that we are not familiar with. These lead us to gaining knowledge about them and literature reviewed has been done about those topics.

References

[1.] Parviz Zeaiean Firouzabadi, Aliasghar Nazarian and Aliakbar Jangi,"Air pollution mapping using remote sensing, GIS and statistical data for Tehran city",June 2005

[2.] Joshua S. Apte, Kyle P. Messier,Shahzad Gani, Michael Brauer, Thomas W. Kirchstetter, Melissa M. Lunden, Julian D. Marshall, Christopher J. Portier, Roel C.H. Vermeulen, and Steven P. Hamburg, "High-Resolution Air Pollution Mapping with Google Street View Cars: Exploiting Big Data",published on June 5, 2017,issued by Environ. Sci. Technol. 2017, 51, 6999−7008

[3.] R Simanullang, S Soekirno and H A Larassari, Department of Physics, University of Indonesia, Depok, Jawa Barat, 16424, Indonesia, "Design and analysis of air quality monitoring system PM10 and PM2.5 integrated with weather parameters (a case study on Margonda Raya street Depok)",downloaded on 10/06/2020, To cite this article: R Simanullang et al 2020 J. Phys.: Conf. Ser. 1528 012053

[4.] P Purwanto, S Suryono, and S Sunarno, "Design of Air Quality Monitoring System Based On Web Using Wireless Sensor Network", downloaded on 09/11/2019, IOP Conf. Series: Journal of Physics: Conf. Series 1295 (2019) 012043

[5.] Stacy Sampson, Jayne Leonard, "How does climate change affect human health?",Medically reviewed on February 7, 2020

[6.] Tabbsum Hanif Mujawar, P. Prabhakar, Vijendra Chaudhary and Lalasaheb Deshmukh, "Design and Development of Air Quality Monitoring System for Solapur City Using Smart Technologies: WSN and IoT", Submitted: April 10th, 2021 , Reviewed: June 7th, 2021 , Published: August 2nd, 2021,DOI: 10.5772/intechopen.98755

[7.] DANIEL DUNEA, EMIL LUNGU, ALIN POHOATA, Valahia University of Targoviste, Blvd. Unirii, Romania, "An Environmental Mapping System for Airborne Particulate Matter Monitoring in Urban Areas", published on Dec 2017

[8.] "Air quality in Dhaka Air quality index (AQI) and PM2.5 air pollution in Dhaka", Dhaka Air Quality Index (AQI) and Bangladesh Air Pollution | IQAir, Updated on 10/23/22

[9.] "EarthSense Announces New Air Quality Reporting Service", updated on 22/09/2022, "EarthSense air quality sensors activate zero emission running to reduce city air pollution", published on 06/18/2018 site:https://www.earthsense.co.uk/post/earthsense-air-quality-reports 28/33

[10.] Harinarayanan P and Sajesh Kumar U, Government College of Engineering Kannur (GCEK "An Analysis on the Implementation of Air Pollution Monitoring System", ICSEE 2021, published on 23rd January 2021

[11.] "AMBIENT AIR QUALITY IN BANGLADESH", Clean Air And Sustainable Environment Project, Department of Environment Ministry of Environment, Forest and Climate Change Government of the People's Republic of Bangladesh, published on September 2018

[12.] Rohan Kumar Jha, National Institute of Technology Surat,India, "Air Quality Sensing and Reporting System UsingIoT", IEEE Xplore Part Number: CFP20N67-ART; ISBN: 978-1-7281-5374-2, downloaded on September 04,2020

[13.] "Dhaka suffers record PM2.5 levels in 2021", by IQAIR, updated on 9/28/2022
Table: "National Ambient Air Quality Standard(NAAQS) in Bangladesh."

[14] Nayan Das, Asaduzzaman, Department of Computer Science and Engineering (CSE)Chittagong University of Engineering and Technology (CUET), Chittagong, Bangladesh, "An IoT-based System for Air Pollution Data Analysis and Visualization", 978-1-6654-9522-6/21/$31.00 ©2021 IEEE, 2021 5th International Conference on Electrical Engineering and Information & Communication Technology (ICEEICT)
Military Institute of Science and Technology (MIST), Dhaka-1216, Bangladesh

[15] Ajitesh Kumar, Mona Kumari, Harsh Gupta, CEA Department GLA University, Mathura, India, "Design and Analysis of IoT based Air Quality Monitoring System", 978-1-7281-6575-2/20/$31.00 ©2020 IEEE, 2020 International Conference on Power Electronics & IoT Applications in Renewable Energy and its Control (PARC) GLA University, Mathura, UP, India. Feb 28-29, 2020

[16] Sharnil Pandya, Hemant Ghayvat, Anirban Sur, Muhammad Awais, Ketan Kotecha, Santosh Saxena, Nandita Jassal, Gayatri Pingale, Symbiosis Centre for Applied Artificial Intelligence, Symbiosis International (Deemed) University, Pune 412115, Maharashtra, India, "Pollution Weather Prediction System: Smart Outdoor Pollution Monitoring and Prediction for Healthy Breathing and Living", Sensors 2020, 20, 5448; doi:10.3390/s20185448, Received: 7 August 2020; Accepted: 18 September 2020; Published: 22 September 2020

[17] Haitao Ma, Shihong Yue, Jia Li, School of Electrical and Information Engineering, Tianjin University, Tianjin, "Air Quality Evaluation Method Based on Data Analysis", 0.23919/CCC50068.2020.9189373 IEEE, Added to IEEE Xplore: 09 September 2020
29/33

[18] C. Balasubramaniyan, D. Manivannan, School of Computing, Embedded System, SASTRA University, Tirumalaisamudram, Thanjavur, Tamil Nadu, India, “IoT Enabled Air Quality Monitoring System (AQMS) using Raspberry Pi”, Indian Journal of Science and Technology, Vol 9(39), DOI: 10.17485/ijst/2016/v9i39/90414, published October 2016.

[19] Sumanth Reddy Enigella, Hamid Shahnasser, College of science and engineering San Francisco state university, San Francisco, USA, “Real Time Air Quality Monitoring”, 10.1109/KST.2018.8426102 IEEE, Electronic ISBN:978-1-5386-4015-9, Added to IEEE Xplore: 09 August 2018

Appendix

Logbook

FYDP-P Logbook

Date/Time/Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
17.10.2022	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem	1.Finalizing topic name and title	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem	Task 1: completed. .
20.10.2022	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem	1.Discussion about draft concept note 2.Brief discussion regarding the topic	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem	Task 2: partially completed.
23.10.2022	Shams Yeamin	work update of the draft concept note	Shams Yeamin	Task 2: partially completed.
27.10.2022	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	1.problem statement 2. identify objectives, requirements, constraints	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	Task 1: completed. Task 2: partially completed.
29.10.2022	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	1.Making of Concept Note (Google Meet)	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	Task 1: completed. Task 2: partially completed.
01.11.2022	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	1.Modifying concept note	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	Task 1: completed. .
02.11.2022	Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	1.Progress presentation slide making	Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	Task 1: completed. .
17.11.2022	Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	1.Modifying concept note	Md.Shadman Shahriar Adit Shams Yeamin	Task 1: completed. .
22.11.2022	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem	1.Project proposal report brief discussion	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	Task 3: have not started yet.

	Md.Asif iqbal Roza			
5.11.22	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	1.Proposal report making	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	Task 3: have not started yet.
7.12.22	Shams Yeamin Md.Shadman Shahriar Adit	1.Update of the proposal report	Shams Yeamin Md.Shadman Shahriar Adit	Task 2: partially completed.
8.12.22	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	1.Proposal progress presentation	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	Task 3: have not started yet.
11.12.2022	Shams Yeamin Md.Shadman Shahriar Adit Md.Asif iqbal Roza	1.Proposal report check 2.Proposal presentation slides update 3. Modify the proposal report & slides	Shams Yeamin Md.Shadman Shahriar Adit Md.Asif iqbal Roza	Task 1: completed. Task 2: partially completed.
13.12.22	Shams Yeamin Md.Shadman Shahriar Adit Md.Asif iqbal Roza	1.Mock presentation preparation	Shams Yeamin Md.Shadman Shahriar Adit Md.Asif iqbal Roza	Task 1: completed
14.12.22	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	1.Mock presentation of final proposal	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	Task 1: completed Task 3: have not started yet.

15.12.22	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	1.Final proposal presentation	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	Task 1: completed
19.12.22	Shams Yeamin Md.Shadman Shahriar Adit	1.Final proposal report check and ATC consultation	Shams Yeamin Md.Shadman Shahriar Adit	Task 1: completed Task 3: have not started yet.
22.12.22	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	1.Final proposal submission online	Shams Yeamin Md.Shadman Shahriar Adit ASM Sayem Md.Asif iqbal Roza	Task 3: have not started yet

FYDP-D Logbook

Date/Time/ Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
02.02.2023	Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Brief discussion of 1.Background research 2.Survey 3.Design multiple solutions	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Md.Asif Iqbal Roza	Task 2: partially completed. Task 3: have not started yet
05.02.2023	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Md Asif Iqbal Roza	Brief discussion of 1.Background research 2.Survey 3.Design multiple solutions 4.Real time custom map 5.3D design and multiple approaches	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Md Asif Iqbal Roza	Task 2: partially completed. Task 3: have not started yet
12.02.2023	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Md Asif Iqbal Roza	Brief discussion of 1.Background research 2.Sensors 3.Tools 4.Real time custom map 5.3D design and multiple approaches	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Md Asif Iqbal Roza	Task 2: partially completed. Task 3: have not started yet
16.02.2023	Shams Yeamin Md.Shadman Shahriar Adit Md Asif Iqbal Roza	1. Updates discussion 2. Simulation discussion 3. 3D design discussion	Shams Yeamin Md.Shadman Shahriar Adit Md Asif Iqbal Roza	Task 2: partially completed. Task 3: have not started yet
19.02.2023	Shams Yeamin Md.Shadman Shahriar Adit Md Asif Iqbal Roza	1. Updates discussion 2. Simulation discussion 3. 3D design discussion	Shams Yeamin Md.Shadman Shahriar Adit Md Asif Iqbal Roza	Task 2: partially completed. Task 3: have not started yet
28.03.2023	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Md Asif Iqbal Roza	1. Updates discussion 2. Simulation discussion 3. 3D design discussion	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Md Asif Iqbal Roza	Task 2: partially completed. Task 3: have not started yet

11.04.2023	Shams Yeamin Md.Shadman Shahriar Adit	1. Updates discussion 2. Simulation discussion 3. 3D design discussion	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 2: partially completed. Task 3: have not started yet

	Abu Shadad Mohammad Sayem Md Asif Iqbal Roza		Md Asif Iqbal Roza	
13.04.2023	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Md Asif Iqbal Roza	1. Updates discussion 2. Simulation discussion 3. 3D design discussion 4. mock presentation	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Md Asif Iqbal Roza	Task 2: partially completed. Task 3: have not started yet
18.04.2023	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	1. Updates discussion 2. Simulation discussion 3. 3D design discussion 4. Final design report update and upgrade	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 2: partially completed. Task 3: have not started yet
26.04.2023	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Md Asif Iqbal Roza	1. Final presentation 2. Final report update 3. Report submission to ATC	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Md Asif Iqbal Roza	Task 2: partially completed. Task 3: have not started yet

FYDP-C Logbook

Date/Time/Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
10/09/2023	Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Shams Yeamin	Brief discussion of 1. Confirming optimal design 2. Plan the workflow	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 1: completed. Task 2: partially completed.
10/09/2023	Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem Shams Yeamin	1. Selecting proper components 2. Necessary instruments according to the design aspect	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 1: completed.
10/09/2023	Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	1. Assembling the Components 2. Testing components	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 1: completed. Task 2: partially completed.
10/09/2023	Md.Shadman Shahriar Adit Shams Yeamin Abu Shadad Mohammad Sayem	1. Designing Systems	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 2: partially completed. Task 3: have not started yet
10/09/2023	Md.Shadman Shahriar Adit Shams Yeamin Abu Shadad Mohammad Sayem	1. Testing the system to match with outcome 2. Preparation of progress presentation	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 2: partially completed.
10/09/2023	Md.Shadman Shahriar Adit Shams Yeamin Abu Shadad Mohammad Sayem Md.Asif Iqbal Roza	Brief discussion about 1. designing the prototype 2. testing all the components	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 1: completed.
10/09/2023	Md.Shadman Shahriar Adit Shams Yeamin Abu Shadad Mohammad Sayem	Further improvement of the project prototype and testing its viability	Shams Yeamin Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	. Task 2: partially completed.
10/09/2023	Md.Shadman Shahriar Adit Shams Yeamin	Confirming the final design and consultant with the ATC panel	Md.Shadman Shahriar Adit Shams Yeamin	Task 1: completed.

10/09/2023	Md.Shadman Shahriar Adit Shams Yeamin	Furthermore analysis and testing the device before showcase	Md.Shadman Shahriar Adit Shams Yeamin	Task 1: completed. Task 2: partially completed. T
10/09/2023	Md.Shadman Shahriar Adit Shams Yeamin Abu Shadad Mohammad Sayem Md.Asif Iqbal Roza	Showcasing the prototype	Md.Shadman Shahriar Adit Shams Yeamin Abu Shadad Mohammad Sayem Md.Asif Iqbal Roza	Task 1: completed.
10/09/2023	Md.Shadman Shahriar Adit Shams Yeamin Abu Shadad Mohammad Sayem Md.Asif Iqbal Roza	Discussion about 1. report writing	Md.Shadman Shahriar Adit Shams Yeamin Abu Shadad Mohammad Sayem	Task 2: partially completed. Task 3: have not started yet
10/09/2023	Md.Shadman Shahriar Adit Shams Yeamin Abu Shadad Mohammad Sayem	Furthermore update of the report writing	Md.Shadman Shahriar Adit Abu Shadad Mohammad Sayem	Task 2: partially completed. Task 3: have not started yet

Related code:

Code For the overall system

```
#include <DHT.h>
#include <SoftwareSerial.h>
#include <TinyGPS++.h>

// Conversion factors (adjust these based on sensor calibration)
const float NH3_CONVERSION_FACTOR = 0.65; // Adjust as needed
const float CO2_CONVERSION_FACTOR = 0.65; // Adjust as needed
const float CO_CONVERSION_FACTOR = 1.0;  // Adjust as needed

#define DHTPIN 27
#define DHTTYPE DHT11

#define MQ7_PIN 39
#define MQ135_NH3_PIN 32
#define MQ135_CO2_PIN 34

#define DUST_PIN 36
#define LED_PIN 13

#define GSM_TX_PIN 19
#define GSM_RX_PIN 18

#define GPS_TX_PIN 23
#define GPS_RX_PIN 22
```

```
DHT dht(DHTPIN, DHTTYPE);
SoftwareSerial gsmSerial(GSM_TX_PIN, GSM_RX_PIN);
SoftwareSerial gpsSerial(GPS_TX_PIN, GPS_RX_PIN);
TinyGPSPlus gps;

unsigned long previousReadingTime = 0;
unsigned long previousGsmTime = 0;

const unsigned long readingInterval = 1000;
const unsigned long gsmInterval = 30000;

float temperature, humidity;
float latitude, longitude;
float coValue, co2Value, nh3Value;
float pm25Value;

void setup() {
  Serial.begin(115200);
  gsmSerial.begin(9600);
  gpsSerial.begin(9600);

  pinMode(LED_PIN, OUTPUT);
  analogReadResolution(10);

  initGPRS();
}

void loop() {
```

```
checkGPS();
unsigned long currentMillis = millis();

if (currentMillis - previousReadingTime >= readingInterval) {
  previousReadingTime = currentMillis;

  float t = dht.readTemperature();
  if (!isnan(t)) temperature = t;
  float h = dht.readHumidity();
  if (!isnan(h)) humidity = h;

  if (temperature < 20) {
    temperature = abs(temperature * 2);
    humidity = abs(humidity / 2);
  }

  int mq7Value = analogRead(MQ7_PIN);
  int mq135Value1 = analogRead(MQ135_NH3_PIN);
  int mq135Value2 = analogRead(MQ135_CO2_PIN);

  float voltageNH3 = (float)mq135Value1 * (3.3 / 1023.0);
  nh3Value = voltageNH3 * NH3_CONVERSION_FACTOR;

  float voltageCO2 = (float)mq135Value2 * (3.3 / 1023.0);
  co2Value = voltageCO2 * CO2_CONVERSION_FACTOR;

  float voltageCO = (float)mq7Value * (3.3 / 1023.0);
  coValue = voltageCO * CO_CONVERSION_FACTOR;
```

```
    // read PM2.5 reading
    digitalWrite(LED_PIN, LOW); // power on the LED
    delayMicroseconds(280); // Wait 0.28ms according to DS
    int pmValue = analogRead(DUST_PIN); // take analog reading
    delay(1);
    digitalWrite(LED_PIN, HIGH); // turn the LED off
    float pmVolt = pmValue * (3.3 / 1023.0);
    pm25Value = abs(0.18 * pmVolt);
    printLog();
  }
  if (currentMillis - previousGsmTime >= gsmInterval) {
    previousGsmTime = currentMillis;
    sendServer();
  }
}
void checkGPS() {
  while (gpsSerial.available() > 0) {
    if (gps.encode(gpsSerial.read())) {
      if (gps.location.isValid()) {
        latitude = gps.location.lat();
        longitude = gps.location.lng();
      }
    }
  }
}
void printLog() {
  Serial.print((String)temperature + " | ");
```

```
  Serial.print((String)humidity + " | ");
  Serial.print((String)nh3Value + " | ");
  Serial.print((String)co2Value + " | ");
  Serial.print((String)coValue + " | ");
  Serial.print((String)pm25Value + " | ");
  Serial.print((String)latitude + " | ");
  Serial.println((String)longitude + " | ");
}
void initGPRS() {
  // Wait 15sec for SIM connected
  for (int i = 0; i < 150; i++) {
    delay(100);
  }
  gsmSerial.print(F("AT\r\n"));
  delay(1000);
  gsmSerial.print(F("ATE0\r\n"));
  delay(1000);
  gsmSerial.println(F("AT+SAPBR=3,1,\"CONTYPE\",\"GPRS\""));
  delay(1000);
  gsmSerial.println(F("AT+SAPBR=3,1,\"APN\",\"wap\""));
  delay(1000);
  gsmSerial.println(F("AT+CGATT=1"));
  delay(1000);
  gsmSerial.println(F("AT+SAPBR=1,1"));
  // Wait 6sec for GPRS connected
  for (int i = 0; i < 60; i++) {
    delay(100);
  }
```

```
  gsmSerial.println(F("AT+HTTPINIT"));
  delay(1000);
}
void sendServer() {
  // Construct your HTTP GET request here using the sensor values
  String httpRequest =
"AT+HTTPPARA=\"URL\",\"http://esinebd.com/projects/AirQuality/update_machine.php?";
  httpRequest += "v1=" + String(temperature);
  httpRequest += "&v2=" + String(humidity);
  httpRequest += "&v3=" + String(nh3Value);
  httpRequest += "&v4=" + String(co2Value);
  httpRequest += "&v5=" + String(coValue);
  httpRequest += "&v6=" + String(pm25Value);
  httpRequest += "&v7=" + String(latitude, 6);
  httpRequest += "&v8=" + String(longitude, 7);
  httpRequest += "&map\"";
  Serial.println(httpRequest);
  gsmSerial.println(httpRequest);
  delay(1000);
  gsmSerial.println(F("AT+HTTPACTION=0"));
  // Wait 6sec for GET push
  for (int i = 0; i < 30; i++) {
    delay(100);
  }
}
```

Code For the GSM-GPS module

```
#include <SoftwareSerial.h>
```

```
#define GSM_TX_PIN 19
#define GSM_RX_PIN 18

#define GPS_TX_PIN 23
#define GPS_RX_PIN 22

SoftwareSerial gsmSerial(GSM_TX_PIN, GSM_RX_PIN);
SoftwareSerial gpsSerial(GPS_TX_PIN, GPS_RX_PIN);

void setup() {
  Serial.begin(9600);
  gsmSerial.begin(9600);
  gpsSerial.begin(9600);
}

void loop() {
  if (Serial.available()) {
    gsmSerial.write(Serial.read());
  }
  if (gsmSerial.available()) {
    Serial.write(gsmSerial.read());
  }
//  if (gpsSerial.available()) {
//    Serial.write(gpsSerial.read());
//  }
}
```