DEVELOPMENT OF HAZE MONITORING SYSTEM

NOR HAFIZA BINTI ZAHID

BACHELOR OF ENGINEERING TECHNOLOGY

(MANUFACTURING)

UNIVERSITI MALAYSIA PAHANG

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DEVELOPMENT OF HAZE MONITORING SYSTEM

NOR HAFIZA BINTI ZAHID

Thesis submitted in fulfilment of the requirements
for the award of the degree of
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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of degree of Bachelor of Engineering Technology in Manufacturing with Hons.

____

(Supervisor's Signature)

Full Name : DR. HADI BIN MANAP
Position : LECTURER, FACULTY OF ENGINEERING TECHNOLOGY,
UNIVERSITI MALAYSIA PAHANG

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ABSTRACT

This paper presents a project entitled Development of Haze Monitoring System, which can detect visibility of the haze in the surrounding area of the device is connected with a cheaper cost compared detector system Air Quality Index (AQI) available in the market. This project is to develop a low cost, mobile Air Quality Index (AQI) Monitoring System, which consists of Sharp GP2Y1010AU0F optical dust detector as a sensor for dust, Arduino Mega and LCD Keypad Shield for reading the Air Quality Index (AQI). This project also improved from the time consuming because conventional device takes a long time to give a result. So, this project is reliable from the aspect of time since the sensor give a real time reading of the results. Readings from the sensor has been compared with the conventional device (Dust Mate) by conducting experiment at different surrounding which are at the outdoor, indoor area and at the car exhaust (NGV and petrol). In this way information about the unhealthy condition of IPU will quickly known for ease of initial steps and security measures taken. The developed dust detector is expected to provide a relatively accurate API reading and suitable to be used for the detection and monitoring of dust concentrations for any area especially industrial areas.

ABSTRAK

Kertas kerja ini membentangkan satu projek yang bertajuk Pembangunan Sistem Pemantauan Jerebu, yang dapat mengesan kewujudan jerebu di kawasan sekitar peranti itu berkaitan dengan kos yang lebih murah berbanding sistem pengesan Indeks Kualiti Air (AQI) yang terdapat di pasaran . Projek ini adalah untuk membangunkan Sistem Pemantauan Indeks Kualiti Udara (AQI) kos rendah, yang terdiri daripada pengesan debu optik Sharp GP2Y1010AU0F sebagai sensor untuk habuk, Arduino Mega dan Perisai Papan Kekunci LCD untuk membaca Indeks Kualiti Udara (AQI). Projek ini juga merupakan penambahbaikan dari segi masa yang diambil kerana peranti konvensional mengambil masa yang lama untuk memberikan hasil. Oleh itu, projek ini boleh dipercayai dari segi masa kerana sensor memberikan bacaan masa sebenar hasilnya. Bacaan dari sensor telah dibandingkan dengan peranti konvensional (Dust Mate) dengan menjalankan eksperimen di sekitar yang berbeza di kawasan luaran, tertutup dan ekzos kereta (NGV dan petrol). Dengan cara ini, maklumat mengenai keadaan IPU yang tidak sihat akan diketahui dengan cepat untuk memudahkan langkah awal dan langkah-langkah keselamatan diambil. Pengesan habuk yang dibangunkan dijangka memberikan bacaan API yang agak tepat dan sesuai untuk digunakan untuk pengesanan dan pemantauan kepekatan habuk untuk mana-mana kawasan terutamanya kawasan perindustrian.

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LIST OF SYMBOL AND ABBREVIATIONS

AQI	Air Quality Index
CO_2	Carbon Dioxide
NO_2	Nitrogen Dioxide
SO_2	Sulfur Dioxide
MAQI	Malaysian Air Quality Index
EPA	United States Environmental Agency
PSI	Pollutant Standard Index
IRED	infrared emitting diode
°C	Celcius
F	Farad
PC	polycarbonate
CHCL3	Chloroform
mg	miligram
m	meter
V	voltage

CHAPTER 1

INTRODUCTION

1.1 Project Background

Nowadays, every year haze will be common phenomenon which has been particularly bad with the Air Quality Index (AQI) reaching over 300 on numerous occasions. Haze can be defined as an air pollution where atmospheric condition in which various substances are present at concentrations high enough, above their normal ambient levels to produce a measurable effect on people, animals, vegetation or materials (Bangladesh environment 2015).

Haze often occurs when dust and smoke particles accumulate in relatively dry air. It can be defined as partially opaque condition of the atmosphere caused by very tiny suspended solid or liquid particles in the air (Morris 1975). When weather conditions block the dispersal of smoke and other pollutants they concentrate and form a usually low-hanging shroud that impairs visibility and may become a respiratory health threat. The particles that cause the haze phenomenon can originate from many sources, some of which are natural and some anthropogenic. Natural sources include the oceans, forests and ground surface. However the majority of the particulates are from human activities which include open burning, forest fires, land clearing, vehicular emissions combustion of fossil fuels in industrial (e.g, CO, NO_2, SO_2) and particulate matter (e.g, organic matter and graphitic carbon).

Air quality monitoring is very important as it has a direct impact on human health and the environment. It has become an essential need to control air pollution to provide a safer future for today and the next generation. For this project, the aim of the project is to design and develop a low cost and portable AQI monitoring system in real time. The AQI is a simple and generalized way to describe the air quality, which is used in Malaysia. It is calculated based on the visibility of the particulate matters by using optical sensor. The latest technology has been used are High-volume PM10 Sampler and Beta Attenuation (BAM 1020) method.

AQI an indication of the quality of the air. The AQI is calculated based on the average level of parameters granule-sized solid particles less than 10 microns and some types of gas, namely sulfur dioxide, nitrogen dioxide, ozone and carbon monoxide. The AQI is used as a guide to determine the status of air quality and its effects on health. Here is the schedule of Air Pollutant Index. Malaysian Air Quality Index (MAQI) follows closely to Pollutant Standard Index (PSI) develop by United States Environmental Agency (EPA). The air pollutant included in Malaysia's API are carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3) and suspended particulate matter less than 10 microns in size (PM10). Table 1.1 shows API system adopted in Malaysia.

Table 1.1 API system adopted in Malaysia

API	Air Pollution Level
0 - 50	Good
51 - 100	Moderate
101 - 200	Unhealthy
201 - 300	Very unhealthy
>300	Hazardous

This project develops haze monitoring system using optical dust sensor. The proposed haze monitoring system helps users limit time exposure in the haze for long period by managing their outdoor activities. The technology which has been used in haze monitoring system in Malaysia is fairly inaccurate. This is due to the fact that is practices a 24-hour API measurement and distribute the API value. For instance, as a third-degree haze condition gets worse into fourth-degree condition, API reading remains in the three category, and only changes to four the day after. As a result, the current practice often creates confusion on the genuine current AQI value. Therefore, a real time monitoring system is designed to be one of the criteria in this project.

Real time is defined as information that is delivered immediately after collection. There is no delay in the timeliness of the information provided. Real time monitoring means that the data shown is based on the current situation. This project is called real time monitoring because data collected from the device will be displayed on the spot on LCD. Motivated by the existing situation in haze monitoring system, this project recommend usage of particular matter PM2.5 sensor to detect small particle less than $10\mu m^3$. Instead of collecting data hourly as practiced by the current system, this project recommends real time data collection of every minute. A portable haze detector is proposed in addition to providing display the data collected for haze monitoring system.

1.2 Problem Statement

AQI is basically a scale to gauge the severity or how polluted the air is. The greater number of the AQI represents the more dangerous the air quality to human health. The unpredictable weather that occurred in our country in recent months has exposed our environment towards to natural disasters especially fire which results in hazy environment. Haze will definitely affect the AQI in that particular area where the fire occurs. On the other hand, industrial waste such as unreached gas could also affect the AQI especially the area nearby the industrial area. Nowadays, individual who wants to have an AQI system has to pay a fortune because the installation cost is very high and expensive. The size is also large and not portable. These systems are usually used by government's bodies and large companies who own industrial plants to monitor the air quality. This project has been proposed to produce a cheaper version of AQI system and portable using cheaper materials costs, readily available Optical Dust Sensor and Arduino microcontroller. Besides that, the current AQI updating process need calculation based on data retrieved from remotely controlled air quality monitoring station. The data at least need one hour to be processed before AQI readings can be obtained.

1.3 Objectives

There are few objectives that need to be achieved at the end of this project. The objectives of this project are:

i) To design and develop a low cost and portable air AQI using Optical Dust sensor.
ii) To develop a real time measurement program using Arduino software (IDE).
iii) To examine the develop system performance and measure AQI.

1.4 Project Scope

In order to achieve the objectives of the project, several scopes have been outlined. The following are the scopes of the project:

i) Using dust sensor by optical sensing system with an infrared emitting diode (IRED) and a phototransistor that are diagonally arranged and signal conditioning circuit to detect air quality pollutant at surrounding.
ii) Create suitable program coding for reading a data from sensor to Arduino microcontroller.
iii) The sensor output display is an analog voltage proportional to the measured dust density due to project limitation focus on concept of particulate matter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss about the literature review from previous research related to this project. Literature review is a process of collecting and analyzing data and information which are relevant to this study. The required data and information are collected through variable sources such a journal's, articles, reference books, and online databases. The previous projects give some ideas and understanding on the basic principles involved in this study.

2.2 History of Air Quality Index

The AQI made its debut in 1968, when the National Air Pollution Control Administration undertook an initiative to develop an air quality index and to apply the methodology to Metropolitan Statistical Areas. The impetus was to draw public attention to the issue of air pollution and indirectly push responsible local public officials to take action to control sources of pollution and enhance air quality within their jurisdictions. Jack Fensterstock, the head of the National Inventory of Air Pollution Emissions and Control Branch, was tasked to lead the development of the methodology and to compile the air quality and emissions data necessary to test and calibrate resultant indices.

The initial iteration of the air quality index used standardized ambient pollutant concentrations to yield individual pollutant indices. These indices were then weighted and summed to form a single total air quality index. The overall methodology could use concentrations that are taken from ambient monitoring data or are predicted by means of a diffusion model. The concentrations were then converted into a standard statistical distribution with a preset mean and standard deviation. The resultant individual pollutant indices are assumed to be equally weighted, although values other than unity can be used. Likewise, the index can incorporate any number of pollutants although it was only used to combine SO_2, CO, and TSP because of a lack of available data for other pollutants.

While the methodology was designed to be robust, the practical application for all metropolitan areas proved to be inconsistent due to the paucity of ambient air quality monitoring data, lack of agreement on weighting factors, and non-uniformity of air quality standards across geographical and political boundaries. Despite these issues, the publication of lists ranking metropolitan areas achieved the public policy objectives and led to the future development of improved indices and their routine application. An air quality index (AQI) is a number used by government agencies to communicate to the public how polluted the air currently is or how polluted it is forecast to become. As the AQI increases, an increasingly large percentage of the population is likely to experience increasingly severe adverse health effects. Different countries have their own air quality indices, corresponding to different national air quality standards. Some of these are the Air Quality Health Index (Canada), the Air Pollution Index (Malaysia), and the Pollutant Standards Index (Singapore).

Computation of the AQI requires an air pollutant concentration over a specified averaging period, obtained from an air monitor or model. Taken together, concentration and time represent the dose of the air pollutant. Health effects corresponding to a given dose are established by epidemiological research. Air pollutants vary in potency, and the function used to convert from air pollutant concentration to AQI varies by pollutant. Air quality index values are typically grouped into ranges. Each range is assigned a descriptor, a color code, and a standardized public health advisory.

The AQI can increase due to an increase of air emissions (for example, during rush hour traffic or when there is an upwind forest fire) or from a lack of dilution of air pollutants. Stagnant air, often caused by an anticyclone, temperature inversion, or low wind speeds lets air pollution remain in a local area, leading to high concentrations of pollutants, chemical reactions between air contaminants and hazy conditions. The index is based on the concentrations of 5 pollutants. The index is calculated from the concentrations of the following pollutants: Ozone, Nitrogen Dioxide, Sulphur Dioxide, PM2.5 (particles with an aerodynamic diameter less than 2.5 µm) and PM10. The breakpoints between index values are defined for each pollutant separately and the overall index is defined as the maximum value of the index. Different averaging periods are used for different pollutants ("What is the Daily Air Quality Index? - Defra, UK", 2017)

Index	1	2	3	4	5	6	7	8	9	10
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very High
μgm^{-3}	0-11	12-23	24-35	>36-41	>42-47	>48-53	54-58	59-64	65-70	71 or more

Table 2.1 : PM2.5 Particles

Index	1	2	3	4	5	6	7	8	9	10
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very High
$\mu g/m^3$	0-16	17-33	34-50	51-58	59-66	67-75	76-83	84-91	92-100	101 or more

Table 2.2 : PM10 particles

The air quality index is a piecewise linear function of the pollutant concentration. At the boundary between AQI categories, there is a discontinuous jump of one AQI unit. Figure 2.1 show an equation on how to convert from concentration to AQI:

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

where:

I = the (Air Quality) index,

C = the pollutant concentration,

C_{low} = the concentration breakpoint that is ≤ C,

C_{high} = the concentration breakpoint that is ≥ C,

I_{low} = the index breakpoint corresponding to C_{low},

I_{high} = the index breakpoint corresponding to C_{high}.

Figure 2.1: Equation to convert from concentration to AQI

O_3 (ppb)	O_3 (ppb)	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	CO (ppm)	SO_2 (ppb)	NO_2 (ppb)	AQI	AQI
C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low}- C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	I_{low} - I_{high}	Category
0-54 (8-hr)	-	0.0-12.0 (24-hr)	0-54 (24-hr)	0.0-4.4 (8-hr)	0-35 (1-hr)	0-53 (1-hr)	0-50	Good
55-70 (8-hr)	-	12.1-35.4 (24-hr)	55-154 (24-hr)	4.5-9.4 (8-hr)	36-75 (1-hr)	54-100 (1-hr)	51-100	Moderate
71-85 (8-hr)	125-164 (1-hr)	35.5-55.4 (24-hr)	155-254 (24-hr)	9.5-12.4 (8-hr)	76-185 (1-hr)	101-360 (1-hr)	101-150	Unhealthy for Sensitive Groups
86-105 (8-hr)	165-204 (1-hr)	55.5-150.4 (24-hr)	255-354 (24-hr)	12.5-15.4 (8-hr)	186-304 (1-hr)	361-649 (1-hr)	151-200	Unhealthy
106-200 (8-hr)	205-404 (1-hr)	150.5-250.4 (24-hr)	355-424 (24-hr)	15.5-30.4 (8-hr)	305-604 (24-hr)	650-1249 (1-hr)	201-300	Very Unhealthy
-	405-504 (1-hr)	250.5-350.4 (24-hr)	425-504 (24-hr)	30.5-40.4 (8-hr)	605-804 (24-hr)	1250-1649 (1-hr)	301-400	Hazardous
-	505-604 (1-hr)	350.5-500.4 (24-hr)	505-604 (24-hr)	40.5-50.4 (8-hr)	805-1004 (24-hr)	1650-2049 (1-hr)	401-500	

Figure 2.2: EPA's table of breakpoints

Corresponding to air quality in the "Good" range. To convert an air pollutant concentration to an AQI, EPA has developed a calculator. If multiple pollutants are measured at a monitoring site, then the largest or "dominant" AQI value is reported for the location. The ozone AQI between 100 and 300 is computed by selecting the larger of the AQI calculated with a 1-hour ozone value and the AQI computed with the 8-hour ozone value.8-hour ozone averages do not define AQI values greater than 300; AQI values of 301 or greater are calculated with 1-hour ozone concentrations. 1-hour SO2 values do not define higher AQI values greater than 200. AQI values of 201 or greater are calculated with 24-hour SO2 concentrations.

Real time monitoring data from continuous monitors are typically available as 1-hour averages. However, computation of the AQI for some pollutants requires averaging over multiple hours of data. (For example, calculation of the ozone AQI requires computation of an 8-hour average and computation of the PM2.5 or PM10 AQI requires a 24-hour average.) To accurately reflect the current air quality, the multi-hour average used for the AQI computation should be centered on the current time, but as concentrations of future hours are unknown and are difficult to estimate accurately, EPA uses surrogate concentrations to estimate these multi-hour averages. For reporting the PM2.5, PM10 and ozone air quality indices, this surrogate concentration is called the NowCast. The Nowcast is a particular type of weighted average that provides more weight to the most recent air quality data when air pollution levels are changing.

2.3 Air Pollutant Index of Malaysia

2.3.1 Continuous Air Quality Monitoring (CAQM)

The Met One Instruments, Beta Attenuation Monitor 1020 (BAM 1020) automatically measures and records ambient particulate mass concentration levels using the principle of beta ray attenuation. This method provides a simple determination of the ambient concentration of particulate matter in mg/m3 or µg/m3. A small 14C (carbon 14) element inside of the BAM 1020 provides a constant source of beta rays. The beta rays traverse a path through which glass fiber filter tape is passed before being detected with a scintillation detector. At the beginning of the measurement cycle the beta ray count ten across clean filter tape is recorded. Then, an external pump pulls a known volume of PM-laden air through the filter tape thereby trapping the PM on the filter tape. At the end of the measurement cycle the beta ray count thirteen is premeasured across PM-laden filter tape. The ratio of ten to thirteen is used to determine the mass density of collected PM on the filter tape.

The BAM 1020 is almost always configured to operate on 1 hour cycles. The BAM 1020 has a real time clock which controls the cycle timing. The count time on the BAM 1020 is user selectable, but is generally set to 4 minutes for PM10 measurement or to 8 minutes for PM2.5 measurements. In the example timeline below the BAM 1020 makes an 8-minute beta measurement at the beginning and the end of each hour, with a 42-minute air sample period in between, for a total of 58 minutes. The other two minutes of the hour are used for tape and nozzle movements during the cycle. This timeline applies if the BAM 1020 is set for a count time of 8 minutes, which is required for all EPA, designated PM2.5 configurations. BAM 1020 monitors operating with firmware 3236-5 version 3.7.1 or later may be configured for PM10 or PM2.5 operations. When configured as an EPA designated equivalent method for PM2.5, count time must be set to 8 minutes. When running the BAM 1020 as an EPA designed equivalent method for PM10 count time may be set to 4, 6, 8, or 10 minutes and total is 1 hour. The pump sampling time may be calculated by subtracting twice the count time from 60 minutes and then subtracting an additional 2 minutes to allow for tape movement. Therefore, a count time of 8 minutes would provide a pump sampling time of 42 minutes (60-8-8-2). This cycle will be slightly altered if the BAM 1020 is operated in the special Early Cycle mode with an external data logger.

Another drawback other than time consuming, BAM 1020 also have an air leak found which almost always occurs at the interface between the nozzle and the filter tape due to debris buildup. There is normally an insignificant amount of leakage at the tape interface, but an excessive leak lets an unknown portion of the 16.7 liter/min sample flow to enter the system at the leak point instead of the inlet. This could cause the total volume of air sampled through the inlet to be incorrect, and the resulting concentration data could be unpredictably biased. The BAM 1020 cannot automatically detect a leak at the tape or nozzle interface because the airflow sensor is located downstream of the filter tape. Allowing a significant leak to persist may result in concentration data being invalidated. Routine leak checks and nozzle cleaning prevent any significant leaks from forming. Performing an as-found leak check before cleaning the nozzle or performing any service is needed for validating data collected since the last successful leak and flow check. Even if the leak check value is found to be within acceptable bounds, the nozzle and vane should still be cleaned if any buildup or debris is noticed.

Furthermore, errors setup screen for the analog output also occurs. The setup errors screen allows the option of encoding BAM 1020 errors onto the analog output signal when used with an external analog data logger. Using this method, the BAM 1020 sets the analog output voltage to full scale (1.000 volts) whenever any of the enabled error types occurs. When there are no alarming conditions present, the voltage represents the last valid concentration level. Some minor alarms can occur when there may be nothing wrong with the hourly concentration value, yet these alarms are still typically enabled to set the analog output to full-scale in order to alert the data system of their presence. In this case, the concentration value can still be downloaded from the BAM digitally. Regardless which error types are enabled for the analog output, all alarms and errors are always stored in the BAM 1020 digital alarm log and data log, and may be viewed by downloading the data.

Significant, there are many other problems faced by BAM 1020 which some of the more common it problems may be encountered are the BAM won’t start a measurement cycle, the analog output voltage or digital concentration reading are full-scale, the BAM data shows repeated concentration values hour after hour, and the filter tape keeps breaking during normal operation. The Figure 2.3 below show BAM 1020 particulate monitor.

Figure 2.3: BAM 1020 particulate monitor

2.3.2 Manual Air Quality Monitoring (MAQM)

High and low volume air samplers are instruments used to collect samples of air particles. High volume air samplers typically sample more than 1500 cubic meters (m3) of air over a 24-hour period, while low volume air samplers draw through only 24m3 of air or less. High-Volume Air Samplers using Mass Flow Control (MFC) are capable of 24-hour continuous measurement of PM2.5, PM10 or TSP for indoor or outdoor sampling. They feature a high speed motor, durable all-weather shelter and ruggedized electronic components for accurate sampling. Volumetric Flow Control (VFC) High-Volume Air Samplers are supported by a protective shelter that ensures the surface of the filter rests in a horizontal position. This aerodynamic design allows for the collection of particles for PM2.5, PM10 or TSP.

High Volume Air Samplers are in High Volume (70SCFM) air sampling. They draw precise volumes of air through a filter paper of known weight for a set period of time. Filter papers are then reweighed so the particulate loading of the air (in mg/m^3) can be calculated. The paper contents can also be examined and analyzed. The PM10 head separates particles smaller than 10 microns from other airborne particulates. Particulates that are greater than 10 microns settle out in the impaction chamber are removed during cleaning or routine maintenance. The particles smaller than 10 microns are carried upward by the air flow and settle in a laboratory supplied quartz fiber filter.

The TSP head collects Total Suspended Particles, without separating particles of different sizes. It is designed to meet requirements for sampling airborne particulates at a known flow rate for a determined amount of time, allowing for proper calculation or airborne particulate concentrations. Laboratory supplied Glass Fiber Filters are recommended wherever gravimetric weighing analysis may be required because of their non-hygroscopic properties. They will maintain constant weight under wide-ranging ambient humidity conditions and their excellent loading characteristics make them ideal for routine air monitoring, specialized monitoring of solid pollutants, microorganisms, oil and acid smokes.

A Total suspended particulate sampler or TSP high volume air sampler is used for the collection of total suspended particulate matter in ambient air with no preference to size selection. The TSP high volume air sampler collects particulate at a flow rate between 40-60 ft/^{3}min over a constant sampling period. The TSP high volume air sampler is used to determine the concentration of total suspended particulates or it can be used to determine the identity of the particulates. TSP high volume air samplers come in a variety of configurations. The basic system is composed of an anodized aluminum outdoor shelter with a gabled roof assembly. It will include a timing device to turn the instrument on and off, a filter holder to hold the filter media in place, a vacuum motor, a device to control the flow, a pressure recorder to record the flow rate, and an elapsed time indicator to count the sample time. The TSP high volume air sampler collects total suspend particulates in the air. The vacuum motors pull ambient air onto the 8″ x 10″ glass fiber filter at a flow rate between 36-60 cfm. TSP air particulate samplers do not use a particle separator which results in the collection of all ambient particulates. The glass fiber filters are weighed pre and post sample and the weight is used to determine the total suspended particulate matter.

The uses of high volume sampler there are some weaknesses of various factors. Apart from time consuming, the high volume sampler also a compact unit consisting of a protective housing for each process. Expressly, also it takes a long time to get the real data. In operation, this traditional TSP sample draws ambient air into the sampler through the air inlet gap between the cover and the sampler housing walls. Significant problems to determine the flow rate corresponding to every situation. The high-volume sampler employs two basic types of flow control systems. One is a mass-flow-control (MFC) system; the other is a volumetric-flow-control (VFC) system. Because the calibration and standard operating procedures differ considerably between these two types of flow-control systems, this method presents procedures that are control-system-specific. PM10 inlets can be used with either the MFC or VFC systems.

In addition, selecting a filtration substrate for time-integrated monitoring must be made with some knowledge of the expected characteristics and a pre-determined analytical protocol. For any given standard test method, the appropriate medium will normally be specified. The use of filters it requires a difficult process in which filters ready for field use have been pre-weighed in the laboratory, under prescribed climate control conditions of temperature and relative humidity. Filter material may be brittle and subject to shearing and breakage. Laboratory and field personnel must be aware of these characteristics and handle sample filters with care. A filter identification number must be assigned to each filter. Because of difficulty in seeing the "up" side (i.e., the side with the slightly rougher texture) of the filter, consistency in labeling these filters will allow the operator easy access to the filter ID number for documentation and cross-referencing laboratory data forms. This consistency will also eliminate confusion in loading the filter cassettes for subsequent sampling. If the filter ID number is embossed by the operating agency, gentle pressure must be used to avoid filter damage, and extreme care must be taken to avoid duplication or missed numbers. Even though, the most significant problem encountered with using of these devices are Air Pollution Index system has to pay a fortune because the installation cost is very high and expensive due to the large size of equipment and not portable. The Figure 2.4 below show PM10 sampler.

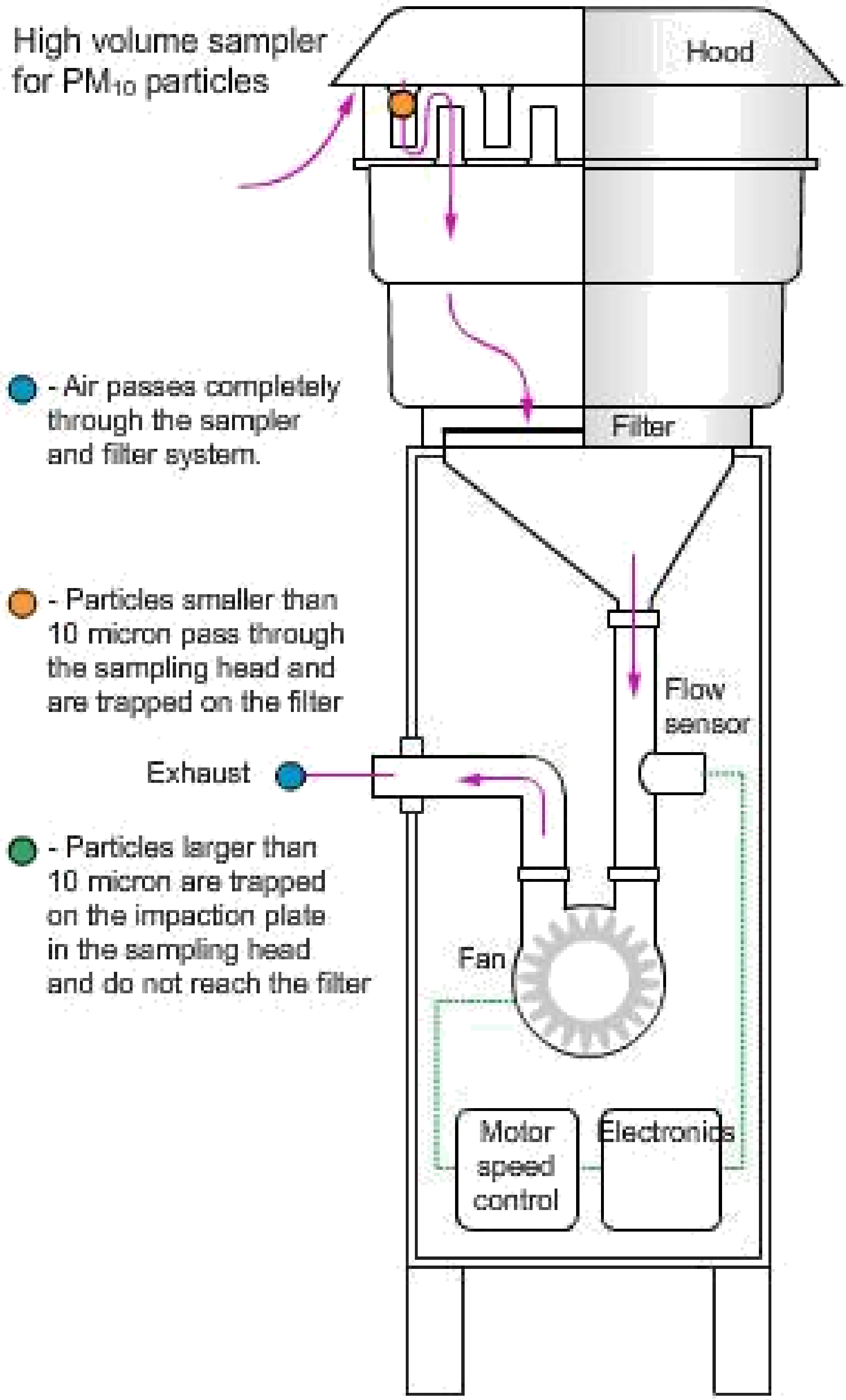

Figure 2.4: PM10 Sampler

2.4 Related studies

Designed and implemented a new generation of detectors, nanotechnology based metal oxide semiconductors such as ZnO semiconductor to substitute the typical analytical tools and adapt or extend the air quality monitoring system (Andrew L). In fact, these solid state gas sensors offer an excellent opportunity for implementation in environmental monitoring due to light weight, extremely small size, robustness, low cost and also as they can be installed anywhere to collect data covering extensive areas. The air quality data can eventually be transmitted through a Wireless GIS network system to the general public.

Development of a RF wireless sensor module with optimal communication condition to monitor indoor air quality in a room or office (Sung, J.O and Wan, Y.C). The monitoring work can be done by web-based monitoring system together with other home networking system by using PDA (Personal Digital Assistant). There are several sensors for instance; temperature sensor, humidity sensor, Carbon Dioxide sensor and flying dust sensor were built in the RF transmitter board for monitoring the room environment. An Intel 8051 microcomputer was used to control the power switches of consumer electronics through signals received from PC or PDA.

Design and implemented a system called in Airthatable to measure, visualize, and share indoor air quality (V KimandPaulos). ADC 1100 air quality is used to measure the level of indoor pollutant, an AVR-based Arduino which transplant inside the air quality monitor, and an iPod Touch is used to process, visualize and transmit the data wireless to the Arduino. The data will be reported every 15 seconds at the same time the Arduino will encode the data into a series of audio tones like a modem and will be read by iPod Touch via microphone port. The data can be shared from central server in real-time by using Wi-Fi networking.

A low cost API system is designed for a Rice Mill Factory located in Pering, Kedah Darul Aman (Zakaria, N., S.,). The factory needs to provide a good air quality surrounding not only for its employee but also for the neighboring villagers. A 24 hours' production time also contributed to its pollution factor and the level of exposure endured by the employee during the work shift needs to be considered as well. Rice

Husk/Dust Air Particle Sensor using ZigBee Wireless Sensor Network was developed using SHARP GP2Y1010AU0F optical dust sensor as the measurement tools, an Arduino Fio board was used as the development board for its expansion capabilities using ZigBee Wireless Modules. A point to point approached was developed with the data being transmitted back to its host computer, and a serial port was used to read the HEX string data. Parallax Microcontroller Acquisition to Excel (PLX DAQ) software is used to read the string data and save it to Microsoft Excel software. Using Visual Basic Application on Microsoft Excel, a graph displaying the dust measurement can be viewed on the real time basis. Conclusively, the sensor and methods used for this project was substantial enough to monitor the dust density for reducing the dust pollution in the Rice Mill Factory.

Present a room dust monitoring system. The main objective of the system was to monitor the dust concentration of a room and show the readings on a personal computer in real time. These systems used an Arduino Uno controller work based on a Shinyei PPD20V particle sensor to measure the dust concentration in a room. The readings taken from the sensor will be sending to computer to show in real time using Graphical User Interfacing (GUI) by using Visual Basic program. The result was taken in several conditions including clean room, dusty room, room with cooking haze and room with cigarette smoke. The result varied with the condition of the room. With this device, the awareness of the effects of human activities on indoor pollutants can be rose up and thus lead to human health and well-being (Phang Qili).

Describing a fully computer-controlled differential optical absorption spectroscopy system for atmospheric air pollution monitoring. A receiving optical telescope can sequentially tune in to light beams from a number of distant high-pressure Xe lamp light sources to cover the area of a medium-sized city. A beam-finding servo system and automatic gain control permit unattended long-time monitoring. Using an astronomical code, can also search and track celestial sources. Selected wavelength regions are rapidly and repetitively swept by a monochromatic to sensitively record the atmospheric absorption spectrum while avoiding the detrimental effects of atmospheric turbulence. By computer fitting to stored laboratory spectra, can evaluate the path-averaged concentration of a number of important pollutants such as NO_2, SO_2, and O_3. A measurement of NH_3 and NO close to the UV limit is also demonstrated (Edner, Ragnarson, Spännare, & Svanberg, 1993).

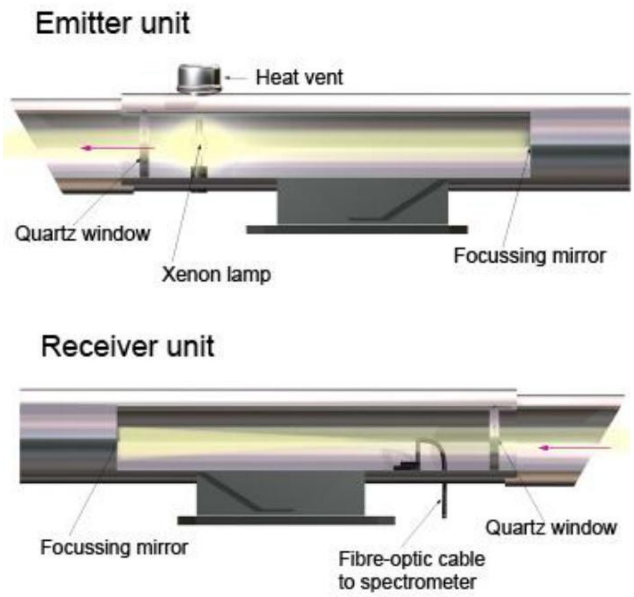

Figure 2.5: DOAS System

Practicalities of using a laser light scattering portable particulate monitor (Turnkey Instruments DustMate), in combination with a GPS, to map PM10 and PM2.5 concentrations on city-wide scales in Newcastle upon Tyne/Gateshead (UK), during a series of walking surveys. A heated inlet is necessary to remove moisture droplets from the sampled air prior to analysis by the instrument, though this also result in the loss of volatile particulate components, particularly from the PM2.5 fraction. A co-location calibration study was carried out with a reference urban background Tapered Element Oscillating Micro-Balance/Filter Dynamics Measuring System (TEOM-FDMS) system in Newcastle that is part of the UK's Automatic Urban and Rural Network (AURN) of air quality monitoring stations. For PM10, orthogonal regression of the DustMate against TEOM-FDMS data gave a slope and intercept. These parameters are comparable to literature calibration studies using this technology. There was good agreement between simultaneous samples taken using two DustMate instruments: for PM10. Correction factors based on the slope and intercepts obtained from the calibration exercise were applied to raw data collected from the DustMate. An annually-normalised correction procedure was then used to account for different background particulate concentrations on different sampling days. These corrected PM10 and PM2.5 concentrations and corresponding GPS coordinates were displayed on a base map using Google Fusion Tables and Google Earth Professional. Almost all areas surveyed in Newcastle/Gateshead were well below the EU Air Quality Standards for PM10 and PM2.5 9 (Deary, Bainbridge, Kerr, McAllister, & Shrimpton, 2016).

All of the past projects successfully created a system which could monitor the reading of the air quality within their operating environment either through the usage of dust sensor or particle sensor. The readings then were transferred to their very own output system through various medium including wireless technology to create a great input and output air monitoring system that not just monitor the air quality but display the results and analysis in real time basis as well. Being a real time system really did make the system more practical to be applied in our life as the value of air quality could be affected by many factors. Taking accuracy, precision and real time monitoring into account, a well-built system could be produced to tackle various problems related to air quality in our daily life.

2.5 Summary of related studies

Table 2.3 shows the comparison of related project that has been researched in order to implement API monitoring system.

Table 2.3: Comparison of related project

No	Title of Project	Description	Advantages	Disadvantages
1	Room Environment Monitoring System formPDA Terminal	-control by PDA terminal -RF wireless sensor module	-Easily replaced	-Difficult to control more than one sensor
2	In Air: Sharing Indoor Air Quality Measurements and Visualization	-Arduino -Ipod Touch	-Increased awareness of, and reflection on air quality	-Limited for indoor
3	Room Dust Monitoring System	-Shinyei PPD 20V particle sensor -Visual Basic	-Detected condition of the room	-Limited area
4	Design and System Development Quality Monitoring Air and Alarms	-TGS 2600 -PIC16F877A	-Display the condition of dust concentration which is normal, care and danger	-Program memory is not accessible
5	Plantation Monitoring System using Multiple Sensor and Arduino Uno	Multiple sensor -Arduino - ZigbeeModules	Capable to measure the value of temperature, relative humidity in the air and percentage of moisture in the soil	-Wired cable and sensor are not practical used
6	Rice Husk/Dust Air Particle Sensor using Zigbee Wireless Sensor Network	-Optical dust sensor (Sharp) -Zigbee Module	-Practical -Low cost	-Only limited for measuring the respirable dust in a Rice Mill factory to maintain its good air quality policy

7	Differential optical absorption spectroscopy (DOAS) system for urban atmospheric pollution monitoring	-Xenon lamp -Beer Lambert's absorption law - spectrometer	- High specificity due to broad band spectra. -High sensitivity due to long path lengths	-Limited number of molecules have suitable absorptions in UV and visible region.
8	Practicalities of mapping PM10 and PM2.5 concentrations on city-wide scales using a portable particulate monitor	-Turnkey Instruments DustMate -GPS	-Portable, hand-held monitor -Identify high pollution vehicles at road side	-Not exact value of data

2.6 Material Selection

The material should be light and cut the cost based on the objective. One of the materials is acrylic (polymethyl methacrylate) that, in addition to the above ambitus is also transparent. Acrylics offer high light transmittance with a Refractive Index of 1.49 and can be easily heat formed without loss of optical clarity. Prolonged exposure to moisture, or even total immersion in water, does not significantly affect the mechanical or optical properties of acrylic. Most commercial acrylics have been UV stabilized for good weather ability and resistance prolonged sunlight exposure. Acrylics are unaffected by aqueous solutions of most laboratory chemicals, by detergents, cleaners, dilute inorganic acids, alkalis, and aliphatic hydrocarbons.

Acrylics are easily sawed, drilled, milled, engraved, and finished with sharp carbide-tipped tools. Cut surfaces may be readily sanded and polished. They are also readily bend or thermoformed at low temperature and solvent bonding of properly fitting parts produces a strong, invisible joint. Acrylics are available in colorless clear as well as a wide variety of colors and tints. They are available in extruded and/or cast material in sheet, rod and tube forms as well as custom profiles.

2.7 Fabrication Process

2.7.1 Heat Bending/ Thermoforming

Thermoforming is a manufacturing process where plastic sheet is heated to a pliable forming temperature, formed to a specific shape in mold, and trimmed to create a usable product. In its simplest form, a small tabletop or lab size machine can be used to heat small cut sections of plastic sheet and stretch it over a mold using vacuum. This method is often used for sample and prototype parts. In complex and high-volume application, very large production machines are utilized to heat and form the plastic sheet and trim the formed parts from the sheet in a continuous high-speed, and can produce many thousands of finished parts per hour depending on machine and mold size and the size of the parts being formed (Engineers Edge, 2016).

Heat gun is a necessary device that used in heat bending process to emit a stream of hot air, usually at temperature between 100°C and 600°C (200-1000 °F), with some hotter models running around 760°C (1400 °F), which can be held by hand. Heat guns usually have the form of an elongated body pointing at what to be heated, with a handle fixed to it at right angles and a trigger, in the same general layout as a handgun, hence the name. Successful bending requires that the appropriate amount of heat be applied uniformly to the required length of acrylic to be bent. Thus presents the greatest challenge for field bending, as the heating method used must provide the necessary amount of heat over the required length of AC in a reasonable amount of time.

2.7.2 Joining Process

Plastics have become an integral part of everyday life. From packaging components and automotive parts to cosmetic and medical devices, plastic provide design flexibility, product durability, and pleasing appearance. To work effectively with plastics, manufacturers must be able to efficiently and permanently join plastic components into complete assemblies. The joining of plastic is becoming important because of the emerging structural applications of these materials. There are several reasons that joining of the plastic process became an important in this project.

Firstly, such materials are being used in complex structural assemblies, in which joining consideration and cost are becoming important. Second, the emerging structural joints(load-bearing) applications of polymeric materials require structural joints that must withstand static and fatigue loads. Plastic joining is the method of joining semi-finished products of plastic materials together or to other materials as a fabrication process or damage apart. Joining method can be classified into three categories:

- Mechanical fastening
- Adhesive bonding
- Welding

Focusing an adhesive bonding, an adhesive is placed between the parts to be bonded (adherents) where it serves as the material that joins the parts and transmits the load through the joint. In solvent bonding, the application of a solvent at the bond line induces sufficient mobility for the polymer chains to interdiffuse. Because the solvent must strongly plasticize the polymer surface, this joining technique is primarily applied to glassy amorphous thermoplastics, such as polycarbonate (PC), acrylic (AK), and polystyrene (PS) resins. These techniques have found wide use by virtue of their low cost and adaptability to high-speed production. In addition, adhesive and solvent bonds provide a relatively uniform distribution of stresses over the assembled areas and a high strength-to-weight ratio. Solvent bonding is applicable only for joining of amorphous thermoplastics, whereas adhesive bonding can be used with almost all plastics.

However, adhesives bonding have certain limitations. Adhesives require setting and curing time, the time it takes for the adhesive to fixture and strengthen fully. They also need some surface preparation before assemble and disassemble the joint repeatedly. When determining the best adhesive for an application, a lot depends on the substrate. Plastics are broadly characterized as thermoset materials or thermoplastics. Each family of plastics has unique bond-strengths performance characteristics; several families are designated ad “difficult-to-bond” (Patrick J,2000).

Light-curing cyanoacrylates (Super Glue) are fast-fixturing light-cure adhesives that also cure naturally in shadowed areas due to a secondary moisture-cure mechanism. This hybrid technology overcomes many limitations of cyanoacrylates and light-cure acrylics, offering minimal blooming/frosting, increased cure depth, rapid dry-surface cure, high-bond strength, and compatibility with primers. These adhesives limit stress cracking on sensitive substrates, such as polycarbonate and acrylic, by curing the adhesive before it has the ability to diffuse into the plastic surface and attack the material. Ideal for high-volume bonding applications, light-cure cyanoacrylates are increasingly used for bonding medical devices, cosmetic packaging, speakers, electronic assemblies, and small plastic parts. Rapid cure speed allows parts to be processed in seconds rather than minutes, often delivering 60 percent of their final strength after only five seconds of exposure to light.

Next, silicones have unique properties compared to other adhesives based on organic polymers because silicones have different chemical backbone. They remain highly elastic at low temperature, -1000F (-75°C), and also have splendid temperature stability; up to 3900F (200°C) continuous exposure and up to 5750F (300°C) for short periods. The properties of silicones are nearly inert to chemicals and have excellent resistance to moisture and weathering. Bonds made with silicones can, however, only be subjected to relatively small mechanical loads. That is why they are chiefly used sealants. Due to their surface tension they cannot be painted. They are used for bonding metal when the low bond strength is offset by the higher flexibility and resistance to low temperatures.

Chloroform is a colorless, volatile, non-flammable, slightly water-soluble, pungent, sweet-tasting liquid, $CHCL_3$ usually derived from acetone, acetaldehyde, or ethyl alcohol by the reaction of chloride of lime: used chiefly I medicine as a solvent and formerly as an anesthetic. There is some function of chloroform such as anesthetic, gluing acrylic and as a reagent and solvent in a chemical reaction. Chloroform is well absorbed, metabolized and eliminated rapidly by mammals after orals, inhalation, or dermal exposure. Accidental splashing into the eyes has caused irritation (Peter Watts, 2004).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will cover the details explanation of methodology that is being used to make this project complete. The method is used to achieve the objective of the project that will accomplish. This project used three major steps to implement project starting from planning, implementation and analysis. All the method used for finding and evaluating data regarding the project related.

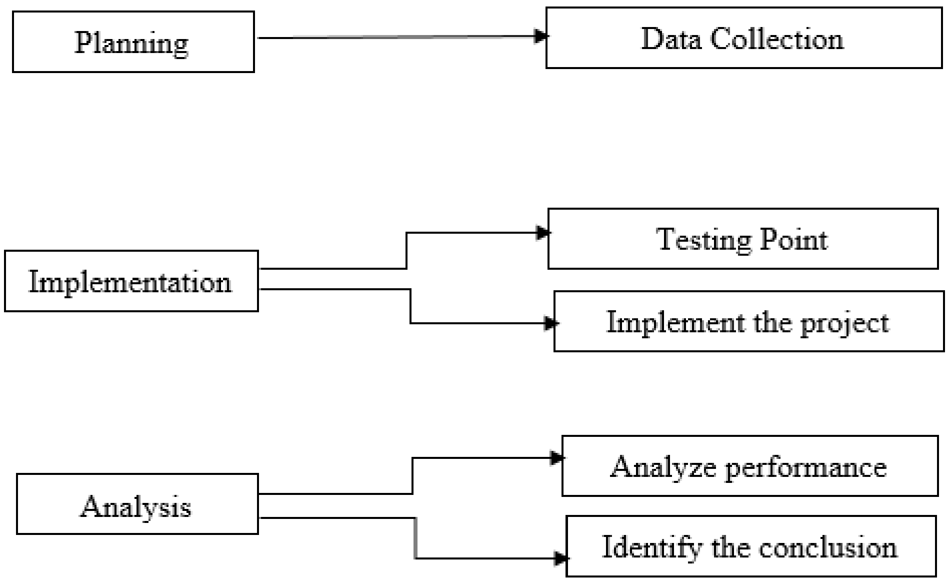

Figure 3.1: The Major Step for the Project

3.2 Flowchart of Methodology

Figure 3.2 show the flowchart of methodology for this project. Firstly, the material selected must meet with this project requirement. Then continue with designing and complete the design after finish the fabrication process. Then, install all the electrical part before testing the project. Lastly, finish the summarization and documentation for this project.

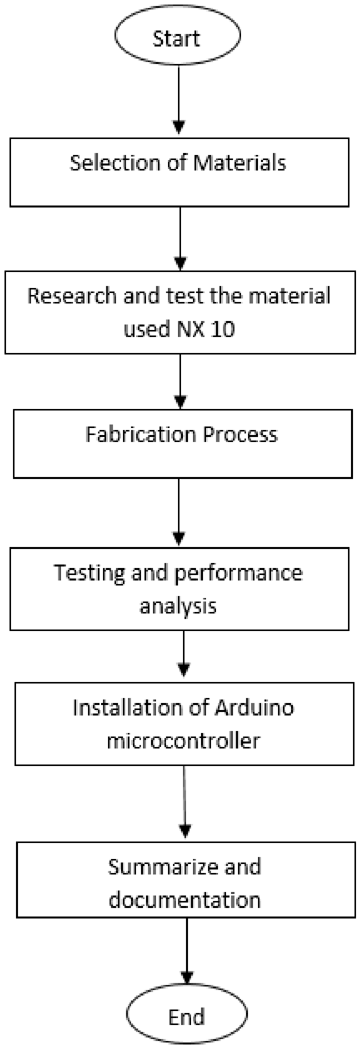

Figure 3.2: Flowchart of the activities

3.2.1 Selection of Materials

There are several requirements to determine the suitable materials for this project. The primary function of the box is weatherproof because the experiment will conduct either indoor or outdoor. The requirement of choosing materials for box includes:

a) The materials must be weatherproof.

UV resistant grades of acrylic sheet are frequently used for outdoor glazing. The materials are less than half the weight of glass and have better impact resistance than glass. Acrylic sheet offers the advantage of superior light transmission. Additionally, thermoformable grades of acrylic sheet generally require less drying prior to thermoforming compared with other plastics. Acrylic has superior toughness it is often specified when outstanding impact strength and durability are required. Acrylic plastic is highly resistant to variations in temperature and humidity, making it useful in outdoor applications.

b) The materials chosen must be lightweight and less in cost.

Acrylic weighs 50 percent less than glass, making it easier to handle. Acrylic shoes, dentures and artificial nails are more comfortable due to the polymer's light weight. This is an important requirement since the project must be portable to carry anywhere. So, the lightweight material must be considered. The acrylic also is a low cost of a plastic that it meet the requirement for the material.

c) High corrosion resistant materials must be choosing.

Materials with high corrosion resistant must be chosen. This requirement is to avoid any corrosion while doing the experiment with the smoke from mosquito repellent.

Plastic is widely used in construction industries, chemical processing industries and automotive industries by offering high resistance to uniform attack, exceptionally localized corrosion and ease of fabrication. So, acrylic plastic is chosen to make the box for the project. Figure 3.3 shows the example of acrylic plastic. Acrylic plastic is a high performance, a sustainable and eco-efficient material used in a large variety of everyday applications. It has a unique combination of properties, offering clarify, durability, safety and versatility, as well as heat. The Table 3.1 below shows properties of acrylic plastic.

Table 3.1: Properties of Acrylic Plastic (Stachiw, 2004)

Property	Acrylic
PHYSICAL	
Density (lb/in³) (g/cm³)	0.043 1.18
Water Absorption, 24 hrs (%)	0.3
MECHANICAL	
Tensile Strength (psi)	8,000 - 11,000
Tensile Modulus (psi)	350,000 - 500,000
Tensile Elongation at Break (%)	2
Flexural Strength (psi)	12,000 - 17,000
Flexural Modulus (psi)	350,000 - 500,000
Compressive Strength (psi)	11,000 - 19,000
Compressive Modulus (psi)	-
Hardness, Rockwell	M80 - M100
IZOD Notched Impact (ft-lb/in)	0.3
THERMAL	
Coefficient of Linear Thermal Expansion ($\times 10^{-5}$ in./in./°F)	5 - 9
Heat Deflection Temp (°F / °C) at 264 psi	150-210 / 65-100
Melting Temp (°F / °C)	265-285 / 130-140
Max Operating Temp (°F / °C)	150-200 / 65-93
Thermal Conductivity (BTU-in/ft²-hr-°F) ($\times 10^{-4}$ cal/cm-sec-°C)	 3.9 1.2
Flammability Rating	-
ELECTRICAL	
Dielectric Strength (V/mil) short time, 1/8" thick	400
Dielectric Constant at 60 Hz	4.0
Dissipation Factor at 60 Hz	0.05
OPTICAL	
Light Transmission, minimum (%)	92
Refractive Index	1.48-1.50

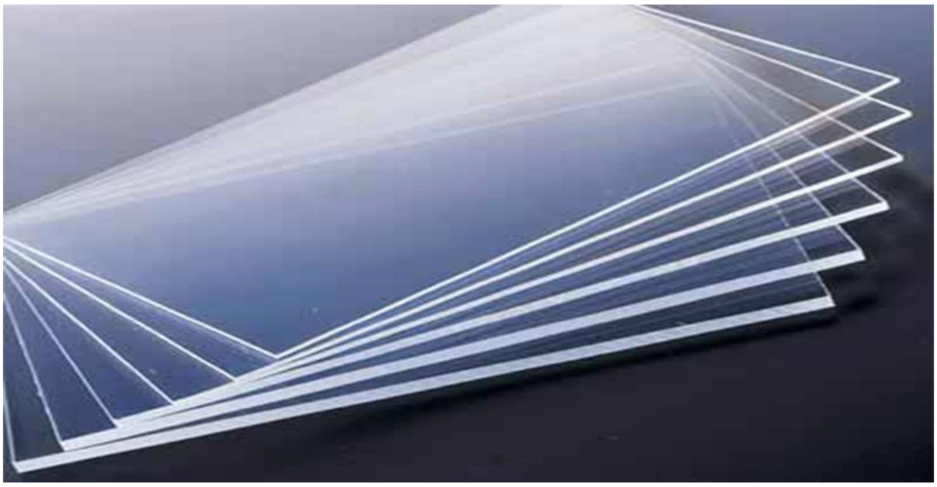

Figure 3.3: Acrylic Plastic Sheet (Stachiw, 2004)

3.2.2 Mechanical Design using Siemens NX10

For the body design, the body design that will be use is a shape like rectangle. The shape is simple, stable, and dynamic to move indoor and outdoor. The box also will be divide into to part. The upper part for the sensor and for the flow of smoke while for the lower part for the electrical wiring. This is the main part for the design of the box by using software tool (Siemens NX10). Figure 3.4, 3.5 and 3.6 below shown the design of the box.

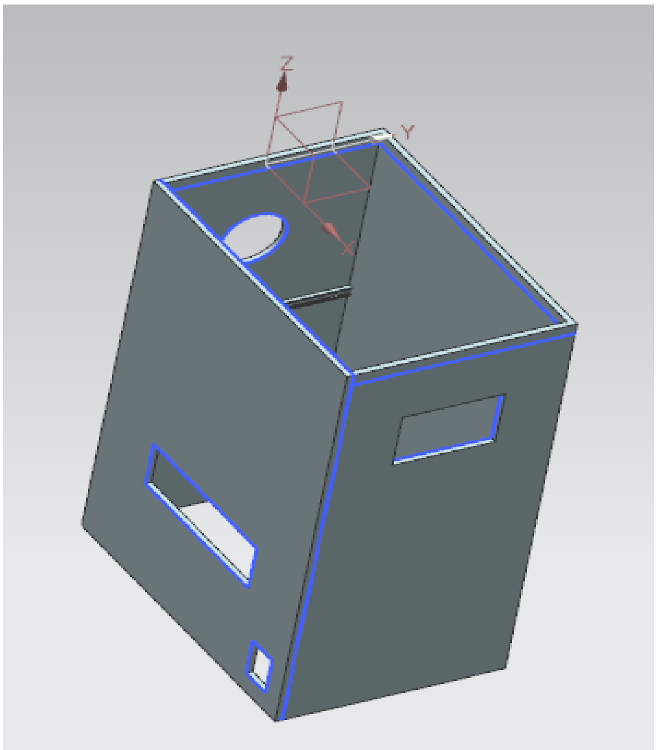

Figure 3.4: Initial box without divider

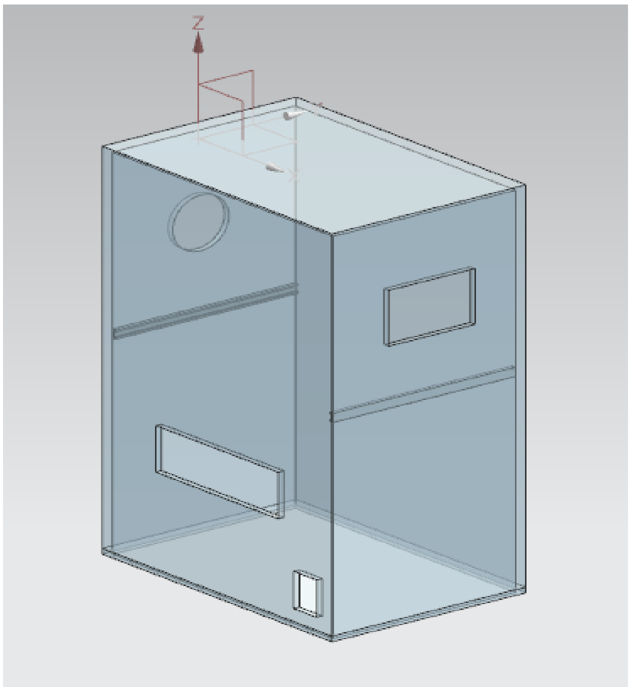

Figure 3.5: Finished box

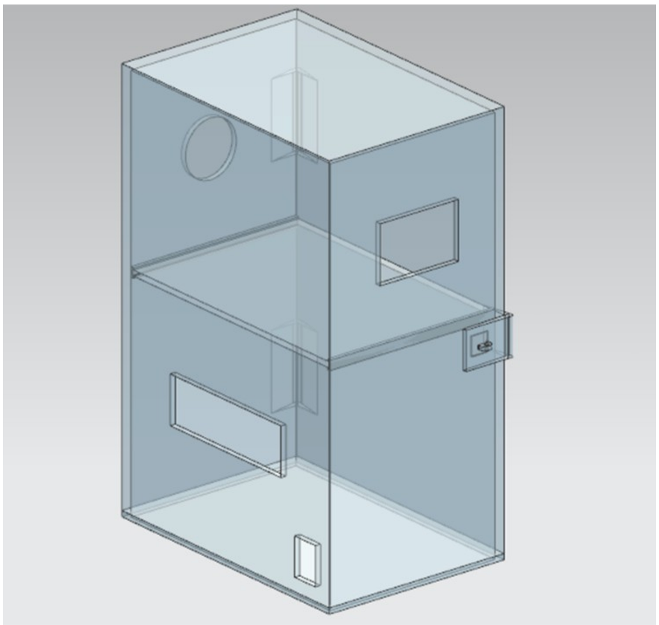

Figure 3.6: Final design with the hinge and divider

3.2.3 Fabrication Process

a) Step of cutting Acrylic Plastic:

1) Cutting the acrylic using suitable tools after sketches the line that need to used. Figure 3.7 and 3.8 below shows the tools that we can use in the cutting of acrylic plastic.

Figure 3.7: Hand Knife

Figure 3.8: Grinder

b) Steps of joining process:

Firstly, to attach the shapes of acrylic plastic after cutting process, we use Chloroform glue which is relatively straightforward and not at all dissimilar to gluing any other two materials together and another being fusing the two together. Fusing is superior to using chloroform as the end result tends to look seamless, almost invisible, and the bond itself is stronger and more resilient. After applying chloroform, to give more effect on bonding, the Super Glue was added to the bonded area. It is because the bonded of Chloroform tends to apart at the bonded area at a high or low temperature. At the last finishing bonding process, Silicon Glue is added to all area of bonding part. The reason to use silicone glue is to avoid any small hole at the acrylic box. There are several steps involve in this process:

1) The best first step would be to clean the areas that will adhere thoroughly.
   - This is best done by rinsing the sheets with lukewarm water before washing it in soapy water of the same temperature use a gentle cloth or sponge and wipes it, preferably in the direction of the grain. It is important that do not scrub or use anything with a rough surface, as the sheet will blemish. Rinse it one last time and then dry it off with another cloth.

2) Once dried, start the process of fusing the sheets together by applying Chloroform long the edge of the sheet.
   - That intend to fuse be sure to carry this out in a well-ventilated area, as Chloroform is toxic and the fumes can be harmful. It should only take a moment but give the adhesive some time to soak into the sheet and become slightly sticky before placing the edge directly onto the surface of the other sheet where would like its bond.

3) Hold the sheets carefully in place, ensuring that the two surfaces that are being fused remain in constant contact.
   - To this end it is also a good idea to apply a small amount on the sheets, encouraging a stronger bond to form. Leave to dry for a minimum of a

full 48 hour recommend that put as little strain on either of the pieces as possible as doing so before the bond has fully formed may result in a weaker bond, or cause the two sheets to come apart.

4) Put the Super Glue at the bonded area.
    - Since Chloroform is easy to fall apart, carefully put the Super Glue at the bonded area to give more bonding impact of the bonded area. The strong effect of super Glue will support the bonded area to avoid any leakage in the body of the acrylic box.

3.2.4 Inspection

After went through fabrication process, the body must be inspected. All body parts of the box are inspected to see is there any holes on it. Then, the holes are touch up with silicone who acts as sealant. Then, we conduct an experiment to see that the meet the requirement or not.

3.2.5 Testing

The last process is to test by conduct an experiment after the electrical part are implement into the acrylic box. By following the scope of project, we were conducting the experiment at indoor and outdoor by comparing with the conventional device.

3.3 Fabrication Steps

Step 1: Forming

- Starts to cut the acrylic plastic to desired shape. Figure 3.9 shows the lines are sketched before cutting process.
- Use suitable tools to cut the acrylic plastic such as grinder, wheel cutter and hand knife. Figure 3.10 refers the cutting process.

Figure 3.9: The lines are sketch first on the acrylic plastic before cutting.

Figure 3.10: Cutting process

Step 2: Joining process

- The shapes and part are using three type of glue to make sure they are no holes in the body. Firstly, Chloroform is applied to attach the part each other. Secondly, Super Glue us used to strengthen the joining part of the acrylic box. Lastly, Silicone Glue is used as sealant to avoid any tiny holes. Figure 3.11 and 3.12 shows the joining part is cured while Figure 3.13 shows the glue that has been used.

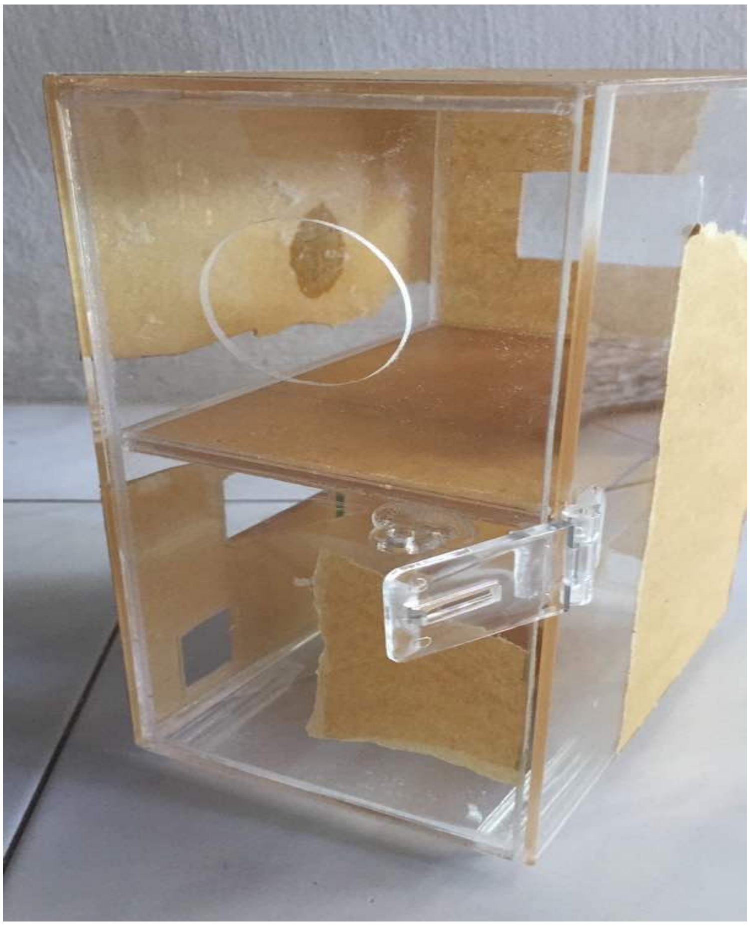

Figure 3.11: The glue is being cured

Figure 3.12: The glue is being cured

Figure 3.13: The glue that has been used

Step 3: Tinted the acrylic box

- The acrylic box is tinted using tinted film. We used tinted to make the box be opaque and the reading can be more accurate. Figures 3.14 show the tinted film had been used and Figure 3.15 shows the acrylic box after being tinted.

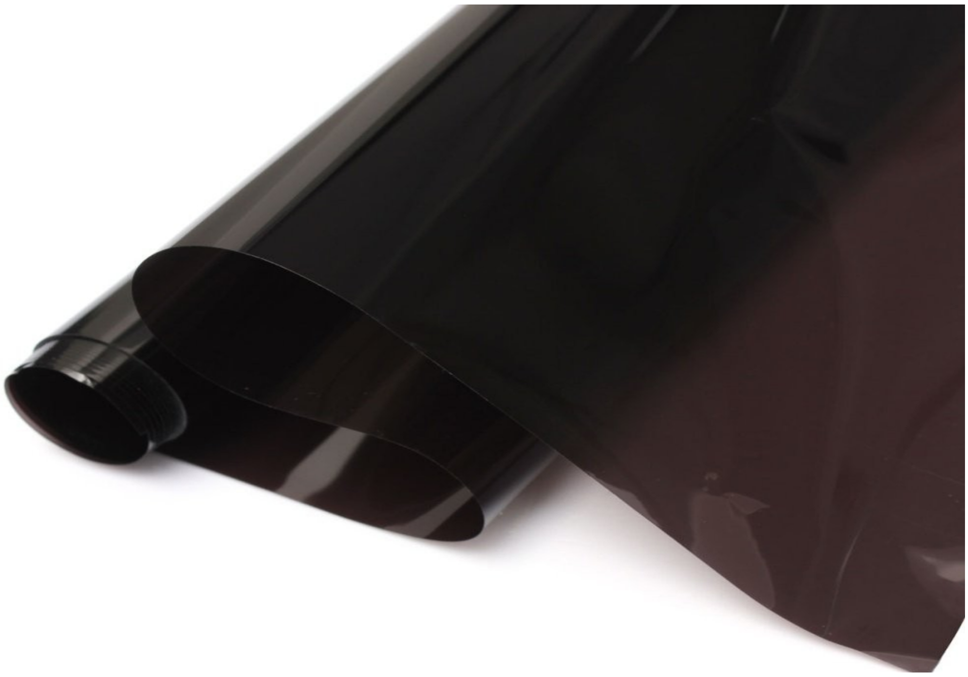

Figure 3.14: Tinted film

Figure 3.15: After tinted

Step 4: Wiring process

- Start the electrical part by using Arduino Microcontroller with operating voltage is 5V. Then we also use LCD to display the reading and the important one is the optical dust sensor. All the part is connecting by using soldering process. The Figure 3.16 shows the electrical part being testing before put it in the electrical part of the acrylic box. Then, Figure 3.17 shows an electrical part in the box after finished testing without any error.

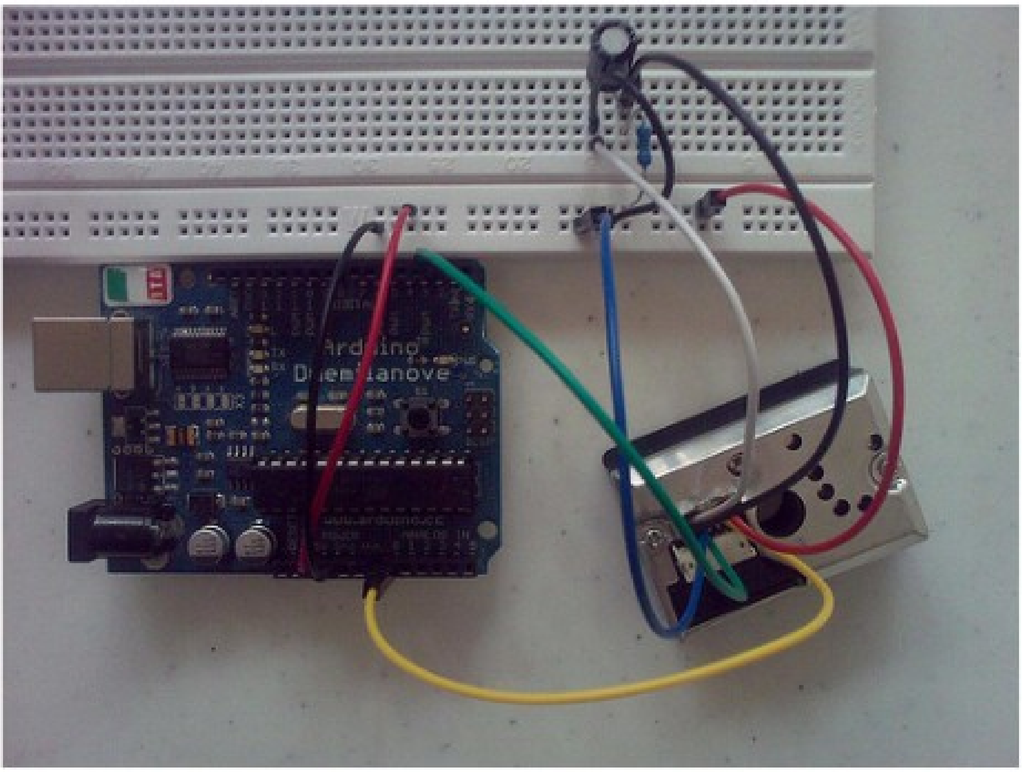

Figure 3.16: Testing the Optical Dust sensor

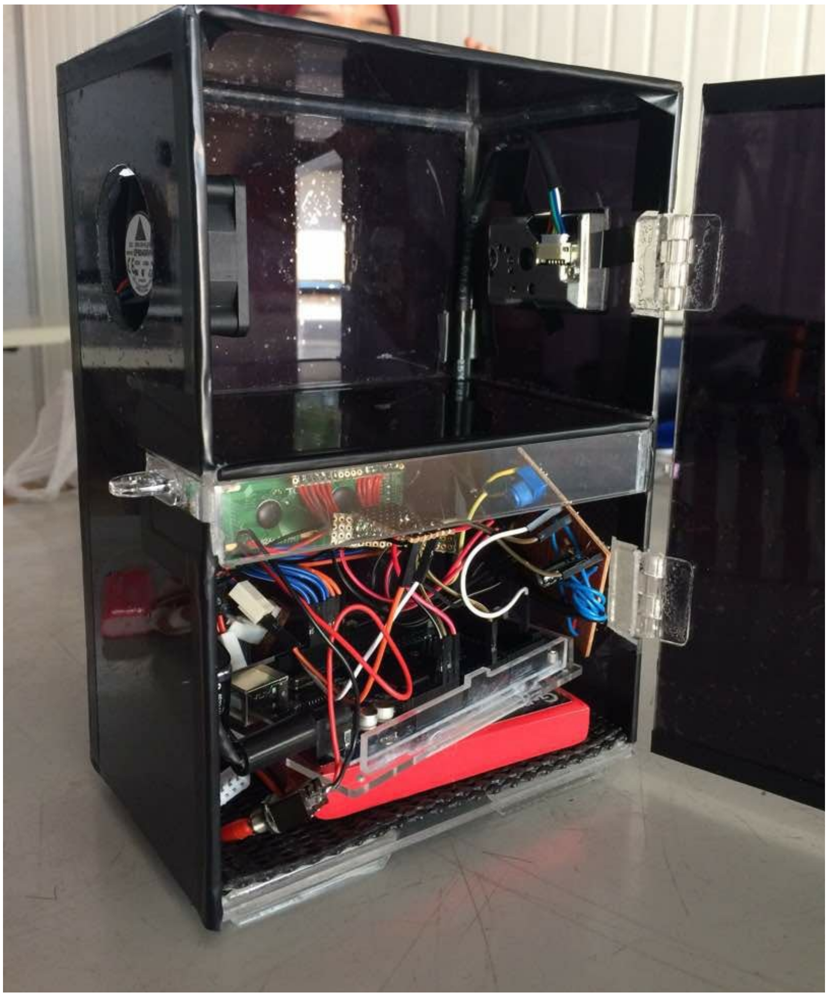

Figure 3.17: Electrical parts

Step 5: Testing

- Conducting the experiment indoor and outdoor by comparing with the conventional device (dust mate). Figure 3.18 shown the experiment setup in the fire chamber at UMP. The Figure 3.19**,** 3.20 and 3.21 shows the experiment conducted at different surrounding which are at indoor, outdoor and using car exhaust.

Figure 3.18: Experiment using mosquito repellent in the fire chamber

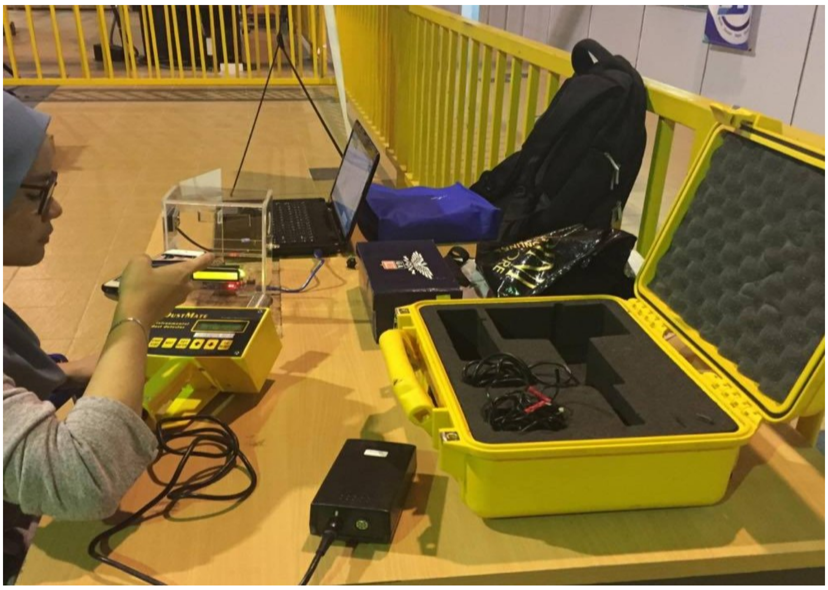

Figure 3.19: Indoor experiment at Blok T

Figure 3.20: Outdoor Experiment

Figure 3.21: Experiment using Car Exhaust (NGV and Petrol)

CHAPTER 4

RESULT AND DISCUSSION

In this chapter, the result of this project, the final hardware design of the system and the outcome of the measurements, and its analysis are discussed. The measurements are carried out at three different locations. The reading at each location will be presented and compared with the conventional device (Dust Mate) and refer to the AQI of Singapore since the scope for this project for Particulate Matter 2.5 (PM2.5).

4.1 Result

For the first experiment, we had conduct experiment for every one minute at the fire chamber. Fire chamber is a suitable place for the experiment because it is an airtight area. So, we can see the accumulation of smoke from the mosquito repellent.

a.) Experiment Data every one minute

Table 4.1: Comparison of Dust Mate and Optical Sensor every one minute

Time, min	Dust Mate (PM2.5), mg/m^3	Optical Sensor, mg/m^3	Output Voltage, V
1	0.20673	0.23	0.76
2	0.30339	0.37	1.6
3	0.33555	0.35	1.45
4	0.51954	0.52	2.44
5	0.2793	0.37	1.57
6	0.59151	0.52	2.48
7	0.49808	0.48	2.22
8	0.35697	0.59	2.91
9	0.35571	0.42	1.87
10	0.62075	0.6	2.95

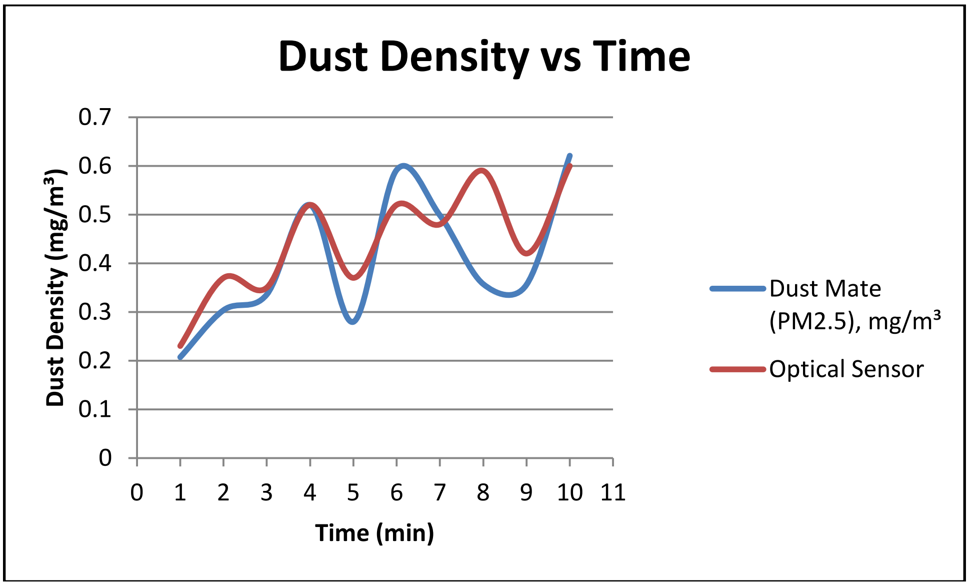

Figure 4.1: Comparison between Optical Dust Sensor and Dust Mate Every one minute

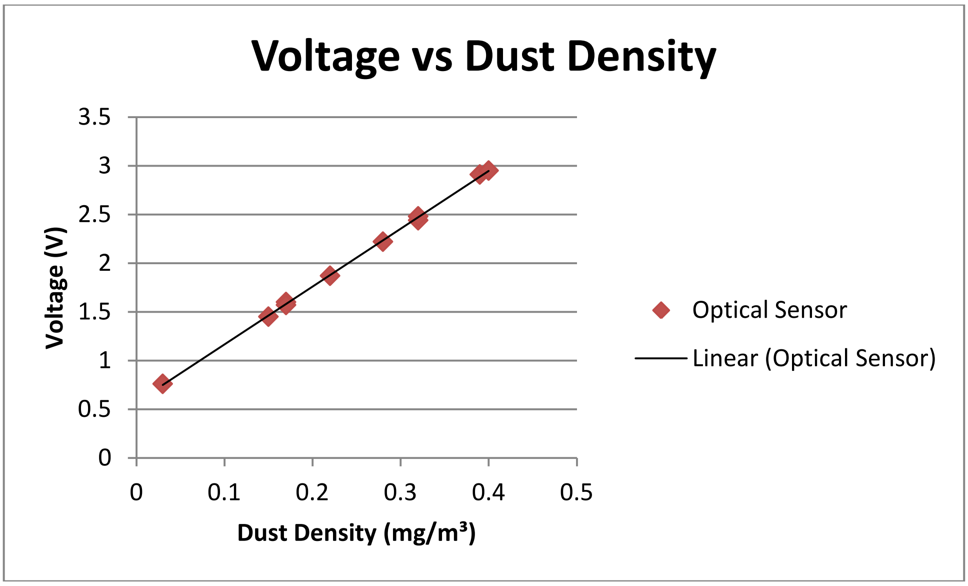

Figure 4.2: Output Voltage against Dust Density of Optical Dust sensor Every one minute

b.) Experiment Data every three minute

Table 4.2: Comparison between Dust Mate and Optical Sensor every three minute

Time, min	Dust Mate (PM2.5), mg/m³	Optical Sensor ,mg/m³	Output Voltage, V
3	0.45919	0.35	1.48
6	0.63618	0.61	3.03
9	0.5963	0.51	2.42
12	0.44598	0.41	1.83
15	0.53841	0.33	1.35
18	0.49339	0.49	2.28
21	0.47876	0.45	2.21
24	0.53342	0.43	1.93
27	0.43995	0.4	1.84
30	0.413497	0.36	1.59

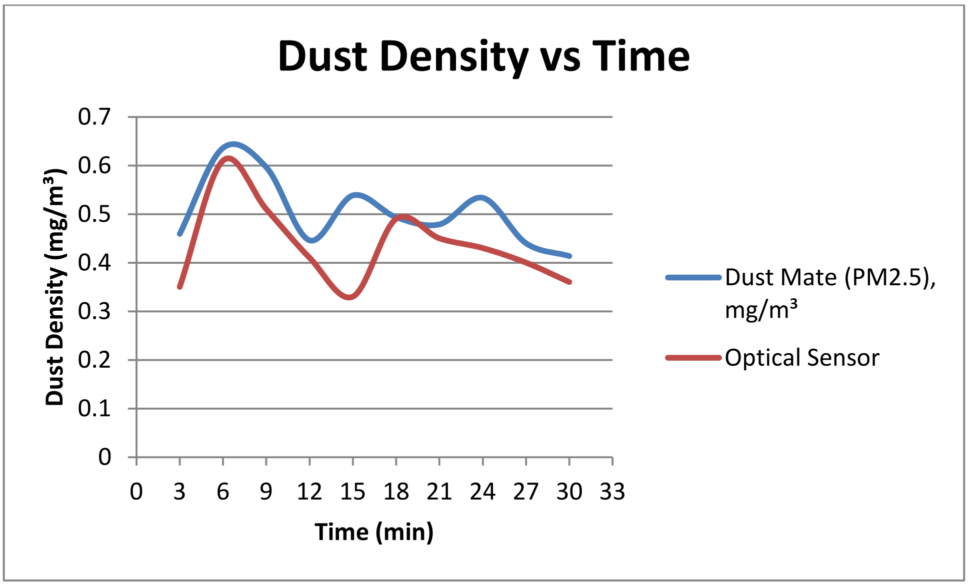

Figure 4.3: Comparison between Optical Dust Sensor and Dust Mate Every three minute

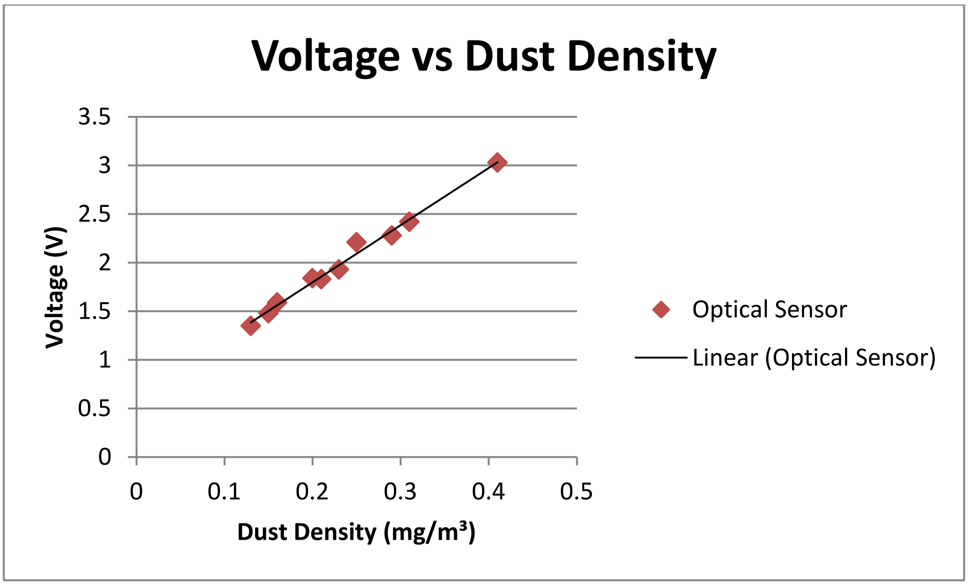

Figure 4.4: Output Voltage against Dust Density of Optical Dust sensor Every three minute

Based on the project testing experiment, the comparison between Optical Dust Sensor and Dust Mate has been proven that optical dust sensors functioning properly. With the data obtained from this experiment, it clearly demonstrates that optical dust sensors well functioning according to it theory, increases the reading of dust density, the output voltage also increases. The output of the sensor is an analog voltage proportional to the measured dust density.

The other evidence that sensor works well is the graph trends of Optical Dust Sensor still follow the Dust Mate trends. It has been proved by when the reading of Dust Mate increases, sensor reading also increases and vice versa. Dust Mate is used as a parameter of calibration because it is a device that has been successful and commercialized.

This is 10 and 30 minutes period of experiment testing with every 1 minute and 3 minutes has been recorded. The experiments are to test the effectiveness of Optical Dust Sensor by using mosquito's repellent smoke. The graph appears fluctuating although experiments are carried out in a sealed fire chamber room. This is because the smoke is in small amount that causes the smoke reached and touched to sensor with uneven condition. This is why graph reading is down and rises within certain period even though the smoke is accumulate in the room.

The data is taken and recorded within a maximum of 30 minutes due to the smoke only can achieve its flame stability in the period of 30 minutes. This is because the room without ventilation will be resulting in oxygen deficiency. The main component of air that supports combustion is oxygen. Specifically, combustion requires oxidizer where the molecule that accepts electrons. It turns out that combustion requires the fuel to be oxidized, that is it donates electrons. So, need something to accept the electrons, and that's the oxidizer, which is then reduced. Oxygen is a great oxidizer because it is so electronegative, which means it really wants to accept electrons (Chemistry StackExchange, 2013).

4.2 Ethical Recommendation

There are few safety measures to be taken into accounts. First of all, one should wear safety boots, jackets, goggles and gloves when handling tools and machine such as hand saw, grinding machine and cutter machine in the workshop. Most of the concerns that have revolved around is the safety during the finishing this project in workshop. Without any guidance from lecturer or teaching engineers, any task that related to the risk for student is prohibited.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This project presents the development of haze monitoring system by using optical sensor. By doing our project it could be a useful component to give awareness to the public safety. The development of this project can be implemented to give the public precautions step to avoid from having any outdoor and indoor activities if the level of air is hazardous. Besides, the developed system is low cost and low power to be implemented in our area. To that end, we created a system to measure, visualize, and share real-time local air quality information with others. Our project was success since it follow the theory and the result also tally to the conventional device. The design that we make is in a low cost material and easily to carry anywhere. The device also give a real time measurement and the device also can use for indoor and outdoor activities. The material that we used is suitable for the both activities. So, the system is accepted since the objective had been achieved .The proposed method is verified to be highly beneficial for haze monitoring.

5.2 RECOMMENDATIONS

1) Add a data log memory to save all the reading for an aware from any error while detecting the reading.
2) Add a push button on the electrical part for the calibration using suitable software.
3) Use a material that is long lasting and more sturdy than acrylic plastic
4) Create a program that is when the reading of air quality index (AQI) in unhealthy, the system will be sent unhealthy condition to Smartphone using short messaging system (SMS).

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APPENDIX A

COST ANALYSIS

Mechanical

No.	Item description	Quantity	Unit Price (RM)	Total Amount (RM)
1	Acrylic Sheet	1	119.90	119.90
2	Super Glue	5	1.30	6.00
3	Chloroform	1	20.00	20.00
4	Silicone Glue	1	16.00	16.00
Total				**RM 161.00**

Electrical and Electronics

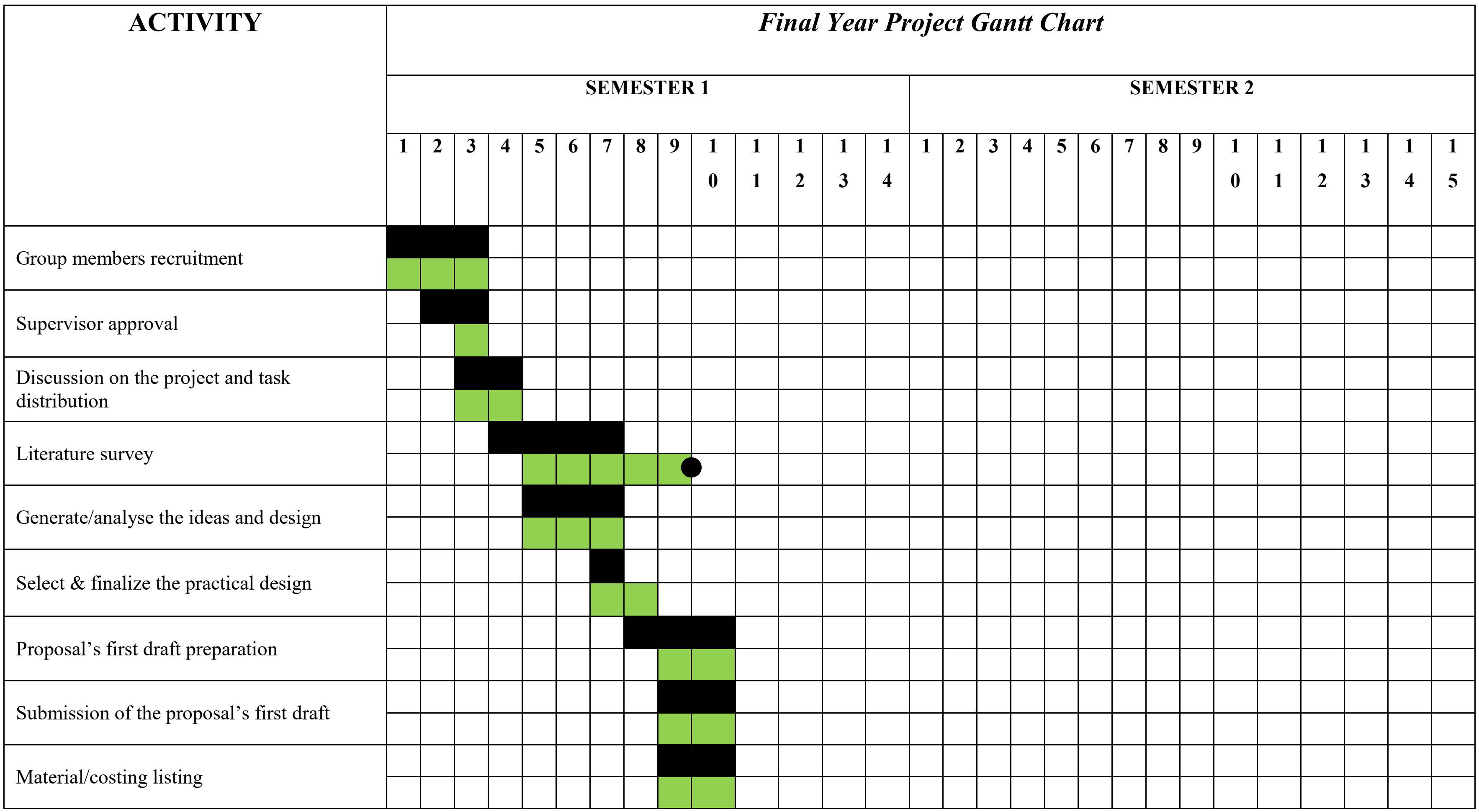
Items	Quantity	Price
Optical Dust Sensor	1	RM67.84
Arduino Mega	1	RM189.74
LCD Display(16x2)	1	RM19.08
Jumper Wire	2	RM30.00
Set Breadboard	1	RM50.00
220 uF capacitor	1	RM0.05
150 Ohm resistor	1	RM0.05
10k Potentiometer	1	RM1.27
Duracell MN1604 9 Volt	1	RM9.75
9v Battery Clip with 2.1mm X 5.5mm	1	RM5.20
Male DC Plug for Arduino		
Podoy 6A 125VAC SPST Sub-Mini	1	RM22.90
Toggle Switch		
	Total	RM395.88

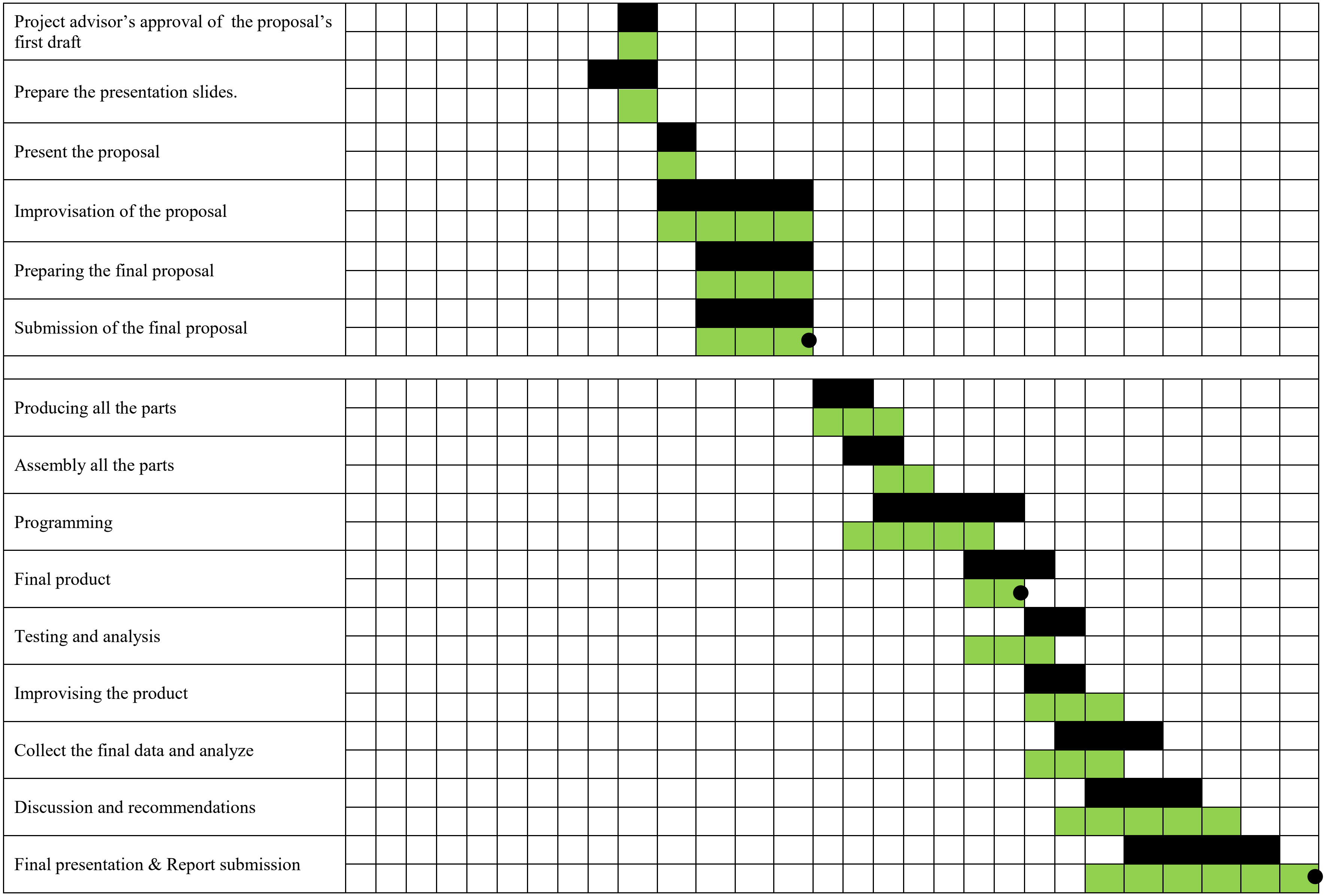
Total Cost Project

No	Particular	Amounts
1	Electrical Budget Cost	RM395.88
2	Mechanical Budget Cost	RM161.00
	Total	RM556.88

APPENDIX B

GANTT CHART AND MILESTONE




Project advisor's approval of the proposal's first draft
Prepare the presentation slides.
Present the proposal
Improvisation of the proposal
Preparing the final proposal
Submission of the final proposal
Producing all the parts
Assembly all the parts
Programming
Final product
Testing and analysis
Improvising the product
Collect the final data and analyze
Discussion and recommendations
Final presentation & Report submission

Milestone: 1)04/05/2017- Completion Literature Review
2)12/06/2017- Completion of Proposal Presentation & Report Submisson
3)30/10/2017- Completion of prototype
4)18/12/2017- Completion of Final Presentation & Report Submission

Remarks:

■	: Plan
■ (green)	: Actual
●	: Milestone