Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF IOT BASED AIR POLLUTION MONITORING SYSTEM USING ARDUINO

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A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electrical Engineering Technology with Honours

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2023

DECLARATION

I declare that this project report entitled “Development Of IoT Based Air Pollution Monitoring System Using Arduino” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

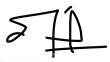
Signature : 

Student Name : Nurul Aqilah binti Mahmudin

Date : 12th January 2023

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology with Honours. (please change the red text into black after edited)

Signature : 

Supervisor Name : Ts. Dr. Ahmad Zubir bin Jamil

Date : 25 January 2023

Signature :

Co-Supervisor :

Name (if any)

Date :

DEDICATION

To my beloved mother, Faridah binti Haji Yusak, and father, Mahmudin bin Haji Sulaiman,

and

To all my family members and friends.

ABSTRACT

Air pollution is the content of air in which there are foreign objects in concentrations that disturb or endanger humans, flora, fauna and property. This pollution occurs due to natural disasters, smoke from vehicle exhaust, open logging and burning. Accordingly, the human respiratory system will be disrupted as well as the earth's ozone layer of the air becomes thinner. Air quality management systems have been developed to regulate the concentration and quality of gases found in the atmosphere, such as carbon dioxide and oxygen to keep healthy. This project will utilize development of IoT based air pollution monitoring system to help consumer monitor the level of air pollution and air quality can be maintained and controlled. In addition, the purpose of this project is to alert the community regarding air pollution information by developing website ThingSpeak. It is because all air pollution information from multiple-ground based stations into one common area for effective and efficient monitoring and analysis of air pollution. This method of project allow users to check air quality data in an easy way like ThingSpeak that is connected to smartphones and computers anywhere and access the system data via Wi-Fi or Bluetooth by using Nodemcu V2. This method shows the data from ThingSpeak website. For next step, all the information can be access, monitor and check through smartphones and computer anywhere effectively and preciously. As results, the air pollution detected by MQ135 sensor meanwhile the readings data and status displayed in Serial monitor. Then, the data send to ThingSpeak to analysis purpose through a graph. For community, the status air pollution can be check in ThingView app. The impacts by doing this project is enhance the skills and gain experience in develop Internet of Things (IoT) air pollution monitoring system. It is also gain our knowledge about air quality and the importance to check the status for better life.

ABSTRAK

Pencemaran udara adalah persekitaran udara yang terdapat bendasing membahayakan manusia, flora, fauna dan harta benda. Pencemaran ini berlaku adalah disebabkan bencana alam, asap dari ekzos kenderaan, pembalakan dan pembakaran terbuka. Sistem pernafasan manusia akan terganggu serta lapisan ozon bumi udara menjadi makin nipis. Oleh itu, sistem kawalan kualiti udara diperkenalkan bagi tujuan untuk mengawal tahap kepekatan dan kualiti gas yang terdapat di udara seperti karbon dioksida, oksigen dan sebagainya untu kekal sihat. Projek IoT dalam sistem kawalan pencemaran udara dijalankan untuk membantu komuniti mengawal tahap kualiti udara. Tambahan lagi, salah satu objektif projek ini untuk memberi peringatan kepada pengguna dalam membangunkan suatu laman web ThingSpeak yang dapat mengumpul semua maklumat tentang tahap kualiti pencemaran udara. Hal ini kerana majoriti masyarakat telah maju dan moden dengan dapat mengakses ThingSpeak dengan mudah melalui penggunaan telefon pintar dan komputer. Projek ini memperkenalkan kaedah penggunaan telefon pintar yang dapat mengakses Wi-Fi atau Bluetooth melalui NodeMcu V2 untuk menyemak semua data tahap kualiti udara dalam aplikasi ThingView. Semua data akan dipaparkan di laman web ThingSpeak. Dengan ini, semua maklumat boleh diakses, kawal dan periksa melalui telefon pintar secara efektif di mana-mana sahaja. Hasilnya, tahap kualiti pencemaran udara dikesan oleh MQ135 dan pada masa yang sama, data bacaan dan status dipaparkan di serial monitor. Kemudian, data akan dihantar ke ThingSpeak untuk tujuan analisis dalam bentuk graf. Tahap pencemaran udara boleh diperiksa melalui aplikasi ThingView bagi pihak masyarakat. Implikasi dalam menjalankan projek ini adalah memperoleh kemahiran dan pengalaman dalam membangunkan sistem kawalan pencemara udara dalam menggunakan teknologi IoT.

ACKNOWLEDGEMENTS

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My highest appreciation goes to my parents, and family members for their love and prayer during the period of my study. An honourable mention also goes to my supervisor also for all the motivation and understanding. And to my best friend, thanks for keeps moral support and understanding me physically and mentally.

Finally, I would like to thank all the staffs at the Electrical and Electronic Engineering Technology Faculty (FTKEE), fellow colleagues and classmates, the faculty members, as well as other individuals who are not listed here for being co-operative and helpful.

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PM	-	Fine Particulate Matter
	-	
	-	
	-	
	-	
	-	
	-	
	-	

LIST OF ABBREVIATIONS

PPM	-	Parts per Million
GPS	-	Global Positioning System
GPRS	-	Generate Packet Radio Services
GSM	-	Global System for Mobile Communication
IoT	-	Internet of Things
LED	-	Light Emitting Diode
LCD	-	Liquid Crystal Display
LTE	-	Long Term Evolution
SOC	-	System of Chip
TCP/ IP	-	Transmission Control Protocol/ Internet Protocol
WHO	-	World Health Organization

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

In today's world, pollutants is one of the major human health concern. An air pollution is any mechanical, physical, or biological element that alters the natural features of the atmosphere, whether indoors or outside. Household combustion devices, motor vehicles, industrial operations, and forest fires are all common sources of air pollution. The World Health Organization (WHO) stated the data that almost all of the worlwide population breathe air that exceeds PM2.5 and PM10 contains high amounts of contaminants, with the poorest and middle-income countries being the most affected. An air pollution cause respiratory and other diseases and it is important source of morbidity and mortaility.

Air quality has long been a topic of discussion, dating back to the Roman era. Authorities eventually took action following a succession of significant pollution episodes, beginning with the reduction of emissions. Donora, Pennsylvania was engulfed in a deadly haze in October 1948. Over the course of five days, about half of the town's 14,000 residents suffered from serious respiratory or cardiovascular problems. It was difficult to take a breath. The death toll has grown to more than 40. The streets of Donora are enveloped in a thick coating of grey cloud in these terrifying images. High above the city, a warm air pocket had passed, trapping colder air and pollution below.

Donora was no new to pollution. Steel and zinc smelters have long fouled the town's air. The air pocket, on the other hand, prevented pollutants from escaping. As they simmered on the streets, residents inhaled them in lethal proportions. Donora's illness was

severe, but it was part of a bigger pattern. Air pollution has become a terrible consequence of industrial progress across the country and around the world. Crisis like Donora was widely publicized. People noticed and began to act.

Since it happened, the link between air pollution and health has been studied by experts. The state has begun to enact legislation to decrease pollution in the air. And in 1970, a milestone year, The Clean Air Act was amended by Congress, which sets national air quality standards.

Throughout the years, the evolution of technology keep advanced in worldwide. Recently, Internet of Things (IoT) is one of the popular system or the internet-connected network of physical items (or "things") equipped with sensors, software, and other technologies for the purpose of networking and sharing data with other devices and systems.

An IoT ecosystem is made up of web-enabled smart devices that acquire, send, and act on data from their surroundings using embedded systems such as CPUs, sensors, and communication gear. IoT devices can exchange sensor data with an IoT gateway or other edge device, which can then be sent to the cloud for analysis or examined locally. On occasion, these devices may communicate with one another and act on the data they receive. Individuals may engage with the devices to set them up, provide instructions, or obtain data, but the devices conduct the majority of the work.

For example, air pollution can be observe, collect all information and check air quality level (K. Kumar Sai *et al*., 2019). Air sensors, such as the MQ135 Gas Sensor, are used to detect various dangerous chemicals in the air, such as CO2, and are connected to the Arduino Uno, a microcontroller that is utilised in the system and constantly transmits data to the application via the Wi-Fi module.

To control the data information, the best microcontroller need to be choose for the monitoring system is Arduino. Because of its simple structure and wide variety of

working conditions, it is one of the best microcontrollers. Arduino microcontroller are essentially a controller for electronics. They can utilise their inbuilt CPU to transform inputs like light on a sensor or an item near a sensor to outputs like driving a motor, ringing an alarm, turning on an LED, displaying information on an LCD, and so on. Furthermore, Arduino also may be tuned using relatively simple design criteria and is straightforward to build using analogue or digital components. Thus, the interface connection of the monitoring system is connecting internet with IoT devices to provide all data.

1.2 Problem Statement

One of the growing public concerns is regarding human health, safety and comfort. There are so many form of pollution that degrades the atmosphere, causes biodiversity loss, stratospheric ozone depletion, damaging acid rain, and global warming, climate change and land degradation. Particularly fast urbanization in growing nations has become a common phenomenon. Air pollution must be controlled in order to ensure the healthy and clean climate.

The emission of combustion fossil fuel vehicles is one of the main causes of air pollution in Malaysia. Other human innovations and activities, in addition to industry, contribute to air pollution. Air quality based on pollutants level which has the parameters like carbon dioxide, nitrogen dioxide, sulfur dioxide etc. As a result of these factors, there is an increasing need for an air pollution management and monitoring system.

It is necessary to impose regulations governing the rigorous monitoring of air pollution. All air pollution and information from multiple ground-based stations, ground-based and aerial mobile sensors, remote sensing and atmospheric models, and social media into one common area for effective and efficient monitoring and analysis of air pollution in

the urban environment. Thus, lung cancer asthma, coronary artery disease including chronic pulmonary diseases, coughing and other diseases can be reduced.

1.3 Project Objective

The project is being carried out with the following goals in mind:-

a. To use ThingSpeak to monitor air quality and maintain it under control for a brighter future and cleaner environment.
b. To monitor the level of pollution using collected data shown on the ThingSpeak website at any time and from any location using your computer or mobile device.
c. To develop website specifically to alert community regarding on air pollution infomation.

1.4 Scope of Project

a) This project to create an equipment that allowing for easy integration into any other sort of internet-based architecture (IoT) that permits the use of sensors capable of collecting information on sensors connected to smart city environment measurements, with the goal of giving data on environmental pollution-related data.
b) With rapid growth in infrastructure and industrial modules, environmental issues have fueled a significant need for smart monitoring systems. The Internet of Things (IoT) has become an alternative nowadays because to its cost effectiveness, high performance, and other factors.
c) The Internet of Things (IoT) allows computers and mobile devices to connect with one another.
d) To minimise any doubt about the project's feasibility owing to limits and restraints, the scope of the project is described as follows: Arduino Uno, NodeMcu V2

ESP8266 Wi-Fi Module, MQ135 Gas Sensor, LED, Trimmer Potentiometer, and Buzzer.

e) ThingSpeak software will be use to collect and display the data include analysis for prediction based on data readings. As an example, quality of air is good or not. All data is saved at http://thingspeak.com, which is a programme that allows users to upload and store sensor data to the cloud.

f) The environment data obtained can be monitored from anywhere. Wi-Fi Modules are used as network connectors in this system. These gadgets, however, must be placed near the Wi-Fi hotspot. Furthermore, this method only shows the data from the ThingSpeak website.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the reviews of researchersworks or project carried out by previous related to the project topic. This chapter will also include fundamental knowledge with respect to the topics, mostly on area of air pollution, what is the types of microcontroller that use in device and how IoT works on and help in monitoring system. All the data is simplified based on the title, abstract, introduction, conclusion, and full text. All the information that is focused on the same or different objective can be used as a comparison, which can make the outcome project better.

2.2 History of Air Pollution

In October 1948, the town of Donora, Pennsylvania, was shrouded in a fatal haze. Over the course of five days, about half of the town's 14,000 residents suffered from serious respiratory or cardiovascular problems (E. Jacobs *et al.*, 2018). It was difficult to take a breath. The death toll has grown to more than 40. The streets of Donora are covered in a thick coating of grey cloud in these terrifying images. Warm air had passed high above the city, trapping cooler air and pollution below.

Donora was no acquainted to pollution. The town's air has long been polluted by steel and zinc blast furnaces. The air pocket, on the other hand, prevented pollutants from escaping. As they simmered on the streets, residents inhaled them in dangerous proportions. Donora's illness was severe, but it was part of a bigger pattern. Air pollution has become a terrible consequence of industrial progress across the country and around the world.

When tragedies like Donora's were made public, people began to react. Scientists started investigating the link between air pollution and health. States began passing legislation to reduce air pollution levels. In 1970, Congress passed the Clean Air Act Amendments, which established national air quality requirements.

According to the Malaysia Department of Environment, there are main sources of air pollution in Malaysia such as development activities, land clearing, power generation, open burning and forest fires, land clearing and motor vehicles. Because of that, air pollutant index should be measuring. Air pollutant index (API) is an indicator for the air quality status at any certain area. Based on five major air pollutant which are nitrogen dioxide, carbon monoxide, sulphur dioxide, ground level ozone and particulate matter with diameter less than 10 micron, the index are calculated.

Table 2.1 Air Pollutant Management Index

PPM	STATUS
0 – 50	Good
51 – 100	Moderate
101 – 200	Unhealthy
201 - 300	Very Unhealthy
Above 300	Hazardous

Table 2.2 Health Effect based on Air Pollutant Index (API) status

PPM	Health Effect	Health Advice
0 – 50	No bad effect on health in low pollution	Maintain healthy lifestyle.
51 – 100	Does not pose any bad effect on health	No restriction to do outdoor activities in public.

101 – 200	High risk to the people who has heart and lung compilations.	Outdoor activities have to be limited for high risk people.
201 – 300	Low tolerance of physical exercises and health condition become worse to the people who has heart and lung compilations. Also, bad effect to the public health.	Must to stay indoor and physical activitiesshould be reduced for old and high risk people. Must be referred to doctor if get any bad compilations.
>300	Hazardous to high risk people and public health	Probihited to old and high risk people to do outdoor activities. Public could be prevented from doing outdoor activities.

2.3 Previous Related Work

2.3.1 Types of Microcontroller based System

2.3.1.1 Raspberry Pi and Arduino

S. Malleswari *et al.* (2021) published an article based on air pollution to collect and provide the data information about air quality level by using Arduino and Raspberry Pi as a microcontroller. Arduino have been used to collect sensors data then send it to Raspberry Pi for transmitting to the cloud. Through local area network (LAN), all the information data will be analyze using Wi-Fi and the air quality can be check through an android app. Hence, the air quality in particular area can be monitoring. The author suggested to see the results of air quality on maps at certain location.

2.3.1.2 Raspberry Pi 3

Air quality management system research paper have been written by P. Pullan *et al.* (2020). This research is about collects data pollution levels in taking into the PM2.5 value through some processes and calculates the AQI by using of mobile nodes that have been implemented together with basic sensors. This mobile nodes have been placed at many kind of places that used to mark the path and indicate the level of pollution with various color codes. This monitoring system consists of a Raspberry Pi 3 as a microcontroller. PPD42NS Dust sensor have been used to detect the gas and get the data of PM2.5 concentration. This system connects to a GPS/GPRS module, making it easier for users to detect pollution locations based on previously marked routes. On lastly, they proposed that the system can be built with all the individual moving nodes to collect data in various location then it can be stored in a database to predict the future trends in certain area.

2.3.1.3 Raspberry Pi

V. Sajjan (2021) analysed this study report, which worked on employing sensors to detect pollution levels, dangerous substances, and air quality through an internet-based web server. By using DHT11, LM-35 temperature sensor, Mics 2714 NO2 sensor and MQ7 sensor, the air level concentration and type of gases like NO3 data can be detect and determined the air quality index by calculating in formula. The Raspberry Pi used as a microcontroller has been interfaced with the MQ2 gas sensor the usage of the python coding language.

2.3.1.4 Arduino Uno

An affordable Arduino-based Air Quality Monitoring system employing MQ series sensors have been design to be used both indoors and outdoors if properly calibrated before installation (K. Kumar Sai *et al.*, 2019). Air sensors like MQ135 Gas sensor connected with Arduino Uno which is microcontroller that used in system to detect presence of harmful gas in the air and constantly transmit this data into over the application. Furthermore, ESP-01 Wi-Fi module also used to transmit data from MQ135 gas sensor to IoT platform.

2.3.2 Types of Communication

2.3.2.1 LTE Modem

J. Jo *et al.* (2020) developed an air sensing quality device that called as "Smart- Air". The purpose of this development project is getting indoor air quality measurements that are precise level monitoring precisely. There a few of technologies that have been focused on IoT technologies to monitor the air quality. However, smart air have been mounted with Long-term Evolution (LTE) modem. By classifying and visualising air quality, an LTE modem is used to communicate detected data straight to a web server. Usually, gateway or data loggers are including in the system in the most of IoT problems. Besides, a microcontroller replaced the gateway to collect the data from sensors and send it into web server. The operation of this device is to automatically display air quality in a specific region through LED. As an example, the light is set to purple when the status of indoor air quality is good.

2.3.2.2 Wi-Fi Module

S. Malleswari *et al.* (2021) released an article on air pollution to collect and provide data information on air quality levels across a local area network (LAN) using a Wi-Fi module that connects directly to the internet. Cloud receives the sensor data to analyze that given data for user. We can use an android app to check the air quality.

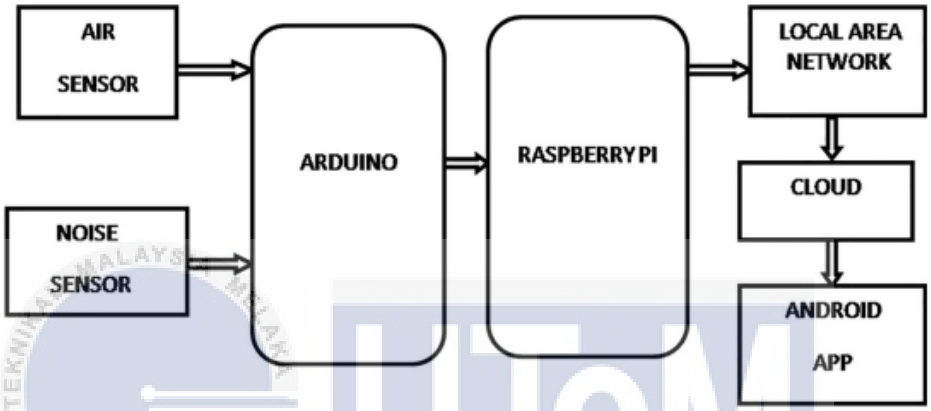


Figure 2.1 Block diagram of air pollution monitoring system using Wi-Fi

2.3.2.3 ESP-01 Wi-Fi Module

K. Kumar Sai *et al.* (2019) analyzed air quality through ThingSpeak using ESP-01. The ESP-01 is an inexpensive self-contained SOC with built-in TCP/IP protocol stack that allows any microcontroller to connect to your WiFi network. This system integrates ESP-01 Wi-Fi Module as network connector to send all the information and data air quality from sensors into the ThingSpeak. The air quality in PPM displayed on the LCD and ThingSpeak.

2.3.2.4 GSM Module

Monitor air quality through a web server that connects to the internet (K. Nirosha *et al.*, 2018). If the air quality level going down beyond threshold level, the

system will trigger a buzzer or an alarm. The air quality in PPM displayed on the LCD and webpage. The LCD and webpage will be display “Fresh Air”. When the air quality level exceed the limit of 1000 PPM, the buzzer will start ringing and display “Poor Air, Open Windows” on the LCD and webpage. It will it cause us to had headaches, sleepiness and stagnant, stuffy air. If it exceeds beyond 2000 PPM, the buzzer will keep beeping and give a notification message on smartphone through GSM module.

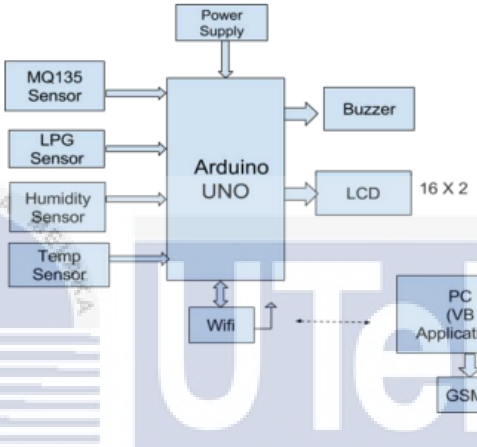
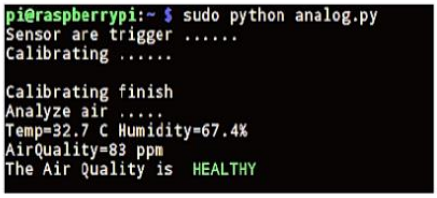


Figure 2.2 Block diagram of IoT based air pollution monitoring system using GSM module

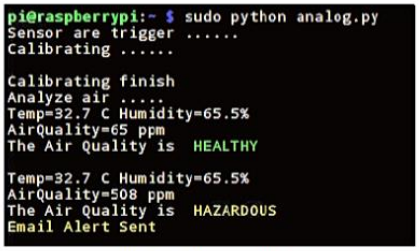
2.3.3 Types of IoT based Devices

2.3.3.1 ThingSpeak

V. Sajjan (2021) analysed this study report, which worked on employing sensors to detect pollution levels or dangerous gases and air quality through an internet-based web server. A microcontroller has been interfaced with the MQ2 gas sensor the usage of the python coding language. The measured values are in the ppm (parts per million) range. The results or output air quality messages can be displayed through ThingSpeak web server that have shown in Figure 2.3.



Sensor shows the reading after calibrated.



Warning notification using e-mail alert.

Figure 2.3 Air quality output messages

2.3.3.2 ESRI ArcGIS

A. Talib et al. (2021) proposed designing and implementing an affordable and reasonable air pollution monitoring system that can be utilised on the fly using Arduino-based GIS-GPS. (2021). Based on this research paper, ESRI ArcGIS have been used to analysis and display the collected data. ESRI ArcGIS 10.6 shape file is overlaid on a map of the research region based on GPS sensor latitude and longitude measurements.

2.3.3.3 Cloud server

The results of an IoT-based air pollution control system are shown online using air quality control over a cloud web server (S. Malleswari et al., 2021). All data that have gain from sensors have transmit to cloud server. Through LAN, board Wi-Fi connect internet directly to send and receive the sensor data. Then, the given data analyzed in cloud web server for check the air quality through an android app.

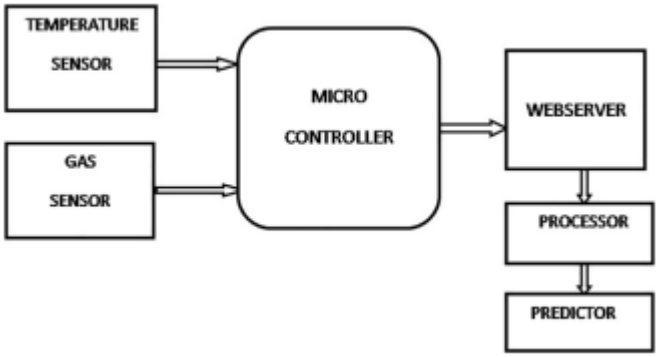


Figure 2.4 Block diagram air quality control system that cloud web server as IoT

2.4 Comparison of Literature Review

A system that displays data from a machine and may be programmed to present the information that we wish to see is called monitoring. One of the various monitoring systems is the Global Positioning System (GPS). The individuals use to keep track of their surroundings. Basically, GPS can assist in recognizing the pre-programmed working space limiting border. (R. Maddison *et al.*, 2009).

Air quality management system that connect with GPS/ GPRS module (P. Pullan *et al.*, 2020). This technique allows users to more easily discover pollution locations based on previously marked routes. This node is connected to a database that stores for incoming data in actual time. Received data can be viewed via an app that uses the Google Maps API to highlight routes in different colors of the user's data based on the Air Quality Index (AQI) of a certain area. Consider the journey from Haryana's Subhash Chowk to the ACP Office. India have been chosen as a location to test their setup. The results or data are observed and obtained in each 30 seconds and sent the average of data to the Firebase database in every one minute. The PM2.5 and AQI data displayed on an app.

No	Title/Author(s)	Details
1	Air pollution monitoring system using IoT devices: Review (S. Malleswari *et al.*, 2021)	**Project outcome:** To comprehend information on environmental variables, as well as the ability to integrate it into any other type of internet-based application (IoT) design that allows sensors to communicate with each other to assemble information that connected to the environment of the smart city measures, with the goal of delivering data on pollution levels in the environment. **The method:** Receiving all the information via a local area network (LAN) from sensors. Then, data transmit to cloud web server can use an android app to check the air quality. Raspberry Pi used as microcontroller.
2	Development of an IoT-Based Indoor Air Quality Monitoring Platform (J. Jo *et al.*, 2020)	**Project outcome:** Developed an air sensing quality device that called as "Smart-Air". The purpose project is getting indoor air quality measurements that are precise. **The method:** Smart air is equipped with a Long-Term Evolution (LTE) modem that sends observed data straight to a web server dedicated to classification and visualisation of air quality. A microcontroller replaced the gateway to collect the data from sensors and send it into web server. The purpose of this device

		is to use LED to automatically display air quality in a specified area.
3	Air Quality Management System (P. Pullan *et al.*, 2020)	**Project outcome:** Collected data pollution levels in taking into the PM2.5 value through some processes and calculates the AQI by using of mobile nodes that have been implemented together with basic sensors. This mobile nodes have been placed at many kind of places that used to mark the path and indicate the level of pollution with various color codes. **The method:** The monitoring system consists of a Raspberry Pi 3 and PPD42NS Dust sensor that used to detect the gas and get the data of PM2.5 concentration. The system has been connected to a GPS/GPRS module, making it easier for users to detect pollution locations based on the path that has been marked. **Suggestion:** Proposed that the system can be built with all the individual moving nodes to collect data in various location then it can be stored in a database to predict the future trends in certain area.
4	Analysis Of Air Pollution By Using Raspberry Pi-IoT (V. Sajjan, 2020)	**Project outcome:** Pollution levels or harmful gases and air quality level can be through an internet-based web server have been track by using sensors. **The method:**

		By using DHT11, LM-35 temperature sensor, Mics 2714 NO2 sensor and MQ7 sensor, the air level concentration and type of gases data can be detect. The Raspberry Pi used as a microcontroller has been interfaced with the MQ2 gas sensor. Python is a programming language that is widely used. The values will be produced following code execution if The smoke level is too high. The sensor uses air sensing to update the results every 30 seconds. IoT device that be used is ThingSpeak.
5	IOT Based Air Pollution Monitoring System (K. Nirosha *et al.*, 2018)	**Project outcome:** Monitored air quality through a web server that connects to the internet. **The method:** If the air quality level going down beyond threshold level, the system will trigger a buzzer or an alarm. PPM stands for particulate matter in the air displayed on the LCD and the internet. The LCD as well as the webpage will be displayed "Fresh Air". If it exceeds beyond 2000 PPM, the buzzer will keep beeping and give a notification message on smartphone through GSM module.
6	With Dataset Analysis, a Low-Cost IoT Based Air Quality Monitoring Setup Using Arduino and	**Project outcome:** Designed an affordable Arduino-based Air Quality Monitoring system employing MQ series sensors that used to both indoors and outdoors if properly calibrated before installation. **The method:**

	MQ Series Sensors (K. Kumar Sai *et al.*, 2019)	Air sensors like MQ135 Gas sensor connected with Arduino Uno which is microcontroller that used in system to detect the presence of dangerous gases in the air and communicate this information on a regular basis into over the application through ESP-01 Wi-Fi module.
7	GIS-GPS based national air pollution monitoring system (A. Talib *et al.*, 2021)	**Project outcome:** Design and implement monitoring of air pollution at a reasonable cost device that can be used on the go using Arduino based GIS-GPS. **The method:** Based on this research paper, ESRI ArcGIS have been used to analysis and display the collected data. ESRI ArcGIS 10.6 shape file is overlaid on a map of the research region based on latitude and longitude information from a GPS sensor. **Suggestion:** To increase scanning coverage and speed, the equipment may be placed on drowns.

2.5 Summary

This chapter has reviewed several number of related topics and presenting a number of case studies due to air pollution. In this context, the project's theories are explained in detail, including those related to the project's cloud computing and theories, the research and development, design process, and the essential component or components

utilised in electrical appliances in air pollution monitoring system. The project can be implemented after all the info and data have been gathered.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will describe the project's overall flow, the programme structure, the concept “Development of IoT Based Air Pollution Monitoring System using Arduino” in details. The project is planned methodically on how to implement as well as software and hardware innovation. There are several different components that form the hardware framework for the system. This chapter will give an overview of the system building methodology used for this project. This chapter describes and highlights this project's development.

3.2 Methodology

This thesis presents development IoT based air pollution monitoring system. Flowcharts are featured in the system's simple process design and documentation. The concept for developing a system application emerged from the identification of available opportunities. Using a flowchart makes it easier to comprehend each stage of a process and how it is carried out.The flow of the project is shown in Figure 3.1.

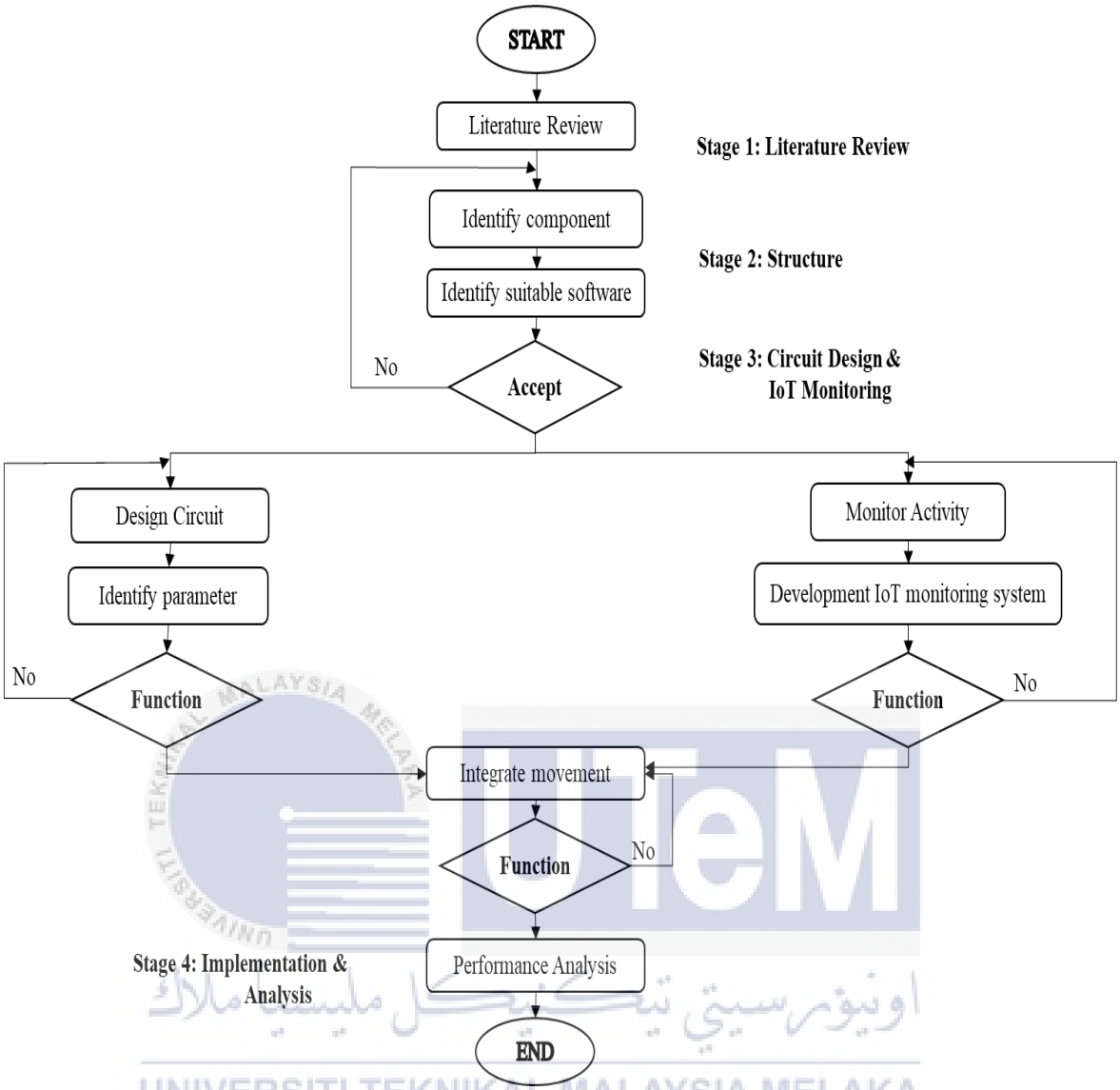


Figure 3.1 Project Flowchart

3.2.1 Stage 1: Literature Review

The construction, design circuit, and the monitoring system are all explored at this stage. In this overview of the literature, the core topic is handled as a problem assertion. In addition, the project's goal is proposed, as well as the research's scope. Before putting a genuine prototype together, the appropriate software and hardware components had to be found. This study will guarantee that the project runs successfully and without problems.

3.2.2 Stage 2: Structure

In most cases, the structure is built depends on a variety of characteristics, such as making the system more portable and cost-effective. Aside from that, the components and materials had been thoroughly inspected so that in the event of damage, the damaged parts could be simply replaced. Furthermore, the hardware's construction will be studied, and it must be an environmentally friendly machine. The software that will be utilized is identified. This software was chosen for the project because of its compatibility.

3.2.3 Stage 3: Circuit Design and IoT Monitoring System

The strategy for designing circuits and selecting the appropriate monitoring system is identified and purposed at this step. The microcontroller has also been looked into in order to guarantee that it can be improved and perform better depending on the design. Following the design of the controller, software such as 'Proteus 8 Professional' and 'Arduino' is created. The simulation was made with Proteus 8 Professional and Arduino, and the system was linked to confirm it worked according to the concept and plan.

3.2.4 Stage 4: Implementation and Analysis

After the simulation has been completed, the analysis step is completed to record and assess the project. This is significant because the data gathered is recorded. Any problems are recognized and improvements are done based on the data. This analysis must be discussed and presented due to the design that was planned earlier in the project's life cycle to see if it completely captures the project's scope and objectives. As all of the analysis has been completed, the project is completed, and the system functions well with the Arduino, software, as well as all of the materials and components.

In the end, we can summarize that this project methodology begins with a literature review on a topic iot of air pollution monitoring systen according to the flowchart. From a variety sources like journal articles and conference papers, the data was acquired. A Gantt chart was made by following to ensure the project process is done perfectly on time and to prevent a frantic schedule.

Next, the circuit will be examined. It will proceed to the following procedure, which is result and data analysis, if it passes and can operate successfully. The process will continue to designing the circuit if the project fails as a result of a mistake.

The data will be analysed and gathered once the project is over in order to continue writing reports.

Following completion and finalisation, the report will then be submitted to the panels and supervisor for marking. The BDP 1 is finally done after the report and presentations are accomplished.

3.3 Experimental Setup

3.3.1 Hardware Development

Several pieces of hardware and components are used in this project to make it operate. It is usually based on required properties that result in the final product.

a) Arduino UNO R3 with ATmega328P

A board based on the ATmega328P microprocessor (datasheet). It features 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz quartz crystal. A USB port, a power jack, an ICSP header, and a reset button are all included. It comes with everything you'll need to get started with the microcontroller. To get started, simply connect it

to a computer via USB connection or power it with an AC-to-DC adapter or battery.

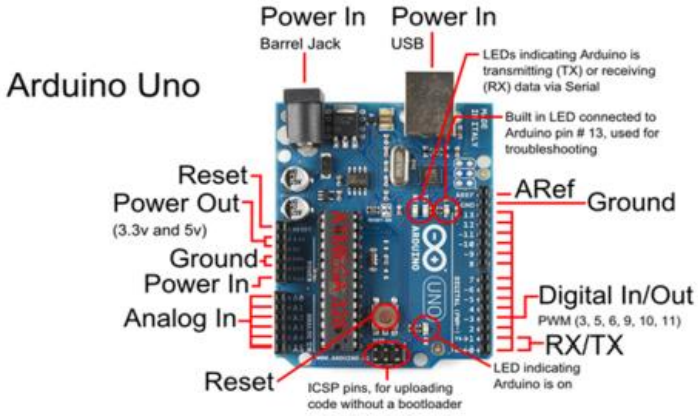


Figure 3.2 Arduino UNO

Microcontroller	ATmega328P
Input Voltage (recommended)	7 – 12 V
Analog Input pins	6
Operating Voltage	5 V
Digital I/O pins	14 (of which 6 provide PWM output)
DC current per I/O pin	20 mA
PWM Digital I/O pins	6
DC current for 3.3V pin	50 mA
Built – in LED	13
Clock speed	16 Hz
Flash Memory, SRAM, EEPROM	32 B, 2 kB, 1 kB

Table 3.1 Arduino UNO specifications

b) NodeMcu V2 ESP8266 Wi Fi Module

Based on the ESP-12 module, NodeMcu is an open source Internet of Things platform and the best microcontroller. The board is pre-programmed with LUA firmware, allowing you to quickly prototype your Internet of Things (IoT) solution. The Arduino IDE can also be used to programme it. This development kit features a breadboard-compatible CP2102 TTL to USB chip for programming and debugging in addition to being easily powered by a micro USB connector. After setting up the esp8266 boards, you may start programming your own Nodemcu board. The micro-USB cable should first be connected to the nodemcu before being used to plug in the laptop. Return to tools > board > esp8266 boards in the Arduino IDE and choose "nodemcu 1.0-12e module."

Figure 3.3 NodeMcu V2 ESP8266 Wi-Fi Module

c) MQ135 Gas Sensor

The Sensitive material employed in MQ135 gas device is SnO2. The physical phenomenon of this material is lower in clean air. The sensor conductivity will increase with the increasing concentration of target pollution gas. MQ135 will monitor completely different sorts of harmful gases comparable

to sulphide, ammonia gas, benzol series steam and CO2. The detection vary is 10-10,000 ppm with the voltage rate of concerning 5.0V±0.1V AC or DC.

Figure 3.4 MQ135 Gas Sensor

d) LED

A light-emitting diode (LED) produces light when current travels through it. Electrons recombine with electron holes in a semiconductor to produce energy in the form of photons. The amount of energy required for electrons to pass through the band gap of a semiconductor determines the colour of light (equivalent to the energy of photons).

Figure 3.5 LED

e) Trimmer Potentiometer

It is miniature packagesbthat build in board stand offs. It has multi-wire wiper to minimise contact resistance variation. For automatic nmachine,

rotor designed to adjust interface. It sealed in immersion cleaning and withstand harsh environments purpose.

Maximum resistance	10k Ohm
Mounting Type	Through hole
Power Rating	0.5W
Series	3362
Tolerance	±10%
Temperature Coefficient	±100ppm/°C

Table 3.2 P103 specifications

Figure 3.6 Trimmer Potentiometer

f) Buzzer

It emits a tone when it is coordinated with other sensors or when it is designed to do so for a specific purpose.

Figure 3.7 Buzzer

g) Resistor

In an electronic circuit, a resistor is an electrical component that controls or regulates the passage of electrical current.

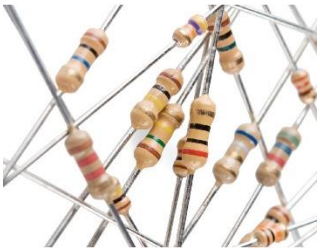


Figure 3.8 Resistor

h) Breadboard

It is a building block that's used to create electronic circuit prototypes.

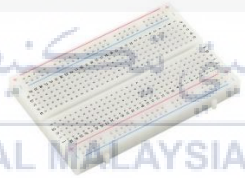


Figure 3.9 Breadboard

3.3.2 Software Development

One of the most significant roles to perform and achieve the desired objectives in this project is software development. There is three software that we utilised which is Proteus 8 Professional, Arduino and ThingSpeak.

a) Proteus Professional

Proteus 8 Professional is a programme that allows you to create schematics, PCB layouts, code, and even simulate schematics. Many of Proteus' components may be simulated. Simulating may be done in two ways: run the simulator or proceed frame by frame. It's also capable of simulating microcontrollers. You may even use switches, resistors, and LDRs to interact with the simulation in real time. Virtual voltmeters, ammeters, oscilloscopes, logic analyzers, and other instruments are available. We may also design our own PCBs or have Proteus do it for us.

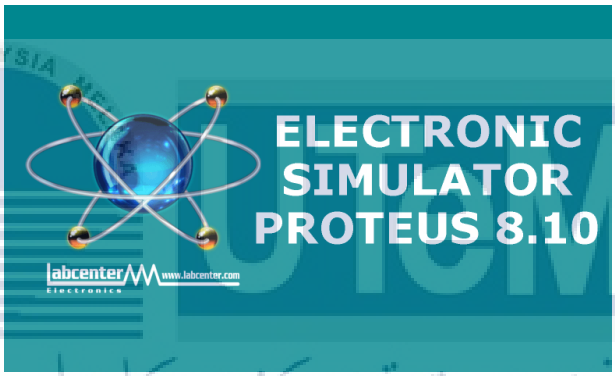


Figure 3.10 Proteus Software

b) Arduino Programming Language

Arduino is a free and open-source electronics platform. It is an easy-to-use platform that makes use of minimal hardware and software. Arduino boards can read inputs such as buttons and switches. a finger on a button, switch on an LED, and post anything to the internet. In this project, we create coding for the air pollution monitoring system. ESP8266, ThingSpeak and LiquidCrystal library had been used in this project's coding. ESP8266 also had be chosen for board tools and use 9600 baud rate in Serial Monitor.

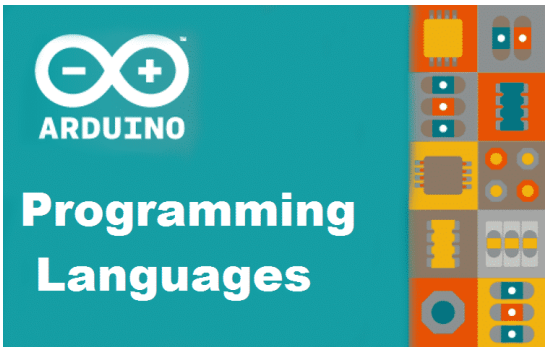


Figure 3.11 Arduino Software

c) ThingSpeak

ThingSpeak is a cloud-based IoT analytics tool that lets you gather, visualise, and analyse live data streams. ThingSpeak delivers real-time visualisations of data sent to ThingSpeak by your devices. For this project, the data reading had be shown and collected in ThingSpeak from the hardware through Wi-Fi. We must sign in into ThingSpeak account and create Channel ID to get API Key. After that, we put the API Key into coding Arduino IDE to connect the hardware and ThingSpeak for collecting data purpose. In ThingSpeak also the graph of data collection had be shown.

Figure 3.13 ThingSpeak Software

3.4 Project Costing

All pricing is determined by the product's quality to provide optimal performance while minimizing handling errors. To make the best decision, all costs are determined after conducting a poll and reviewing feedback from prior customers. When assembled, all components should provide the best performance possible.

NO	NAME	DESCRIPTION	QUANTITY	PRICE (RM)
1	Arduino Uno + USB	1 Unit = RM47.89	1	RM47.89
2	ESP8266 NodeMCU V2 + USB	1 Unit = RM24.60	1	RM24.60
3	MQ135 Sensor	1 Unit = RM6.90	1	RM6.90
4	16x2 LCD Display	1 UNIT = RM14.89	1	RM14.89
5	LED	10 Unit = RM1.20	3	RM3.60
6	Trimmer potentiometer	1 Unit = RM0.60	1	RM0.60
7	Resistor	10 Unit = RM0.99	1	RM0.99
8	Buzzer	1 Unit = RM0.99	1	RM0.99
9	Breadboard	1 Unit = RM3.90	1	RM3.90
10	Wire jumper (Male to Male)	40 Unit = RM8.00	1	RM8.00
11	Wire Jumper (Female to Male)	40 Unit = RM5.60	1	RM5.60
12	Wire Jumper (Female to Female)	40 Unit = RM8.70	1	RM8.70
				TOTAL = RM126.66

Table 3.3 Project Costing

3.5 Project Architecture

Because of their ability to send data across that IoT is a network that does not require human-to-human or human-to-computer interaction. Systems were chosen to monitor this project. Figure 3.13 shows a block diagram for using IoT to monitor the air pollution system. The block diagram shows how it will use the sensor as the main controller and the Arduino as the Wi-Fi module. The NodeMcu V2 ESP8266 component will serve as a communication link between the mobile device and the Arduino.

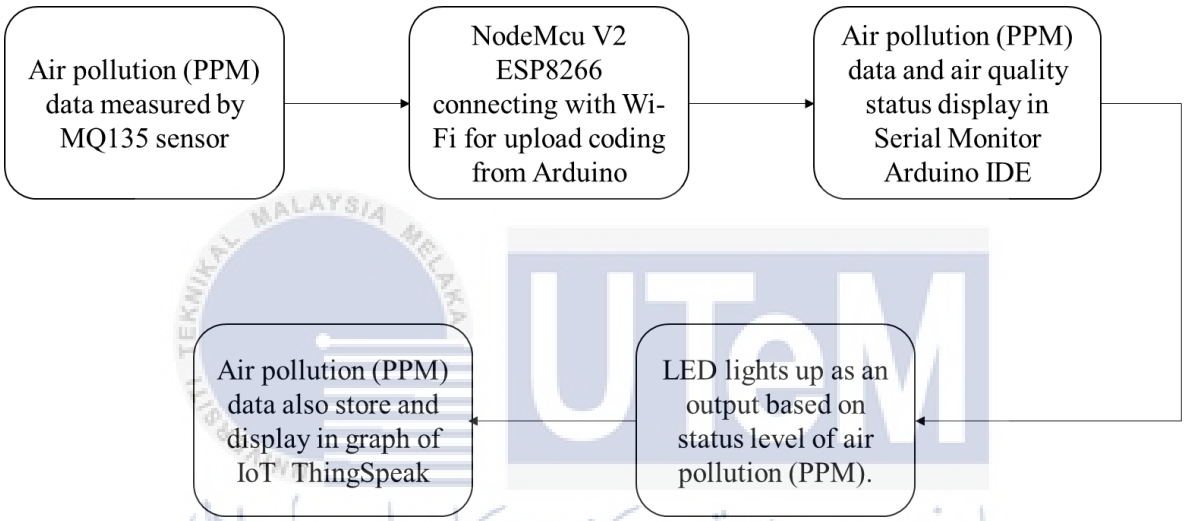


Figure 3.13 Block diagram of monitoring system

Wi-Fi connection to ESP8266 NodeMCU V2 is required to read the sensor and detect the obstruction. If it is not connected to the internet, it won't be able to detect it. When the sensor detects an impediment, it sends data to Arduino, and when Arduino receives it, it sends data to ThingSpeak. It will keep repeating at the sensor detector if no data is received.

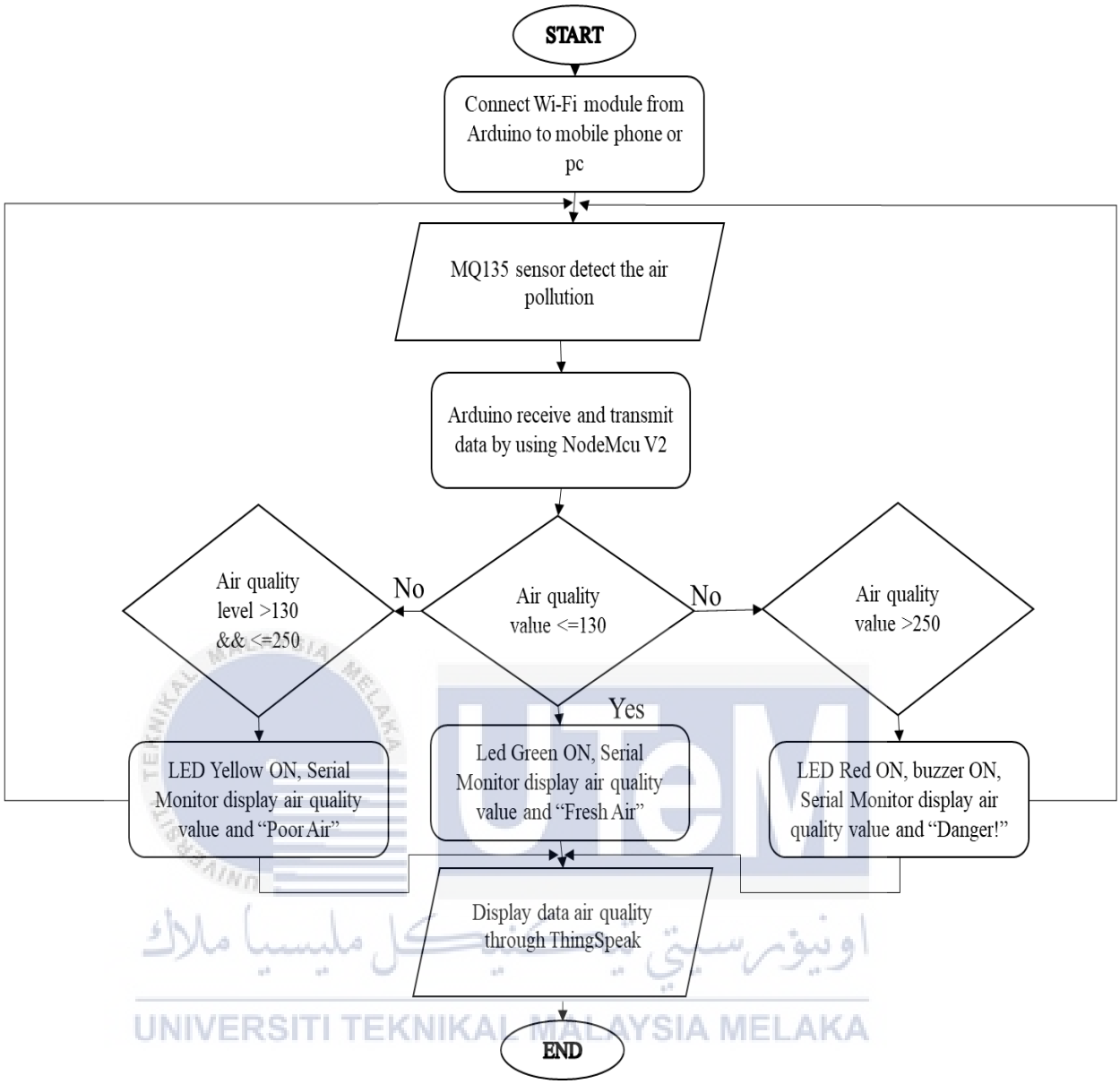


Figure 3.14 Flowchart of air pollution monitoring system of IoT

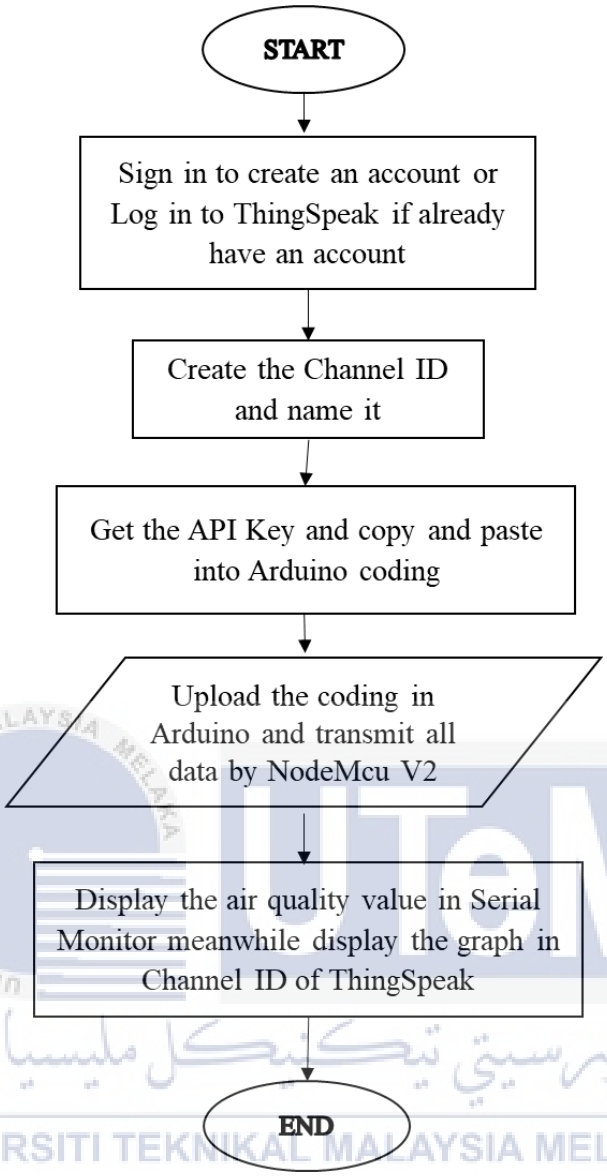


Figure 3.15 Flowchart of Develop A Website to Monitor Air Pollution

3.6 Project Design

3.6.1 Simulation Circuit Design of Air Pollution Monitoring System using IoT

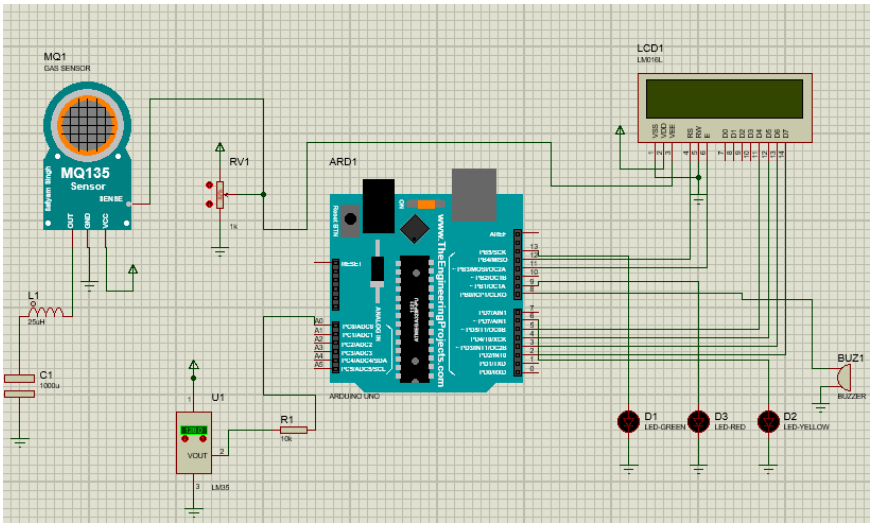


Figure 3.16 Circuit design air pollution monitoring system of IoT

3.6.2 Hardware Circuit Design of Air Pollution Monitoring System using IoT

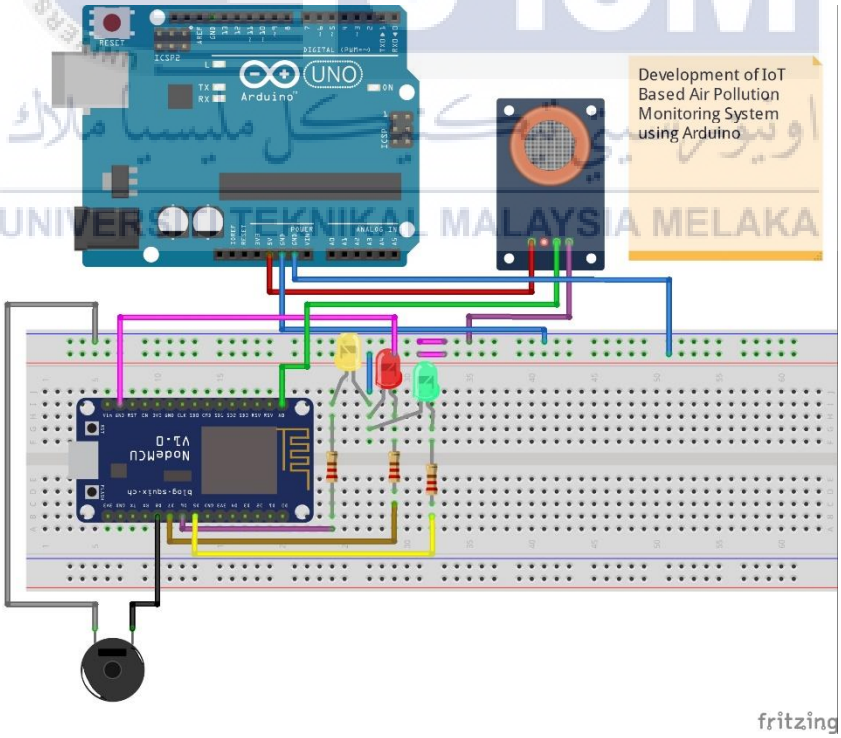


Figure 3.17 Hardware Design Air Pollution Monitoring System using IoT

3.7 The Mechanism of Project Construction and Testing

In this section, the project and testing will be discussed. Project testing is a crucial component of quality control. It is the process of making sure a project has met its requirements and functions as anticipated. Testing makes sure the project is suitable for the goal for which it was designed. The research and findings of this project through the work system and the function of its circuit design with the sensor relevant to their project. Results obtained after the implementation of the project jurisdiction for its functions shall include.

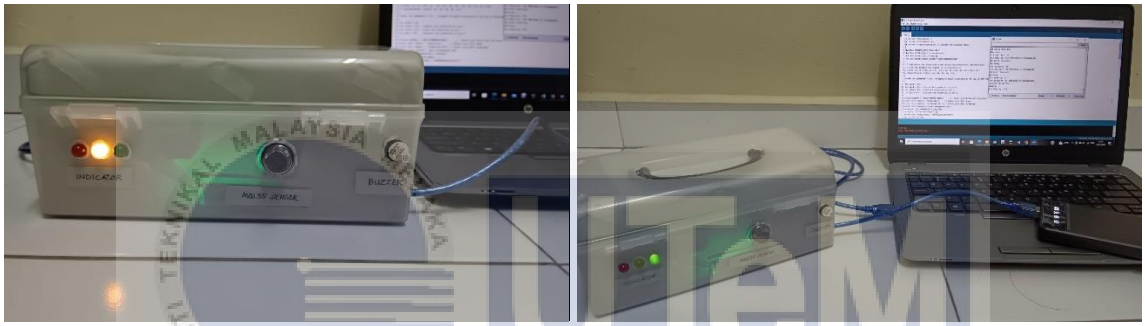


Figure 3.18 Final Design

From Figure 3.18 shows that in this project the ESP8266 NodeMcu V2 is a key component compile all other components. The coding for this project is designed by linking components with the sensor which is MQ135 Sensor. Node MCU V2 also linking with Buzzer and three LED which are green, yellow and red. All of this is to get the system working perfectly. At the beginning of the project test, MQ135 is used to detect air quality in PPM. The coding from Arduino IDE that connecting with NodeMCU V2 will be linked with serial Monitor which displays the air quality reading, either below 130 PPM “Fresh Air”or in between 130 PPM until 250 PPM “Poor Air” or above 250 PPM “Danger!”. It means if the air quality reading does not exceed 130 PPM, the air quality is in a healthy and safe condition but if the temperature 250 PPM, the air quality is likely to be in a sick and

strong unhealthy state. It is as a safety tool to detect the air quality of the surroundings whether it is safe or not for a place.

Next, the operation of the LED is use to indicate the system is running, it will light green when the air quality reading is below 130 PPM and will light red when the air quality reading exceeds 250 PPM. Thus, the function of the buzzer is as an alarm which is a sign if the air quality of the surroundings is above 250 PPM. With this, people around will be more sensitive if there are people around who are not healthy.

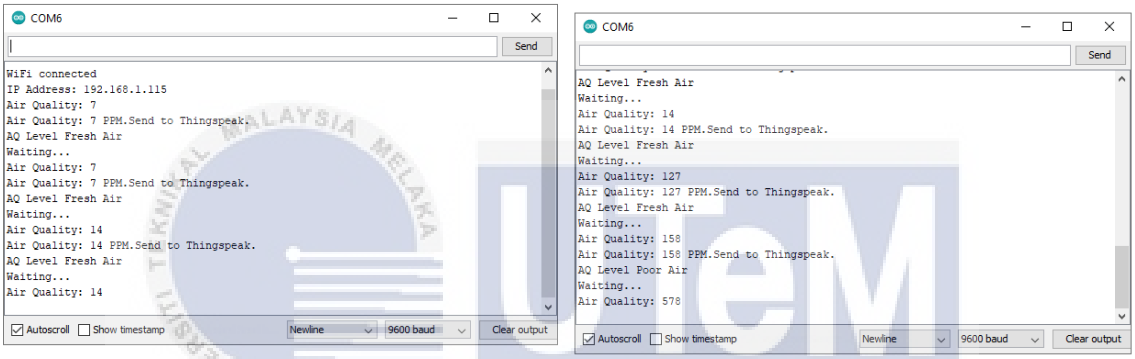


Figure 3.19 Serial Monitor from Arduino IDE

From Figure 3.19 shows that the air quality reading and status have been shown in Serial Monitor of Arduino IDE after Wi-Fi connected. In serial Monitor, IP Address of Wi-Fi also displayed. API Key of your ThingSpeak Channel ID was needed to connect with NodeMcu V2. The air quality status and reading also shows in ThingSpeak as a reference to the user to examine the air quality data and graph.

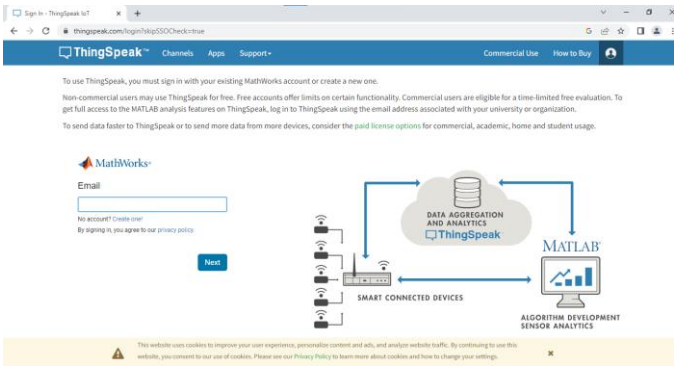


Figure 3.20 Sign in IoT ThingSpeak page

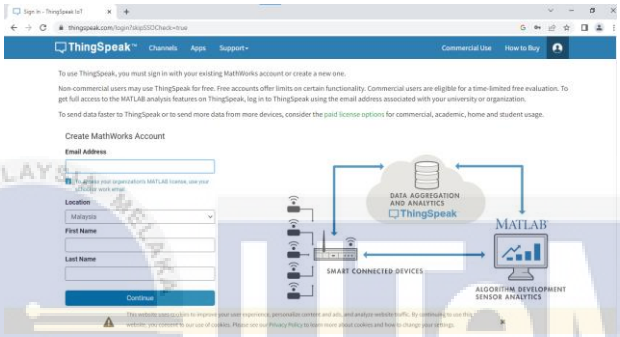


Figure 3.21 Informations that need to sign in IoT ThingSpeak

For part Internet of Things (IoT), we used ThingSpeak to monitor data air quality. Regarding Figure 3.20 and Figure 3.21, we signed in ThingSpeak to create an acount by using an email address.

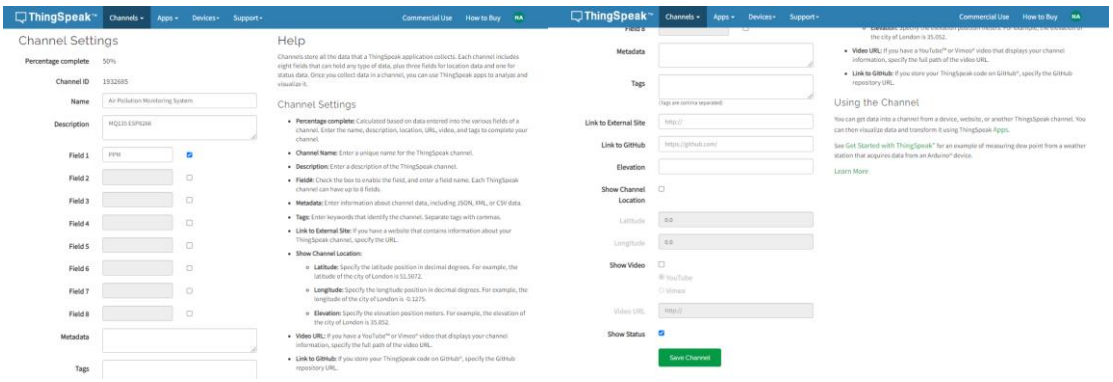


Figure 3.22 Channel Settings in IoT ThingSpeak

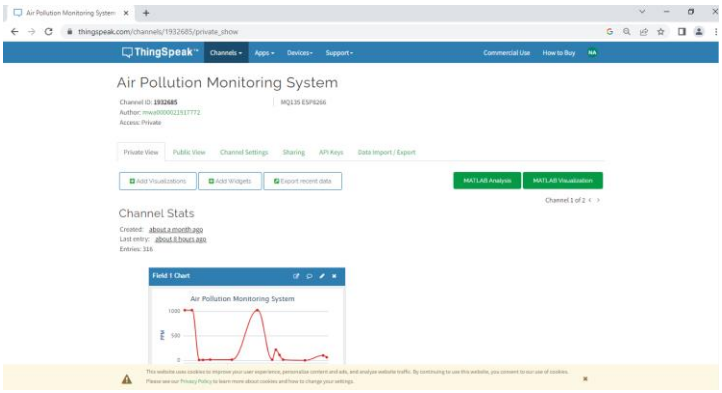


Figure 3.23 Air Pollution Monitoring System Channel page created

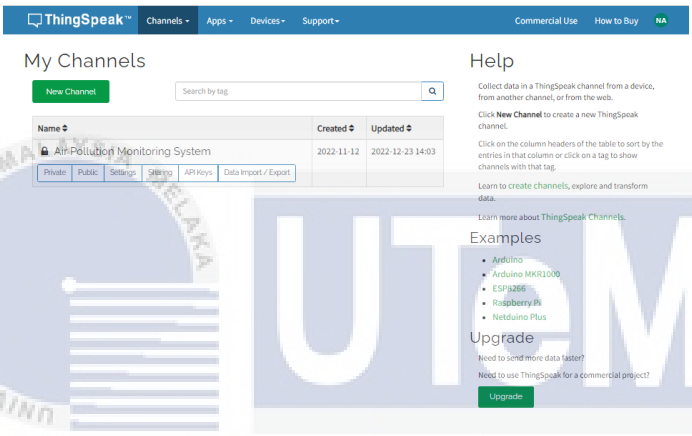


Figure 3.24 List of My Channels in ThingSpeak account

After that, we set all informations of the air pollution monitoring system like Figure 3.22. As an example, we insert the name and description of the project that we worked on it. We also insert the parameters that we observe in our project. Based on project that we worked on it, we observe the air quality in PPM so, we filled in the Field 1box as PPM. After key in all the informations, channel ID (1932685) of air pollution monitoring system created like Figure 3.23. For the additional information, many Channel ID can be create in one ThingSpeak account and it in keep under My Channels page.

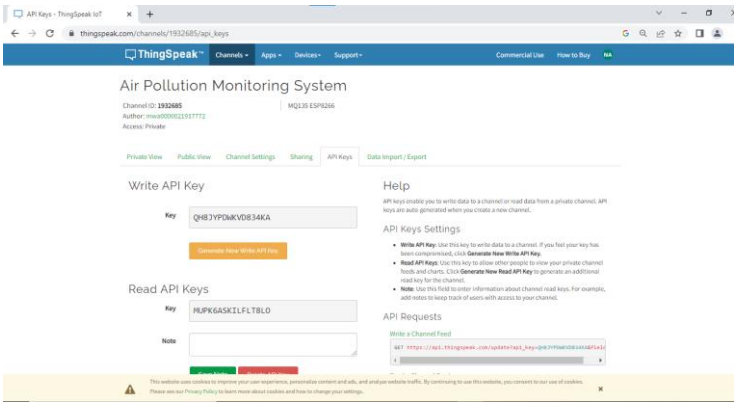


Figure 3.25 API Keys Page in IoT ThingSpeak

According to Figure 3.25, API Keys Page in my ThingSpeak Channel have been shown. As mentioned before this, API Key of ThingSpeak Channel ID was needed to connect with NodeMcu V2. Hence, Write API Key (QH8JYPDWKVD834KA) in Figure 3.25 had to copy and paste into Arduino coding. In addition, the Wi-Fi name and password also must be insert into the coding. The purpose for this action was to complete the project architecture that need IoT ThingSpeak to monitor the graph of air quality. The overview coding of IoT air pollution monitoring system had been shown in Figure 3.26 below.

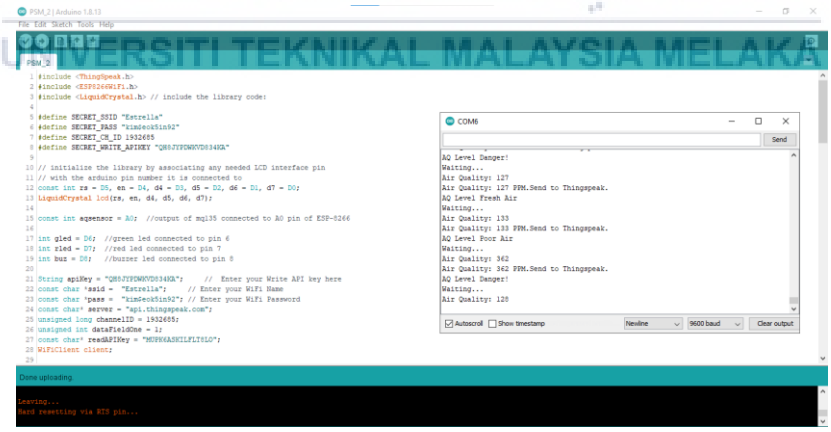


Figure 3.26 The coding of the project

After that, ThingSpeak as Internet of Things (IoT) tools used to monitor the data for community to use. Hence, based on Figure 3.27, ThingView is one of the apps or tools that

community can use for checking air pollution data. ThigView can be installed by Google Play Store for Android user.

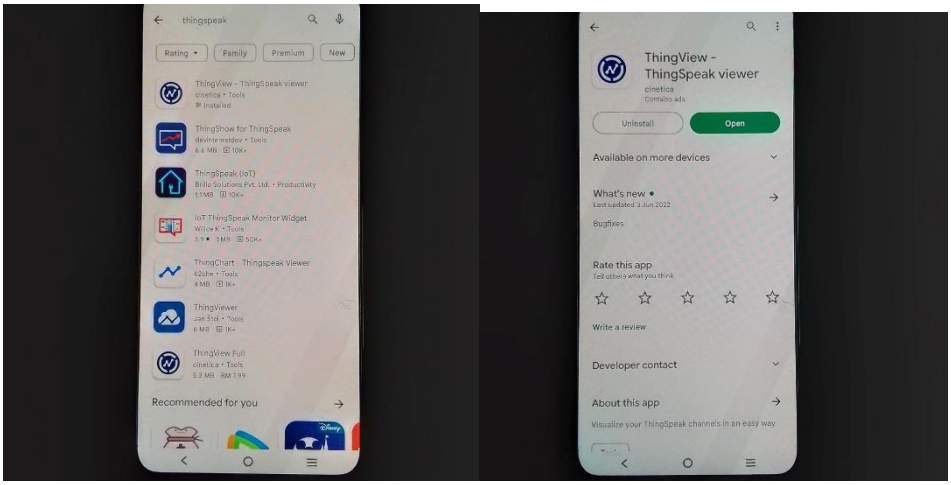


Figure 3.27 ThingView for Android user

After installed, the main page of ThingView have been shown in Figure3.28. We can add channel to ThingView by refer to Figure3.28. We can add channels whether the channels is in private or public status in ThingSpeak website.

Figure 3.28 The main page of ThingView

Then, channel ID added to ThingView to open the channel for community to check the data. In addition, Channel ID can be shared to people even our own ThingSpeak Channel is in private. According to Figure 3.29, Channel ID added to ThingView for public channel to view data and graph.

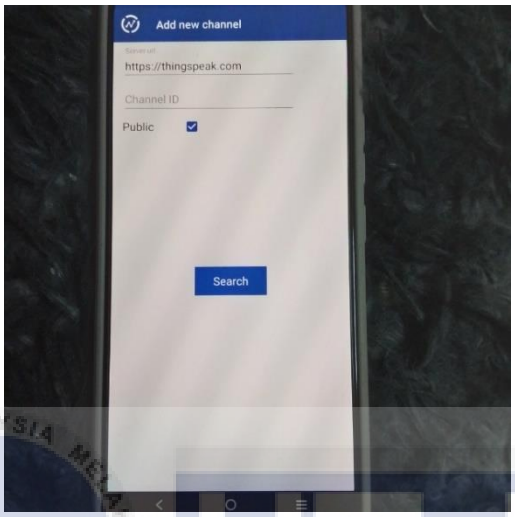


Figure 3.29 ThingView page to add the Channel ID

However, Channel ID which is in private channel should be setting like Figure 3.30. Channel ID and API Key required for open the private channel in ThingView. Then, the channel added in the main page of ThingView like Figure3.31 which is in green box.

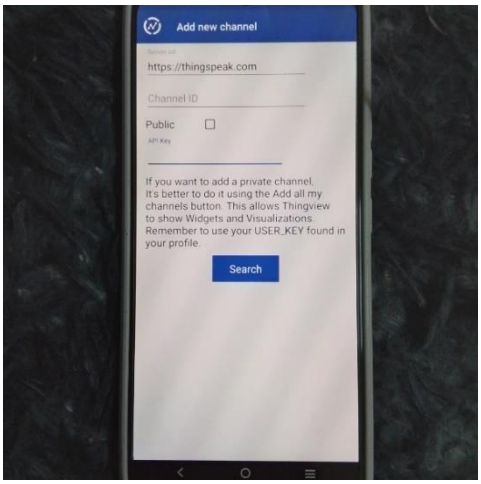


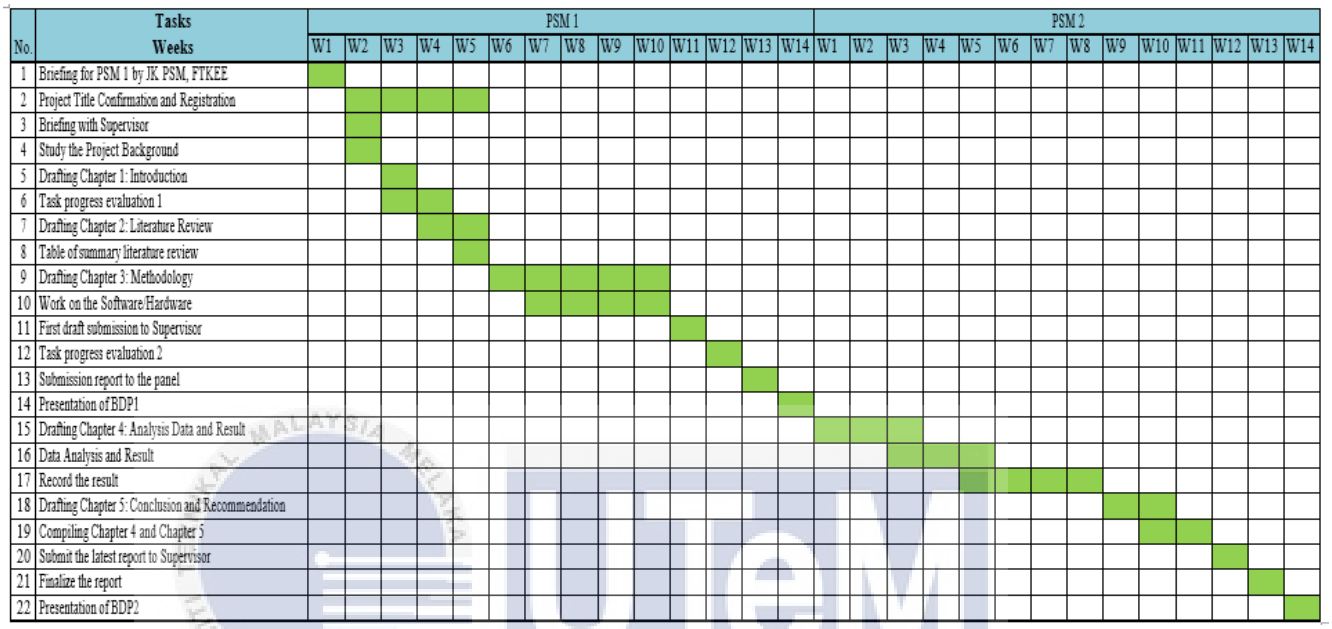
Figure 3.30 Setting private channel in ThingView

Figure3.31 Air Pollution Monitoring System Channel in ThingView

This project is done to help solve the problem of people to detect the air quality in their surroundings. It is easy to detect air quality if there are hazardous air pollutants, it gives us more precautions when we in an unhealthy are or place.

3.8 Gantt Chart

The Gantt Chart showed the flow of the project schedule in terms of date and task, which will keep this project on track. Time management will be more efficient and more conducive when it is planned from the beginning.



No.	Tasks / Weeks	PSM 1														PSM 2													
		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1	Briefing for PSM 1 by JK PSM, FTKEE																												
2	Project Title Confirmation and Registration																												
3	Briefing with Supervisor																												
4	Study the Project Background																												
5	Drafting Chapter 1: Introduction																												
6	Task progress evaluation 1																												
7	Drafting Chapter 2: Literature Review																												
8	Table of summary literature review																												
9	Drafting Chapter 3: Methodology																												
10	Work on the Software/Hardware																												
11	First draft submission to Supervisor																												
12	Task progress evaluation 2																												
13	Submission report to the panel																												
14	Presentation of BDP1																												
15	Drafting Chapter 4: Analysis Data and Result																												
16	Data Analysis and Result																												
17	Record the result																												
18	Drafting Chapter 5: Conclusion and Recommendation																												
19	Compiling Chapter 4 and Chapter 5																												
20	Submit the latest report to Supervisor																												
21	Finalize the report																												
22	Presentation of BDP2																												

3.9 Summary

From this chapter we can summarize that the proposed process used to establish a new project. The project used the software simulation and the hardware testing for the purpose of successful complete the framework This chapter describes the flow of the project also the block diagram and the list of components, specification and function.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter will explain the progress of the project, particularly in circuits. This chapter shows product testing and analysis, such as the output outcome and the product's influence using the variance in input distance, and an analysis will be made to see if the final project is capable in a new age. There are many advances towards producing the expected product.

4.2 Results and Analysis

4.2.1 Software Analysis

Figure 4.1 shows the simulation in Proteus software for the initial condition for air pollution monitoring system before simulated. Due to the zero of supply power, all the lights will be off.

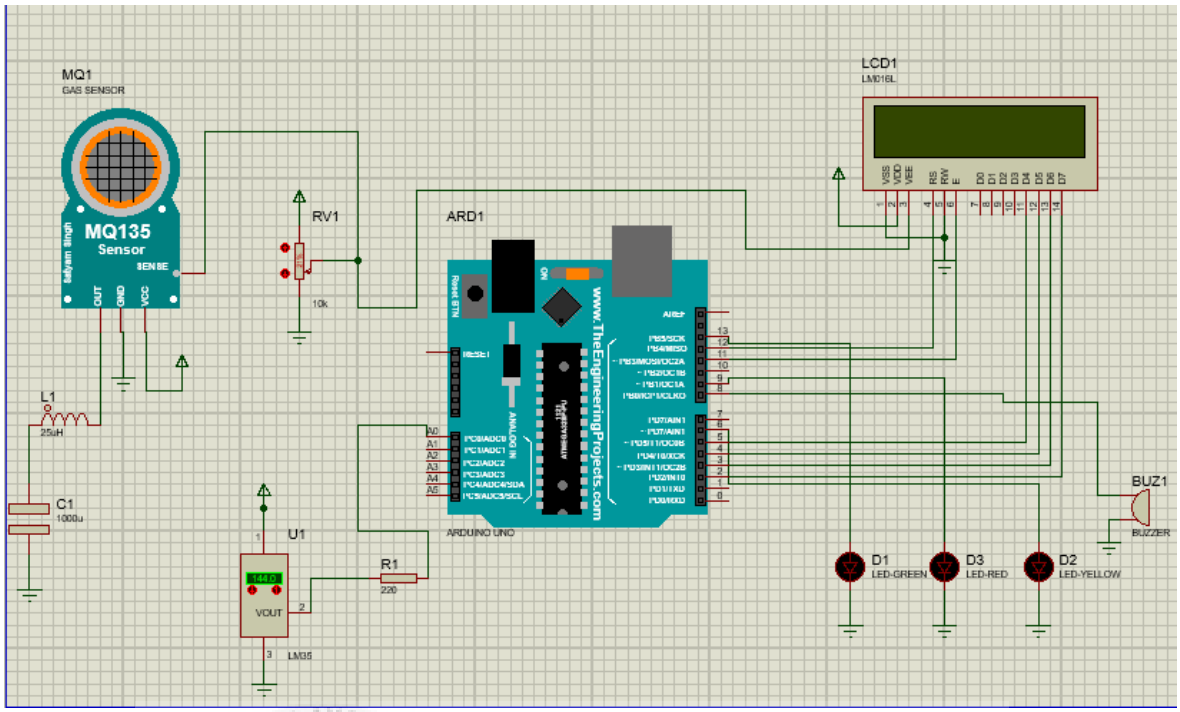


Figure 4.1 The incoming voltage and output voltage

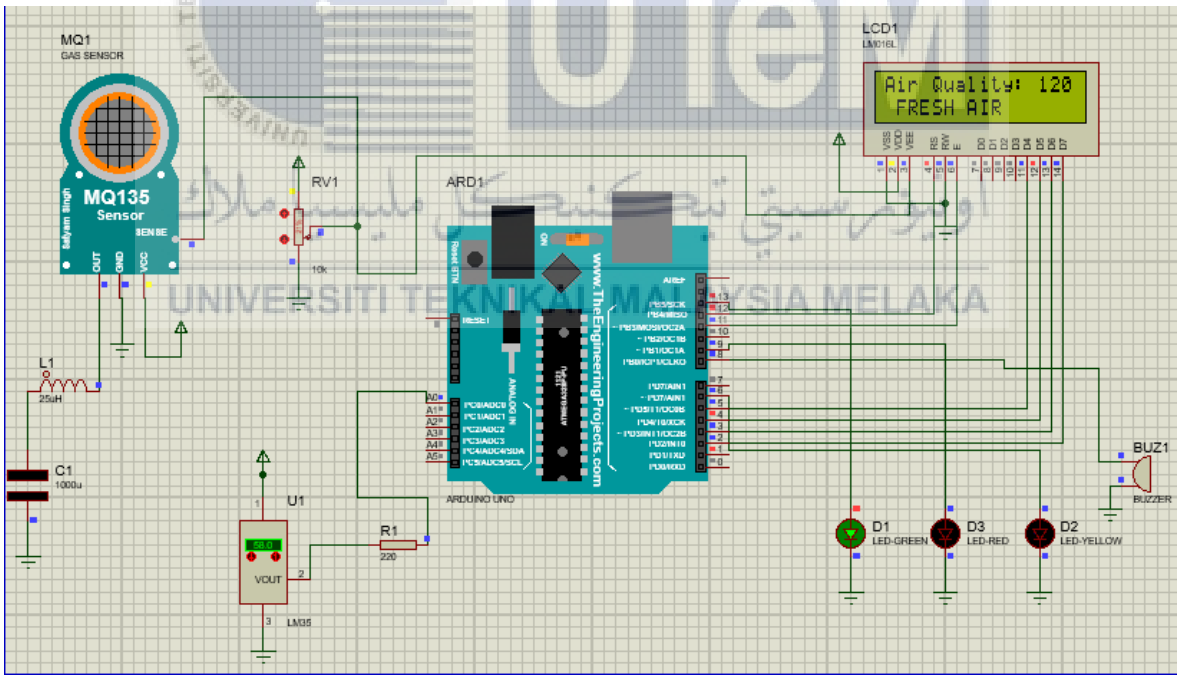


Figure 4.2 The result of circuit simulation in "Fresh Air"

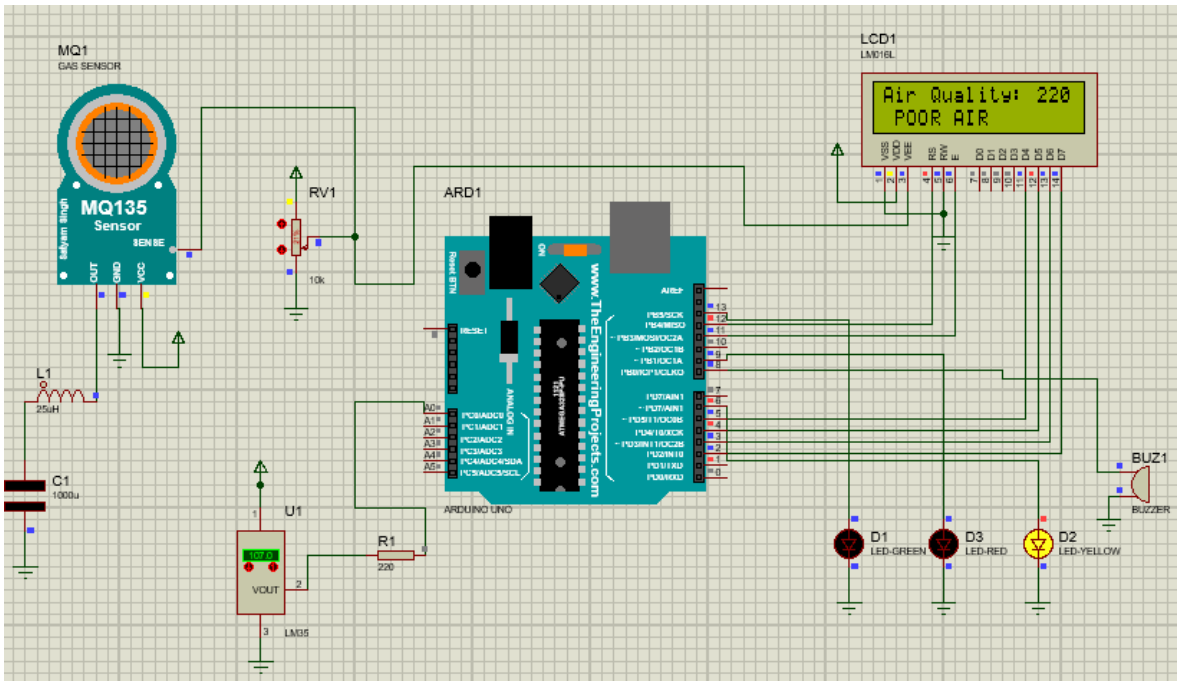


Figure 4.3 The result of circuit simulation in "Poor Air"

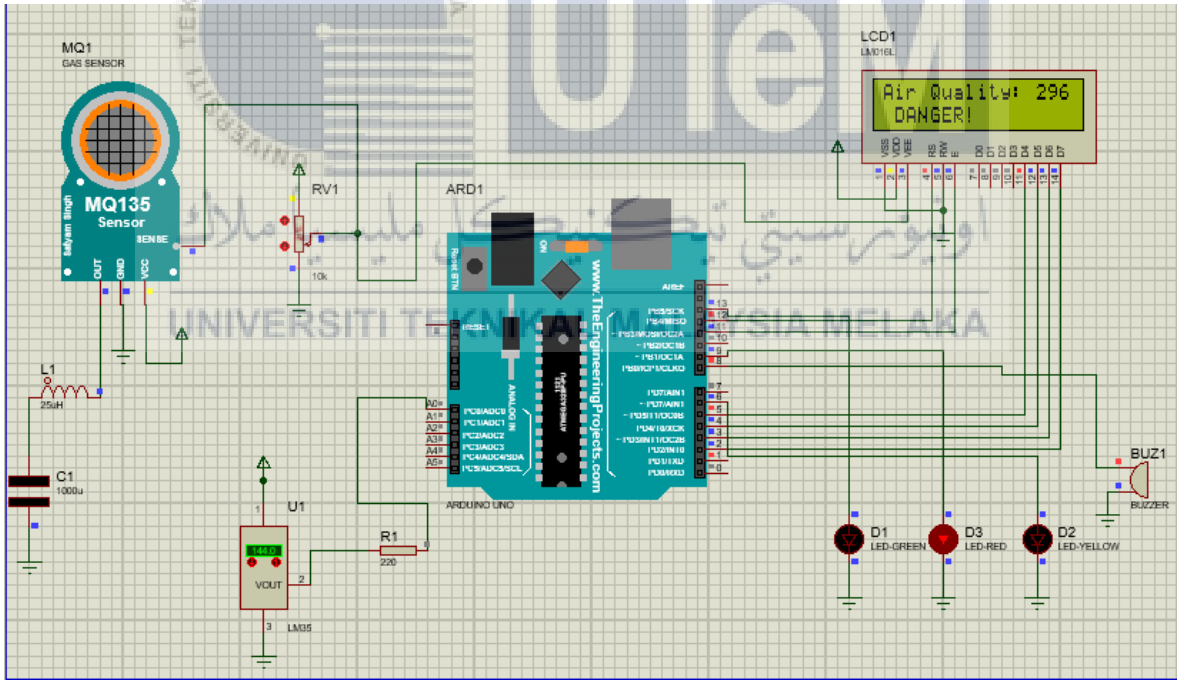


Figure 4.4 The result of circuit simulation in "Danger!"

Figure 4.2 shows the condition of the circuit after it has been simulated. The LCD was displayed the value air quality in PPM and status of the air quality within Fresh Air, Poor Air and Danger. When temperature value increased, the total air quality value also

increased. At the same time, green led lights up when the air quality status diplayed “Fresh Air”, yellow led lights up if the air quality status displayed “Poor Air” meanwhile red led lights up when the air quality status displayed “Danger!”. When the air quality reached to the Danger level, buzzer ON. The resistor needs to be connected to avoid any over current or over voltage from its resistive to make the component safe.

4.2.2 Hardware Analysis

Objective 1: Use ThingSpeak for monitor air quality

Hardware analysis encompasses electronic design and serves to reduce project risk while increasing confidence in the upcoming hardware build. For the hardware analysis part, there is four parameters or area analyzed the air quality (PPM) for a house such as bedroom, living room, garage parking and backyard. All parameters were recorded and the results are shown in the table and graph.

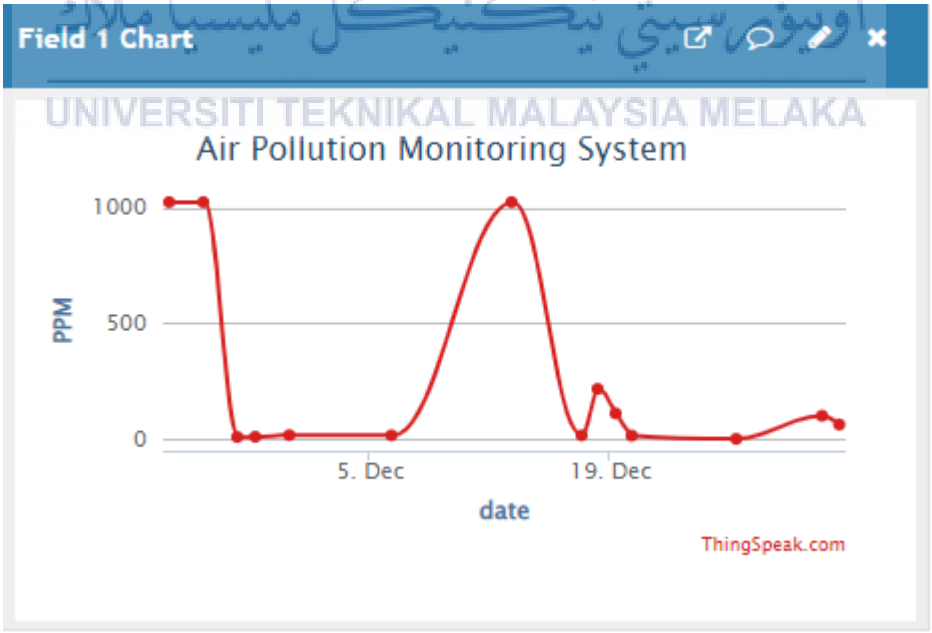


Figure 4.5 The graph data collection in ThingSpeak

According to Figure 4.5, we use ThingSpeak to monitor air quality and maintain it under the control before it become to worse condition. All the data area that analyzed has been put in one graph.

Objective 2: To monitor level of air pollution using collected data

After connecting with Wi-Fi, all the data collected and have been stored and shown in ThingSpeak. The collected data have been measured for eight days in different area which are bedroom, living room, garage parking and backyard. The data started to be measure during afternoon which the duration is around 30 minutes for each area.

1. Bedroom Area

Date	Air Quality [PPM]					
	P1	P2	P3	P4	P5	Avg
19-Dec-22	110	111	97	86	77	96
20-Dec-22	97	81	100	98	88	93
21-Dec-22	78	96	123	84	115	99
26-Dec-22	100	110	104	127	102	109
31-Dec-22	106	100	96	72	69	89
01-Jan-23	102	99	133	120	130	117
02-Jan-23	97	105	87	111	99	100
03-Jan-23	112	100	102	78	97	98

Table 4.1 Air Quality (PPM) data in Bedroom

Displays the analysis results of air quality in a house. All the readings have been taken five times and all the readings have been averaged. From the Table 4.1, the graph will be plotted.

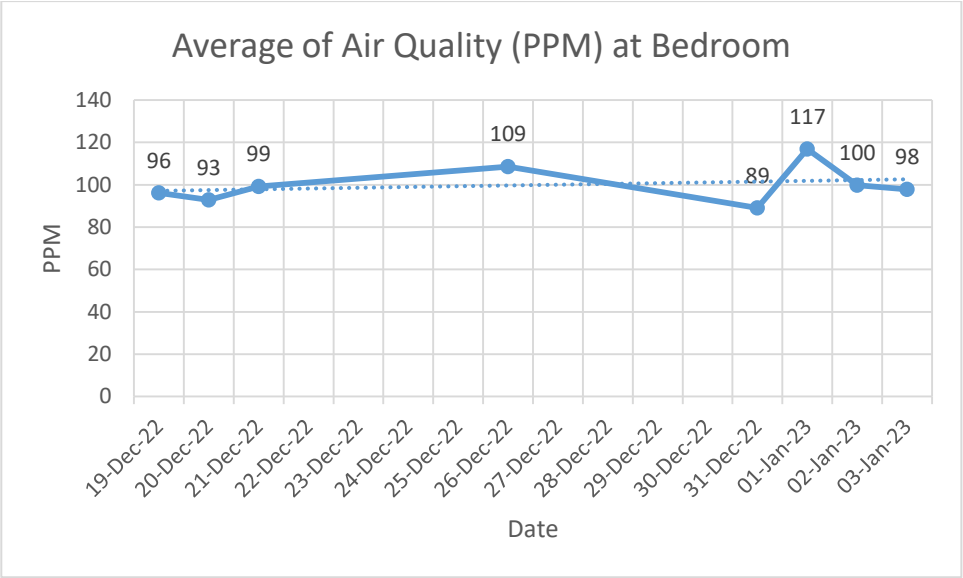


Figure 4.6 The average of air quality (PPM) data in Bedroom

According to Figure 4.6, the air quality data value is the greatest on 1st January 2023 and the air quality value is the lowest on 31st December 2022. It is because high temperature and hot weather during the sunny day and there was smoke in the house surroundings. In addition, the location of this bedroom is on the second floor which is upper of kitchen area. So, the smoke cooking from the kitchen can easily come and detect into the bedroom area. The problem solving for this issue is the room ventilation system in the house have to be good so the smoke cannot be trapped in the house and always open the windows to decrease the air quality index. Meanwhile, low temperature and cold weather happened because of rainy that happened on that day. Based on Table 4.1, we can conclude that overall data that have been measured are normal or fresh air because it was not exceed 130 PPM. Hence, it was safe for people to live in that area.

2. Living Room Area

Date	Air Quality [PPM]					
	P1	P2	P3	P4	P5	Avg
19-Dec-22	100	97	88	77	68	86
20-Dec-22	77	81	96	81	76	82
21-Dec-22	68	84	110	106	117	97
26-Dec-22	98	70	67	87	135	91
31-Dec-22	106	100	96	72	69	89
01-Jan-23	100	94	124	117	133	114
02-Jan-23	102	100	94	101	76	95
03-Jan-23	106	97	110	68	99	96

Table 4.2 Air Quality (PPM) data in Living Room

Displays the analysis results of air quality in a house. All the readings have been taken five times and all the readings have been averaged. From the Table 4.2, the graph will be plotted.

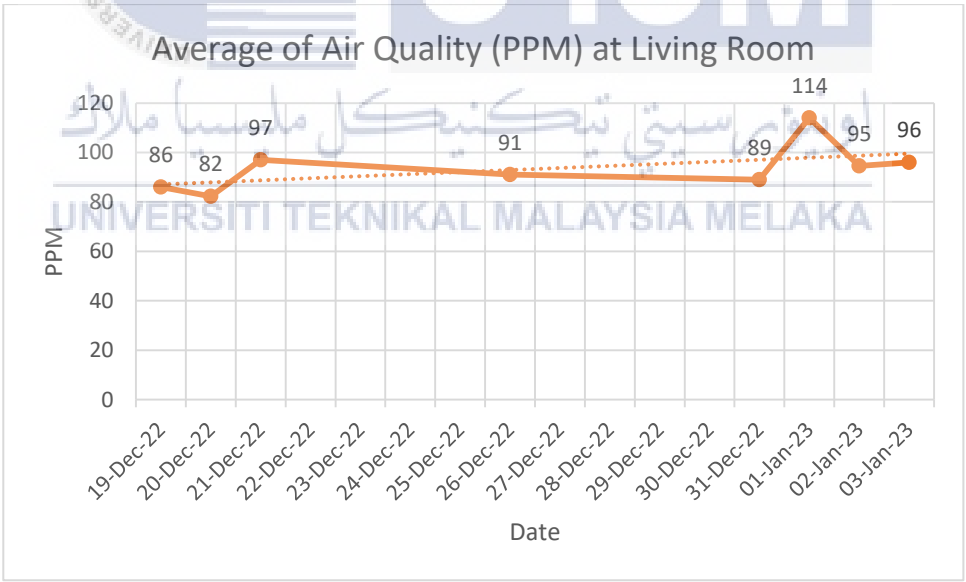


Figure 4.7 The average of air quality (PPM) data in Living Room

According to Figure 4.7, the air quality data value is the greatest on 1st January 2023 and the air quality value is the lowest on 20th December 2022. It is because high temperature

and hot weather during the sunny day and there was smoke in the house surroundings. In addition, the location of the living room is really nearby with dining and kitchen area. So, the smoke from cooking in the kitchen can easily detect into the living room area. The problem solving for this issue is the room ventilation system in the house have to be good so the smoke cannot be trapped in the house and always open the windows to decrease the air quality index. Based on Table 4.2, we can conclude that overall data that have been measured are normal or fresh air because it was not above 130 PPM. Hence, there are warm temperature and good humidity for people in the house to live.

3. Garage Parking Area

Date	Air Quality [PPM]					
	P1	P2	P3	P4	P5	Avg
19-Dec-22	102	112	88	74	85	92
20-Dec-22	77	61	124	145	153	112
21-Dec-22	50	79	118	175	127	110
26-Dec-22	60	70	142	127	135	107
31-Dec-22	56	50	61	193	205	113
01-Jan-23	106	96	88	105	113	102
02-Jan-23	69	73	144	135	170	118
03-Jan-23	100	109	94	114	104	105

Table 4.3 Air Quality (PPM) data at Garage Parking

Displays the analysis results of air quality in a house. All the readings have been taken five times and all the readings have been averaged. From the Table 4.3, the graph will be plotted.

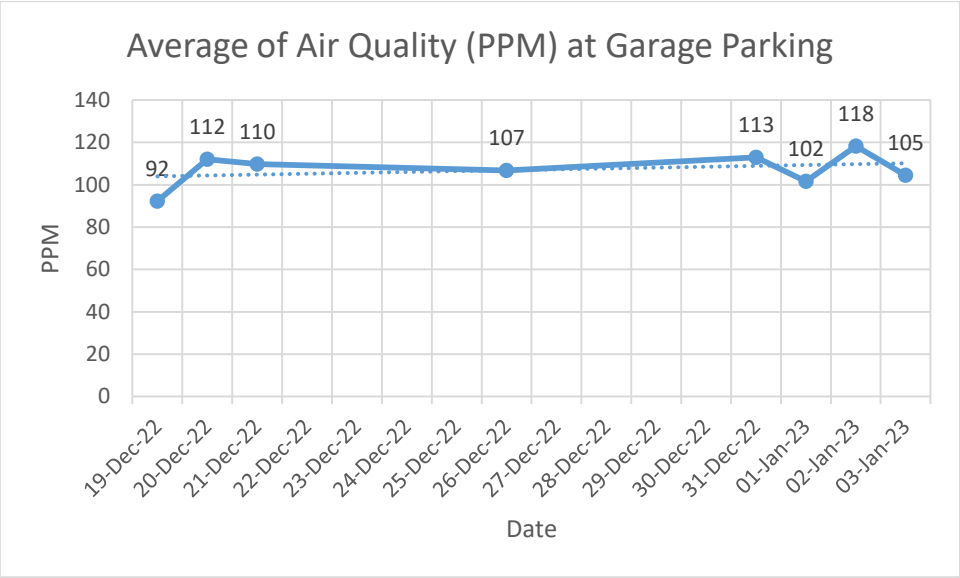


Figure 4.8 The average of air quality (PPM) data at Garage Parking

According to Figure 4.8, the air quality data value is the greatest on 2nd January 2023 and the air quality value is the lowest on 19th December 2022. It is because high temperature and hot weather during the sunny day on 2nd January 2023 and there are a few of cars and motorcycle at the house are used during that day which causes the air pollution data increased. Meanwhile, there are a rubbish truck stopped by in front of the house during the day of air quality measured. So, the smoke from the truck detected by the sensor. But, we can conclude that overall data based on Table 4.3 are normal or fresh air because it was under 130 PPM. Hence, there are warm temperature and good humidity for people around the house to live.

4. Backyard Area

Date	Air Quality [PPM]					
	P1	P2	P3	P4	P5	Avg
19-Dec-22	65	58	69	75	77	69
20-Dec-22	79	73	112	99	75	88
21-Dec-22	80	77	66	70	68	72
26-Dec-22	77	89	92	90	93	88
31-Dec-22	58	60	66	72	81	67
01-Jan-23	81	85	78	115	104	93
02-Jan-23	67	60	74	82	79	72
03-Jan-23	80	87	88	101	97	91

Table 4.4 Air Quality Data (PPM) at Backyard

Displays the analysis results of air quality in a house. All the readings have been taken five times and all the readings have been averaged. From the Table 4.4, the graph will be plotted.

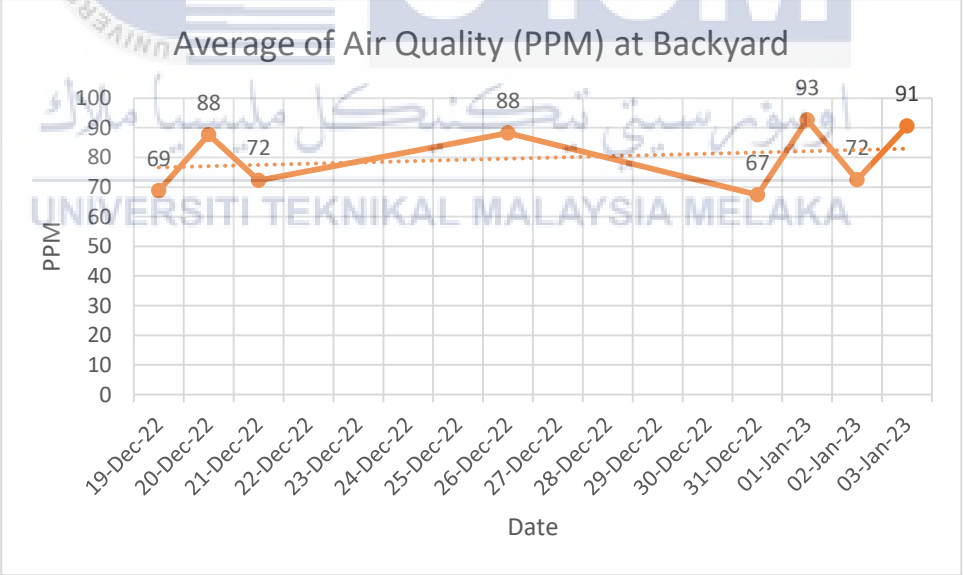


Figure 4.9 The average of air quality (PPM) data at Garage Parking

According to Figure 4.9, the air quality data value is the greatest on 1st January 2023 and the air quality value is the lowest on 31st December 2022. Because the temperature on

that day was very hot. But, regarding to Table 4.4, the overall data shown it was normal condition and safe to people to stay in that area. Because thare was no vehicles like cars and motorcycles were parking or passingby at the backyard.

Objective 3: To develop website to alert community

There are a few of platforms or apps can detect air quality to community be aware regarding air pollution. In Figure 4.10, ThingView as an example can be installed in smartphone or personal computer to detect air quality. The user just only key in the Channel ID of ThingSpeak to know the status of air pollution in a certain area. The benefit by using this application is community easily to check the status of air quality by showing the data graph which have been shared in a website.

Figure 4.10 ThingView in Google Play Store

Firstly, we installed the ThingView through Google Play Store for Android users like in Figure 4.10. After installed, insert the ThingSpeak Channel ID in ThingView to view the

channel which have been created in ThingSpeak website. Graph of air pollution monitoring system channel have been shown in Figure 4.11.

Figure 4.11 The graph of air pollution monitoring system

Lastly, air quality data area that have been chosen can be monitor by a user to check and control the air pollution. Furthermore, it is use as a precaution to community for not doing any activities that can cause air pollution.

4.3 Summary

First, ThingSpeak web was chosen to monitor air quality and maintain it in the level of healthy air. All the data area which are bedroom, living room, garage parking and backyard that analyzed has shown in a graph.

Next, all the data collected and have been stored and shown in ThingSpeak. The collected data have been measured and analyzed for eight days in different areas which are bedroom, living room, garage parking and backyard are achieved. Mostly, air pollution has normal condition achieved based on the overall average of four areas data in the table and

graph. This gives the best output for indoor air quality and the average status level of air quality for each area is “Fresh Air”.

Finally, ThingView platform or app can detect air quality to community be aware regarding air pollution. The graph of air quality for four areas from ThingSpeak achieved to display. From the graph results in ThingView, community can take it as a precaution to maintain the air quality. The very good indoor air quality can affect to someone’s health, comfort and ability to work. Inconvenience, illness, and reduced productivity at work are all consequences of poor indoor air quality. Very good air quality protects building inhabitants' health and enhances their comfort and well-being.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter will discuss the total completion of the "The Development of IoT Based Air Pollution Monitoring System using Arduino" projects. This chapter would clarify various recommendations and prospective work that might be used to further the project's development.

5.1 Conclusion

In conclusion, all of the project's theories, including those relating to related products and theories, the process of product design and development, and the crucial component or components utilised for electrical appliances in air pollution monitoring systems. After being accustomed with all the facts and data, the project can progress on.

Next, the proposed procedure for beginning a new system project is presented in Chapter 3. To achieve the project's objectives, each enhancement in this chapter must be done well. This chapter goes into great detail about each hardware and software stage of the system.

A flowchart and a block diagram are also used to illustrate the step process and show how the project system functions. The hardware and software used for this project were explained in great detail in this chapter. In addition, the setup of the entire project is described in this chapter, and all the parameters are monitored using tools, such as ThingSpeak for air pollution readings. The construction and testing hardware process was

successful like indicator green led lights up when the air quality readings is normal, serial monitor displayed the status air pollution and also readings detected through ThingSpeak.

The discussion of the analysis from the project setup based on examples from Chapter 3 is the next topic for Chapter 4. As an example, based on the overall average data for four areas in the table and graph is in normal condition or “Fresh Air” which is the air quality value is less than 250 PPM for air quality level. This gives the best output for air quality. The normal status is ideal in this situation.

Then, the data displayed through graph in ThingSpeak. It proved that the air pollution can be monitor through ThingSpeak and maintain it under the control before it become to worse condition. It is also proved include the ThingView app can be used by community to check the air pollution data and status whether it is normal air, poor air and danger.

Last but not least, the creation of IoT indoor air pollution monitoring systems is now becoming popular to create awareness among people in the globe today, especially for those in rural regions, the conclusion is that with the rapid advancement of science and technology. The goal of developing the system to provide desirable and accurate outputs is thus successfully achieved by the presented methodology.

5.2 Future Works

For future improvements, accuracy of the air pollution monitoring estimation results could be enhanced as follows:

i) State the GPS for detect the location of air pollution.

ii) Provide tracking system for detect someone that you know whether he or she at the hazard location or not.

iii) Provide notifications update about air pollution location to alert community like GSM.

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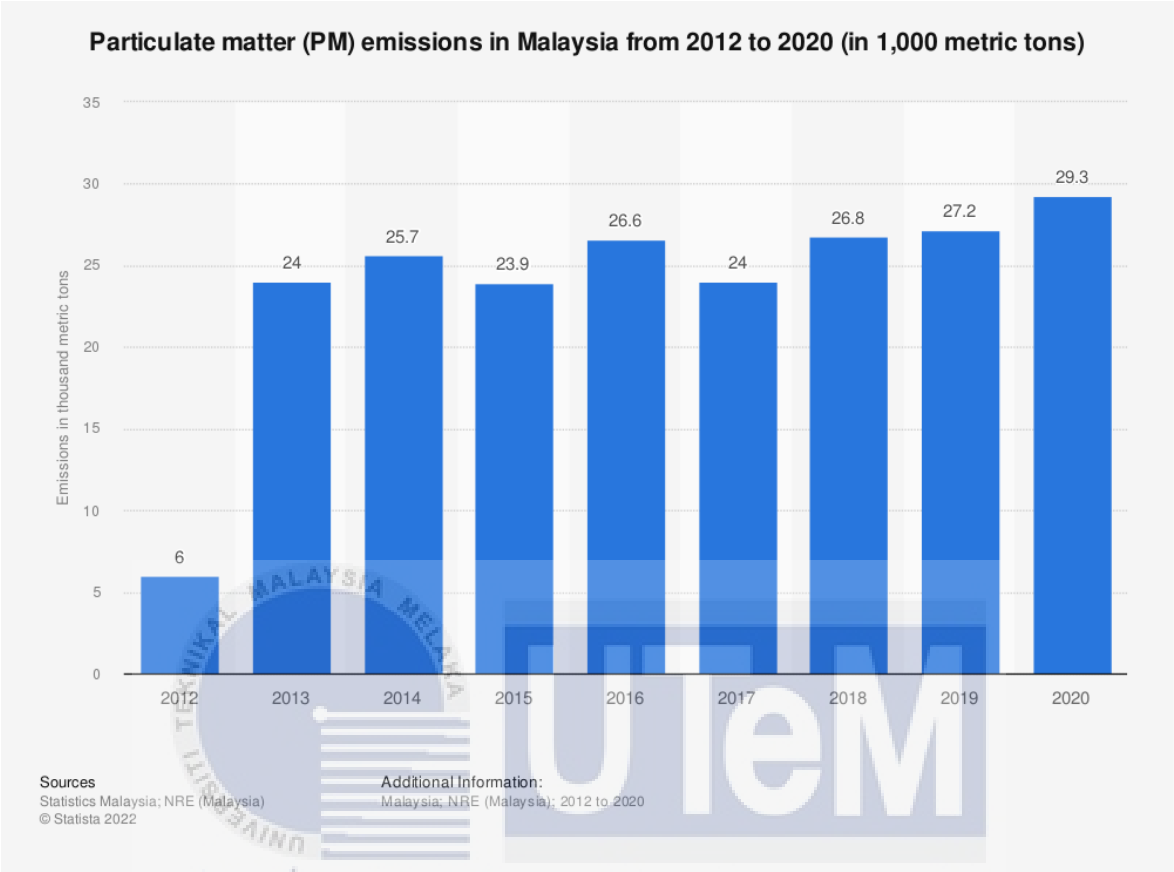
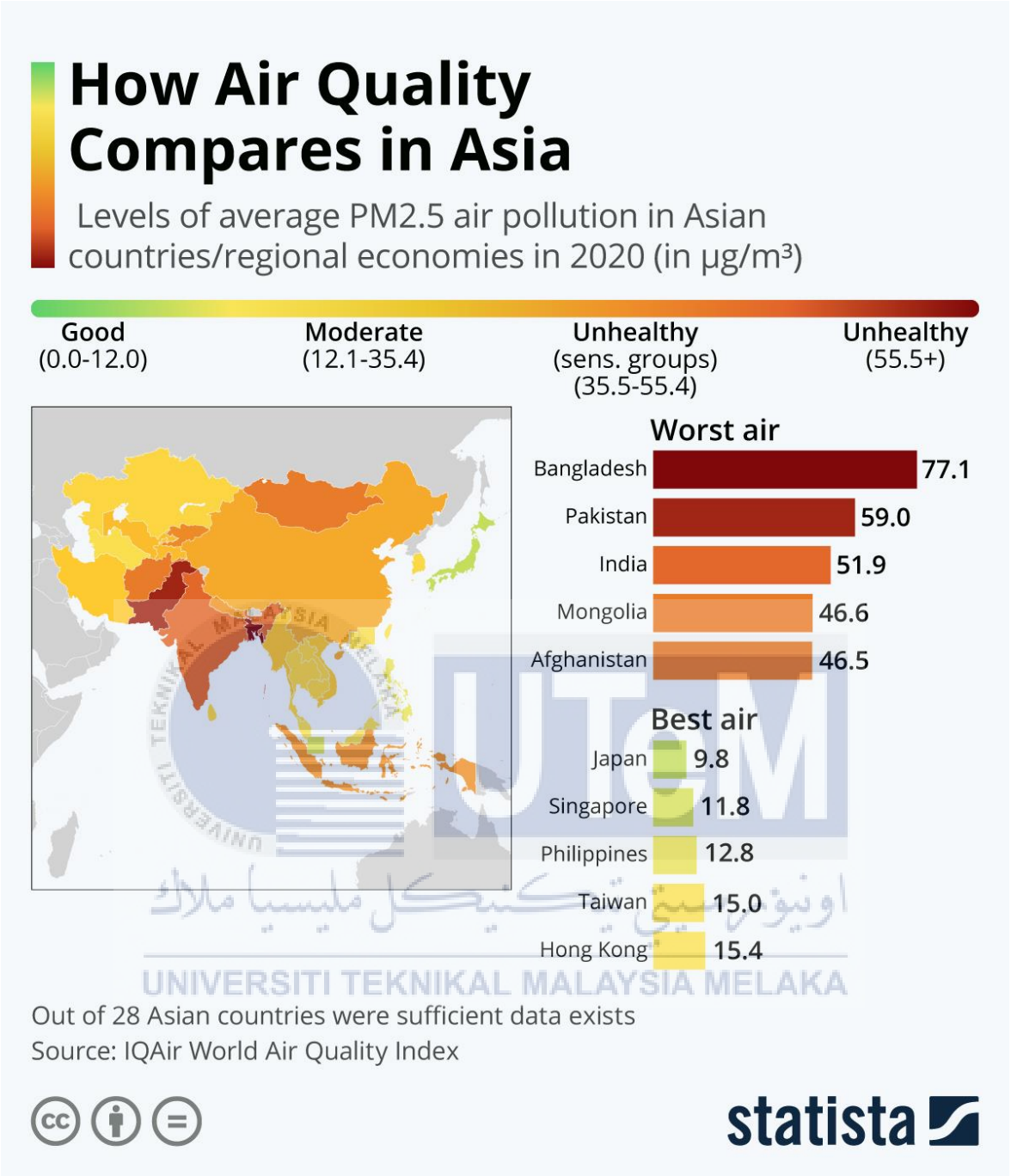
APPENDICES



Appendix A: Particulate matter (PM) emissions in Malaysia (2012-2020)



Appendix B: Comparison of air quality levels in Asia