FACULTY OF ELECTRICAL ENGINEERING

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DEVELOPMENT OF INTELLIGENCE AUTOMATED AIR VENTILATION SYSTEM USING ARDUINO

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I hereby declare that I have read this fully report entitled "Development of Intelligence Automated Air Ventilation System Using Arduino" and found that it has comply the partial for awarding the degree of Bachelor of Electrical Engineering (Industrial Power).

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DEVELOPMENT OF INTELLIGENCE AUTOMATED AIR VENTILATION SYSTEM USING ARDUINO

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A report submitted in partial fulfilment of the requirement for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

I declare that this report entitled "Development of Intelligence Automated Air Ventilation System Using Arduino" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

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Date :

To my beloved family especially my father and mother, En. Shahril Bin Abdullah and Aliamah Binti K. Mohammad. Also to my siblings for their support and also goes to everyone that directly or indirectly in this project.

May Allah bless all of us.

Wassalam.

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ABSTRACT

This report addresses the Development of Intelligence Automated Air Ventilation System using Arduino. The Indoor Air Quality is the air quality in a certain area. The Indoor Air Quality is very important because it can affect a person health. The bad Indoor Air Quality can lead to Sick Building Syndrome. The occupants will experience ill-health when they expose or in a building that has Sick Building Syndrome. The main objectives of the project are to investigate and mitigate the Sick Building Syndrome and to develop a new intelligence automated air ventilation system device. One of the ways for better Indoor Air Quality is having good air ventilation. Moreover, the development of this device for residential house is divided into hardware construction and project simulation. The Air Quality Sensor is used to detect the level of contaminant air and the automated air ventilation system is control by the servo motor and DC fan. The Liquid Crystal Display will be used to print out the air quality reading and condition. The output from the Liquid Crystal Display can be seen in the smartphone application via Bluetooth connection from the Bluetooth module. Other than that, the total cost of this project is around RM 250.00. All the result in this paper is taken from the data obtained and analyzed throughout the project.

ABSTRAK

Laporan ini merujuk kepada tajuk Pembangunan Kepintaran Sistem Pengalihan Udara Automatik Menggunakan Arduino. Kualiti Udara Dalaman adalah kualiti udara di dalam sesebuah ruangan. Kualiti Udara Dalaman ini amat penting kerana ianya boleh menjejas kan kesihatan seseorang itu. Kualiti Udara Dalaman yang tidak bagus boleh boleh membawa kepada Sindrom Bangunan Sakit. Seseorang itu akan mengalami kurang sihat apabila dia terdedah atau pun berada di dalam bangunan yang mempunyai Sindrom Bangunan Sakit. Objektif utama bagi projek ini adalah menyiasat dan mengurangkan Sindrom Bangunan Sakit dan membangunkan kepintaran system pengalihan udara automatic yang baru. Salah satu cara untuk Kualiti Udara Dalaman yang lebih baik adalah dengan mempunyai pengaliran udara yang bagus. Tambahan pula, perkembangan peranti ini khususnya untuk rumah kediaman dibahagikan kepada pembinaan perkakasan dan simulasi projek. Sensor kualiti udara akan digunakan untuk mengesan bahan tercemar di dalam udara dan pengalihan udara automatic di kawal oleh motor servo dan kipas DC. Paparan Kristal Cecair akan digunakan untuk mencetak bacaan kualiti udara. Keluaran daripada Paparan Kristal Cecair boleh juga dilihat di aplikasi telefon pintar via sambungan Bluetooth dari modul Bluetooth. Selain itu, jumlah anggaran kos keseluruhan projek ini adalah RM250.00. Semua keputusan dalam kajian ini diambil dari data yang diperolehi dan dianalisa sepanjang tempoh projek ini.

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ABBREVIATION	TITLE
IAQ	Indoor Air Quality
DOSH	Department of Occupational Safety and health
SBS	Sick Building Syndrome
WHO	World Health Organization
BRI	Building Related Illness
MVAC	Mechanical Ventilation and Air-Conditioning
HVAC	Heating, Ventilation and Air-Conditioning
U.S. EPA	United State Environment Protection Agency
ICOP IAQ	Industry Code of Practice on Indoor Air Quality
OSHA	Occupational safety and Health
PPM	Part Per Million
CFU	Colony Forming Unit
MSAI	Malaysian Society of Allergy and Immunology
EHS	Environment health Science
UPM	University Putra Malaysia
LCD	Liquid Crystal Display
PWM	Pulse Width Modulation
ICSP	In-Circuit Serial Programming
USB	Universal Serial Bus
IDE	Integrated Development Environment
PCB	Printed Circuit Board

CHAPTER 1

INTRODUCTION

1.1 Research Background

Indoor air quality (IAQ), is the air quality inside the buildings or a workplace. This IAQ has a relation with the health of the people in the area. The scientist and the responsible personnel could not be more concern about the IAQ because they find out through survey that most of the people will spend their time in a day more than 70% to 90% indoors [1] [2]. In addition, studies were made and the result shows that the level of outdoor pollution is lower than the indoor pollution [3]. The indoor pollution occurred since the prehistoric era when the people started to live indoor and fire burning inside the closed shelter for cooking and body warmth [2].

Today, the indoor pollution is contributing by smoking, cooking, building materials and furnishing, household cleaning product and others. The maintenance, operation and design of a ventilation system are also will be count as one of the contributor to indoor pollution [2]. Moreover, the outdoor source pollutant that may come from traffic, industrial, open burning, pesticides and construction will also effect the indoor pollution concentrations. This effect on the IAQ will be more notable if the building is located near to industrial area or street with high traffic [3]. Meanwhile, the good IAQ from domestic building is very important to person who is sick and senior citizen because they spend their time indoor compared to others [4].

In Malaysia, the Department of Occupational Safety and Health (DOSH) already give guidelines for the building IAQ to protect workers. Unfortunately, there is no guidelines yet that has been develop for the residential house [5] [2]. There guidelines form DOSH must be followed in order to prevent sick building syndrome (SBS) [5]. Some of the contributing factor are insufficient ventilation, excessive odor and others. The SBS will cause a few discomforts for the occupants such as headaches, eye strain, respiratory problem and others. The good news is that the symptoms may disappeared when the person left the mal-functioning building because of the short duration of the symptoms [6].

The IAQ in Malaysia is kind a new issue and the data is limited for general knowledge especially for residential house. The IAQ must be given more serious attention and further research in Malaysia [2]. Therefore, this project is develop for the occupant in residential house to monitor their IAQ by using efficient and low cost device. This device will able to monitor the IAQ of the residential house and the air ventilation will operate automatically with the device.

1.2 Problem Statement

Bad IAQ can gives ill-health to the occupant such as headaches, sore throat and cough. There are many methods for a better IAQ such as installation of IAQ system for building and IAQ monitor device. Most of this system and monitor device are effective but it will require high cost for the installation for the device and maintenance for the system. Besides that, the IAQ monitor device does not equip with air ventilation when the device detected bad IAQ. Many people cannot afford the IAQ system or monitor device because of the high price in the market. So, this air quality sensor with automated air ventilation will be used to monitor the IAQ level in the residential house. This development will be low in cost but affective for the residential house.

1.3 Objectives

These objective needs to be achieve in order to meet the requirement for IAQ for residential house.

1. To investigate and mitigate the Sick Building Syndrome (SBS).
2. To develop a new intelligence automated air ventilation system device.

1.4 Scope

The scope of the project will cover up these following:

1. This project only mainly focused on the residential house.
2. This project will be including the suitable and affective ventilation system for residential house.
3. Air quality sensor will be used to detect the level of contaminated air.
4. Arduino microcontroller is used for data processing.

1.5 Expected Project Outcome

At the end of this project, this device will be able to measure the IAQ level in a certain area inside the residential house and the automated air ventilation will be operating automatically. The performance of this intelligence automated system is verified.

1.6 Significant of The Project

With the smart air quality monitoring device in the residential house, a better IAQ and improve the bad IAQ can be achieved. The IAQ for the residential house device can accomplish the objective of this project.

1.7 Report Outline

The main focus of this report was to discuss about the IAQ for residential house and monitoring the level and condition with a smart air ventilation system. This report will be separated into five parts such as introduction, literature review, research methodology, results and conclusion.

Chapter 1 is about introduction of this project that discussed about research background, problem statement, objectives, scope, expected project outcome, significant of the project and report outline.

Chapter 2 is entirely for the literature review. This chapter discussed about the basic theories and principles that will be used while conducted this project. The related work being discussed in this chapter will be reviewed along with the references. In addition, this chapter also includes with the studies and research paper that are found relevant to this project. All the papers are being referred thoroughly since some of the options or argument may be gained from the papers as knowledge and information to be applied and used in order to complete this project. The literature review process will still be going through until the end of this project conducted. There are many type of literature review sources such as journals, reference books, articles and other internet sources.

The methodology in chapter 3 is commonly about the operations taken to be done, techniques and steps to complete this project. In this chapter, the overall procedures of the project will be discussed until it is achieving the objectives. The tested system is also showed in this chapter.

For chapter 4, the chapter mostly discuss on the result of the project. All the result obtained will be recorded and analyzed.

Chapter 5 is the final chapter for this report where this chapter will discuss on the conclusion of the project. The conclusion is the project final statement whether all the process and results are achieved the objectives stated or not.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The theory and basic principle of the Indoor Air Quality (IAQ) for this project development will be discussed in this chapter. The related work about IAQ also will be reviewed. There is some pollutant that needed to be measured for better IAQ such as carbon monoxide, carbon dioxide, tobacco smoke emitted due to burning from tobacco product, formaldehyde emitted from furnishing and much more. Each of the pollutants has the different acceptable range that needed to follow to achieve good IAQ. Studies and researched paper about this theory also included in this chapter. The theory of this IAQ also will be discussed in subsequence so that it can be clearly understood.

2.2 Theory and Basic Principle

IAQ is the air quality in a certain place such as a workplace or home that will affect the comfort and health of a person. IAQ also is the influenced of numerous of gas, microbial or particulates that can harm a person [7]. Most of the people will control the environment in their home to provide comfort and health. This scenario can be seen when people will not use the freshly painted room until the paint odor gone away [8]. A poor IAQ will be a major contribute toward Sick Building Syndrome (SBS) [9].

The SBS was introduced by World Health Organization (WHO) in 1982 because general, skin and mucosal symptom contain by inhabitants building with the IAQ problem [10]. The sex gender that these symptoms occur is among the females. Females have greater longevity which experiences greater morbidity. While males have the higher rate for impairments, life threating chronic disease and long term disability [11]. The male and female also have differences in many aspects such as different inherited biological risk due to genes and hormones, different illness behavior and different risk encounter in the workplace [12].

A study in United State was held that showed poorer health condition of women stems largely from their position and stress, and their personal health. This will make the women more susceptible the SBS symptoms [11]. Other than that, female with a lower position, often exposed to tobacco, have children, often work open plan office and handle many paperwork will often have SBS symptoms than man [11]. These factors needed to be concerned with the management of the building as they are endangering their workers to be exposed to the ill-health. Moreover, there are some SBS symptoms that occur among man and women also because of outside work environment factors such as hormones, life style, illness behavior and others [11].

Moreover, the children and senior citizens are both categorized as the most sensitive personnel toward indoor air pollutant. These group of personnel can be more polluted by indoor air than outdoor air [4]. A study in Hong Kong school was held, and the data showed that the overcrowded classrooms will result an ill-health of the children because of poor IAQ [8]. This is because the metabolic of a normal children is much higher than normal adults as the children respiratory rate is higher as they breathe in much air pollutions [13]. The sources of air pollutant in school are such as chalk dust, lab chemicals, mold and cleaning agent. In order to improve the IAQ level, there should be a limit to the student in indoor classrooms per square meter [14].

In addition, the reason that can be identified towards the airborne of the building contaminants is known as Building Related Illnesses (BRI) [15]. The causes of BRI can be divided into many factors such as biological factors, chemical factors and also physical factors. Moreover, the physical factors will include the factors of temperature, air movement, lighting, humidity and noise. On the other hand, the chemical factors consist of the pollutant that arising from the paint, new furniture, carpets, drapes, environmental tobacco smoke and insecticides. For biological factors, it consumes of microorganisms that play an important role for this factor.

This factor can be very serious when there is inhalation of the fungal, bacteria and micro algal spore. These actions will cause an allergic reaction to a person [16]. Therefore, all of this factor will also lead to an indoor air pollutant.

One of the BRI is Legionnaire's disease and it is a form of bacterial pneumonia that categorized by chill, dry cough, fever, diarrhea and muscle aches. The name of Legionnaire's disease was given after group of people were affected by the disease when attending an American Legion's convention in Philadelphia in July 1976. Legionella pneumophila is the name of bacteria that causes the Legionnaire's disease, will grow in any environmental reservoir in which is water, temperature and nutrient are met. Although this bacteria present in the environment, the airborne concentration only will reach levels that are enough to infect occasionally otherwise normal subject. Besides that, these bacteria have been identified as a major source in the water cooling towers and warm water systems in buildings. Therefore, without water treatment and maintenance of the system, Legionella can be ubiquitous and then will infect the people in the building through the air handling system [17].

Figure 2.1: Water tank that has been infected with Legionella [17].

Indoor air pollutant can also occupy from the outdoors, building equipment, human activities, Mechanical Ventilation and Air-Conditioning (MVAC) and furnishing. Besides that, there are three frequent reasons that will lead to poor IAQ which is insufficient design or maintenance of Heating, Ventilation and Air-Conditioning (HVAC) systems, lack of air intake into the building or workplace and lack of humidity control and systems [8]. The main reason for these factors occur is mostly because of the high cost. Moreover, the United State Environmental Protection Agency (U.S. EPA) issue statistical data which concluded that indoor air is two to five times more polluted than outdoor air [18].

In Malaysia, the DOSH had issued the Industry Code of Practice on Indoor Air Quality 2010 (ICOP IAQ 2010). This ICOP IAQ 2010 was approved by the Minister to replace the ICOP IAQ 2005. This code was drawn up to help ensure employees and occupants protected from poor IAQ that could affect their well-being and health. Moreover, it is also one of the duties of an employer toward their employees to provide a good IAQ as it has been stipulated under Section 15 of Occupational Safety and Health Act 1994 (OSHA) [19].

The creation of comfortable and health for a workplace will enable the persons to put their abilities to use more effective workplace. A good office environment is a combination of temperature, air quality and humidity. In some workplace, persons can experience an ill-health effect from a bad office environment. Some common ill-health that has been detected in some workplace are headaches, sore throat, cough and much more. In order to prevent such ill-health and provide a better IAQ, these following issues needed to be addressed [20]:

1. Ventilation

   It is referred to the air movement and the air input rate in a certain area. For an office workplace, each personnel require at least 10 liters of fresh air per second for general office place or 10 liters of fresh air per second for 10 square meters of floor space. The air movement should be ventilated naturally or artificially. For a small workplace, opening doors and windows for allowing the fresh air into the workplace is consider adequate ventilation. For the big workplace, the mechanical ventilation system or air-conditioning must be provided to make sure the workplace IAQ is protected.

Figure 2.2: Artificially air ventilation [20].

2. Air Contaminants

   Contaminants included bacteria, fungal and dust that are generated or used in the building will affect the IAQ level. The air-conditioning that provided an inadequate amount of new fresh air will contribute to the emission of carbon dioxide in the air from the air contaminant stated. There are others indoor air contaminants and their acceptable limit that has been designated by DOSH in order to provide a better health and comfortable place for the personnel

Table 2.1: The list of indoor air contaminants and acceptable limits by DOSH [20].

Indoor Air Contaminants	Eight-hours' time-weighted average airborne concentration
Chemical Contaminants	*Part Per Million (PPM)*
Carbon Dioxide	C1000
Carbon Monoxide	10
Formaldehyde	0.1
Ozone	0.05
Total Volatile Organic Compounds	3
Biological Contaminants	*Colony Forming Unit Per Meter Cubic (CFU/M^3)*
Total Bacterial Counts	500
Total Fungal Counts	1000

3. Moulds Contamination

   Moulds are one of the typical forms of fungal on earth. Moulds are made up from masses of filament-like cells called hyphae. Unfortunately, moulds are visible o human eye sight. There is a few type of moulds that exist in the indoor environments such as Cladosporium, Penicillium, Alternaria and Aspergillus. Moulds that found in indoor environment feed them self from dead moist organics such as wood, dust, paper and much more. Other than that, the floods and leaking pipes, roof and windows are all considered as a potential source that can lead to mould infestation. Moulds can be harm as they can cause a range health towards the occupants. Occupants can be exposed to moulds via inhalation or skin contact. Therefore, moulds will produce health effects by a serious infection or allergy.

Figure 2.3: Mould causes by leaking pipes [20].

The President of Malaysian Society of Allergy and Immunology (MSAI), Dr. Amir Hamzah Dato' Abdul Latiff, said that about 4.3 million deaths a year occur because of bad IAQ. Around 30 to 40 percent of Malaysian infected with sinusitis allergy because of poor IAQ in a sick building. According to the Head of Environment Health Science (EHS) from University

Putra Malaysia (UPM), Dr. Juliana Jalaludin, a sick building can be labeled if the occupants that complained suffering a SBS symptoms are higher than 30 percent. The President of MSAI also advised occupants to take the probiotic and prebiotic supplement in order to improve our immunization body system. The SBS symptoms will affect the occupants if the readings are against the limitation by the DOSH in ICOQ IAQ 2010 [10] [21].

Table 2.2: Effect toward the occupant if the reading against the limitation [21].

Parameter	Critical Effect
Carbon Monoxide	A severe headache, Influenza, nausea
Carbon Dioxide	Unconsciousness, dizziness
Formaldehyde	Eye Irritation, sore throat
Ozone	Reduction in lung function, asthma
Total volatile organic compound	Fatigue, tiredness
Bacteria	Various kind of diseases, infection
Fungal	Various kind of diseases, infection

2.3 Review of Previous Related Works

There are many device or system that has been invented in this 21st century which can detect IAQ and help to prevent the poor IAQ level. Most of this system are installed in buildings that provide large workplace. However, the market for IAQ device installation in a residential house is quite low than building. Not all residential owner felt needed and has awareness about the importance of their health [22].

One of the products that have quite a rating is called Awair. The company that develops this product is based in San Francisco, America. One of the special features of this product is that it can work through smart phone and provide a regular update, report and alert about the IAQ condition in a room. This feature can be able for the user by downloading the application into the smart phone. Other than that, this product is also installed with five different sensors to detect dust, volatile organic compound, temperature, humidity and carbon dioxide [22].

Moreover, Awair also comes with a complete semi-customized setting for allergy, sleep and productivity. This three categorized can help the users by alerting them by changing led colour, green is good, yellow is fair and red is poor IAQ. One unit of Awair is sufficient for 1 000 square feet area [22]. Other than that, the shortage of Awair is that the price is USD 199.00 (RM 888.00) and this product also did not come with a smart ventilation system. Therefore, the users just can get alerted from Awair via smart phone about the IAQ condition and need to ventilate the air manually by opening windows, doors or others [22].

Figure 2.4: The Awair operated and showed a green light for good IAQ condition [22].

Another device that can help to monitor IAQ is uHoo. This IAQ device can detect air quality in real time and include with smart phone compatibility that can feed live data through the application via Wi-Fi connection. Other than that, this device design with eight sensors that can detect particulate, volatile organic compound, temperature, humidity, carbon dioxide, carbon monoxide, air pressure and ozone. It also stores all previous history data of IAQ on every area that user place it [23]. This device also can be very helpful to those who suffer from asthma, rhinitis and allergies. Another uHoo feature is that it can be portable and lightweight. The users can easily plug this device to the power source in their selected area and synchronize with their smartphone to get the IAQ data [23].

The cost to purchase this device is USD 299.00 (RM 1335.00) and unfortunately this device does not equip with smart air ventilation system that helps the users to get fresh air automatically when the bad IAQ detected. On the other hands, this device also considered a high cost for those who have an average income.

Figure 2.5: The cross-sectional of the uHoo device [23].

2.4 Summary and Discussion of The Review

A person health can be harm through poor IAQ which the air are polluted with numerous unwanted gas in the indoor air [7]. In order to provide comfort and health, the environment needed to be control and maintain [8]. Therefore, bad IAQ definitely will contribute toward SBS [9]. WHO is the organization that introduced SBS and provide awareness about the symptoms that the occupant will face such as skin irritation, respiratory problems and others [10].

One of the studies shows that female occupant is the one who reported to SBS symptoms often that male. Women showed poor health condition because of the aspects of their position, stress and personal health. Other SBS symptoms also occur because of their hormones, life style and illness behavior [11]. Other than that, the children and senior citizen also are categorized as occupants who sensitive to indoor air pollutant [4].

A study was held in Hong Kong school and showed that overcrowded classroom would cause ill-health toward the children. Children have higher metabolic than an adult will result in respiratory problem because the children breathe more air pollution than normal adults. The source of air pollution in the classroom came from chalk dust, cleaning agents and others [8] [13].

The BRI cause can be divided into three factors which are biological, chemical and physical factors [16]. Legionnaire’s disease is of BRI that causes diarrhea, cough and fever. Legionella pneumophila is the bacteria that will grow in the presence water, temperature and humidity. The water cooling tower and warm need to have periodic maintenance to avoid BRI in the building system [17].

Moreover, indoor air pollutant can come from the outdoor air, furniture, human activities, MVAC, lack of HVAC design, lack of air intake and also lack humidity control systems [8]. The indoor air is two to five times polluted than outdoor air by according to U.S. EPA [18]. In Malaysia, every building must follow the requirement from DOSH by based on ICOP IAQ 2010. This code is to ensure the occupants are protected by poor IAQ [17].

A good office environment is a combination of temperature, humidity and air quality. Some ill-health has been detected if the office has bad office environment such as headaches, sore throat, cough and others. The good office environment can help workers to use their abilities and have good performance [20]. There also about 4.3 million of death per year cause by poor IAQ, according to the President of MSAI. Supplement advised being taken to improve the occupant’s immunization body system [21].

There is few type of product that help the users to monitor their IAQ such as Awair. This product consists of five sensors and can work through a smart phone that provides an update, report and alert for their IAQ. This product can be purchase in US for USD 199.00 and does not equip with a smart ventilation system [22].

Another product that similar with Awair is uHoo and it can feed the users with live data through a smart phone. Moreover, it is consisting of eight sensors including air pressure and ozone. This product can be purchase in United State and also does not come with a smart ventilation system [23].

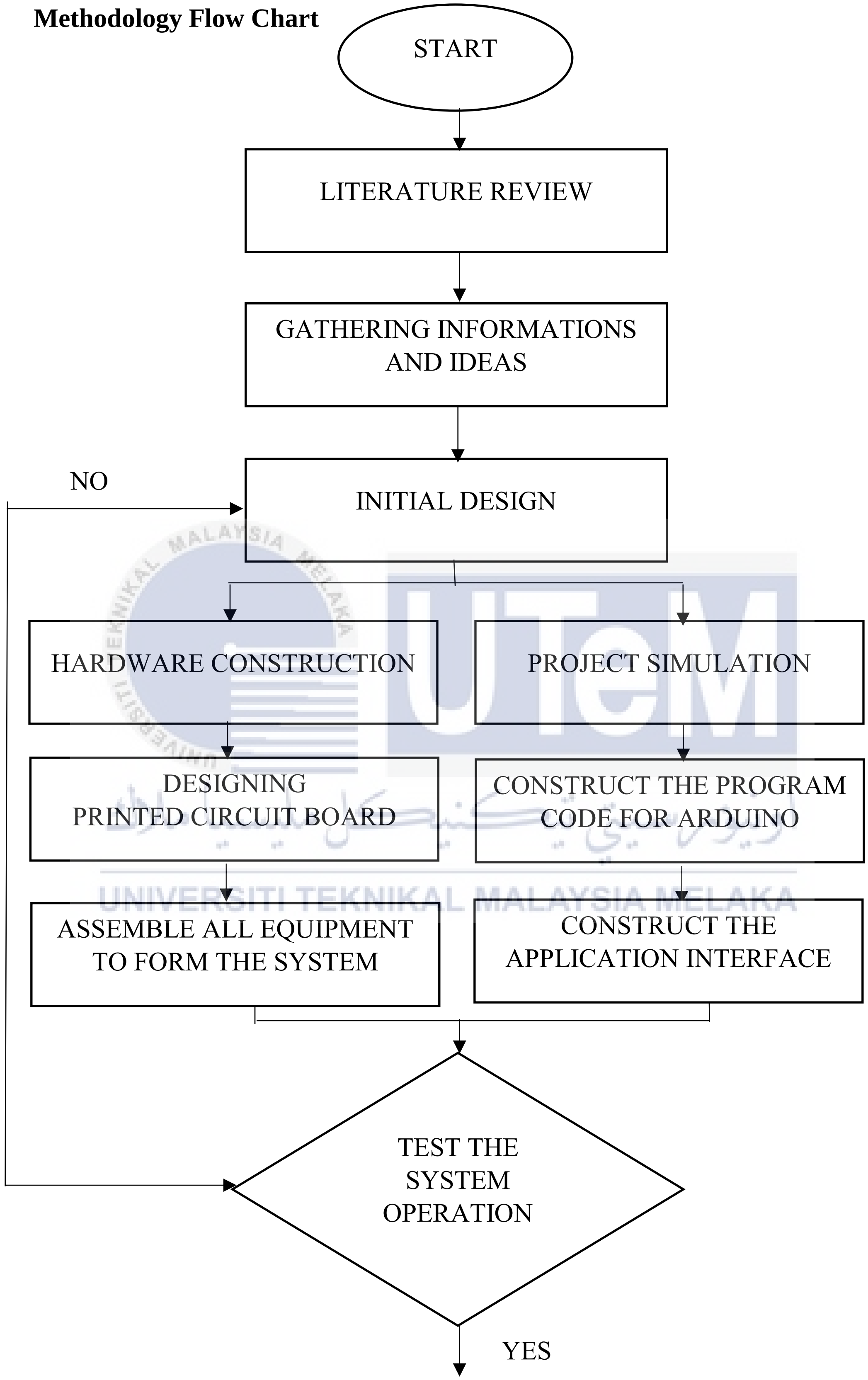
CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This section assumes as an essential part in this anticipate. This part demonstrates how the work step methodology has been actualized with a specific end goal to finish the task. The techniques and strategies has been resolved to remain the work arrangement in advancement keeping in mind the end goal to finish the task to stay away from the past due and ensure the outcome will be get as per the undertaking destinations.

3.2 Methodology Flow Chart



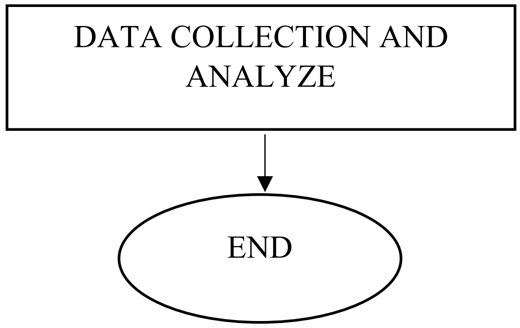


Figure 3.1: Project flow chart

3.3 Detailed Discussion on Method

The discussion on the methodology of this project is discussed more specific and explained briefly in this part.

3.3.1 Explanation Flow Chart Methodology

In this section, the methodology is explained on following statement.

- Literature review

In this part, the research on the Indoor Air Quality (IAQ) is conducted to ensure the understanding on the related scope is achieved. Gathering knowledge on IAQ is an initial step to find the main ideas for this project. After that, the research on the effect of good and poor IAQ also needed to barely know toward the occupants. During this this, all information upon the invention of IAQ monitoring devices are conducted. This will help to show some guidelines in order to improve the existing devices.

- Initial design

The initial design will be used based on a normal size of room. This is because every room in every residential house has different size of rooms. The room that is selected must has proper air ventilation such as windows or door. After that, the design is implemented to the hardware part.

- Construct and test of the hardware and software

For this step, all components will be bought. The software for the system is constructed. All the equipment is assembled for testing and the data will be collected to complete the task.

3.4 Air Quality Monitoring System Planning

The Air Quality Monitoring System planning is the step to follow to construct the hardware and software according to the scheduled timeline. All the equipment and device are assembled to develop the project.

3.4.1 Component of The System

Figure 3.2 shows the main component of intelligence air quality monitoring system. The purpose of this system is focus on in development of indoor air quality with automated air ventilation system by using air quality sensor. Through the purpose of this project, air quality sensor is used to monitor the quality which require Arduino to process the data and Liquid Crystal Display (LCD) for the output display.

LCD display

Air Quality Sensor

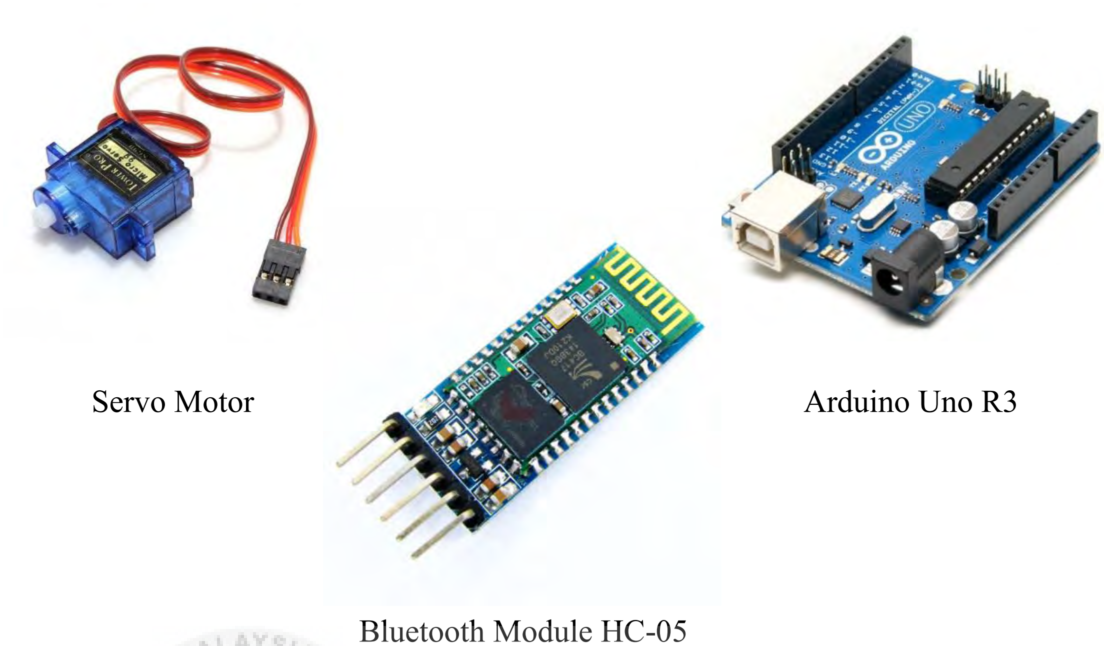


Figure 3.2: The main component of this project.

3.4.2 Air Quality Monitoring System Specifications

Table 3.1: Air quality monitoring system specification.

No.	Device	Function
1	Air Quality Sensor	Detect the indoor air quality level.
2	Arduino UNO R3	Program the code and the data from other devices.
3	Bluetooth Module	Display the air quality reading into the phone application.
4	LCD	Display the output of the system on 16x2 type of LCD.
5	Servo Motor	Receive control signal to open and close for the operation of the window

6	DC Fan	Remove the indoor air when bad air detected

3.4.3 Arduino

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input or output pins which are six outputs can be used as Pulse Width Modulation (PWM) outputs, six as analog inputs, a 16 MHz quartz crystal, a Universal Serial Bus (USB) connection, a power jack, an In-Circuit Serial Programming (ICSP) header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. You can tinker with your UNO without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software Integrated Development Environment (IDE) 1.0. The Uno board and version 1.0 of Arduino Software IDE were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

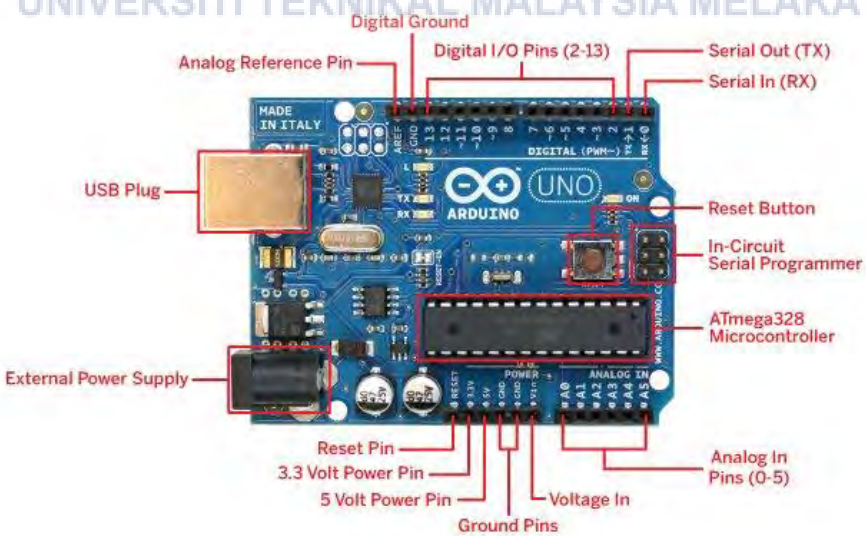


Figure 3.3: The Description for Arduino Uno R3 [24].

3.4.4 Air Quality Sensor

This sensor is basically designed to monitor the indoor air quality. It is a wide scope sensor and helps detect harmful gases such as acetone, alcohol, thinner, carbon monoxide, formaldehyde and so on. Moreover, the cost of this sensor is very affordable and also durable. It is also very compatible with Arduino and easy to program.

The main component in this Air Quality Sensor Module is MP503. The MP503 is an air quality gas sensor, which help the air quality sensor to monitor the indoor air quality. The combination of this component on the module is the Grove Air Quality Sensor. Besides that, MP503 have four electrodes which have their own characteristic. The air quality sensor need to pre-heat at least 2 minutes for a better result. The pin 1 and pin 2 in the MP503 is the heating electrode and pin 3 and pin 4 is the measuring electrode.

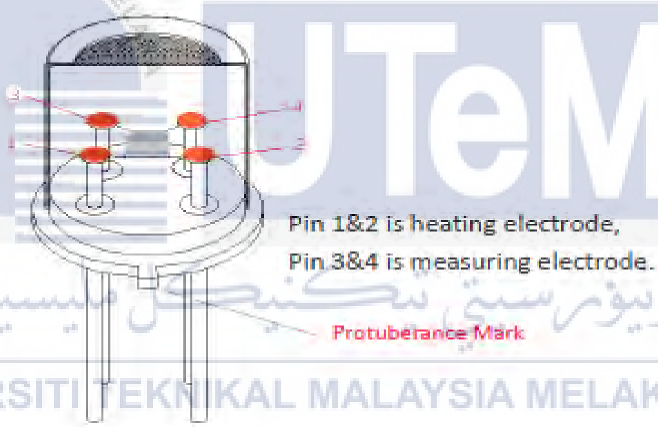


Figure 3.4: The cross-sectional of MP503 [25].

3.4.5 Servo Motor

This servo motor is tiny and very lightweight with a high output power. It can rotate from 0 to 180 degrees and work just like other kinds but smaller. Most servo motor cannot operate more than 180 degrees. It is also coming with 3 arms to help with rotation on the hardware.

This servo motor has operating speed is 0.1s in 60 degrees. Besides that, it also requires a small operating voltage which is good for this project. The operating temperature is around range of 0 to 55 degree Celsius and easy to connect with Arduino board.

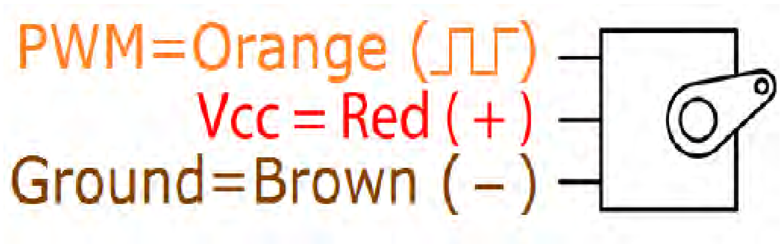
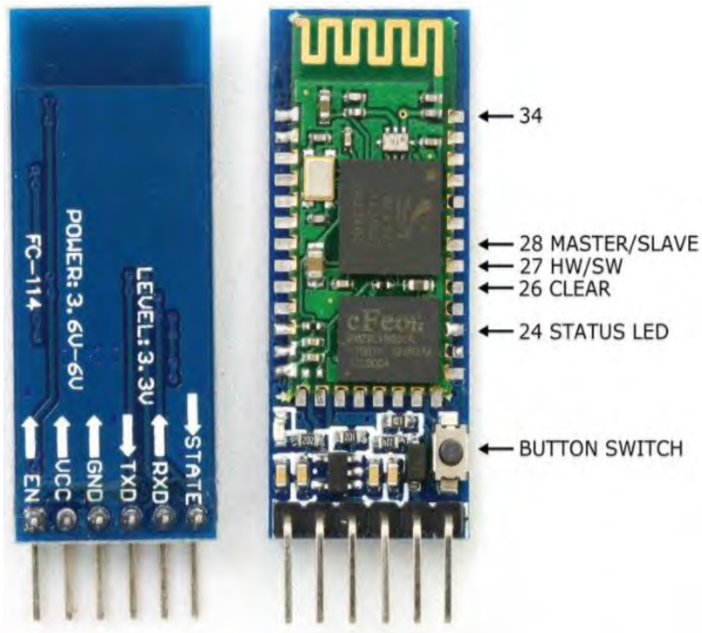


Figure 3.5: The output pins of servo motor [26].

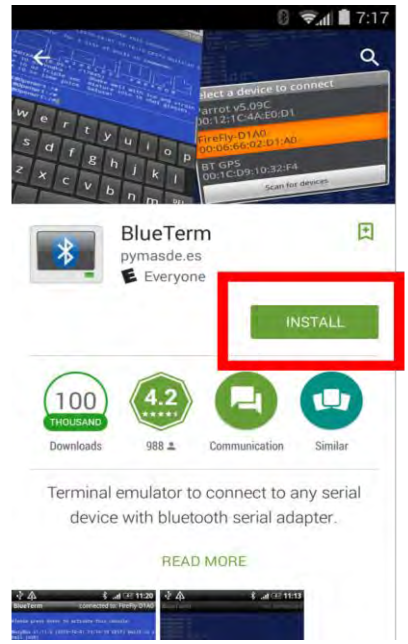
3.4.6 Bluetooth Module and Smartphone Application

The HC-05 Bluetooth Module is the most popular Bluetooth module in the innovation community for wireless communication. It is low cost and easy to use with Arduino. Other than that, HC-05 module exchange data by using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz. With the signal coverage of 9 to 10 meters, the HC-05 module can build a connection to other modules in two ways: as a master or as a slave. For example, a system can be designed to be a master connected to a slave Bluetooth module or as a slave board to make a wireless connection with a computer.

This HC-05 Bluetooth Module is paired with Smartphone application called BlueTerm. The HC-05 helps to display the Air Quality reading and the condition of the indoor air in the phone application. Moreover, this Smartphone application act as monitoring system and print out the serial monitor from Arduino. Besides BlueTerm, another Smartphone application also can be download from the Smartphone operating store.



HC-05 Bluetooth Module



BlueTerm on Android

Figure 3.6: The HC-05 Bluetooth Module output pin and BlueTerm Smartphone application [27].

3.4.7 Printed Circuit Board (PCB)

The circuit that has achieved the built up of the system is made into PCB for the neatness of the system. The circuit of this system is designed and constructed in the Proteus software. With this software, the theory of the circuit can be archived and if there are some corrections, the circuit is easily designed again. The designed is saved and after that opened in ARES software. the thickness of copper thread can be set up with this software. For this system, the thickness of copper thread is set on 1 millimeter because of the power supply is adequate for such thread thickness. If higher power supply is used, the copper thread thickness can be increased.

The circuit from ARES software is printed onto glossy paper and placed on top of cooper board. The copper board used is by according the size of circuit printed. After that, heat is applied, so that the ink of the printed circuit can be stick together with the copper board. After a few minutes, the copper board is place into a bowl of water for removing the glossy paper. Only the ink which stick together with the copper remains. Ferric Chloride is used to remove the excess copper and acetone is used to remove the ink. The only thing that remains on the board is copper thread of the circuit system.

The drilling machine is used to make hole on the copper thread for soldering the equipment legs. The PCB is tested for verify the connection of the copper thread.

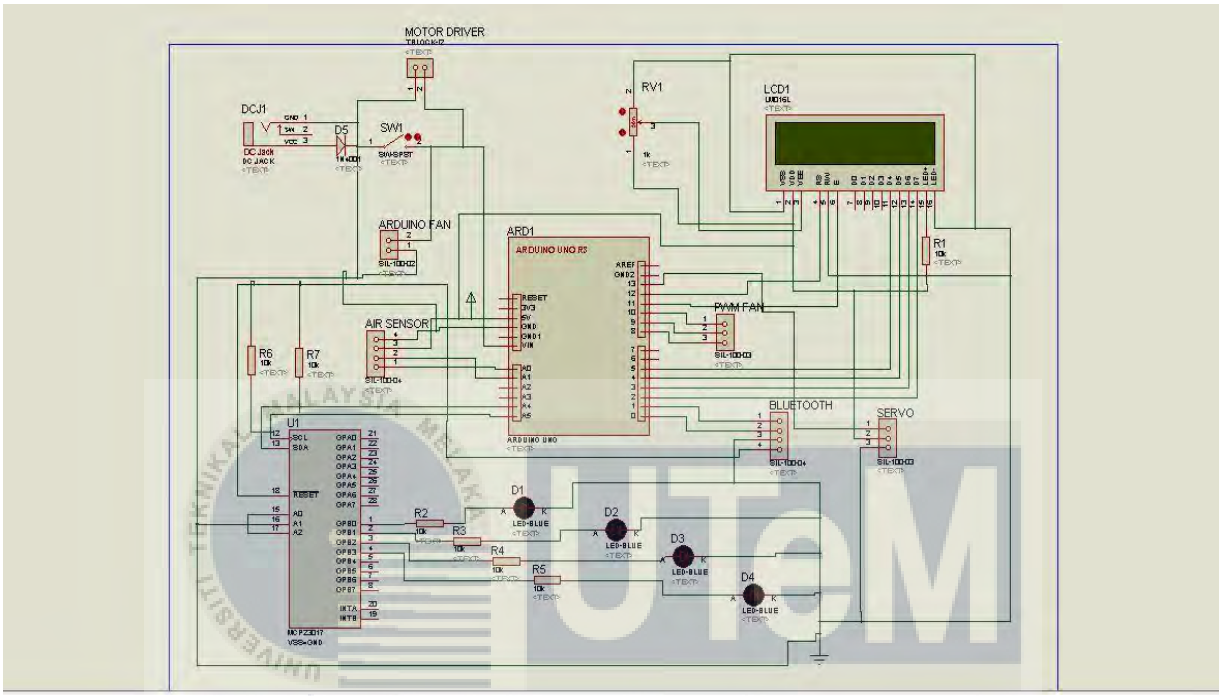


Figure 3.7: The schematic design for the Air Quality Monitoring System in Proteus.

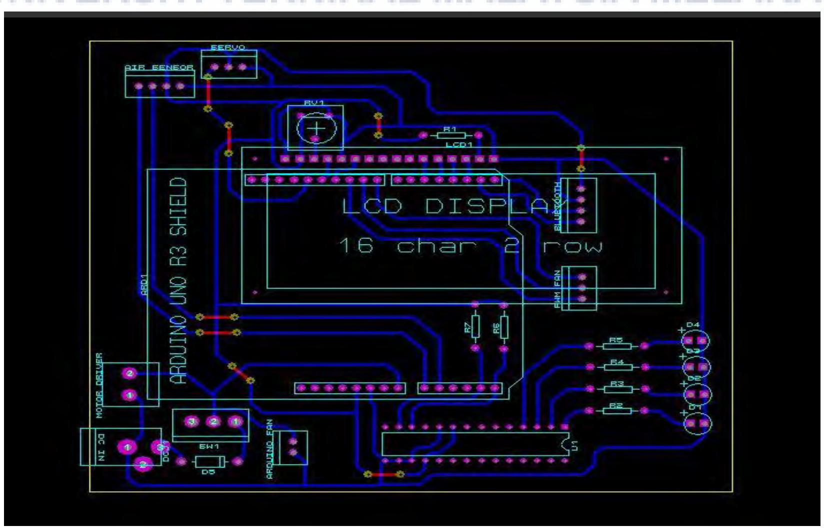


Figure 3.8: The PCB design in ARES.

3.5 Gantt Chart and Key Milestones

Table 3.2: Gantt chart of the project.

Project Planning															
Month / Activities	SEPT		OCT				NOV				DEC				JAN
FYP 1 (SEPT 2016- JAN 2017)															
Choosing a title	■														
Gather the information		■	■												
Project Research				■	■	■	■								
Project Analysis						■	■	■	■	■					
Preliminary result							■	■	■	■	■				
Report Writing				■	■	■	■	■	■	■	■	■	■	■	■
FYP 1 Presentation													■		
FYP 2 (FEB 2017- JUN 2017)	FEB		MAC				APR				MAY				JUN
Project Hardware and Software	■	■	■	■	■	■									
Troubleshooting				■	■	■	■	■	■						
Result and Analysis						■	■	■	■	■	■	■	■	■	■
Report Writing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
FYP 2 Presentation															■

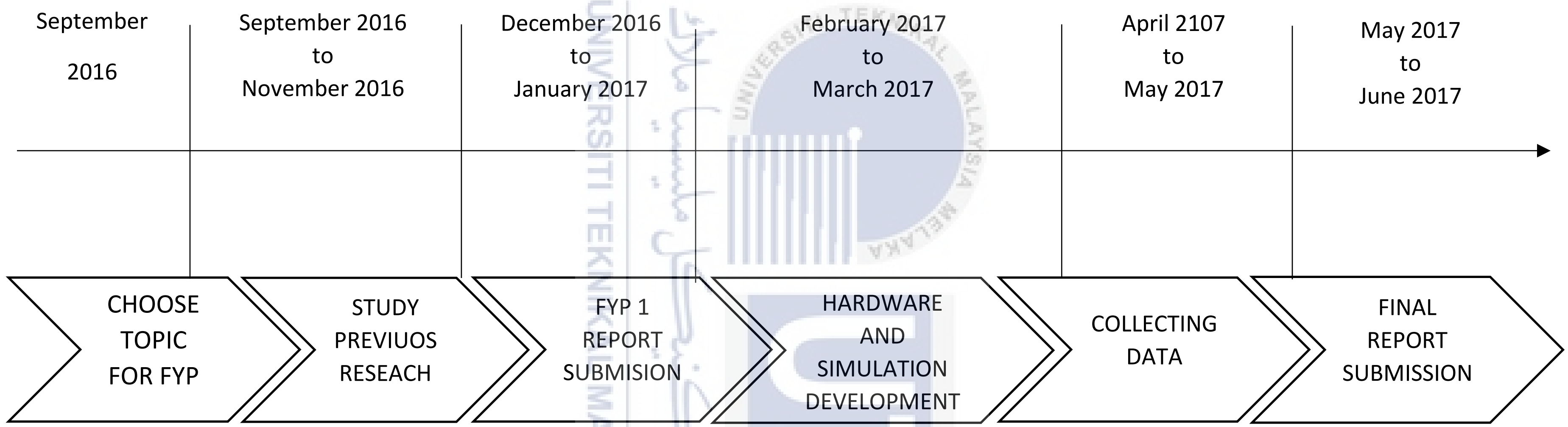


Figure 3.9: Key milestone of the project.

3.6 Summary

Before this project started, the flow chart is made to make the project flow much easier. The important part of the flow charts the literature review. This part is for the research of project is made and to understand more about the task. After that, initial design about the hardware and software is constructed. With the design, the hardware and software can be implemented and ready for data collection.

The components of this project are Air Quality Sensor, Arduino Uno R3, LCD, Servo Motor, DC fan and Bluetooth module. Figure 3.2 showed the components used and table 3.1 showed the function of each components. Moreover, the components are explained in the sub-chapter 3.4.

The Gantt Chart showed and key milestones of the project showed in table 3.2 and figure 3.9 are the plan of work schedule to help follow the due date. Other than that, falling behind the due date is a risk that can affected the whole project work.

CHAPTER 4

RESULT AND ANALYSIS

4.1 Introduction

This section will about the result and analysis of this project. The Air Quality Monitoring System is tested with different substances for their result and analysis for the whole project. Other than that, the data is recorded for further analysis and discussions.

4.2 Result

The Air Quality Monitoring System is tested with different type of substances such as butane gas, cigarette smoke, carbon monoxide and bug spray. The parameter that being observed are the operating time, accuracy and sensitivity of substances towards the Air Quality Monitoring System.

Each substance will be tested for four times to ensure the reliability of collected data. Before the tested begin, the system needed to be switch on for at least two minutes for better result. The substances that are tested are the substances that usually found indoor in the residential house

4.2.1 Butane Gas Testing

Butane gas normally found in the gas tong for gas stove. It can catch with flame easily if there is gas leaking in the residential house. For this testing, a lighter is use as the gas stove. This is because the gas used for gas stove and lighter is the same which is butane gas. For this testing, the lighter released the butane gas for 20 second. The data is observed and recorded.

Figure 4.1: Butane gas testing is conducted.

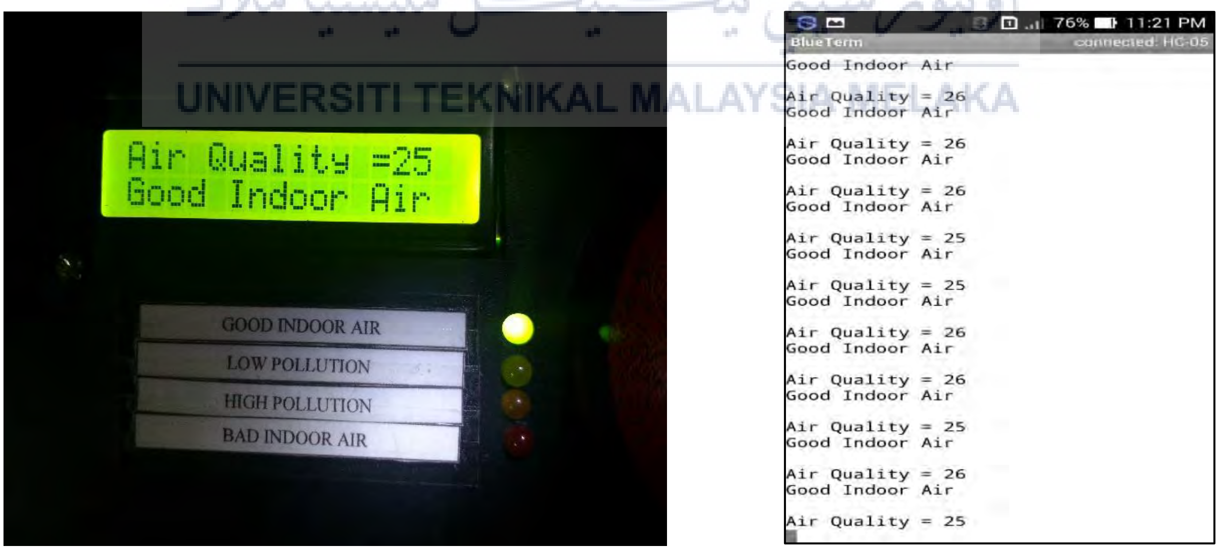


Figure 4.2: “Good Indoor Air” condition is printed out on the LCD and Smartphone application before the butane gas is released.

Figure 4.3: The condition change to “Low Pollution” after 3 second and printed out the condition on the LCD and Smartphone application.

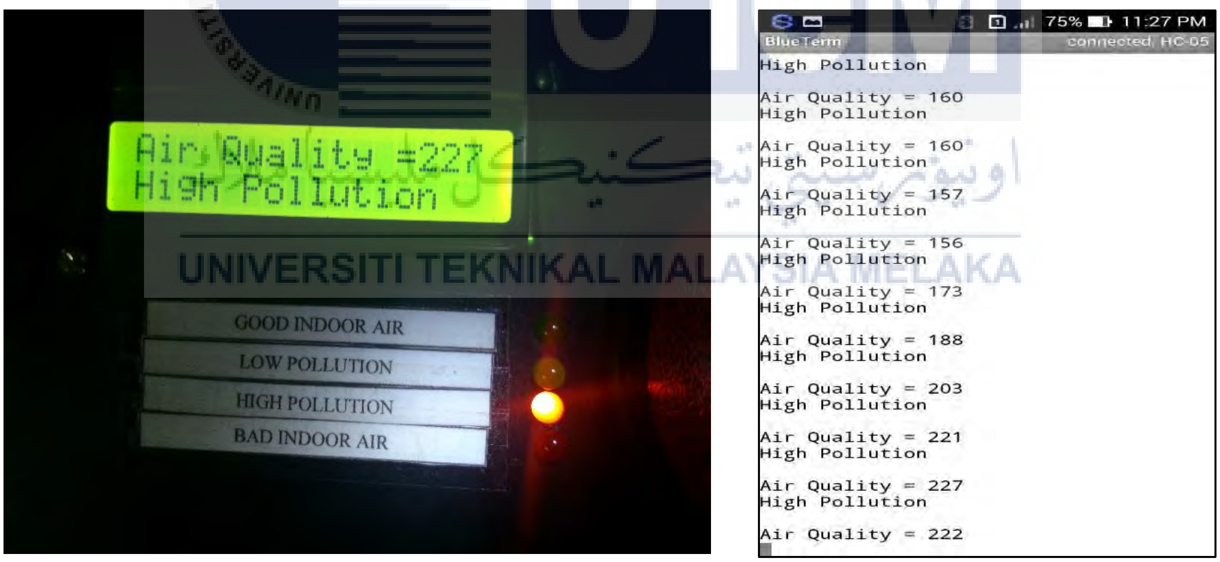


Figure 4.4: The condition change to “High Pollution” after 5 second and printed out the condition on the LCD and Smartphone application

Figure 4.5: The condition change to “Bad Indoor Air” after 7 second and printed out the condition on the LCD and Smartphone application

Table 4.1: Data collected for increasing butane gas.

No of Test	Indoor Air Condition	Time of detection
1	Good Indoor Air	Before the butane gas release.
	Low Pollution	After 3 second from previous detection
	High Pollution	After 5 second from previous detection
	Bad Indoor Air	After 7 second from previous detection
2	Good Indoor Air	Before the butane gas release.
	Low Pollution	After 3 second from previous detection
	High Pollution	After 6 second from previous detection
	Bad Indoor Air	After 7 second from previous detection
3	Good Indoor Air	Before the butane gas release.
	Low Pollution	After 4 second from previous detection
	High Pollution	After 5 second from previous detection
	Bad Indoor Air	After 8 second from previous detection
4	Good Indoor Air	Before the butane gas release.
	Low Pollution	After 3 second from previous detection

	High Pollution	After 4 second from previous detection
	Bad Indoor Air	After 7 second from previous detection

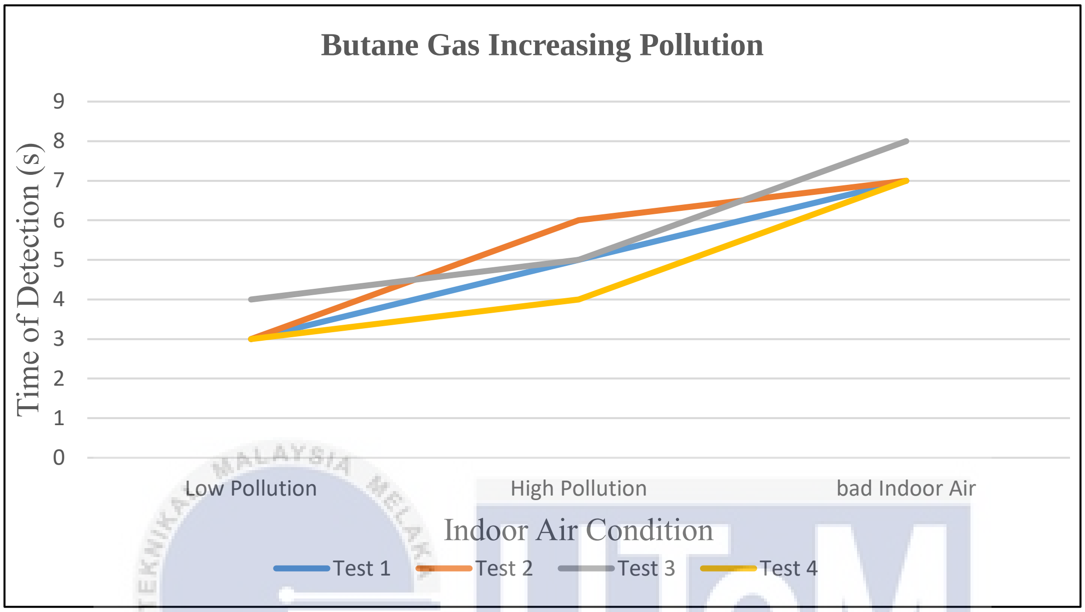


Figure 4.6: Graph for time of detection versus indoor air condition when increasing butane gas.

For increasing butane gas, table 4.1 showed the condition of the Air Quality Monitoring System show in the "Good Indoor Air' range. Then after the butane gas being release, the condition of the system changes by stage. The DC fan will operate in all condition except in condition "Good Indoor Air". So, in the condition "Low Pollution", "High Pollution" and "Bad Indoor Air" the DC fan are operated and removed the butane gas perfectly. The blind windows also operate as it helps the natural air flow to remove the butane gas. Moreover, figure 4.6 show that all four-test showing same condition characteristic. The graph also proved that the system is operated as it designed. The different time is because the unpredictable amount of butane gas released for the testing.

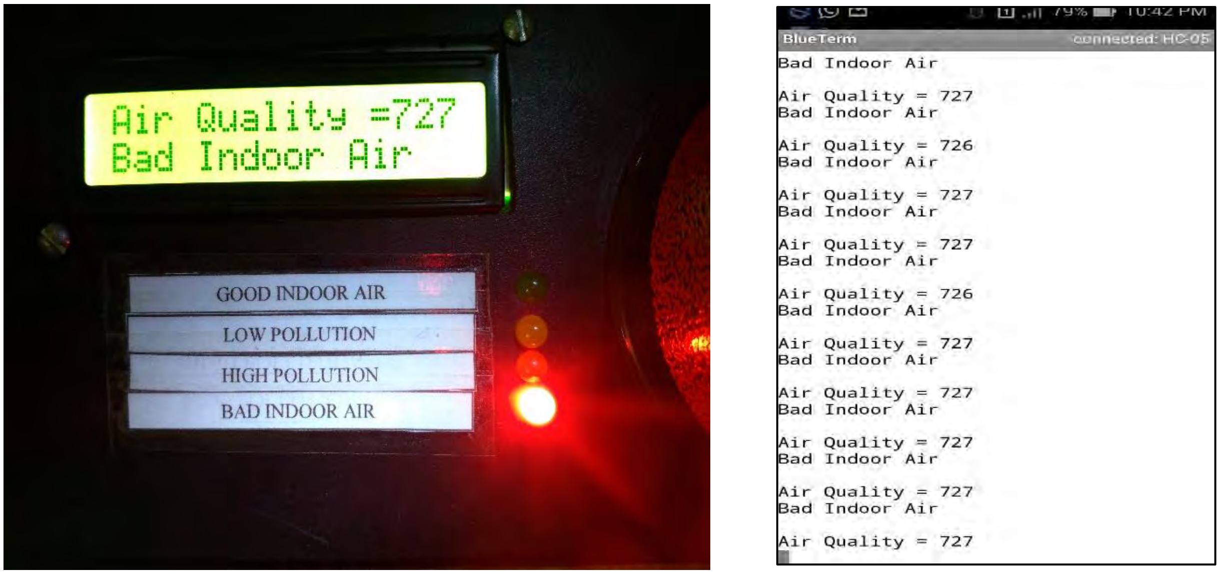


Figure 4.7: “Bad Indoor Air” condition is printed out on the LCD and Smartphone application when the butane gas is decreasing.

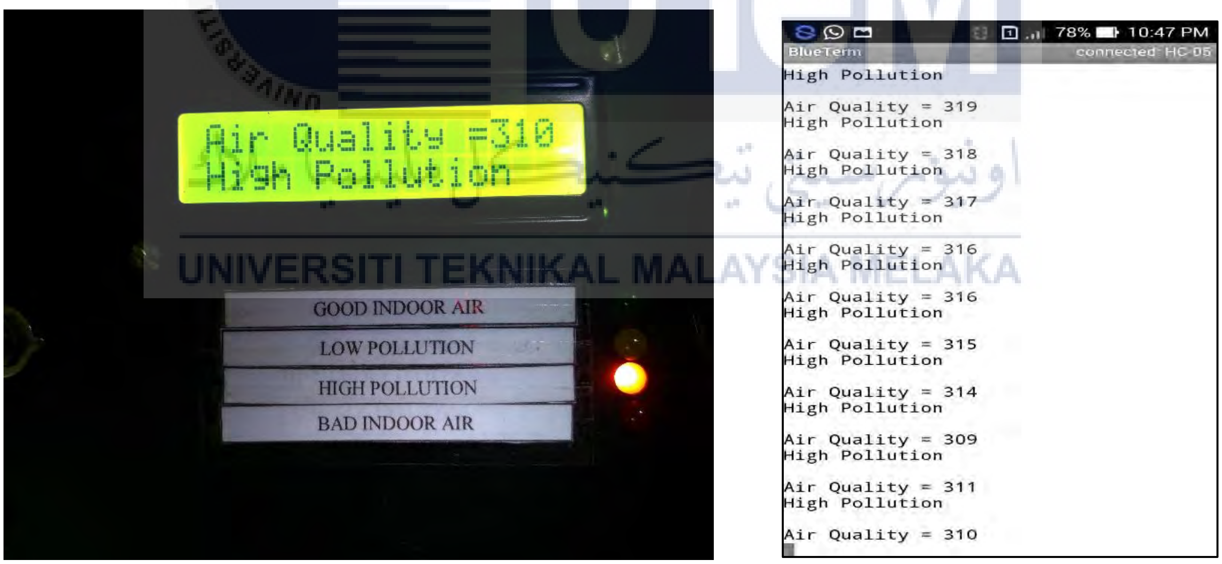


Figure 4.8: The condition change to “High Pollution” after 3 second and printed out the condition on the LCD and Smartphone application.

Figure 4.9: The condition change to “Low Pollution” after 3 second and printed out the condition on the LCD and Smartphone application.

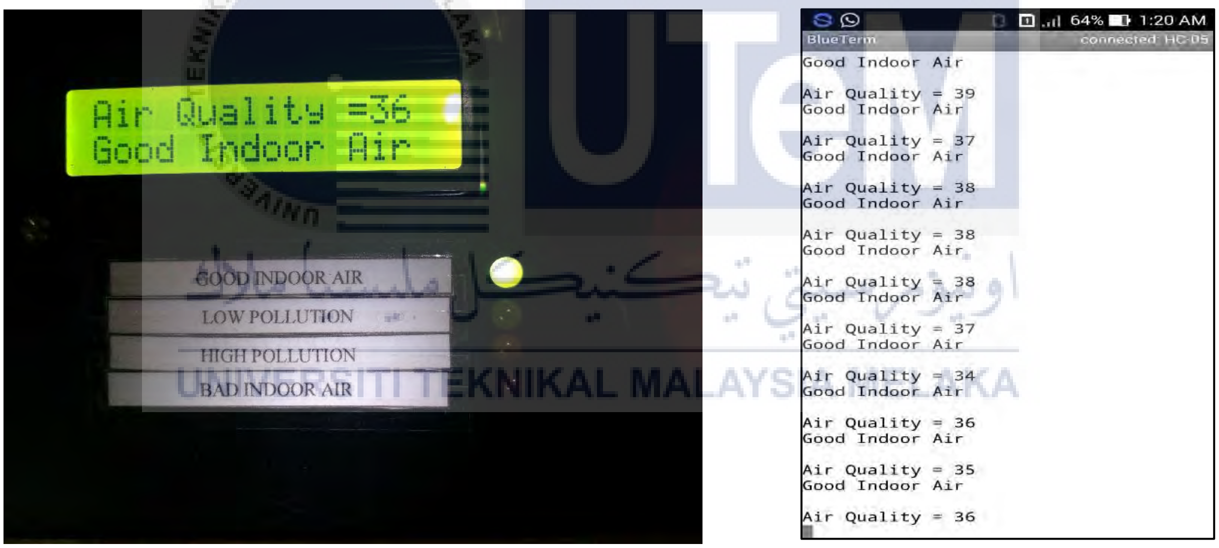


Figure 4.10: The condition change to “Good Indoor Air” after 1 second and printed out the condition on the LCD and Smartphone application.

Table 4.2: Data collected for decreasing butane gas.

No of Test	Indoor Air Condition	Time of detection
1	Bad Indoor Air	Butane gas still exist.
	High Pollution	After 3 second from previous detection

	Low Pollution	After 3 second from previous detection
	Good Indoor Air	After 1 second from previous detection
2	Bad Indoor Air	Butane gas still exist.
	High Pollution	After 3 second from previous detection
	Low Pollution	After 2 second from previous detection
	Good Indoor Air	After 2 second from previous detection
3	Bad Indoor Air	Butane gas still exist.
	High Pollution	After 4 second from previous detection
	Low Pollution	After 3 second from previous detection
	Good Indoor Air	After 2 second from previous detection
4	Bad Indoor Air	Butane gas still exist.
	High Pollution	After 3 second from previous detection
	Low Pollution	After 2 second from previous detection
	Good Indoor Air	After 2 second from previous detection

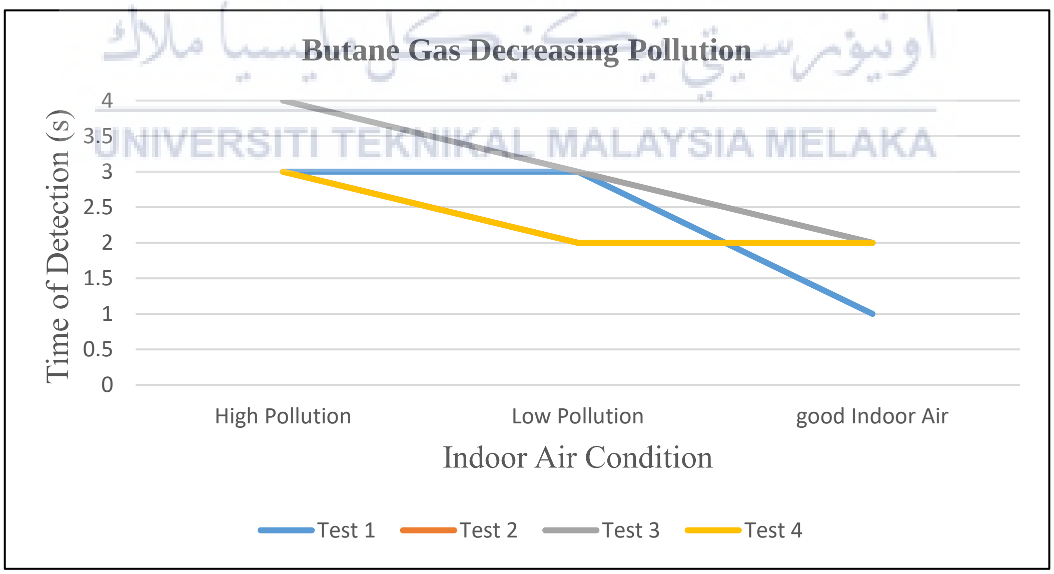


Figure 4.11: Graph for time of detection versus indoor air condition when decreasing butane gas.

For decreasing butane gas, table 4.2 showed the condition of the system when the butane gas decrease by the action of DC fan and blind window. The time taken for changing from “Bad Indoor Air” to become “Good Indoor Air” is short because the DC fan is close with the place where butane gas was released. When the DC fan operate, it right away remove the butane gas, hence the time for decreasing butane gas. Graph from figure 4.11 showed that all test achieved the objective of testing. Only test 2 and test 4 have the same result and other test also showing good result. Moreover, the short time taken recorded proved the effectiveness of the system to clear out the pollute air.

4.2.2 Cigarette Smoke Testing

One of the reason why indoor air of residential house is polluted is because the smoke came from burning cigarette. The hazard form cigarette smoke will harm not only the smoker but also the nonsmoker. This is because both smoker and nonsmoker will inhale the polluted indoor air. Therefore, the indoor air should be clean and not polluted. The cigarette is light for 30 second. The data is observed and collected.

Figure 4.12: Cigarette smoke testing is conducted.

Figure 4.13: “Good Indoor Air” condition is printed out on the LCD and Smartphone application before the presence of cigarette smoke.

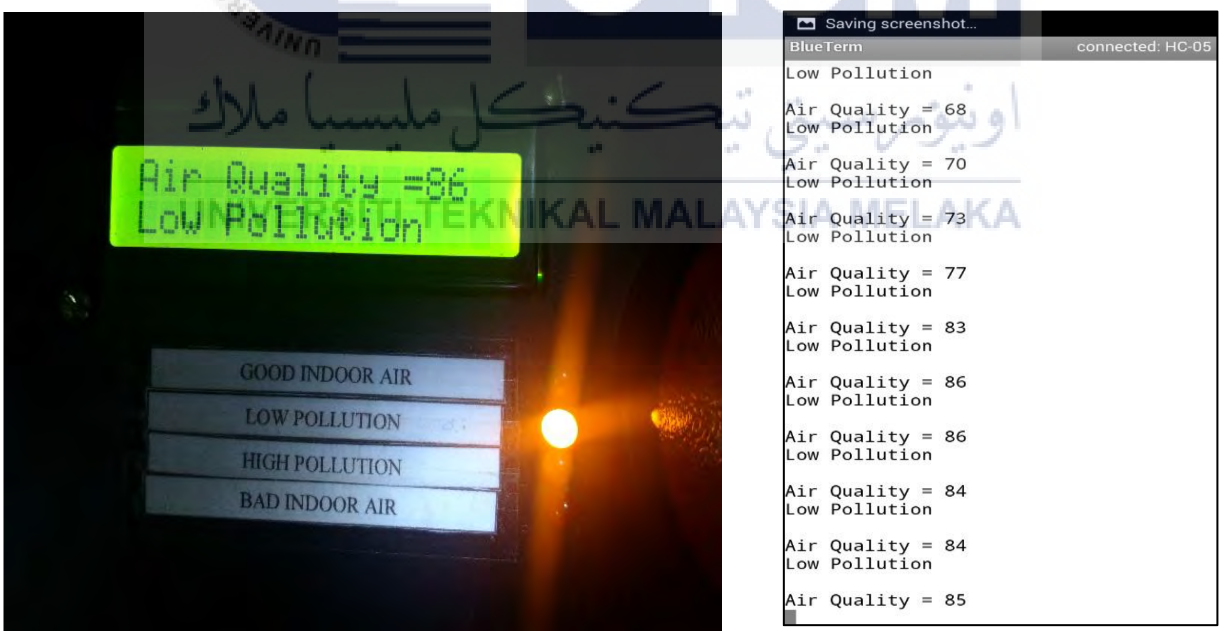


Figure 4.14: The condition change to “Low Pollution” after 3 second and printed out the condition on the LCD and Smartphone application.

Figure 4.15: The condition change to “High Pollution” after 5 second and printed out the condition on the LCD and Smartphone application

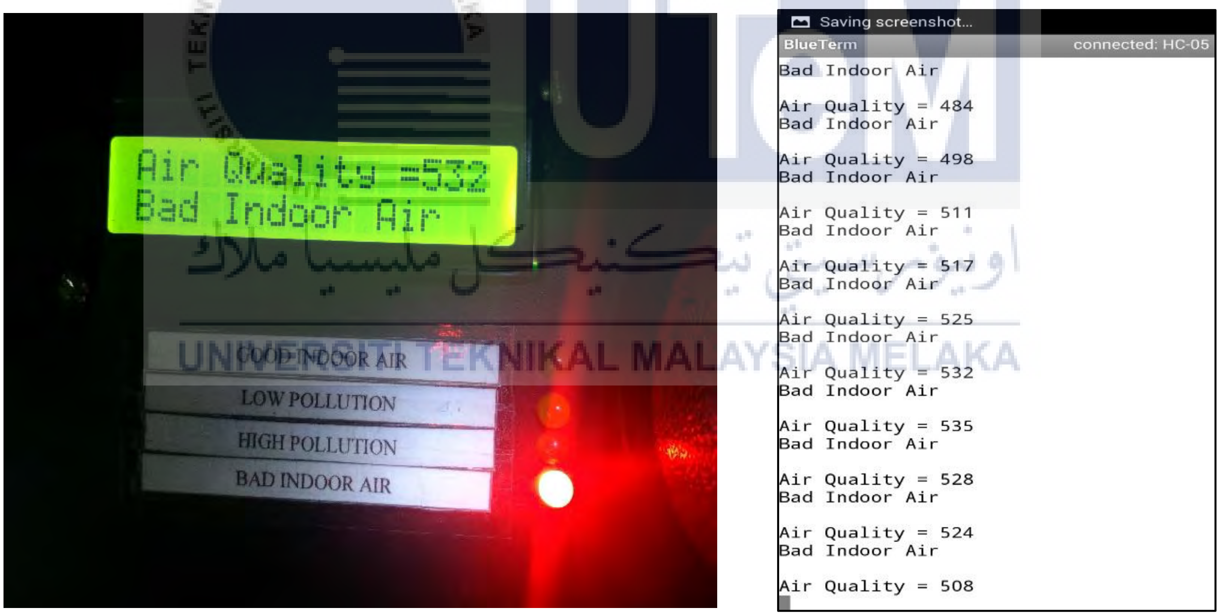


Figure 4.16: The condition change to “Bad Indoor Air” after 6 second and printed out the condition on the LCD and Smartphone application.

Table 4.3: Data collected for increasing cigarette smoke.

No of Test	Indoor Air Condition	Time of detection
1	Good Indoor Air	Before the existence of cigarette smoke

	Low Pollution	After 3 second from previous detection
	High Pollution	After 5 second from previous detection
	Bad Indoor Air	After 6 second from previous detection
2	Good Indoor Air	Before the existence of cigarette smoke
	Low Pollution	After 4 second from previous detection
	High Pollution	After 5 second from previous detection
	Bad Indoor Air	After 7 second from previous detection
3	Good Indoor Air	Before the existence of cigarette smoke
	Low Pollution	After 3 second from previous detection
	High Pollution	After 4 second from previous detection
	Bad Indoor Air	After 6 second from previous detection
4	Good Indoor Air	Before the existence of cigarette smoke
	Low Pollution	After 3 second from previous detection
	High Pollution	After 3 second from previous detection
	Bad Indoor Air	After 5 second from previous detection

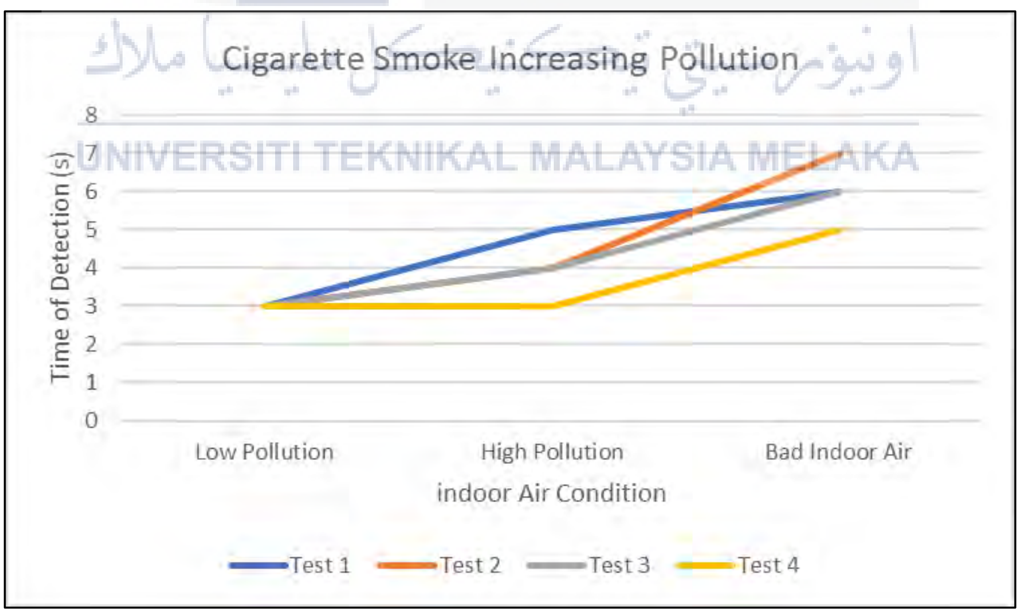


Figure 4.17: Graph for time of detection versus indoor air condition when increasing cigarette smoke.

For increasing cigarette smoke, table 4.3 showed the air condition when there is existence of cigarette smoke. The initial condition is in “Good Indoor Air”, then the condition change as in table 4.3. The time taken of the condition changes has be recorded. Moreover, test 3 and test 1 showed same time taken for the condition change from “Good Indoor Air” to “Low Pollution” and “High Pollution” to “Bad Indoor Air”. As shown in figure 4.17, others test also showed good response form the sensor by observing the time taken.

Figure 4.18: “Bad Indoor Air” condition is printed out on the LCD and Smartphone application when the cigarette is decreasing.

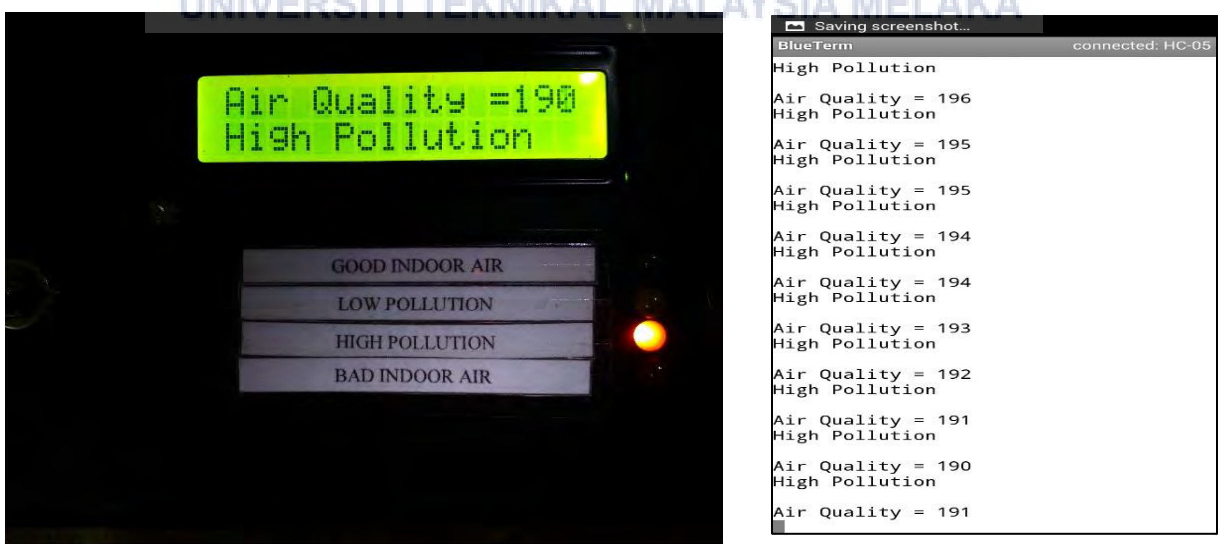


Figure 4.19: The condition change to “High Pollution” after 4 second and printed out the condition on the LCD and Smartphone application.

Figure 4.20: The condition change to “Low Pollution” after 2 second and printed out the condition on the LCD and Smartphone application.

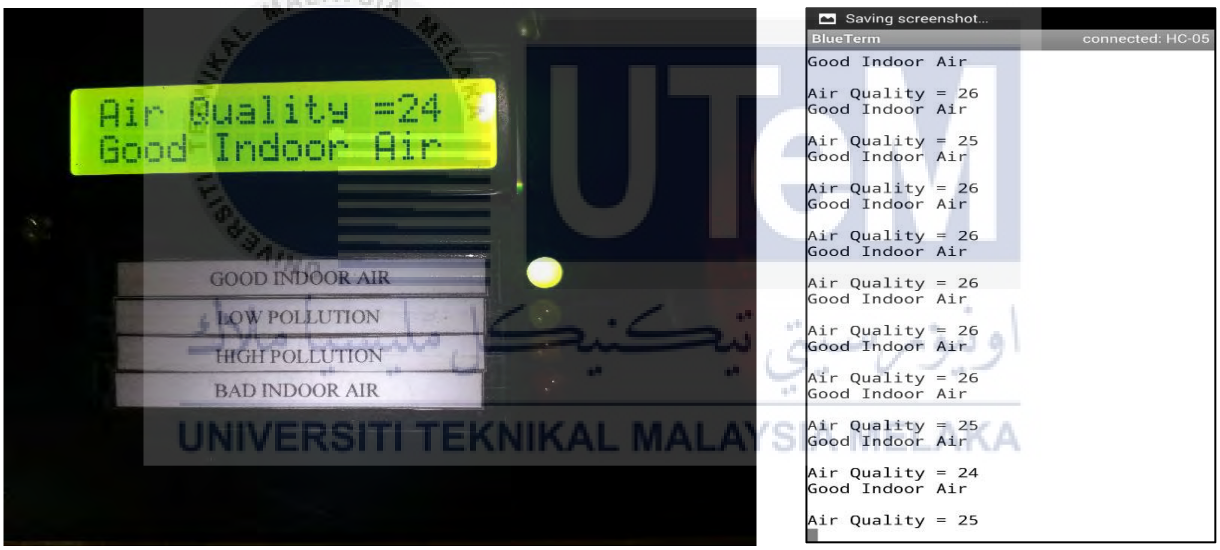


Figure 4.21: The condition change to “Good Indoor Air” after 1 second and printed out the condition on the LCD and Smartphone application.

Table 4.4: Data collected for decreasing cigarette smoke.

No of Test	Indoor Air Condition	Time of detection
1	Bad Indoor Air	Cigarette smoke still exist.
	High Pollution	After 4 second from previous detection
	Low Pollution	After 2 second from previous detection

	Good Indoor Air	After 1 second from previous detection
2	Bad Indoor Air	Cigarette smoke still exist.
	High Pollution	After 5 second from previous detection
	Low Pollution	After 3 second from previous detection
	Good Indoor Air	After 1 second from previous detection
3	Bad Indoor Air	Cigarette smoke still exist.
	High Pollution	After 5 second from previous detection
	Low Pollution	After 4 second from previous detection
	Good Indoor Air	After 2 second from previous detection
4	Bad Indoor Air	Cigarette smoke still exist.
	High Pollution	After 6 second from previous detection
	Low Pollution	After 4 second from previous detection
	Good Indoor Air	After 2 second from previous detection

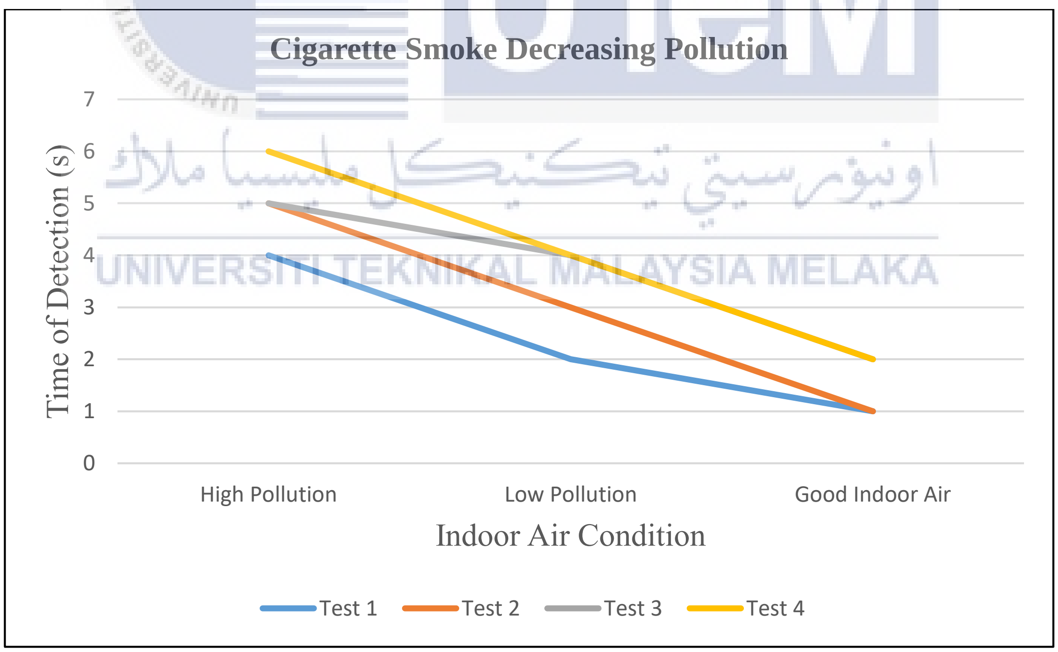


Figure 4.22**:** Graph for time of detection versus indoor air condition when decreasing cigarette smoke.

For decreasing cigarette smoke, table 4.4 showed the condition of when the system tried to remove the polluted air cause by cigarette smoke. The DC fan and window blind operate perfectly to remove the polluted air as can the time taken can be observed in table 4.4. When the condition other than "Good Indoor Air", the DC fan and window blind operated and the time taken is recorded in table 4.4. Other than that, figure 4.22 showed the graph both test 1 and test 2, and test 3 and test 4 has same time taken to reach "Good Indoor Air" condition. This showed that the DC fan and window blind helped to remove the polluted air.

4.2.3 Carbon Monoxide Testing

Carbon monoxide can be found in vehicle smoke. It is produce when operating a stove or an internal combustion engine in an enclosed space. It is colourless, odorless and tasteless gas. It can harm the occupant who are expose to carbon monoxide. The occupant will have a severe headache, influenza, nausea and many more. This testing is held by testing with motorcycle exhaust smoke for 1 minutes because there is presence of carbon monoxide in it. The data is observed and recorded.

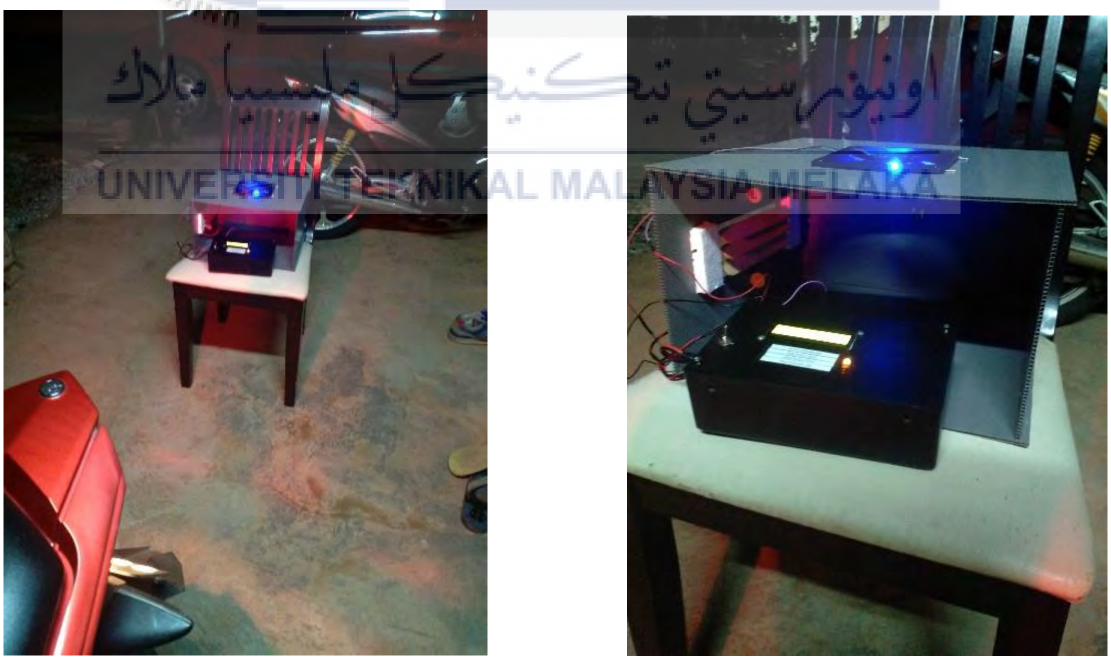


Figure 4.23: Carbon monoxide testing is conducted.

Figure 4.24: "Good Indoor Air" condition is printed out on the LCD and Smartphone application before the presence of carbon monoxide.

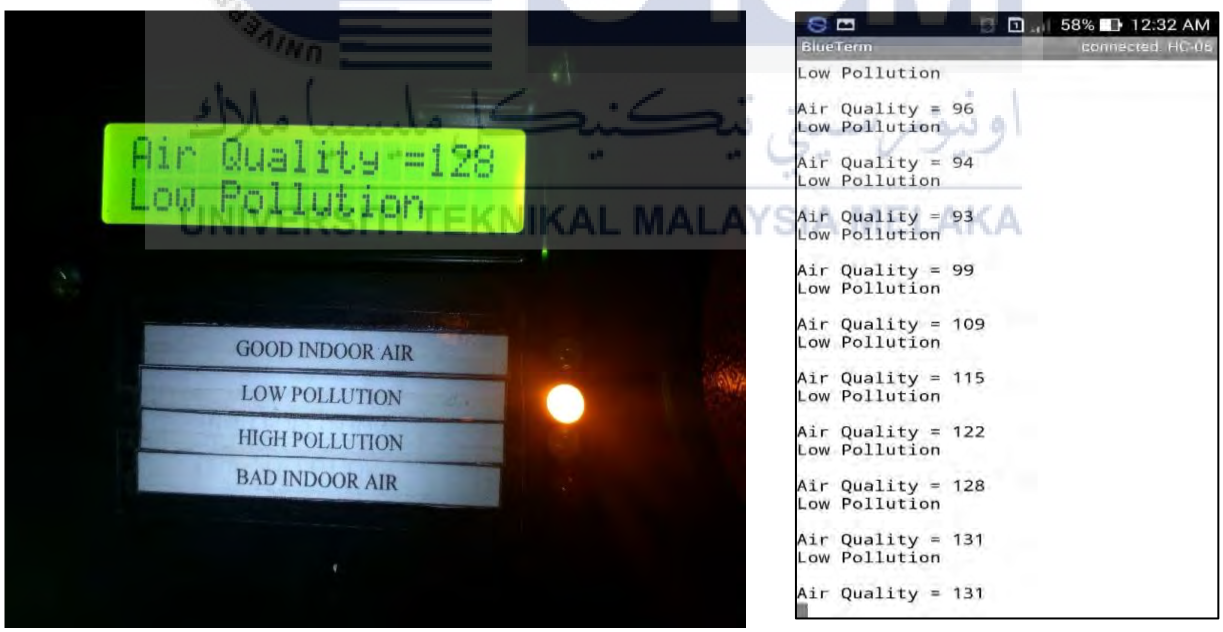


Figure 4.25: The condition change to "Low Pollution" after 6 second and printed out the condition on the LCD and Smartphone application.

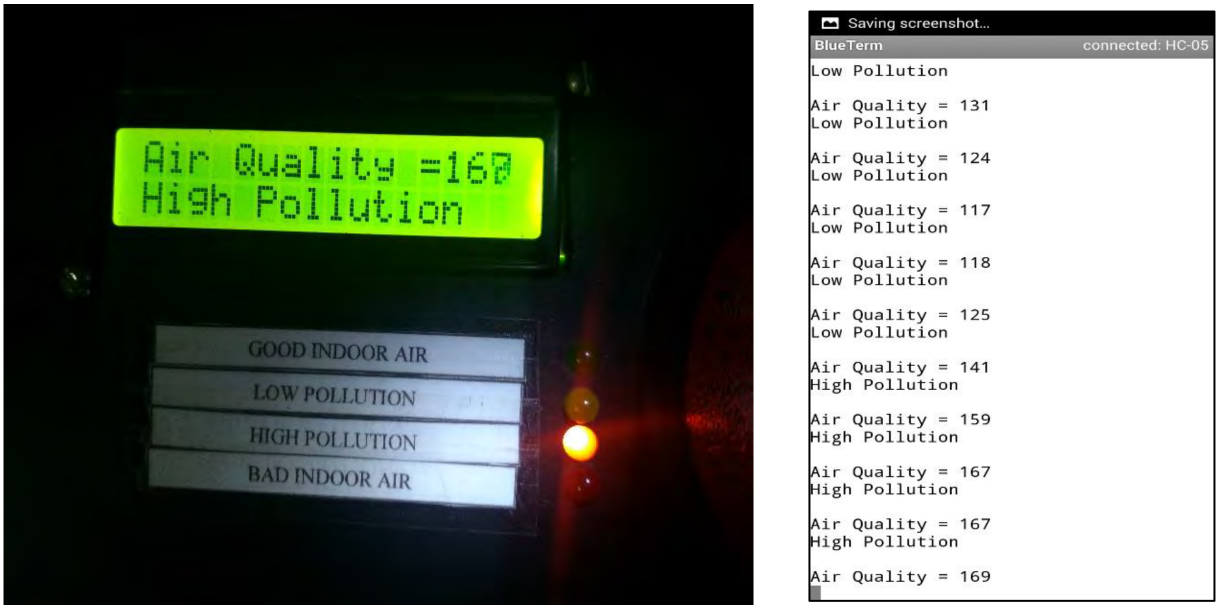


Figure 4.26: The condition change to "High Pollution" after 13 second and printed out the condition on the LCD and Smartphone application.

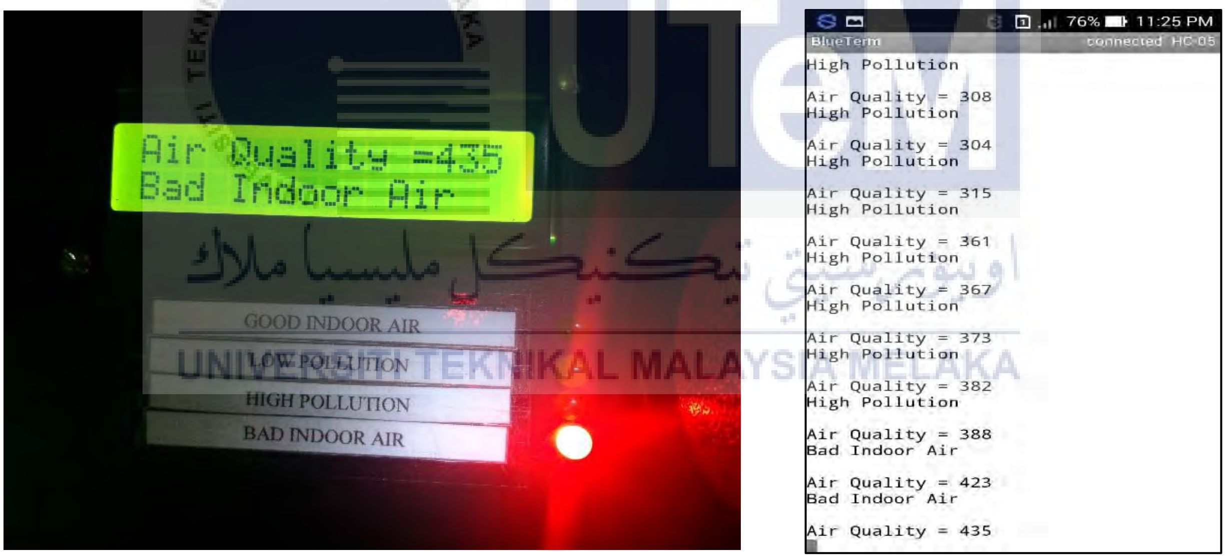


Figure 4.27: The condition change to "Bad Indoor Air" after 15 second and printed out the condition on the LCD and Smartphone application.

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Table 4.5: Data collected for increasing carbon monoxide.

No of Test	Indoor Air Condition	Time of detection
1	Good Indoor Air	Before the existence of carbon monoxide

	Low Pollution	After 6 second from previous detection
	High Pollution	After 13 second from previous detection
	Bad Indoor Air	After 15 second from previous detection
2	Good Indoor Air	Before the existence of carbon monoxide
	Low Pollution	After 5 second from previous detection
	High Pollution	After 14 second from previous detection
	Bad Indoor Air	After 15 second from previous detection
3	Good Indoor Air	Before the existence of carbon monoxide
	Low Pollution	After 8 second from previous detection
	High Pollution	After 16 second from previous detection
	Bad Indoor Air	After 14 second from previous detection
4	Good Indoor Air	Before the existence of carbon monoxide
	Low Pollution	After 9 second from previous detection
	High Pollution	After 11 second from previous detection
	Bad Indoor Air	After 13 second from previous detection

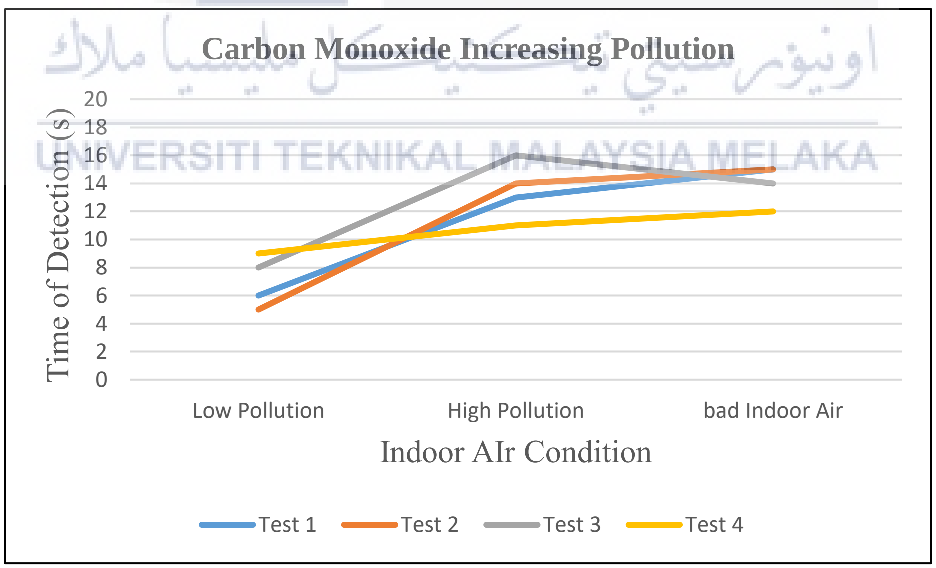

Figure 4.28: Graph for time of detection versus indoor air condition when increasing carbon monoxide.

For increasing carbon monoxide, table 4.5 showed the indoor air condition when there is presence of carbon monoxide. The time taken for test 1 and test 2 showed a difference of 1 second for “Low Pollution” and “High Pollution” condition but have same taken for “Bad Indoor Air” condition. Other than that, test 3 and test 4 have a different time taken to reach “Bad Indoor Air” because the DC fan already remove some of the carbon monoxide. The differences of each test can be seen in figure 4.28.

Figure 4.29: “Bad Indoor Air” condition is printed out on the LCD and Smartphone application when the carbon monoxide is decreasing

Figure 4.30: The condition change to “High Pollution” after 8 second and printed out the condition on the LCD and Smartphone application

Figure 4.31: The condition change to "Low Pollution" after 3 second and printed out the condition on the LCD and Smartphone application

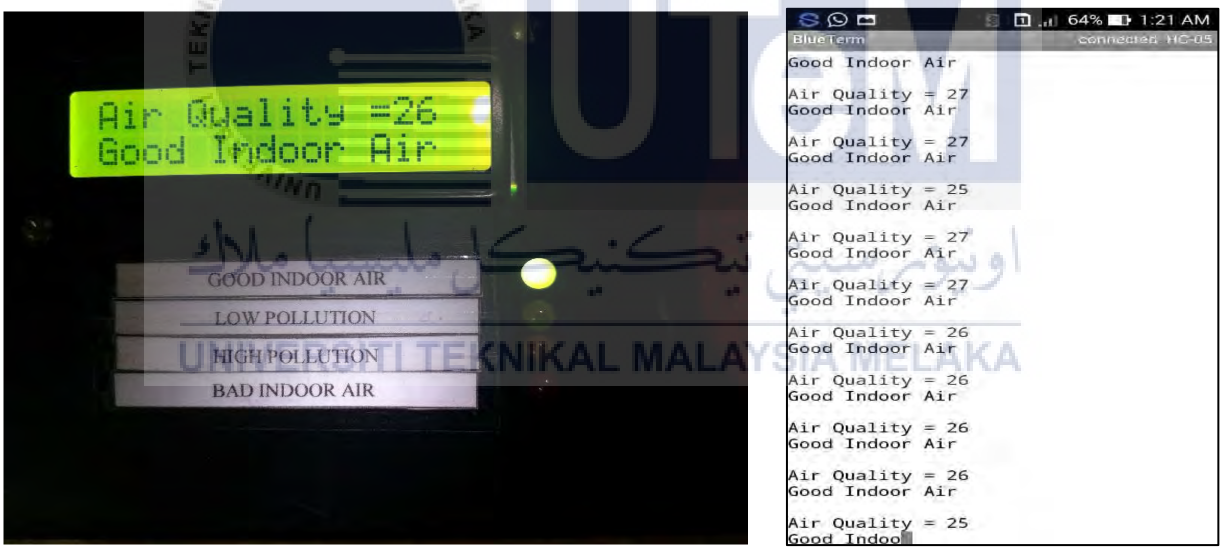

Figure 4.32: The condition change to "Good Indoor Air" after 1 second and printed out the condition on the LCD and Smartphone application

Table 4.6: Data collected for decreasing carbon monoxide

No of Test	Indoor Air Condition	Time of detection
1	Bad Indoor Air	Carbon monoxide still exist.

	High Pollution	After 8 second from previous detection
	Low Pollution	After 3 second from previous detection
	Good Indoor Air	After 1 second from previous detection
2	Bad Indoor Air	Carbon monoxide still exist.
	High Pollution	After 9 second from previous detection
	Low Pollution	After 5 second from previous detection
	Good Indoor Air	After 3 second from previous detection
3	Bad Indoor Air	Carbon monoxide still exist.
	High Pollution	After 8 second from previous detection
	Low Pollution	After 5 second from previous detection
	Good Indoor Air	After 2 second from previous detection
4	Bad Indoor Air	Carbon monoxide still exist.
	High Pollution	After 6 second from previous detection
	Low Pollution	After 2 second from previous detection
	Good Indoor Air	After 1 second from previous detection

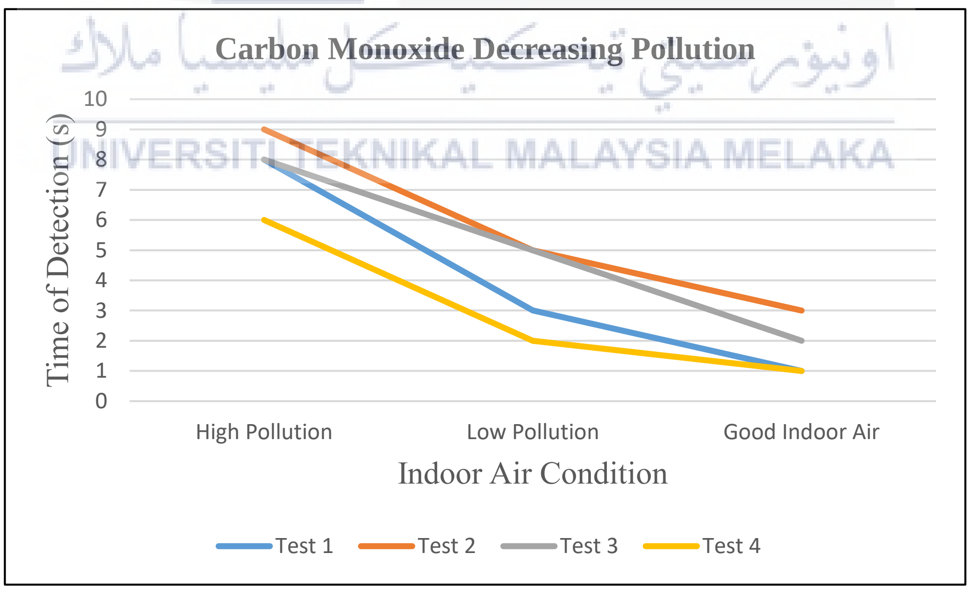

Figure 4.33: Graph for time of detection versus indoor air condition when decreasing carbon monoxide.

For decreasing carbon monoxide, table 4.6 showed the condition of when the system tried to remove the polluted air cause by carbon monoxide. The time taken as in table 4.6 is helped by DC fan and window blind when the operate in all condition expect “Good Indoor Air” condition. Other than that, figure 4.33 showed the graph where test 1 and test 4 has same time and time taken to reach “Good Indoor Air” condition. This showed that the DC fan and window blind helped to remove the carbon monoxide.

4.2.4 Bug Spray Testing

Bug spray is used by the occupant to kill small insect such as mosquito, ant and many more. Bug spray is dangerous because it contains pyrethrins. It is generally considered nonpoisonous bit it can cause breathing problem if breath in large amount. For this testing, the bug spray is sprayed onto a piece of paper. The paper is placed for 20 second. The data is observed and recorded.

Figure 4.34: Bug spray testing is conducted.

Figure 4.35: "Good Indoor Air" condition is printed out on the LCD and Smartphone application before the presence of bug spray.

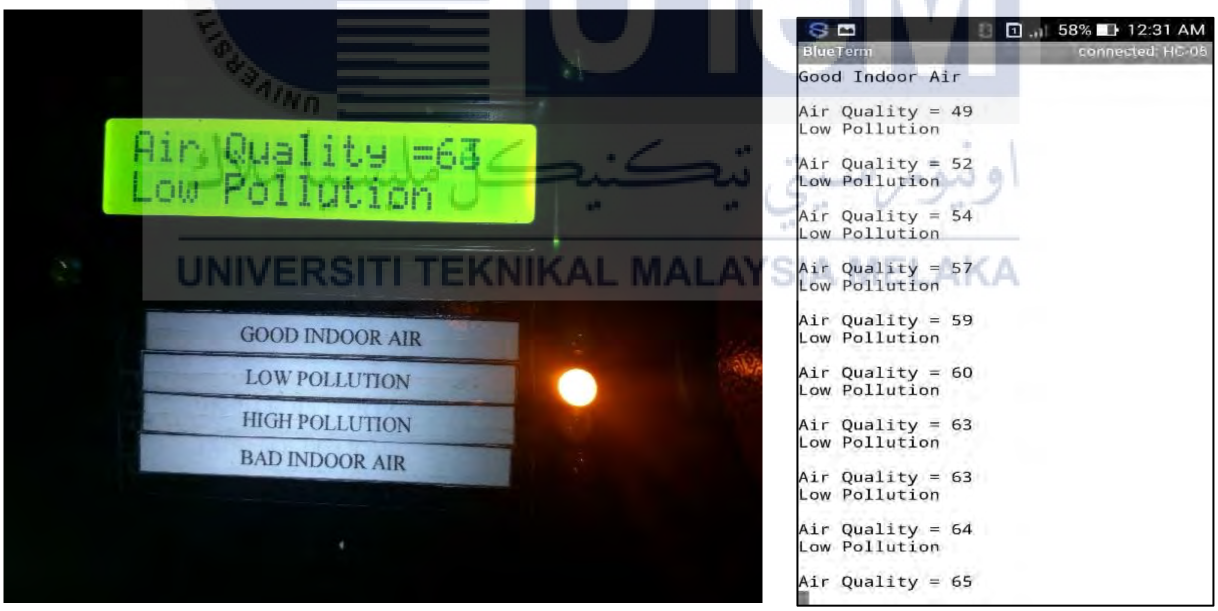

Figure 4.36: The condition change to "Low Pollution" after 4 second and printed out the condition on the LCD and Smartphone application.

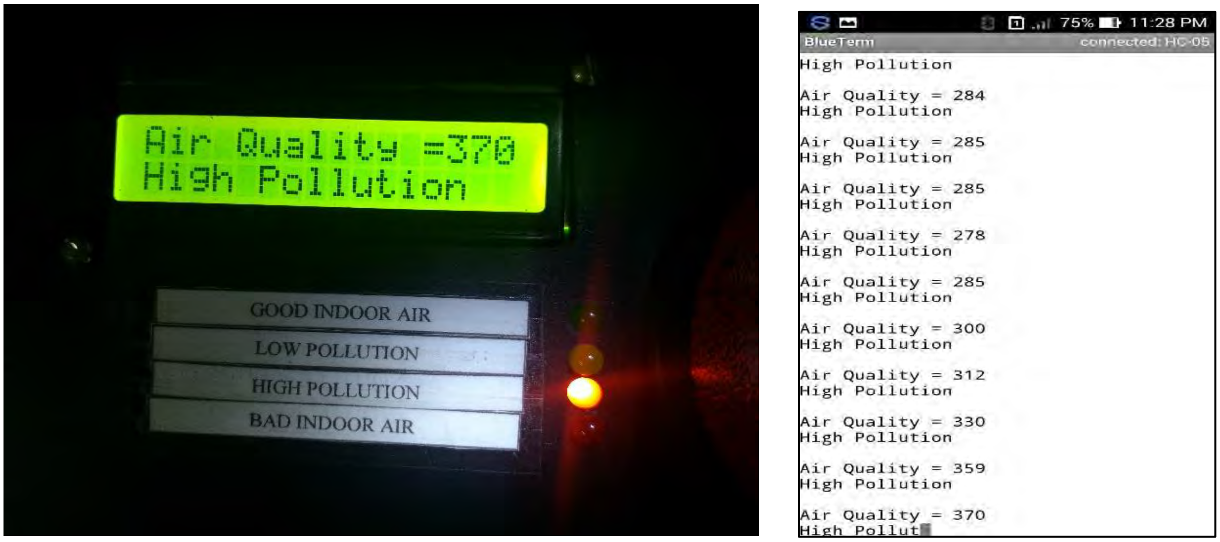

Figure 4.37: The condition change to “High Pollution” after 5 second and printed out the condition on the LCD and Smartphone application.

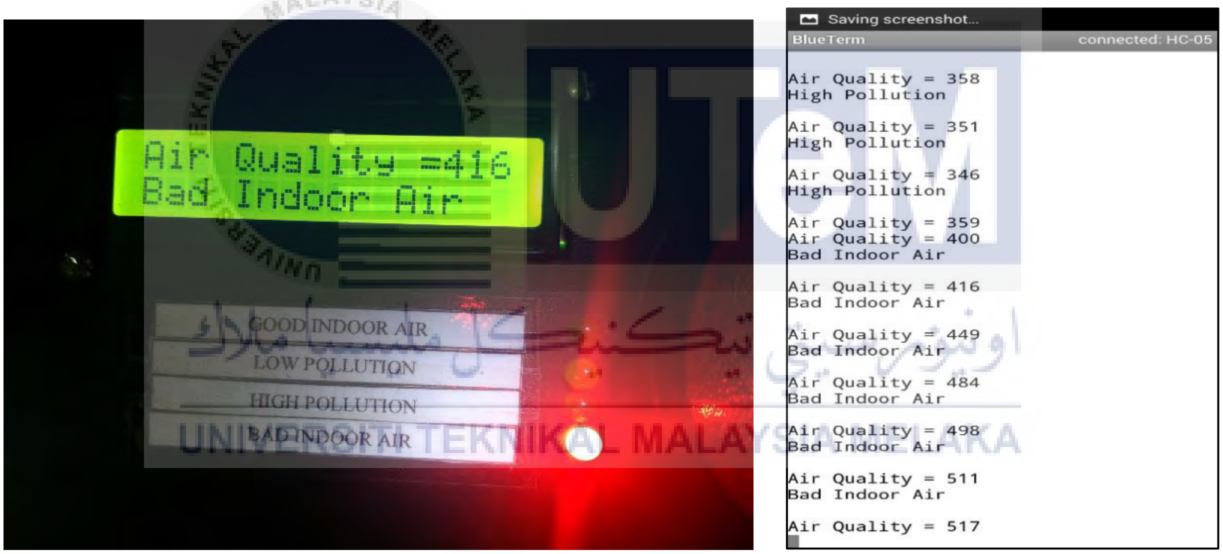

Figure 4.38: The condition change to “Bad Indoor Air” after 3 second and printed out the condition on the LCD and Smartphone application.

Table 4.7: Data collected for increasing bug spray.

No of Test	Indoor Air Condition	Time of detection
1	Good Indoor Air	Before the existence of bug spray
	Low Pollution	After 4 second from previous detection
	High Pollution	After 5 second from previous detection

	Bad Indoor Air	After 5 second from previous detection
2	Good Indoor Air	Before the existence of bug spray
	Low Pollution	After 3 second from previous detection
	High Pollution	After 4 second from previous detection
	Bad Indoor Air	After 6 second from previous detection
3	Good Indoor Air	Before the existence of bug spray
	Low Pollution	After 3 second from previous detection
	High Pollution	After 5 second from previous detection
	Bad Indoor Air	After 6 second from previous detection
4	Good Indoor Air	Before the existence of bug spray
	Low Pollution	After 4 second from previous detection
	High Pollution	After 5 second from previous detection
	Bad Indoor Air	After 6 second from previous detection

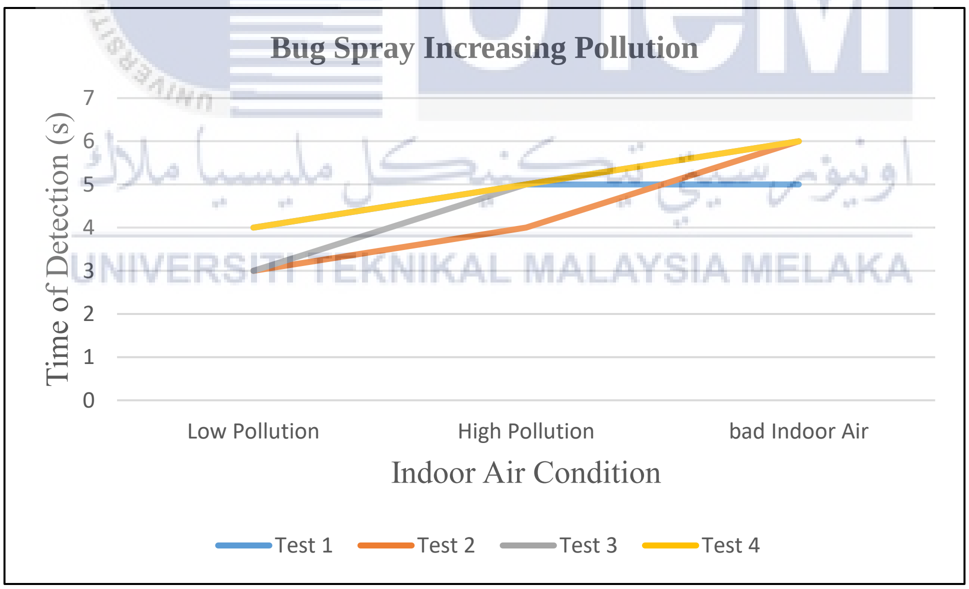

Figure 4.39: Graph for time of detection versus indoor air condition when increasing bug spray.

For increasing bug spray, table 4.7 showed the condition when there is presence of bug spray. The time taken for all test have difference of just 1 second with each other. The time taken showed that test 2 and test 4 have the same time taken at “Bad Indoor Condition”. Test 1, test 3 and test 4 also have same time taken to reach “High Pollution”. The differences between each test can be seen in figure 4.39.

Figure 4.40: “Bad Indoor Air” condition is printed out on the LCD and Smartphone application when the bug spray is decreasing.

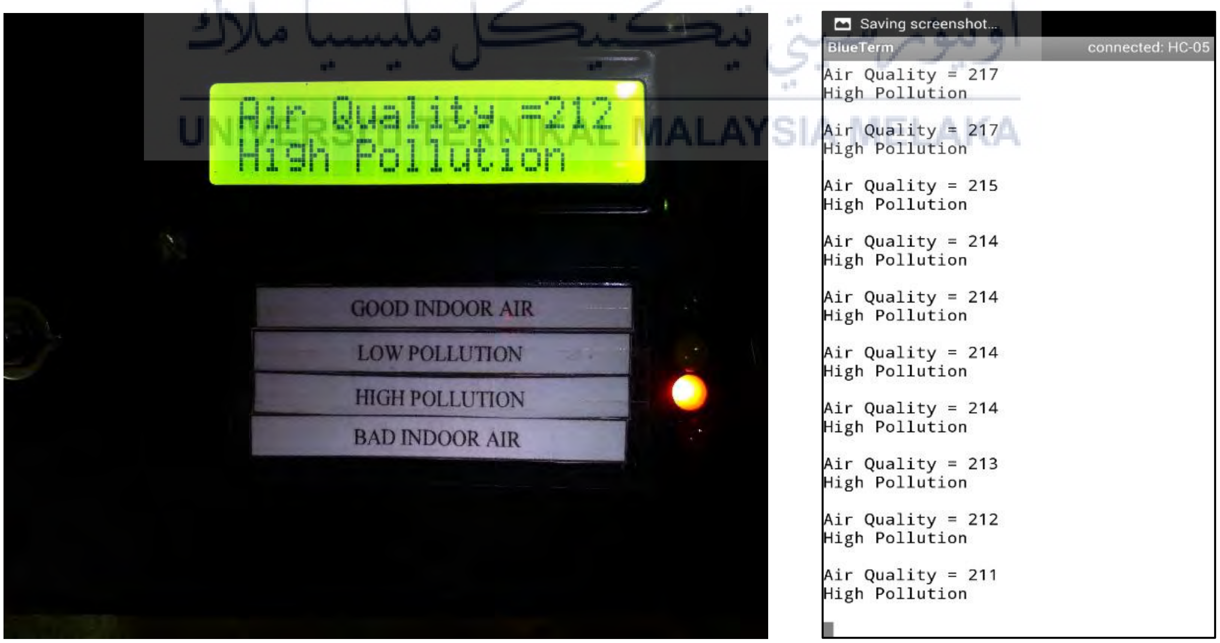

Figure 4.41: The condition change to “High Pollution” after 3 second and printed out the condition on the LCD and Smartphone application.

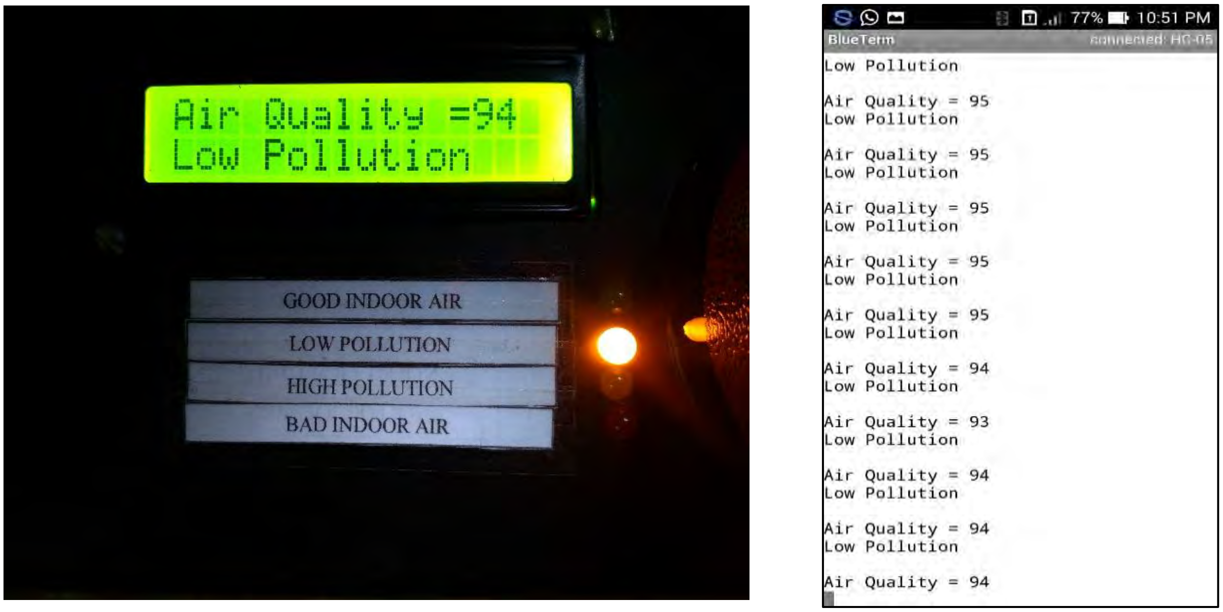

Figure 4.42: The condition change to “Low Pollution” after 3 second and printed out the condition on the LCD and Smartphone application.

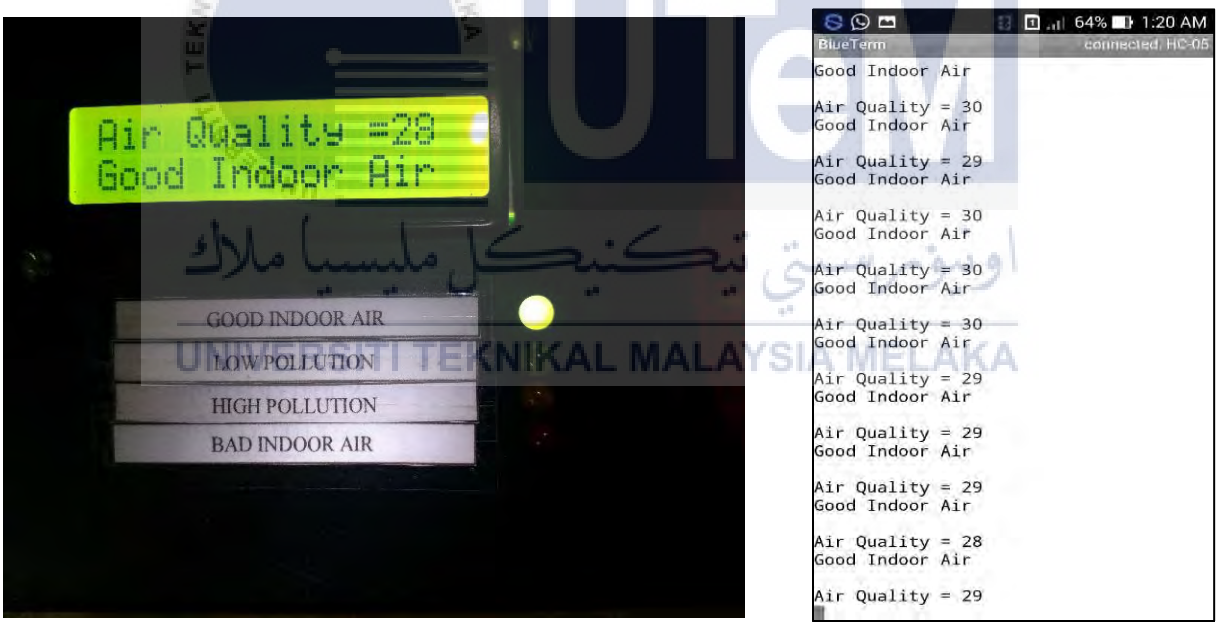

Figure 4.43: The condition change to “Good Indoor Air” after 1 second and printed out the condition on the LCD and Smartphone application.

Table 4.8: Data collected for decreasing bug spray.

No of Test	Indoor Air Condition	Time of detection
1	Bad Indoor Air	Bug spray still exist

	High Pollution	After 3 second from previous detection
	Low Pollution	After 3 second from previous detection
	Good Indoor Air	After 1 second from previous detection
2	Bad Indoor Air	Bug spray still exist
	High Pollution	After 3 second from previous detection
	Low Pollution	After 1 second from previous detection
	Good Indoor Air	After 1 second from previous detection
3	Bad Indoor Air	Bug spray still exist
	High Pollution	After 2 second from previous detection
	Low Pollution	After 1 second from previous detection
	Good Indoor Air	After 1 second from previous detection
4	Bad Indoor Air	Bug spray still exist
	High Pollution	After 3 second from previous detection
	Low Pollution	After 2 second from previous detection
	Good Indoor Air	After 2 second from previous detection

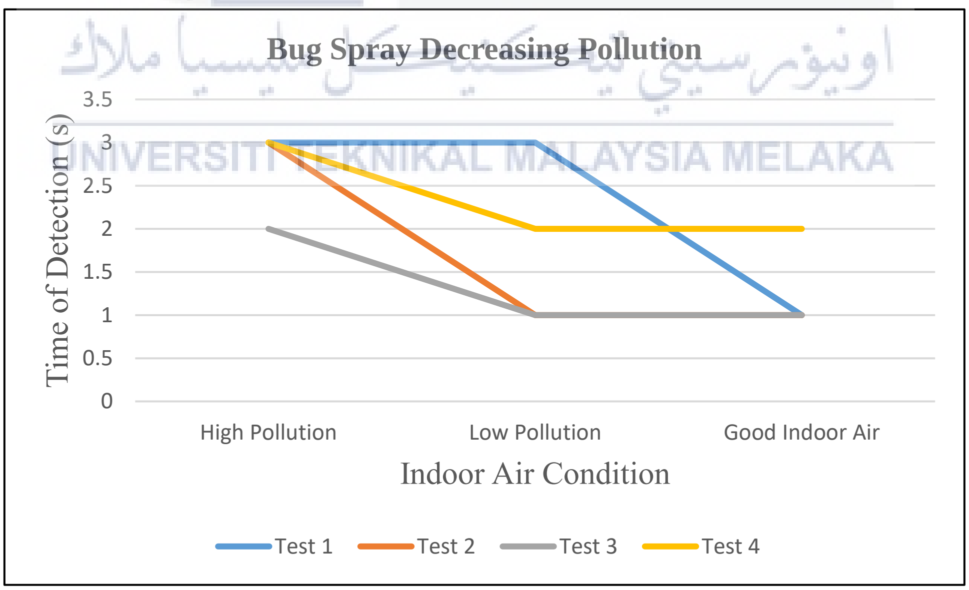

Figure 4.44: Graph for time of detection versus indoor air condition when decreasing bug spray

For decreasing bug spray, table 4.8 showed the condition of when the system is removing the polluted air cause by the bug spray. The DC fan and window blind help to remove the polluted air cause by bug spray as can the time taken can be observed in table 4.8. When the condition other than “Good Indoor Air”, the DC fan and window blind will operate and the time taken is recorded in table 4.8. Other than that, figure 4.8 showed the graph where test 1, test 3 and test 4 has same time taken reach “High Pollution” condition. Other than that, test 1, test 2 and test 3 has same time taken to reach “Good Indoor Air” condition. This showed that the DC fan and window blind helped to remove the polluted air because of the bug spray. The differences between each test can be seen in figure 4.44.

4.3 Summary

From the data that has been observed and collected, the testing of butane gas, cigarette smoke and bug spray showed the effectiveness of the system. The time taken showed that the sensor is sensitive. On the other hand, the time taken for carbon monoxide testing showed that the sensor needed little more time from “Good Indoor Air” to “Bad Indoor Air” condition and “Bad Indoor Air” to “Good Indoor Air” condition compared to other testing.

The operating time, accuracy and the sensitivity can be seen through the graph as all testing showed good response of time taken at all condition. All four test for each testing has the pattern of graph and this conclude that the operating time, accuracy and the sensitivity of this project is compelling.

The DC fan and window blind are represented as the smart air ventilation system of this project. The automated air ventilation system worked perfectly when the indoor air at all condition except at “Good Indoor Air” condition, thus completing this whole project.

CHAPTER 5

CONCLUSION

5.1 Introduction

This section examines the conclusion and recommends future work to further enhance the improvement of the framework. It additionally focuses on the importance and potential application from the research output.

5.2 Conclusion

This project had been successfully done and achieved all the objectives. First and foremost, this project was designed to enable the occupant to monitor their Indoor Air Quality (IAQ) through the device and via smart phone application wirelessly. This system used Android smartphone and Bluetooth connection as the communication interface between the Arduino microcontroller and the indoor air quality sensor.

There is various type of way to mitigate the poor IAQ in residential house. By using air quality monitoring device is one of the methods used to monitor the IAQ level, thus it can be low cost and affordable. Since the device in the market nowadays is quite expensive, therefore this project is carried out. Moreover, the success of new intelligence automated ventilation system to operate at certain IAQ condition, have make the objectives are achieved.

Besides that, the sensitivity of the air quality sensor that is used to detect the IAQ level, helped to detect the existence of pollutants in the air. Moreover, with the help of servo motor and DC fan, the automated air ventilation can be developed. All the sensor and equipment are programed in Arduino for data processing.

The Arduino microcontroller and Android application have been achieved by using the Arduino Integrated Development Environment (IDE) and Bluetooth module. It required only a few of Arduino program code to display the serial monitor into smart phone application. It does not require an expert C language to connect the Arduino with the Bluetooth module.

In today's world, the usage of a Smartphone is becoming prevalence of everyone to fulfil their daily lives. Due to the importance of Smartphone for everyone, this IAQ monitoring device could help the current generation to simplify their lives. Priority is given to the occupant who need an attractive device to replace the existing monitoring device.

As the conclusion, the objectives of this project are achieved. The Sick Building Syndrome (SBS) has been investigate about the causes and ways to mitigate. The new intelligence automated air ventilation system device is developed.

5.3 Future Recommendation

There are some suggestions that are recommended for future work to produce a better device and results. This system could improve to the Internet of Thing (IoT) as the current system can only monitor the IAQ level through the device and via Smartphone application with Bluetooth connection only. With the upgrading to the IoT, this will enable the occupant to monitor their residential house IAQ level anywhere as long they have an internet connection.

In addition, the sensor for this project can be upgrade to more various of gas detection. More dangerous and hazardous gas can be detected to safe the health of the occupant in the residential house. Moreover, the range of the sensor must be expanded so that the sensor can cover more space and less sensor needed.

Besides that, the Smartphone application interface can be more interesting with a beautiful icon and logo. The Smartphone application also can give out notification when there are bad IAQ condition in the residential house. This can alert the occupant more efficiently rather than depending the occupant check the IAQ level by themselves.

The ventilation system can be upgrade to more efficient system, so that it can be installed when the residential house being built. Moreover, type of air ventilation system can be various to make this project more visionary to be commercializes.

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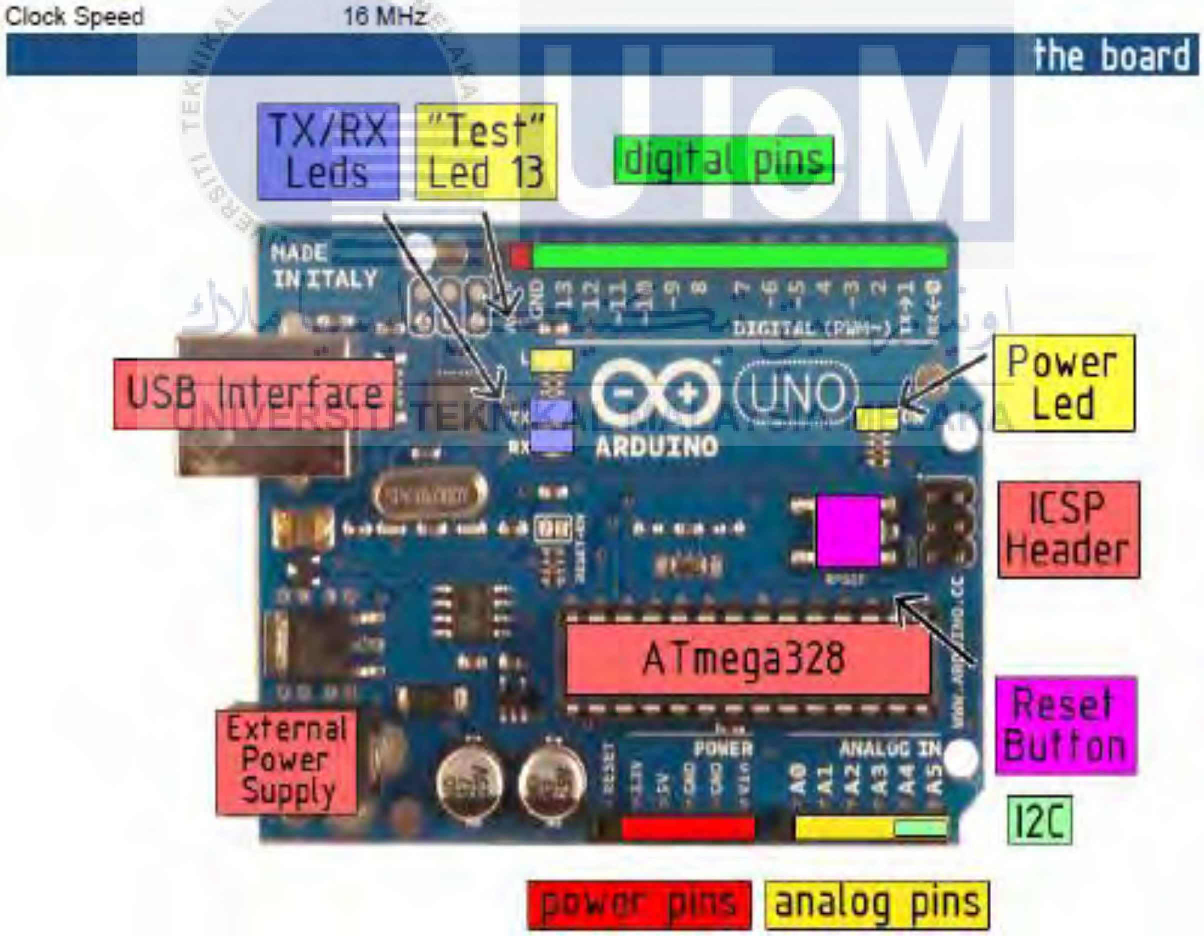
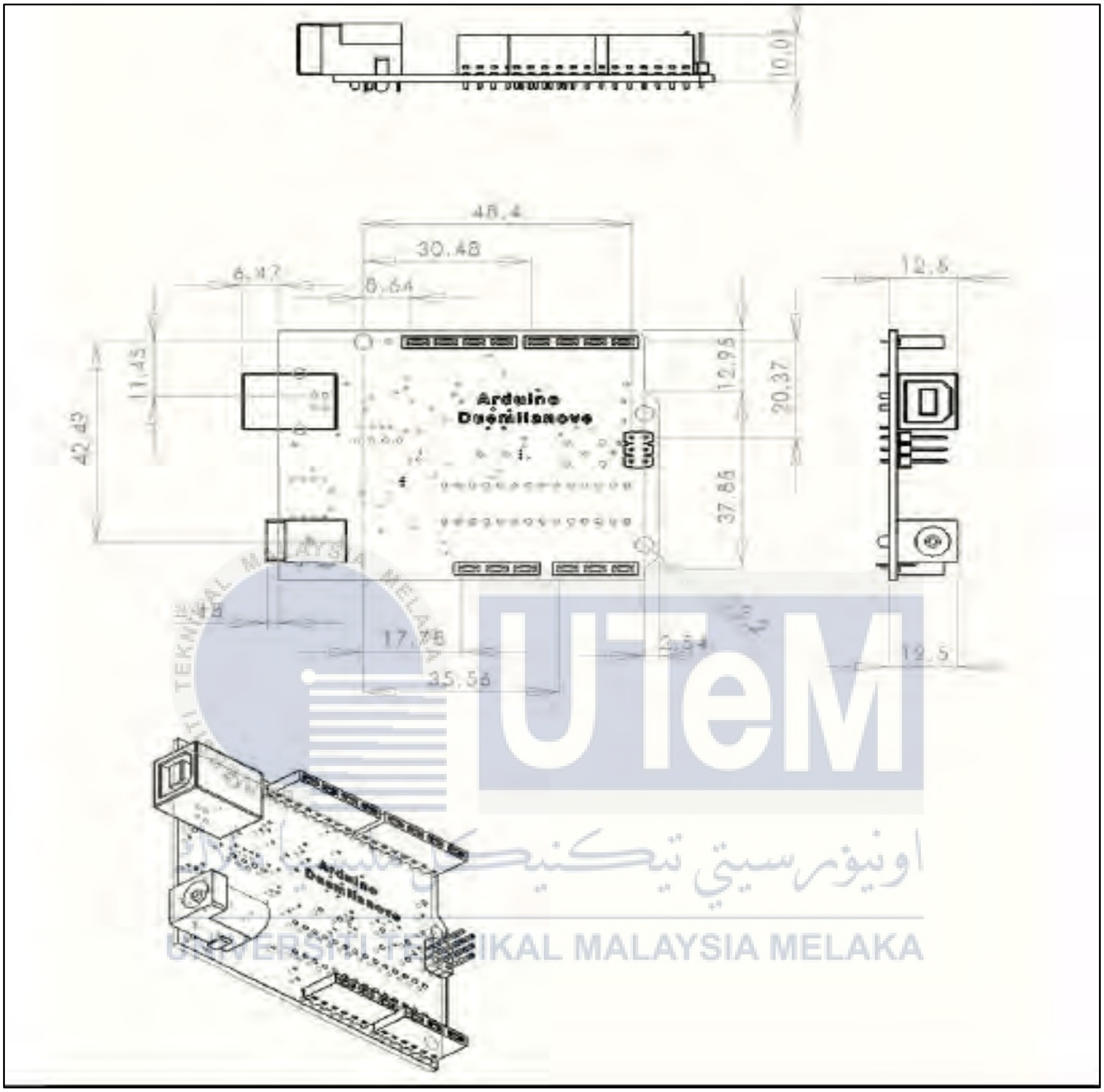
APPENDIX

Arduino Uno R3

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz



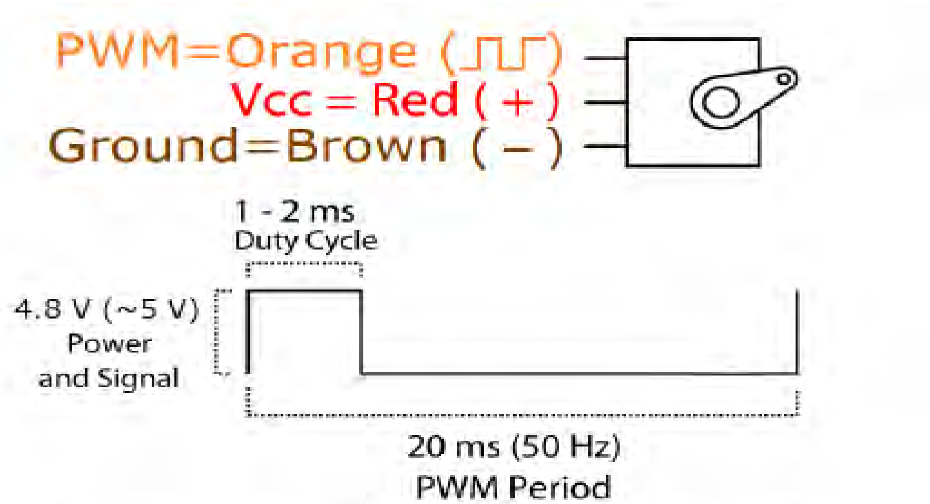

Arduino
Duemilanove
10.0
48.4
30.48
6.47
8.64
12.6
11.45
42.49
12.95
20.37
37.85
17.78
35.56
2.54
12.5

Servo Motor SG90

Tiny and lightweight with high output power. Servo can rotate approximately 180 degrees (90 in each direction), and works just like the standard kinds but *smaller*. You can use any servo code, hardware or library to control these servos. Good for beginners who want to make stuff move without building a motor controller with feedback & gear box, especially since it will fit in small places. It comes with a 3 horns (arms) and hardware.

Specifications

- Weight: 9 g
- Dimension: 22.2 x 11.8 x 31 mm approx.
- Stall torque: 1.8 kgf·cm
- Operating speed: 0.1 s/60 degree
- Operating voltage: 4.8 V (~5V)
- Dead band width: 10 µs
- Temperature range: 0 ºC – 55 ºC



Position "0" (1.5 ms pulse) is middle, "90" (~2 ms pulse) is all the way to the right, "-90" (~1 ms pulse) is all the way to the left.

Air Quality Sensor

Profile

MP503 gas sensor is for air quality. It adopts multilayer thick film manufacturing technology. The heater and metal oxide semiconductor material on the ceramic substrate of subminiature Al_2O_3 are fetched out by electrode down-lead, encapsulated in metal socket and cap. Conductivity of the sensor is affected by the concentration of target gas. The higher the concentration is, the higher conductivity of sensor gets. Users can adopt simple circuit to convert variation of conductivity into output signal corresponding to gas concentration.

Features

High sensitivity to alcohol, smoke, iso-butane, methanal; quick response and resume; low power consumption, simple detection circuit, good stability and long life.

Main Application

It is used in occasions such as household and office for harmful gas detection, automatic exhaust device, air cleaner&etc.

Technical Parameters Stable1.

Model			MP503
Sensor Type			flat surfaced semiconductor sensor
Standard Encapsulation			Metal Cap
Detection Gas			Alcohol, Smoke,iso-butane,methanal
Detection range			10~1000ppm(Alcohol)
Standard circuit	Loop voltage	V_C	≤24V DC
	Heating voltage	V_H	5.0V±0.1V AC or DC
	Load resistance	R_L	Adjustable
sensor features in standard test condition	Heating resistance	R_H	35Ω±10Ω (Room Tem.)
	Heating consumption	P_H	≤300mW
	Surface resistance	R_S	1KΩ~30KΩ(in 50ppm Alcohol)
	Sensitivity	S	Rs(in air)/Rs(in 50ppm Alcohol)≥5
	Concentration slope	α	≤0.6(R_{100ppm}/$R_{50ppm\ alcohol}$)
Standard condition of test	Temperature, humidity		20℃±2℃; 65%±5%RH
	Standard test circuit		V_C:5.0V±0.1V; V_H:5.0V±0.1V
	Warm-up time		More than 48 hours

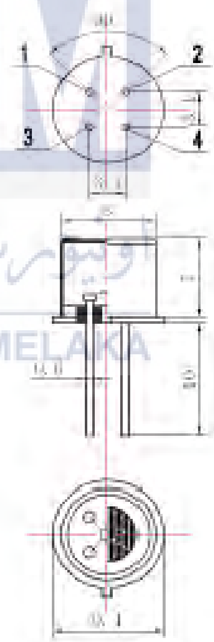


Fig1.Sensor Structure

HC – 05 Bluetooth Module

Specifications

Hardware features

- Typical -80dBm sensitivity.
- Up to +4dBm RF transmit power.
- Low Power 1.8V Operation, 3.3 to 5 V I/O.
- PIO control.
- UART interface with programmable baud rate.
- With integrated antenna.
- With edge connector.

Software features

- Slave default Baud rate: 9600, Data bits:8, Stop bit:1,Parity:No parity.
- PIO9 and PIO8 can be connected to red and blue led separately. When master and slave are paired, red and blue led blinks 1time/2s in interval, while disconnected only blue led blinks 2times/s.
- Auto-connect to the last device on power as default.
- Permit pairing device to connect as default.
- Auto-pairing PINCODE:"1234" as default.
- Auto-reconnect in 30 min when disconnected as a result of beyond the range of connection.

Pin out configuration

Typical Application Circuit