# Portable Air Quality Detector Using Arduino Uno

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*Abstract*— **This report presents the design and implementation of a portable air quality detector using Arduino Uno, dust sensor, LCD, switches, buzzer and multiple LEDs. The air quality detector system was designed using a combination of hardware and software techniques to measure air quality properly. The air quality detector was implemented using an Arduino Uno and dust sensor to generate and determine accurate air quality based on some specific air contents. The following system that was developed used PM10 detection system which identified the amount of dust particles in the area. Based on PM10 readings, the air quality was identified. Moreover, Air Quality Index (AQI) was determined using the PM10 readings. The LCD display, buzzer and multiple LEDs were used to display and indicate the air quality condition and levels. The portable air quality detector was successfully tested and found to be accurate and reliable in determining air quality. This project demonstrates the use of a microcontroller-based system in building a simple yet effective portable air quality detector.**

*Index Terms*— **Air Quality, PM10, AQI, Air Quality Index, Portable, Arduino, Microcontroller**

## I. INTRODUCTION

### A. Background Study to Motivation

Tiny particles in the air, known as dust, can cause problems for both people and nature. Breathing in too much dust can make you sick especially when you are breathing. To help with this we make a project called 'Portable air quality detector using Arduino Uno'. This project uses a microcontroller and some sensors to make a small and easy to use device. This device can tell how much dust is on the air around us and provide necessary information regarding the quality of air around us.

Dust comes from different places like factories, construction sites, cars, and even natural things. Breathing in too much dust for a long time can make you have trouble with breathing and cause many diseases. The reason for this project is to make something that people can check how much dust is in the air around them. This way people can make choices to stay safe and healthy.

High concentration of dust particles in the air is never ideal. This causes various health issues. To warm people about it, a system like an air quality detector can help the general people to know about the status of air in a certain area. There are various measuring systems to detect the quality of air. To detect the amount of dust particles, PM10 is a common and widely used method. Although PM10 is commonly used for scientific purposes, it is not widely popular to the general people who is the main target user for our system. Hence a widely known and simple measuring system is required. Air Quality Index is such a type of measuring air quality that is commonly known to people via various weather applications. Using the values that are obtained through PM10, people can receive understandable AQI values and quality of air within seconds through a proper system.

In summary, this study focuses on designing a system that can detect the air quality of a certain area using a dust sensor capable of detecting dust particles in PM10 range. The results obtained in PM10 will be converted to AQI values and the users on the system would be notified regarding the results.

### B. Project Objectives

The main objective of this project is to design and implement a portable air quality detector using Arduino Uno microcontroller and PM10 dust sensor. The following are the specific project objectives:

- Design a circuit that can analyze the air around the system and determine the quality of the air.
- Develop a system to properly identify the air quality using PM10 detection regulations and methods.
- Present the results obtained by the system in a user-friendly representation using Air Quality Index (AQI).
- Implement a 16x2 display to display the PM10 and AQI readings to user.
- Implement a method to wirelessly connect with the system and receive or read results obtained by the system.
- Test and validate the portable air quality detector to ensure it is accurate and reliable for detecting the air quality.

By achieving these objectives, the project aims to develop a simple yet user-friendly portable air quality detector. The project also seeks to provide a practical application of microcontrollers like Arduino Uno and equip the knowledge and skills required to design basic electronic systems.

The project's ultimate goal is to provide people with a useful and affordable tool that help them to play an active role in tracking air quality. By successfully meeting these targets, the project contributes to increasing awareness about the environment, making well-informed choices and taking proactive steps to reduce pollution.

### *C. A Brief Outline of the Report*

The following report is separated into several segments. Here is a brief outline that will assist in understanding the project report appropriately and assist in learning about the system that has been developed:

- In the ‘Literature Review’ section, several published articles in famous and renowned journals and conference papers were analyzed for necessary information regarding the project. This helped in narrowing the importance of such system. It also helped in understanding what is wanted by the authors in future similar systems developed by fellow engineers.
- In the ‘Methodology and Modeling’ section, an introduction of the system was provided. The working process of the system is discussed elaborately using various flowcharts, diagrams and many other resources. Description of the components that were used is also provided in this section. At last, the experimental setup that was developed was described using various actual hardware pictures.
- In the ‘Results and Discussions’ section, simulation results is provided and experimental outcomes were observed. Comparisons between both results is discussed. A brief cost analysis is also performed. At the end, the limitation of the current system that is developed is discussed.
- At the end of the report, conclusions of the project are provided in the ‘Conclusion and Future Endeavors’ section. The feature improvements that can be done are discussed in this section.

## II. LITERATURE REVIEW

Air is a vital part of our life. It is said that air consists of various necessary elements that is vital for our life and well-being. This important element is constantly being polluted in various ways. Therefore, it is said that air pollution is an environmental evil. Our live-saving air is being polluted through various means. From the equipment we use to the industries that we are developing to make our life comfortable, all of these are polluting the air. Air pollution can have severe consequences for human health. The inhalation of polluted air can lead to respiratory problems such as asthma, bronchitis and other chronic obstructive pulmonary diseases. Vulnerable groups such as children, elderly and individuals with pre-existing health conditions are the prime victims of air pollution. That’s why stopping air pollution has become an important matter these days. But stopping it all at once it a difficult task to accomplish. As various factors need to be considered such as economic consideration, political challenges, enforcement and monitoring and many more. So, this is where the help of various electrical equipment can be taken.[1]

The current world is called a smart world. The whole world is connected through various IoT devices. These devices are sensing our environment and connecting with their surroundings in various ways. Various monitoring devices can be used to find identify these conditions. This is where IoT devices come in. IoT devices are physical objects embedded with sensors, software and connectivity capabilities that enable these devices to collect and exchange data over the internet. These devices are very user friendly and flexible to use. The key characteristics of IoT devices are connectivity, sensors, data processing and analytics, automation and control and many more. IoT devices can determine the condition of our surrounding by various sensors and detection techniques and help us understand the current condition of our environment in a better and broader manner. Although IoT devices offer numerous benefits but there are also challenges to consider including security and privacy concerns, data management and scalability issues, interoperability complexities and many more.[2]

The most effective method to identify these conditions of the environment is using a compact device along with some sensor. These devices can be made with affordable and wide available components. These devices can be made in a short notice as well. These devices usually come with various sensors like particle sensors, dust analyzers and many more. All of these can determine various poisonous elements in the air. These are carbon-di-oxide, carbon monoxide gas and many more. Dust particles can be also measured using these devices as well. For a specific kind of particle, a specific sensor is used. Generally, a laser light being used to determine the dust particles in the air. These devices scatter light on the particle and then determines the particles size range using the sensors that is integrated in the devices. These devices play a significant role in various industrial areas, urban areas and in mega construction site. Although these devices provide numerous beneficial outcomes, these devices have some limitations such as maintenance, infostructure limitations and many more.[3]

The most common devices are made using a widely popular microcontroller board called Arduino Uno. It is built ATmega328P microcontroller. It has 14 digital input/output(I/O) pins of which 6 can be used as pulse-width modulation or (PWM) outputs. It has a dedicated USB interface and through this USB interface a communication between the board and computer is made. This microcontroller is a powerful component that can be used to develop a powerful IoT device like an Air Quality Detector. Various sensors can be used to develop such a device. These sensors detect the quality of the air based on various indexes and can be stored in the device database for future research.[4]

All the data that is collected using these devices need to be shown to the user. The interface needs to be user friendly and easy to access. Although all of these devices more or less have a digital display on the machine, it is vital for the device to be connected through other means as well. Cloud is an important factor of this 21st century. Any device without cloud access is deemed to be not smart. Therefore, it is important that the devices that are used for detecting the quality of air have cloud access. Using this cloud access, the user of the device can access the device from any place, at any time. This provides the user with unrestricted access to the data that is collected and can be easily used for various vital research or action. [5]

Developing the interface for various devices is always welcoming for all people. Any web-based application can be used over any device without making a particular port of the application. A web-based application for a device like an air condition monitoring device is crucial and a demand of time. Through this web application, users can view various data obtained through the microcontroller-based application over the course of time. These data can be visually represented in various ways so that the user feels comfortable in seeing the data that is obtained in this device. Moreover, all the data that is obtained through the help of the sensors of these devices can be viewed at once using this web-based application from anywhere of the world. This will reduce hassle for the user to access the device and view the data that is stored on the device. Moreover, users can view the air condition of the area in a moment's notice from any device that prefer using any wired or wireless medium that is available to the user. [6]

## III. Methodology And Modeling

### A. Introduction

The methodology used for developing a portable air quality detector using Arduino Uno involves various steps. The first step was to understand the which Particulate Matter would be ideal for detecting the dust particles in a residential area. Based on the analysis performed in the literature review, PM10 is the ideal one.

The next step was to develop a particular circuit diagram for the system using Arduino Uno, PM10 DSM501A dust sensor, 16x2 LED display, HM10 Wireless Module, LEDs, Buzzer and Veroboard. After the circuit was developed, the code to operate the system was developed accordingly. Afterwards the system was tested in various suitable environments for gathering test results. The results were also verified using simulated outcomes accordingly.

The developed system is designed in such a way that the user would understand the results in a simple manner. Therefore, the results obtained by the system is showed using the LED display, LEDs and buzzer. The results can also be viewed using wireless communication for easy viewing. The methodology for developing a portable air quality detector using Arduino Uno involves a combination of circuit design, component selection, programming and modeling to create a reliable and accurate timekeeping device.

### B. Working Principle of the Proposed Project

In developing a portable air quality detector using Arduino Uno, a dust sensor will be utilized. In specific a dust sensor called DSM501A will be used. The reason behind using this dust sensor is that it is affordable, widely available and highly accurate when detecting PM10 particles. Using this sensor, the rest of the circuit is designed based on the requirement that we have set. In figure 16, the proposed block diagram for the system is developed.

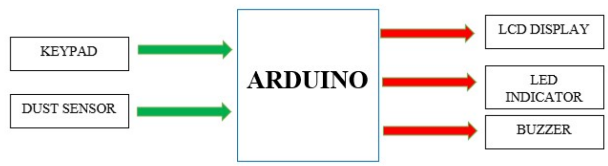


*Fig.16: Experimental Block Diagram of the Project*

In the block diagram it can be seen that an Arduino Microcontroller is taken as the primary hub for operation of the project. A dust sensor is used to gather information regarding the environment and a keypad is used to select the mode of operation of the system. The system will be displaying the results in a LED display. Additionally, all the environment states that is defined in the system will be shown using various color of LEDs and any critical state would be alerted to the user using a buzzer. Afterwards, in order to provide ease of use, a wireless module is also added to the system so that the user can use the system without any wired connection from a distance.

The system that is proposed will have a keypad, the keypad will be connected with the Arduino Uno to send necessary input. Based on the input, the system will operate accordingly as the system will have multiple operation modes. Moreover, this keypad can be used later in the future to scroll through multiple options that can be set in the system.

The keypad will have to options to enter, one is the 'Testing Mode' and the other is the 'Operating Mode'. In the testing mode, the LEDs, LED Display and the Bluetooth Module can be tested accordingly. If the reset button is pressed, the testing will end and return to the main menu. Otherwise, the system will stay in testing mode.

If the user enters the 'Operation Mode', the system will take some time to detect the amount of dust is in the area. Based on that the system will show the PM10 Value on the LED display. The value of the Air Quality Index (AQI) will also show on the LED display. The LEDs and buzzer that are set on the system will glow according to the condition of the environment.

Users can also view the result in the serial monitor while connected to the device. The results can also be obtained and viewed wirelessly through any wireless device like a mobile device. Using the wireless module that is set on the system, users can connect to the system using any wireless medium such as Bluetooth based on the module that is used on the system and view the results using any specific serial monitor application. A standalone application can also be developed using this basic knowledge of how the system is operating wirelessly using third party applications.

The general flow of work for the proposed system starting from the initial beginning of the program to taking reading and up-to completing the reading and showing it on the 16x2 LED display and wireless devices is shown in figure 17.

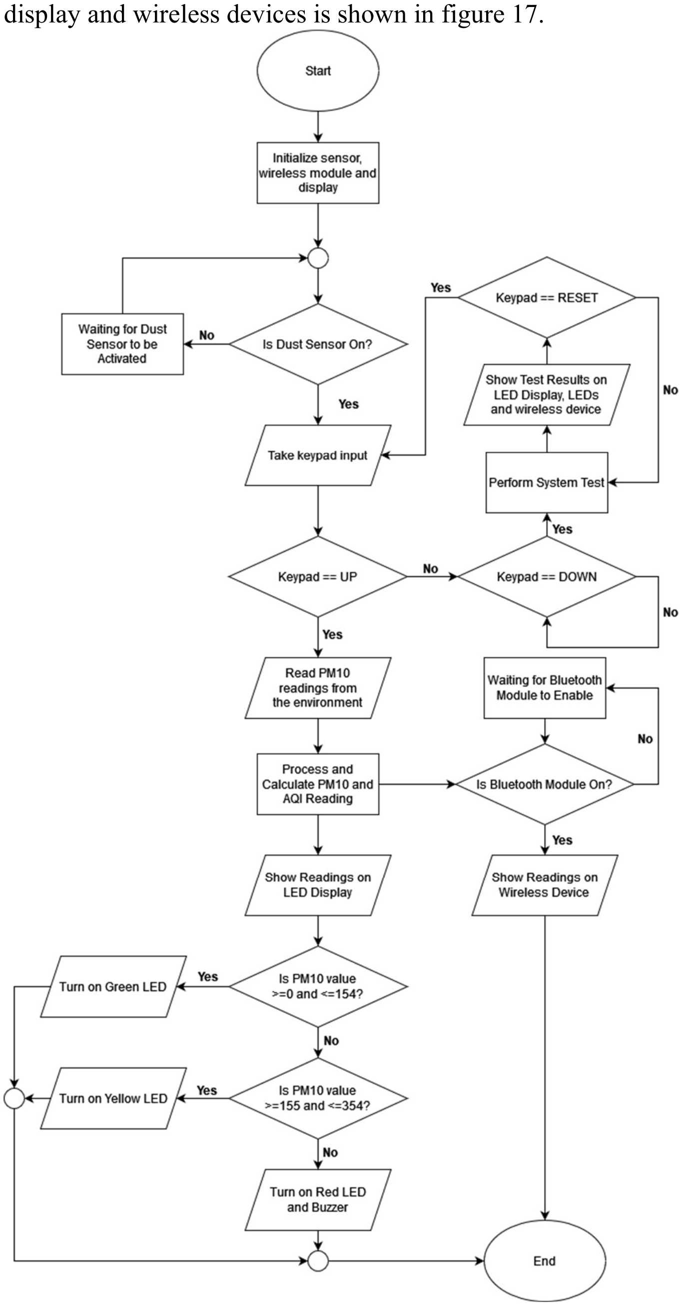


*Fig.17: Flowchart of the Proposed Project*

*B.A. Process of Work*

In developing a portable air quality detector using Arduino Uno, a dust sensor will be utilized. In specific a dust sensor called DSM501A will be used. The reason behind using this dust sensor is that it is affordable, widely available and highly accurate. This dust sensor will be detecting the number of particles using a LED and detector in the sensor module. It also comes will a heater to enhance the operating parameters. An amplification circuit is than used to amplify the results and provide the output using two output circuits known as ;Output circuit 1' and 'Output circuit 2'.

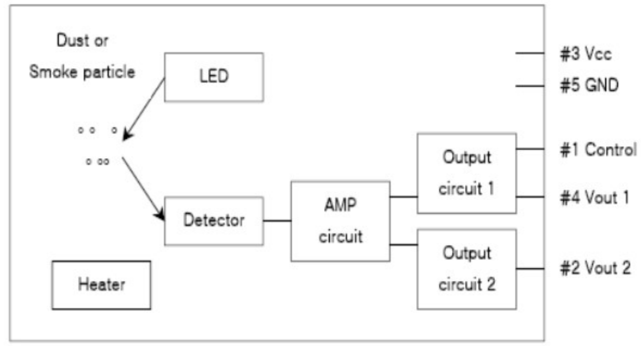


*Fig.18: Block Diagram of DSM501A Sensor*

The data obtained from the DSM501A sensor will be delivered to a microcontroller for further operation. In this project, an Arduino Uno Microcontroller is used. The data that is obtained from the sensor will be send to the Arduino Uno using PIN 12 and 13. For this project specifically, PIN 12 is vital as this is the pin which sends the relevant data regarding PM10 readings.


*Fig.19: Connection of DSM501A Sensor and Arduino Uno*

The obtained data is then processed in the code that is developed and set in the Arduino Uno microcontroller. There are three possible air quality conditions set in our system. They are 'Good', 'Unhealthy' and 'Hazardous'. For certain PM10 concentrations, each of these air qualities will be represented to the user. The user will be notified about the air quality using the LEDs. There are three LEDs in the system. Table I represents the states of the LED, Buzzer and air quality.

TABLE I
LED CORRESPONDING AIR QUALITY CONDITION

| LED | Buzzer | Air Quality |
|---|---|---|
| Green | OFF | Good |
| Yellow | OFF | Unhealthy |
| Red | ON | Hazardous |

Alongside PM10 values, AQI will also be determined using the values of PM10 chart and AQI equality. The AQI calculation equation is provided down below:

$$AQI = \frac{AQI_{Hi} - AQI_{Lo}}{Conc_{Hi} - Conc_{Lo}} \times ((Conc_i - Conc_{Lo}) + AQI_{Lo})$$

Here the $Conc_i$ is the value that is obtained from the DSM501A sensor through PIN 12 of the Arduino Uno. The rest of the value are collected from the Table II according to the condition of the air quality.

TABLE II
AQI AND CONCENTRATION BREAKPOINTS OF PM10

| PM10 Air Quality | $Conc_{Lo}$ | $Conc_{Hi}$ | $AQI_{Lo}$ | $AQI_{Hi}$ |
|---|---|---|---|---|
| Good | 0 | 154 | 0 | 100 |
| Unhealthy | 155 | 354 | 101 | 200 |
| Hazardous | 355 | 604 | 201 | 500 |

Based on the values of the table and the concentration value obtained from the dust sensor, the AQI value will be calculated and show on the LED display. The AQI value is popularly known the people compared to PM10 values as AQI is commonly shown on various mobile weather applications. Hence, this is the biggest improvement over all other air quality sensors that are already in the market and developed by other pervious engineers.

The results that are shown on the display of the LED is shown on the serial monitor. It is shown while connected with a USB cable with the Arduino Uno board at the Baud Rate that is set on the system. The results shown on the serial monitor is also shown on a remote device which is wirelessly connected by a wireless module. The wireless modules was set using the TX and RX pin of the Arduino Uno along with $V_{cc}$ and Ground.

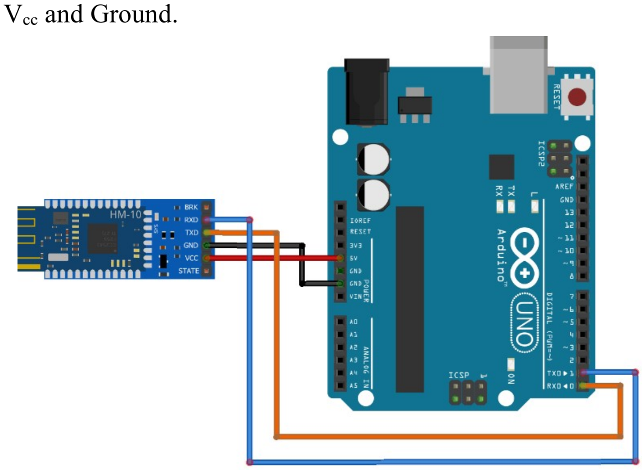


*Fig.20: Connection of HM10 Wireless Module and Arduino Uno*

*C. Description of the Components*

Several components were used in developing the portable air quality detector using Arduino Uno system. Here are the description of the primary components of the system:

- *Arduino Uno:* The ATmega328P microprocessor is used in the Arduino Uno, an open-source microcontroller board. It is made to be user-friendly for beginners and has a USB connection, 6 analog inputs, and 14 digital input/output pins. The Arduino IDE, which has numerous built-in libraries for interacting with sensors and devices, provides a simplified version of C++ that may be used to program the board. The Arduino Uno will serve as the project's primary microcontroller, and code will be written and uploaded using the IDE. On a breadboard and with the help of jumper wires, components will be linked. Due to the versatility of the Arduino Uno, the system can be easily programmed and controlled and new functions may be easily added.

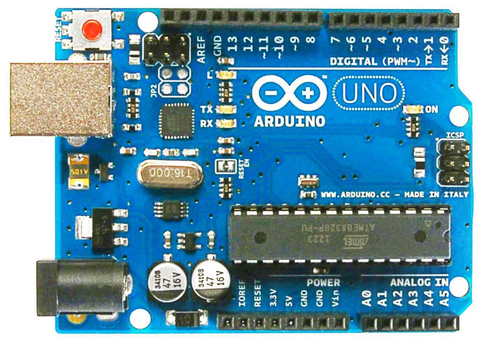


*Fig.21: Arduino Uno Microcontroller*

- *DSM501A Dust Sensor:* DSM501A dust sensor is one of the most affordable dust sensors that can be found in the market. The sensor is widely available in the market and can be used easily on any microcontroller system. The sensor can detect PM10 dust particles. It can also detect PM2.5 dust particles as well but the accuracy of detection is low compared to other available dust sensors in the market.

*Fig.22: DSM501A Dust Sensor*

- *16x2 LED Display:* 16x2 LED display is a widely available display in the market that can be easily configured to show necessary outputs of a microcontroller system. This display shows the output in 2 lines and each line can hold up to 16 characters. The LED display that is used in the system comes with an integrated keypad module that eradicates the need of an additional keypad or buttons.

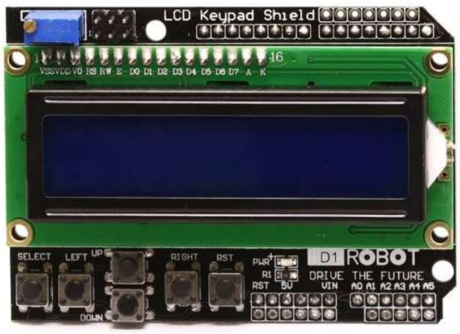


*Fig.23: LCD Keypad Shield for Arduino*

- *HM10 Wireless Module:* Among all the HM wireless modules that are available in the market HM10 is a common one. HM10 uses Bluetooth to wirelessly communicate to any device. Through this wireless module, the system can be viewed and operated remotely at ease.

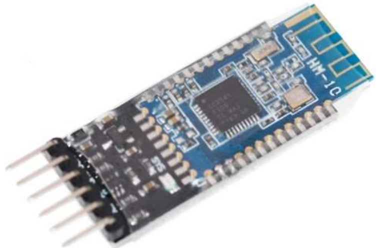

*Fig.24: HM10 Wireless Module*

*D. Test/Experiment Setup*

At first the LCD keypad shield was connected on the Arduino board. As the LCD display that we have used uses all pins of the Arduino and works as a shield for the microprocessor, all the pins of the Arduino Uno would be used by the LCD display keypad shield. But to show data on the display, the keypad uses the pins from PIN 8 to PIN 13, GND and AREF.

*Fig.25: Arduino Uno with LCD Keypad Shield*

As there are multiple components that require 5V and Ground connection, a breadboard was set on the system to provide common power to all components on the board. The DSM501A dust sensor was set on the system afterward. The sensor had 5 pins to connect to the Arduino Uno. In the following Table III, the pin connection of the dust sensor and Arduino Uno are provided.

TABLE III
CONNECTION OF DSM501A SENSOR AND ARDUINO UNO

| Connection Name | DSM501A Sensor Pin | Arduino Uno Pin |
|---|---|---|
| PM10 | 2 | 13 |
| $V_{CC}$ | 3 | 5V |
| Ground | 5 | GND |

HM10 wireless was connected to the breadboard and pin 0 and 1 of Arduino board. The GND and VCC of HM10 was also connected accordingly with the Arduino Board. On figure 21, the pin layout of the HM10 is provided which was used while connecting on the Arduino Uno Board.

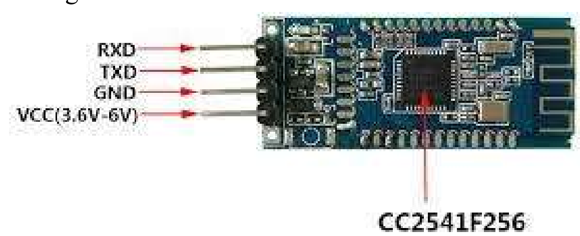


*Fig.26: HM10 Bluetooth Wireless Module Pin Layout*

After that three LEDs (Green, Yellow and Red) were connected to the Veroboard and it was connected to the breadboard through jumper wires. The LEDs were soldered to the Veroboard for better stability of the system. Figure 22 shows how the LEDs and buzzer is connected to the system using a Veroboard and how the soldering was performed.

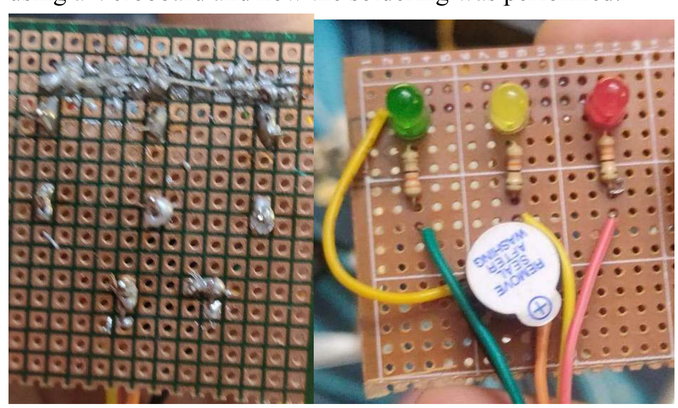

*Fig.27: (Left) Soldering and (Right) Connection of LEDs & Buzzer*

The LEDs were connected to the pin 2,3 and 4 of Arduino board. Lastly, a buzzer was connected on the Veroboard and it was then connected to the breadboard through jumper wires. The buzzer was connected to the pin 6 of Arduino board. The final product is then set of acrylic sheets and the wire components is covered using an acrylic cover. Figure 28 and 29 shows the final system that is developed named as ‘Portable Air Quality Detector using Arduino Uno’.

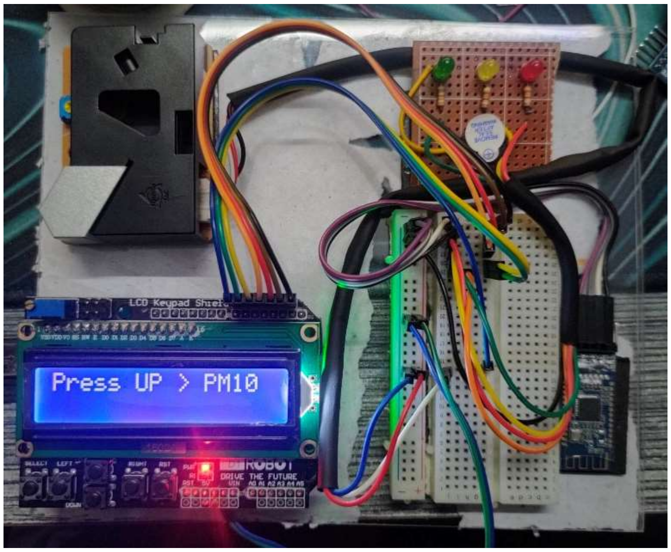


*Fig.28: Portable Air Quality Detector using Arduino Uno without Acrylic Cover*

*Fig.29: Portable Air Quality Detector using Arduino Uno with Acrylic Cover*

## IV. Results And Discussion

### *A. Simulation Analysis*

In the developed system, there are three different states that the system can detect by calculating the PM10 value. The simulation was performed on Proteus simulation. Only the PM10 and AQI value determination is performed as LED Key Shield is not available as a Proteus component library. As a result, the code could not operate the button operations properly. The following figures are the performed simulation analysis:

When PM10 value is within 0 ~ 154:

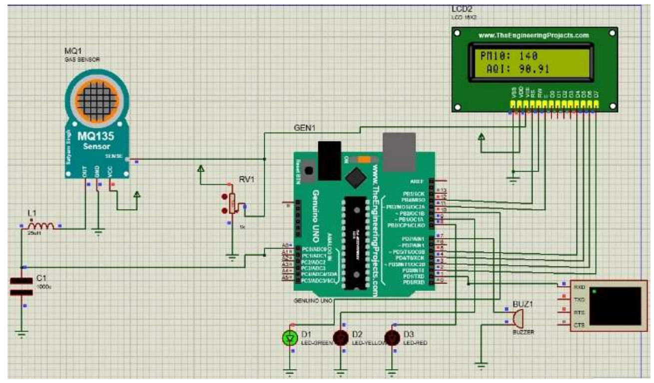


*Fig.30: Simulation outcome of the Developed System while PM10 is within 0 ~ 154*

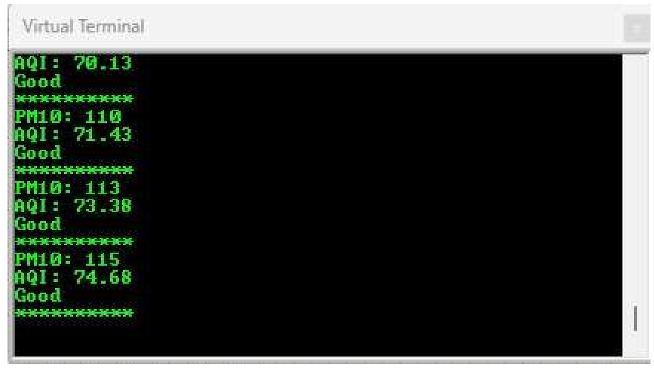


*Fig.31: Simulation outcome of the Developed System while PM10 is within 0 ~ 154 in Serial Monitor and Wireless Device*

When PM10 value is within 155 ~ 354:

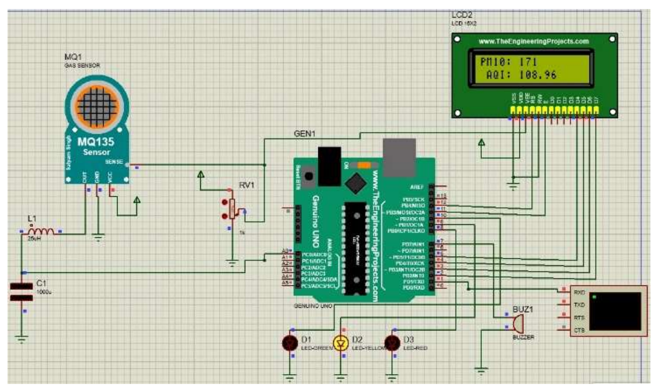


*Fig.32: Simulation outcome of the Developed System while PM10 is within 155 ~ 354*


*Fig.33: Simulation outcome of the Developed System while PM10 is within 155 ~ 354 in Serial Monitor and Wireless Device*

<u>When PM10 value is within 355 ~ 604:</u>

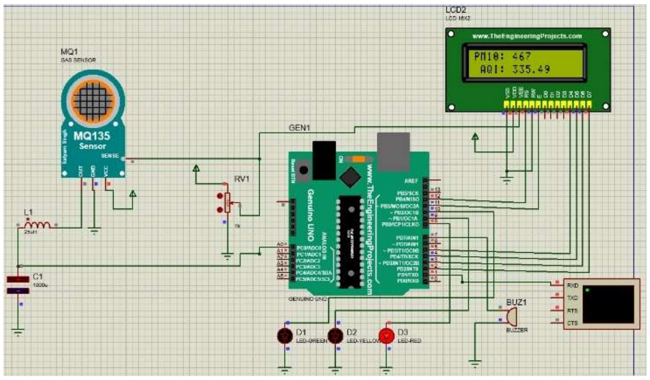


*Fig.34: Simulation outcome of the Developed System while PM10 is within 355 ~ 604*

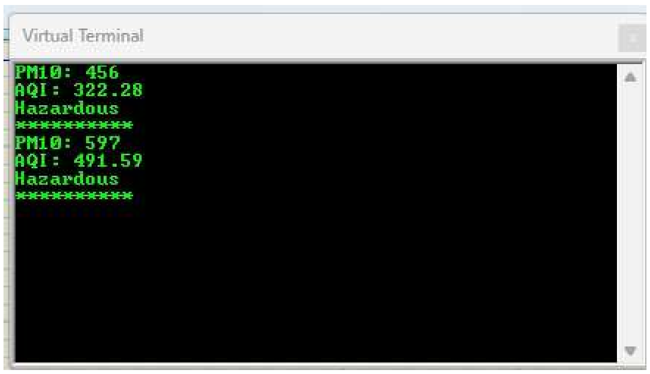


*Fig.35: Simulation outcome of the Developed System while PM10 is within 355 ~ 604 in Serial Monitor and Wireless Device*

*B. Experimental Results*

The product that is developed has two different modes that can be accessed. Using the 'Up' and 'Down' button, the system can enter either 'Test Mode' or 'PM10 Mode'.


*Fig.36: Main Menu of the Portable Air Quality Detector using Arduino Uno*

When pressing the 'Down' Button, the system starts calculating the PM10 and AQI values. Along with that it also starts print data on the serial monitor and wirelessly connected Bluetooth device simultaneously. Here are the results in the following figures that were observed according to the range of PM10 values:

<u>When PM10 value is within 0 ~ 154:</u>

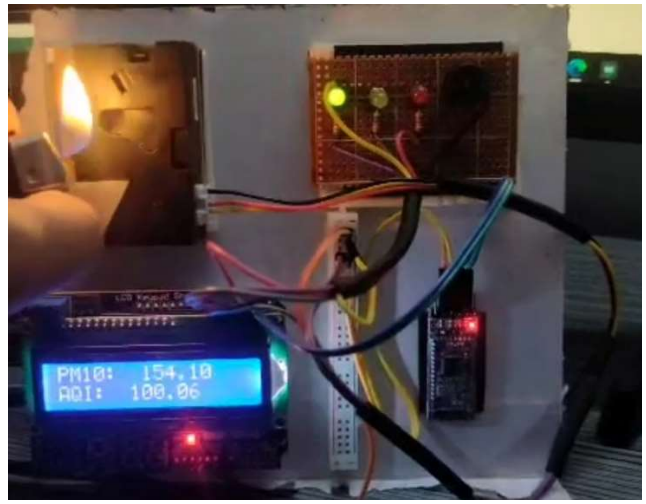


*Fig.37: Experimental Results of the Developed System while PM10 is within 0 ~ 154*


*Fig.38: Experimental Results of the Developed System while PM10 is within 0 ~ 154 on LED Display*

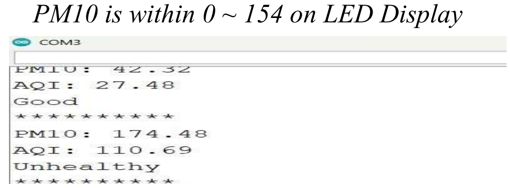


*Fig.39: Experimental Results of the Developed System while PM10 is within 0 ~ 154 on Serial Monitor*

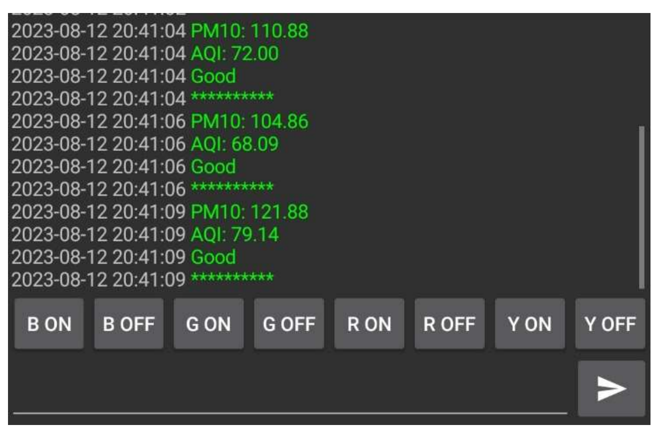


*Fig.40: Experimental Results of the Developed System while PM10 is within 0 ~ 154 on Bluetooth connected device*

When PM10 value is within 155 ~ 354:

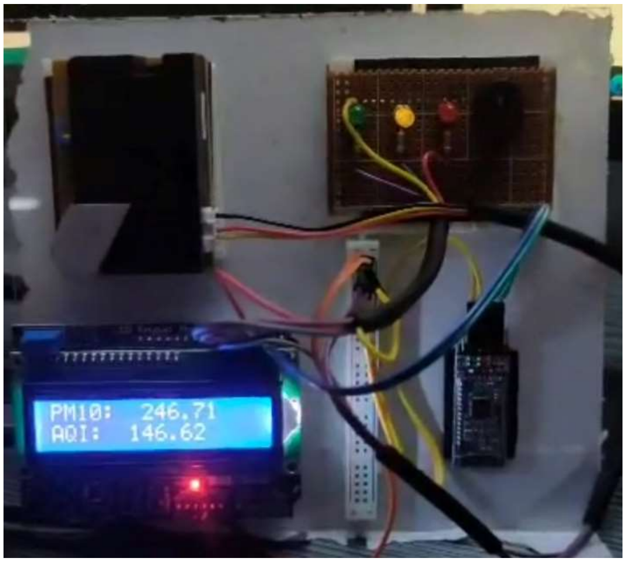


*Fig.41: Experimental Results of the Developed System while PM10 is within 155 ~ 354*


*Fig.42: Experimental Results of the Developed System while PM10 is within 155 ~ 354 on LED Display*

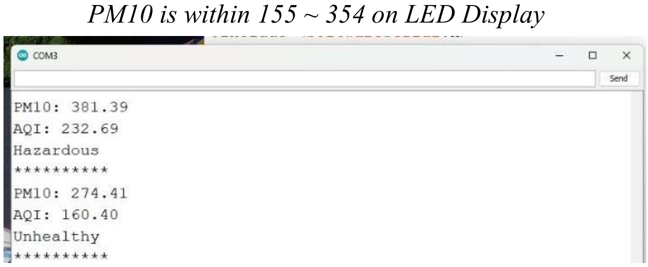


*Fig.43: Experimental Results of the Developed System while PM10 is within 155 ~ 354 on Serial Monitor*

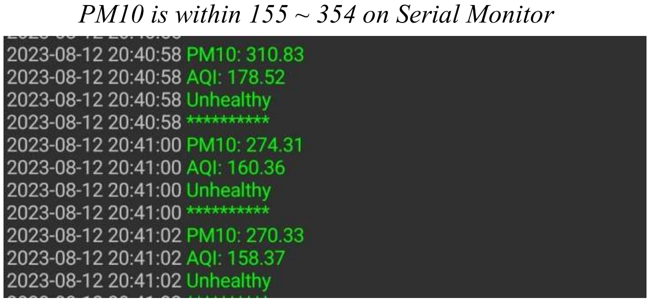


*Fig.44: Experimental Results of the Developed System while PM10 is within 155 ~ 354 on Bluetooth connected device*

When PM10 value is within 355 ~ 604:

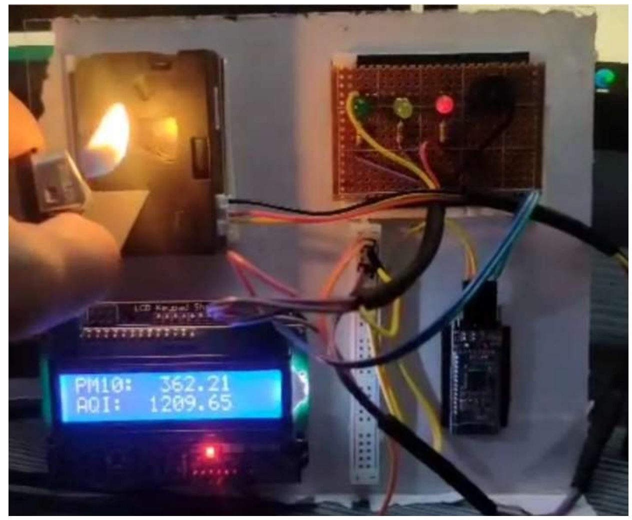


*Fig.45: Experimental Results of the Developed System while PM10 is within 355 ~ 604*


*Fig.46: Experimental Results of the Developed System while PM10 is within 355 ~ 604 on LED Display*

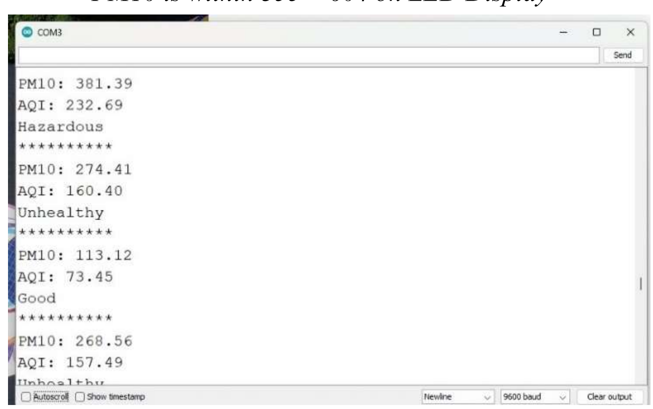


*Fig.47: Experimental Results of the Developed System while PM10 is within 355 ~ 604 on Serial Monitor*


*Fig.48: Experimental Results of the Developed System while PM10 is within 355 ~ 604 on Bluetooth connected device*

While in Hazardous state, the system also alerts the user by the buzzer. The buzzer is set in such a way so that the user can be notified appropriately about the situation in the area.

When pressing 'Select' button, the system returns to the main menu. Afterward, the 'Up' button was pressed to enter the 'Test Mode. In the test mode. The system's various functionality can be tested using the Bluetooth connected mobile device remotely. The following figures represents results that were obtained by performing the various kinds of testing on the system using the remote Bluetooth serial monitor.

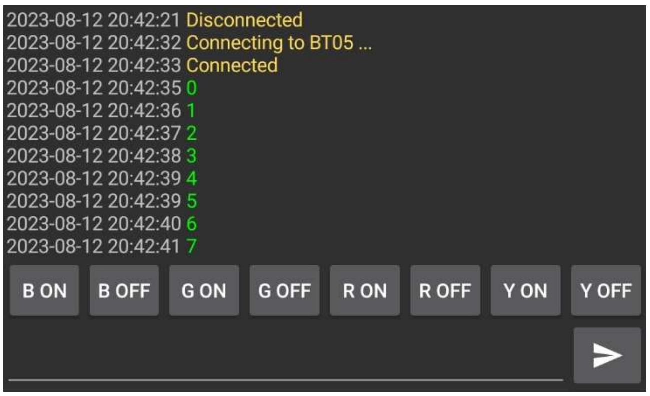


*Fig.49: Experimental Results of the Developed System while performing various testing through the Bluetooth connected device*

When testing the buzzer:


*Fig.50: Display output when Buzzer is ON while testing*

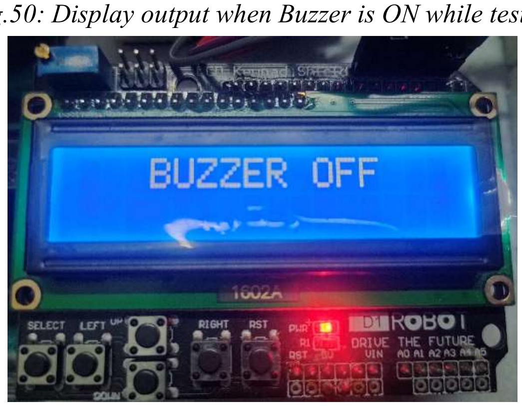


*Fig.51: Display output when Buzzer is OFF while testing*

When testing the Green LED:


*Fig.52: Display output when Green LED is ON while testing*

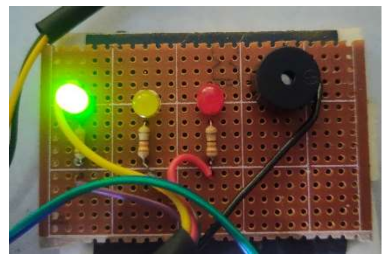

*Fig.53: LED status when Green LED is ON while testing*


*Fig.54: Display output when Green LED is OFF while testing*

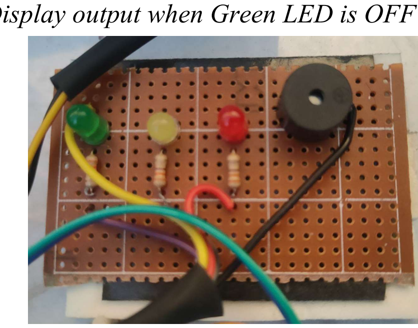

*Fig.55: LED status when Green LED is OFF while testing*

<u>When testing the Yellow LED:</u>


*Fig.56: Display output when Yellow LED is ON while testing*

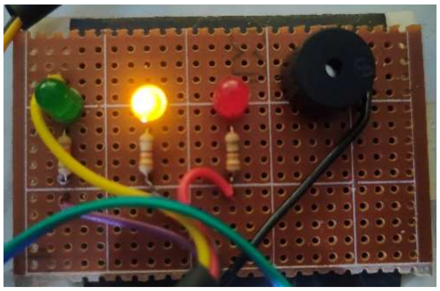

*Fig.57: LED status when Yellow LED is OFF while testing*


*Fig.58: Display output when Yellow LED is OFF while testing*

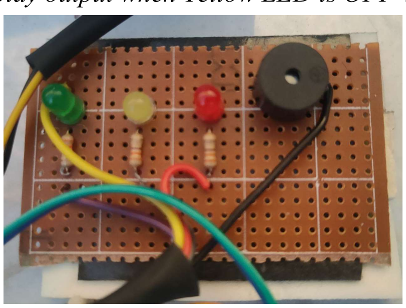

*Fig.59: LED status when Yellow LED is OFF while testing*

<u>When testing the Red LED:</u>


*Fig.60: Display output when Red LED is ON while testing*

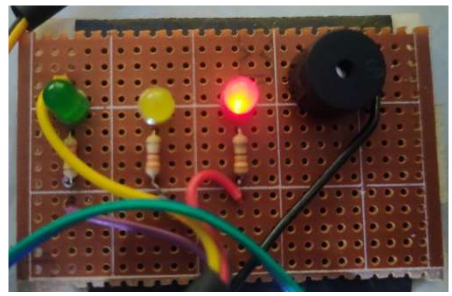

*Fig.61: LED status when Red LED is OFF while testing*


*Fig.62: Display output when Red LED is OFF while testing*

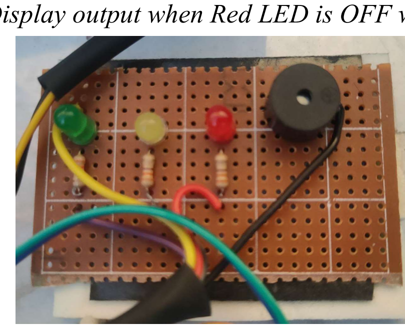

*Fig.63: LED status when Red LED is OFF while testing*

### *C. Comparison between Simulation and Experimental Results*

In order to perform an appropriate comparison between the simulated and experimental results, the AQI values at certain PM10 values were collected accordingly. Based on the obtained values the following Error Rate (%) formula is used.

$$\text{Error (\%)} = \frac{Experimental - Simulated}{Experiment} \times (100\%)$$

TABLE IV
EXPERIMENTAL AND SIMULATED AQI VALUES AT DIFFERENT PM10 VALUES

| **PM10 Value** | **Experimental AQI Value** | **Simulated AQI Value** | **Error (%)** |
|---|---|---|---|
| 60.69 | 39.41 | 38.97 | 1.12 |
| 274.41 | 160.40 | 160.20 | 0.12 |
| 381.39 | 232.69 | 232.22 | 0.20 |

From table IV it can be observed that all the error range at different PM10 values is 0.20% – 1.12%, which is within acceptable range. But if the system is used for scientific purposes this range of error is not acceptable. The error is occurring because of several reasons which is human error and simulation error. In terms of human error, the DSM501A Dust Sensor is not providing appropriate results as there are several environmental issues which can cause these errors. Various obstacles in the sensor can also cause such errors as well. In terms of simulation error, the appropriate dust sensor is not available in proteus simulation software and that is why an alternative sensor which is MQ135 sensor is used. Although the used sensor in the simulation can detect dust particles at PM10 range, it cannot provide results at such accuracy that DSM501A dust sensor can provide. The MQ135 sensor detects dust particles in a different method as well which is not like DSM501A dust sensor. For these reason, the simulation results are generating some errors.

### *D. Cost Analysis*

Products that are purchased to develop system were sources from various sources to ensure the best possible price. As a small quality of the components were purchased, the prices are not as competitive as it would have been if the components were purchased in bulk. The prices of each product and purchase quality along with the total cost of developing the product is provided in Table V.

TABLE V
PRICES OF PURCHASED REQUIRED COMPONENTS OF THE SYSTEM

| **SL** | **Project Cost Analysis** | | |
|---|---|---|---|
| | **Component Name** | **Quantity** | **Cost (BDT)** |
| 1 | Arduino Uno Board | 1 | 1100 |
| 2 | HM10 Wireless Module | 1 | 470 |
| 3 | DSM501A Dust Sensor | 1 | 890 |
| 4 | Veroboard Dot Type | 1 | 25 |
| 5 | LCD Keypad Shield for Arduino | 1 | 550 |
| 6 | Buzzer | 1 | 20 |
| 7 | LEDs | 3 | 15 |
| 8 | Jumper wire | 25~30 | 75 |
| 9 | Resistor | 3 | 10 |
| 10 | Ribbon Tape | 1 | 50 |
| 11 | Acrylic Sheet | 1 | 400 |
| Total | | | 3605 |

As there are other commercial solutions available on the market already, a proper cost analysis of the developed product is vital. By searching the internet and physical shops during our research, the prices of a few noteworthy components were collected. The prices that were collected are represented in Table VI for better understanding along with the average price of a commercial air quality detector.

TABLE VI
PRICES OF COMMERCIAL AIR QUALITY DETECTOR

| **SL** | **Model Name** | **Price** |
|---|---|---|
| 1 | Amazon Smart Air quality monitor | 23499 |
| 2 | Temtop Air quality monitor | 13419 |
| 3 | AcuRite Air quality monitor | 13749 |
| Average | | 16889 |

The cost reduction of the project using the cost reduction formula given below:

$$\text{Cost reduction (\%)} = \frac{Original-New}{Original} \times (100\%)$$

Here,
Original = the average price of the available systems
New = The project price

$$\text{Cost reduction (\%)} = \frac{16889-3605}{16889} \times (100\%) = 78.65\ \%$$

According to the formula, price can be reduced by 78.65%. However, this is without factoring in shipping, licensing and delivery costs which will gradually add up to the new cost. Despite those additional expenditure, due to initial high-cost reduction, the price will stay at a value which will be deliverable to the masses. Also, orders for manufacturing PCB are taken in bulk, resulting in further price reduction.

### *E. Limitations in the Project*

The developed system in the report has some limitations. The limitations happened due to various reasons. Here are the noteworthy limitations of the project:

- The developed system cannot detect smaller particles like PM2.5 accurately as the DSM501A dust sensor cannot detect this kind of particular matter appropriately. The reason behind this is the sensor that the DSM501A uses.
- The developed portable air quality detector cannot run appropriately operate in an industrial area as it cannot detect PM2.5 particles.
- The system does not have a fully developed computer application that can help read the results in a user-friendly interface.
- The system does not come with a mobile application that can connect with the system automatically and view the results using a standalone application.
- A notification alert system is not developed for the

system that can alert the user wirelessly through their mobile or computer.

- The system is not waterproof as a result it cannot be permanently set in the open environment.
- The DSM501A dust sensor that is used can provide inaccurate readings of PM10 particles if the sensor is blocked by any medium.

## V. Conclusion And Future Endeavors

In conclusion, the portable air quality detector using Arduino Uno demonstrates the possibility of developing air quality detectors in a simple, affordable and user-friendly manner. This project has developed an air quality detector that can detect PM10 particles with high accuracy. Based on the information it gathers, it can also present the AQI value based on the PM10 concentration detected by the system. This project has also demonstrated that a air quality detector can be developed by any simple person using a microcontroller like Arduino Nano, Uno and many more. Through analysis and testing, it has been determined that all the knowledge obtained from for the project was implemented accordingly and it can detect the quality of the air in a particular area with high accuracy. Thus, the main purpose for this project has been fulfilled and the project has achieved its objectives of designing and constructing a functional portable air quality detector using Arduino Uno.

In terms of terms of future endeavors, there are several potential improvements that can be made to enhance the portable air quality detector's functionality and accuracy. Here are some of the proposed future endeavors:

- The system can be used at industrial areas if the sensor is changed to be better and high accuracy detection one. As PM2.5 is the ideal measuring range for industrial air quality detection, purchasing a dust sensor that can detect such particles can enhance the operation of the product that has been developed.
- As DSM501A Dust Sensor is a sensitive component which is highly prone to getting damaged due to its cheap build quality, searching for a durable sensor can be a part of the future endeavor while keeping the thought of making it affordable for the general people.
- DSM501A dust sensor can get easily obstructed with big dust particles. Hence, the sensor requires constant cleaning. Developing a system so that it does not require constant cleaning in a regular basis is a research that will take time and effort.
- The project can be made cost effective through the use of automated manufacturing processes to speed up production and reduce labor costs, while also ensuring consistency and quality control. Purchase of bulk products can also reduce cost. Finding a possible solution for that can be an important section of the future endeavors.
- Developing an application on which the user can view the condition of the air around them is vital. As this will take time and enhanced programming knowledge, this can be a part of the future endeavors as well. Figure 64 shows an example of how the interface of the application might look like.
- Developing a database so that the reading that are collected through the system can help in various research purposes. It can also help performing various weather predictions and assist in eradicating air pollution.
- As the developed product is an open-box product, developing a proper cover for the product is important is the product is intended to be used outside.

There are more future endeavors that can be performed in this project. As engineers it is expected that the people who will take this project ahead can be the ones to find out what be done on this project and how it can be done. Therefore, making the product better and viable for the general people to use.

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