Faculty of Electrical and Electronic Engineering Technology

# DEVELOPMENT OF CARBON MONOXIDE DETECTION FOR VEHICLE USING IOT SYSTEM



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**Bachelor of Electrical Engineering Technology with Honours**

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**DEVELOPMENT OF CARBON MONOXIDE DETECTION FOR VEHICLE USING IOT SYSTEM**

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**A project report submitted**
**in partial fulfillment of the requirements for the degree of**
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**2021**

# DECLARATION

I declare that this project report entitled “Development of Carbon Monoxide Detection for Vehicle using IoT System” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

| | | |
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**APPROVAL**

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology with Honours.

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Date : 11/1/2022

**DEDICATION**

*This is dedicated to my beloved mother, Nor Jahan binti Ali Ahmad, father, Hasnan bin Daud and my siblings, Nurin Shairah, Mohd Shakir, Muhammad Hasif, Muhamad Haziq, Muhamad Hazim, Hariz Hamka and Muhammad Hamza. Praise be to Allah SWT, that I am part of this supportive family. Thank you for your advice and best wishes towards me.*

## ABSTRACT

Carbon monoxide (CO) gas leakage in vehicles has become more common in recent years. The leaking of a vehicle's exhaust system poses a significant risk to humans. The human respiratory and circulatory systems, for example, can be affected by hazardous gas, and a shortage of oxygen in the bloodstream can injure the driver and passengers' brains. Hazardous gas primarily affects drivers who have been driving and are on a long trip in a vehicle. The driver is supposed to take a break and nap in their car after along drive. During the hot season, the air conditioner (AC) will be typically turned on, ensuring that the engine is frequently turned on, allowing CO gas leakage into the car. This project is designed at an affordable prices to solve this problem by using the MQ-7 sensor to detect CO gas. To improve the efficiency of this system, an Arduino UNO is utilised as a microcontroller to control both the input and output processes. The CO gas concentration in the car is displayed as a ppm value on the LCD display. Alarms are activated by the use of LEDs and buzzers. ESP8266 is used to send an alert message through WhatsApp application to an authorised person and GPS technology are utilised as tracking device, which functioned to track the location on longitude and latitude. Furthermore, this system is equipped with a power window motor that automatically rolls down the window when the CO gas concentration is dangerously high. As a result, the concentration of CO gas in the car can be controlled, preventing CO gas poisoning and death.

# *ABSTRAK*

Kebocoran gas karbon monoksida dalam kenderaan semakin meningkat saban tahun. Kebocoran sistem ekzos telah memberi risiko kepada pengguna. Sistem pernafasan dan peredaran darah antara dua contoh yang boleh terkesan akibat daripada terhidu gas yang merbahaya dan kekurangan oksigen dalam saluran darah juga boleh mencederakan bahagian otak pemandu dan penumpang yang terhidu gas tersebut. Antara golongan yang paling terkesan adalah pemandu yang telah memandu pada jarak yang jauh. Kebiasaannya, pada musim panas, pemandu akan mengambil masa untuk berehat dan tidur seketika setelah memandu pada jarak jauh dengan tidak akan mematikan enjin kenderaan dan akan menghidupkan sistem penghawa dingin. Hal ini demikian boleh mengakibatkan kebocoran gas karbon monoksida dan memasuki ke dalam kenderaan melalui penghawa dingin. Projek ini diciptakan dengan harga yang berpatutan untuk menyelesaikan masalah ini dengan menggunakan sensor MQ-7 untuk mengesan kehadiran gas dalam kenderaan. Bagi menambah baik keberkesanan sistem ini, Arduino UNO digunakan sebagai mikrokontroler untuk mengawal kedua-dua proses input dan output. Kepekatan gas dalam kereta akan dipaparkan pada paparan LCD dalam nilai PPM. Selain itu, penggera keselamatan akan diaktifkan oleh lampu-lampu LED dan penggera bunyi. Seterusnya, ESP8266 pula digunakan untuk menghantar mesej peringatan kepada pengguna melalui aplikasi WhatsApp dan GPS pula digunakan sebagai peralatan untuk mengesan lokasi kenderaan dalam koordinat longitud dan latitud. Tambahan pula, sistem ini juga dilengkapi dengan sistem motor motor tingkap kuasa yang akan menurunkan tingkap secara automatic apabila kepekatan gas karbon monoksida berada dalam keadaan tinggi dan merbahaya. Sebagai keputusan, kepekatan gas karbon monoksida boleh dikawal untuk mengelak keracunan gas yang boleh mengakibatkan kematian.

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| | | |
|---|---|---|
| $V$ | - | Voltage |
| $CO$ | - | Carbon Monoxide |
| $GPS$ | - | Global Positioning Syatem |
| $LCD$ | - | Liquid Crystal Display |
| $LED$ | - | Light-Emitting Diode |
| $MQ-7$ | - | Carbon Monoxide (CO) gas sensor |
| $IDE$ | - | Intergrated Development Environment |
| $RAM$ | - | Randon Access Memory |
| I/O | - | Input/Output |
| Hb | - | Haemoglobin |
| A | - | Ampere |

## LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

These days, vehicles have been an important part in our daily lives. Living in this era, mostly people use vehicles as their life routine including as working purpose. Besides that, safety issue regarding the safety of the vehicles is getting crucial lately, especially the leakage gas issue that can cause death. Carbon monoxide (CO) can kill people in silent because it is colorless and odorless. CO can be founded in car fumes that is produced when people start the car engine.. There are several symptoms of CO poisoning like headache, weakness, dizziness, chest pain and confusion. In addition, a lot of inhalations can make people pass out or kill people. Even worse, people who are sleeping can die from CO poisoning without having any symptoms.

Arduino UNO is a major part for this project as it is functioning as a microcontroller to monitor all the inputs and outputs for the system. As for the carbon monoxide (CO) detector, this system uses MQ7 semiconductor sensor to sensing the CO gas leakage. WhatsApp application is used as an output where the warning signal will be sent when the MQ7 detects the CO gas, whether it is at a normal or dangerous level. Besides that, this system also implements an automatic motor power window which works to roll down the window when the concentration of CO gas is at the dangerous level. LEDs and buzzer also will be operated as warning signals.

Carbon monoxide (CO) leakage normally happens because of one of two events. First case, the system of air conditioning in car usually operates by filtering air from the outside before it is being used. Nevertheless, it is very recommended to not turn on the air conditioning system while the engine inoperative. Car air conditioner may gather CO gas while the engine inoperative. So, possibly for the gas leakage to happen. Second, CO leakage also can be happened due to the original exhaust has been altered for some reason. Commonly, a normal car has a long exhaust system but modified exhaust system is a little bit shorter. Due to this, carbon monoxide (CO) manages to seep into the car's inner chamber through the modified exhaust system way more easily compared to standard exhaust system.

The most dangerous situation is when the driver is sleeping, they may not have any poisoning symptoms. So, the driver tends to not be able to roll down the window when the CO is at the dangerous level inside the car.

## 1.2 Problem Statement

A long drive usually makes the car drivers a little bit tired and they might take a break for a short nap. In this case, the drivers usually will lock the car from the inside for the safety reasons. They will also keep the engine and the air conditioning running. However, the drivers might not be awared off the presence of carbon monoxide (CO) producing by the running engine because of the characteristic itself, which is colorless.

## 1.3 Project Objective

There are three following objectives for this project as follows:

a) To design a carbon monoxide gas detection system for vehicle with automatic roll down motor window by using Arduino microcontroller.

b) To develop a warning signal and monitoring system for the Carbon Monoxide (CO) gas detection and using ESP8266 to send an alert message through WhatsApp application with the location of the vehicle.

c) To analyse the effectiveness of carbon monoxide detection system and warning signal system to the user and the authorized person.

## 1.4 Scope of Project

This system contains a combination of both hardware and software. Arduino UNO is used as a microcontroller to control the whole system. In order to achieve the first objective, ESP-8266 is used to send a warning signal via WhatsApp application whenever the MQ7, Carbon Monoxide (CO) gas sensor detects the CO gas concentration whether in normal or dangerous level.



Besides, in order to achieve the second objective, the components used are MQ7, Carbon Monoxide (CO) gas sensor as an input and buzzer, LCD display, LEDs and motor for automatic roll down power window as an output. The MQ7 sensor functioned as sensor to detect the existence of CO gas. The green LED will turn ON as a warning when the CO gas is at the normal level but when the concentration of CO gas is at the dangerous level, the buzzer will trigger and red LED will turn ON as a safety alert. The automatic roll down power window will automatically roll down to decrease the concentration of CO gas. Arduino Integrated Development Environment (IDE) is used for the software part of the program section of the application

## 1.5 Project Outline

Basically, this report covers five chapters. All these 5 chapters are covered on the implementation of the project operation. Chapter 1 contains of explanation of this project scope, together with the background of the project, problem statement, objectives, project scope and project outline.

Meanwhile, chapter 2 consists of a literature review. This chapter discusses the related previous studies domeby some researchers. Details on materials, devices and technologies that have been used and implemented by researchers will be examined.

As for the chapter 3, this chapter presents the methodology used to implement this project. The technique and method as a reference have to be developed with a consistent flow of this study. In addition, the block diagram will display the complete purpose of this project scope. Besides, the flowchart will also be used as the method to explain this project throughout the chapters.

Chapter 4 focuses on the preliminary results of the project.

Finally, as for the last chapter, chapter 5 contains the conclusions of the project.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter discusses the related part studies by other researchers, the effects of carbon monoxide (CO) gas to the human body and also the source of CO gas from the vehicle. In addition, this chapter also explains the overview of existing devices, microcontroller in general and CO gas sensor technologies. In comparison, this chapter also will discuss about a variety of previous related articles, works, and journals related with this project.

### 2.1.1 Effect of Carbon Monoxide (CO) on Human Body System

Carbon monoxide (CO) is a toxic gas that can affected generally through human body system. One of the effects of CO on human body system is Hypoxia. Basically, hypoxia is the lack of oxygen in vital or non-vital organs. Carbon Monoxide hinders the blood's ability to carry oxygen to body tissues including vital organs such as kidneys, heart, kidneys. When human body receives CO through inhalation, it combines with the oxygen carrying hemoglobin of the blood and carboxyhemoglobin (COHb) will form. When it combines, the hemoglobin is no longer available to carry oxygen together.

Another effect of Carbon Monoxide is it can cause an inflammation to human body. Inflammation can be happened due to many reasons and as for this study, it can happen due to the lack of oxygen on human body system. CO poisoning may increase the risk of neurologic defects, diabetes, cardiac injury and also death [1].

There are several symptoms vary widely based on exposure level duration and the general health and age on an individual as shown on Table 2.1 below [2].

Table 2.1 This is a sample caption for table. Please push tab once after the table number before you type the caption.

| Concentration of CO gas | Time of exposed | Symptoms |
| --- | --- | --- |
| 0 ppm | - | Fresh air. |
| 9 ppm | - | Maximum indoor air quality level. |
| 10-35 ppm | 8 hours | Headache, dizziness and nausea. |
| 100 ppm | 2-3 hours | Slight headache. |
| 200ppm | 2-3 hours | Mild headache, dizziness, fatigue and nausea. |
| 400 ppm | 1-2 hours | Loss of judgement, serious headache, sweating. |
| 800 ppm | 45 minutes | Unconscious within 2 hours. Dizziness, nausea and convulsions. Death within 2-3 hours. |
| 1,600 ppm | 20 minutes | Headache, tachycardia, dizziness and nausea. Death within 1 hour. |
| 3,200 ppm | 5-10 minutes | Headache, dizziness and nausea. Death within 30 minutes. |
| 6,400 ppm | 1-2 minutes | Headache, dizziness and nausea. Death less than 20 minutes. |
| 12,800 ppm | 1-3 minutes | Unconsciousness. Death within 3 minutes. |

### 2.1.2 Source of Carbon Monoxide (CO) Gas

Carbon Monoxide (CO) formation is usually because of incomplete combustion of carbon compounds; common sources include fire, engine exhaust, and faulty furnaces. As for the vehicles, CO gas emissions could be produced from through the waste product from exhaust pipe system of vehicles and unfinished combustion process from any carbon-based gasoline [3].

System of exhaust piping of vehicle discharges fumes that contains CO gas that are sucked into the cabin through air conditioner when vehicle is in idle condition. High concentration of CO gas can build up to dangerous condition. This usually happens when fuel-burning devices are not rightly operated, vented and well-maintained [4].

When the car was in idle mode such as in heavy traffic, the level of CO gas could rise from 25 ppm to 70 ppm which is will put it in a dangerous level that can causes the passenger inside the car to suffer any kind of symptoms like dizziness, migraine and nausea. The concentration of the CO gas could be getting higher when the car engine was not running [3]



## 2.2 Overview of Existing Project System

This section will analyze some previous existing project implementation that has been applied related with this project system. Some great researchers have done their research in developing the best methods of improving the use of the carbon monoxide (CO) gas detector.

### 2.2.1 Car indoor Gas Detection System

This project system was developed to alert users by detecting carbon monoxide (CO) gas by using 2 units MQ-7 gas sensors and also using buzzer to produce an alarm signal when the concentration level was at the dangerous level. The microcontroller of this system that worked as a main board is Arduino Mega 2560. The user would select HC-05 from the Bluetooth system menu selection to trigger the device for the first time. As for the warning signal devices, it consists of LEDs, LCD buzzer. In addition, this device also used GSM to transmit an alert message to an authorized person and GPS system was used to track the car and the driver coordinates. However, GSM is not applicable as it has a set maximum call site range of 35 kilometres, which is extremely limiting. Besides, GSM has a limited data rate capability, upgraded version GSM devices are utilised for larger data rates. [5].

### 2.2.2 Wireless Sensor Network Application for Carbon Monoxide Monitoring

This system focuses on the network device sensor system for monitoring carbon monoxide (CO) emissions, including the development of software and hardware parts. ATMega8 was used as a microcontroller to operate this system. There are three types of sensors has been used in this system, which are HSM20 G as a humidity sensor, LM35DZ as a temperature reader, and TGS 2600 as a CO gas reader. All the data read by the sensor nodes will be distributed wirelessly by using ZigBee and the data collector will be operated as a reader, data monitor and processor. Besides, this system also used Visual Basic 6.0 as a data display in the form of visuals and tables and the data transfer information should be stored in the database. Nevertheless, this system consists no alert message to the user or an aouthorised person which is not effective for monitoring system. This system also uses PIC Controller as a microcontroller which is not applicable as it runs on a longer code base and requires an additional plugin to connect external hardware devices [6].

### 2.2.3 Air Quality Monitoring System Based on IoT Using Raspberry Pi

The purpose of this project is to create an air quality monitoring device to monitor the atmospheric pollution that is highly reliable, use-friendly and cheap. This project used 2 sensors which are MQ-9 that works as sensor to detect carbon monoxide (CO) gas and MQ-135 has a wide spectrum for detection, such as carbon dioxide (CO2) gas, smoke and alcohol. This project also developed Arduino UNO which used to interact with Raspberry Pi via a USB cable and Wi-Fi adapter used to help Raspberry Pi connects to internet. Then, the value of the parameter taken from the sensor will be changed to the measured value and displayed in IBM Bluemix Cloud. Nonetheless, this system has no alert message system for monitoring which is not ideal for user to monitor the system [7]

### 2.2.4 Gas Leakage Monitoring with Mobile Wireless Sensor Networks

Gas leakage monitoring and early warning system based on mobile wireless sensor networks (MWSNs) is created in this system. The system is made up of two components: remote sensors and an analytical server. In this study, remote sensors are referred to as sensor terminals, and each sensor terminal is made up of a gas sensor, a microcontroller module, a GPS receiver module, a General Packet Radio Service (GPRS) module, and a power module. They are combined and put on mobile devices as well as stationary locations to create stationary sensor terminals and mobile sensor terminals. However STM32F103RBT6 is not relevant to be used as it is hard to find not used friendly [8].

### 2.2.5 SmartCOdetect: An Automated Car Window Opening System on Detection of Carbon Monoxide

The design and development of SmartCOdetect, an arduino-based intelligent embedded device for a vehicle cabin that detects CO gas and displays it on an LCD screen, is the topic of this work. If the CO level rises above a certain threshold, an alert will sound and, if necessary, the ventilation window will be opened promptly. The control unit sends a signal to the control circuit of the vehicle's window to provide ventilation after sending a notification via GSM to the owner's number registered with the SmartCOdetect system. After receiving the response from the owner, the control unit sends the signal to the control circuit of the vehicle's window to provide ventilation. It also ensures the safety and well-being of passengers in the car interior. Nevertheless, GSM is not really good system to be used since GSM only give the location, not the exact location of the vehicles. Besides, GSM also less accurate compared to GPS [9].

### 2.2.6 Comparison Table with Existing Project

Table 2.2 below shows a different between elements and the irrigation method used in the different current project system. Project 2.2.1 is referred to the Car Indoor Gas Detection System while Project 2.2.2 shows the Wireless Sensor Network Application for Carbon Monoxide, Project 2.2.3 illustrates the IoT-based Air Quality Monitoring System using Raspberry Pi, Project 2.2.4 shows the monitoring of gas leakage with Mobile Wireless Sensor Networks and Project 2.2.5 is referred to an Automated Car Window Opening System on Detection of Carbon Monoxide.

By comparing these 5 systems of the current project, it is shown that most of the related project used MQ-7 sensor that functioned to detect the existence of carbon monoxide (CO) gas. LCD display also has been used to display the concentration of CO gas time by time. Finally, buzzer which is functions as an output signal also has been used to give a warn signal whenever the concentration of CO is at dangerous level.

As for the microcontroller, the Car Indoor Gas Detection System and SmartCOdetect: An Automated Car Window Opening System on Detection of Carbon Monoxide used Arduino UNO as their microcontroller for hardware and software part. For the Wireless Sensor Network Application for Carbon Monoxide Monitoring System, this project used PIC Controller as a microcontroller. In order to manage the IoT-based Detection System and Air Quality Monitoring System used Raspberry Pi as main hardware and finally, for the Gas Leakage Monitoring with Mobile Wireless Sensor Networks, this system used STM32F103RBT6 as a microcontroller

Basically, Arduino UNO is used as microcontroller for this project rather than PIC Controller since Arduino UNO is the latest technology and it is also quite easier to program the system compared to others microcontroller. So, the configuration of the circuit can be easily applied to the PCB board.

Table 2.2 : Comparison between the components and the method of irrigation used in the various existing project systems.

| Project system \ Component and irrigation | Arduino Mega | PIC controller | Raspberry PI | STM32F103R | MQ-7 gas | TGS 2600 gas | MQ-9 gas | DLGA-700 | GSM | HC-05 | LCD display | Buzzer | ZIGBEE | IBM Bluemix |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project 2.2.1 | ■ | | | | ■ | | | | ■ | ■ | ■ | ■ | | |
| Project 2.2.2 | | ■ | | | | ■ | | | | | ■ | | ■ | |
| Project 2.2.3 | | | ■ | | ■ | | ■ | | | | ■ | | | ■ |
| Project 2.2.4 | | | | ■ | | | | ■ | | | | | ■ | |
| Project 2.2.5 | ■ | | | | ■ | | | | ■ | | ■ | ■ | | |

## 2.3 Microcontroller

The PIC microcontroller is a widely used microcomputer for monitoring and optimizing devices and processes. PIC stands for Peripheral Interface Controller, and it was created exclusively for Programmed Data Processor (PDP) computers. The Harvard architecture PIC microcontroller has a memory device and memory data, with the bus separating each memory. The Central Processing Unit (CPU) of a microcontroller is accompanied by many other peripherals such as RAM and ROM, I/O ports, timers and counters, analog-to-digital converter (ADC), digital-to-analog converter (DAC) serial ports, interrupt logic, oscillator circuits, and other available blocks on the system.

The assembly languages of the desired microcontroller are usually used to programme them. Unlike microprocessors, which can be used on computers, programmable microcontrollers are designed for embedded devices. Automatic control systems, such as power machines, toys, implantable medical devices, office equipment, vehicle control systems, and other types of embedded systems, use microcontrollers. Many microcontrollers support a variety of assembly languages.

The CPU is the microcontroller's brain, and it is in responsibility of the microcontroller's order, encoding, and execution. The CPU must always decode commands received from the system memory. The microcontroller's memory feature is used to store data and software. The driver or interface of various devices such as LCD, LED, printer, and microcontroller memory usually use parallel input/output ports.

Serial ports, including parallel ports, offer a range of serial interfaces for microcontrollers and other peripherals. Timers and counters, on the other hand, are one of the most important elements of a microcontroller. Within modulations, pulse generation, frequency calculation, and oscillation generation, they have all of the timing and counting functions. It is also capable of measuring external pulses.

The microcontroller has many pros and cons. The use of a microcontroller is practical, easy to troubleshoot, and manageable. The programmer will program the majority of pins to perform a number of tasks in a short amount of time. Microcontrollers, on the other hand, are used in micro-engines and execute a small number of simultaneous executions. It is not possible to connect high-capacity computers directly. The block diagram of the microcontroller is shown in Figure 2.1. Please keep in mind that operating blocks can differ from one system to another [10].

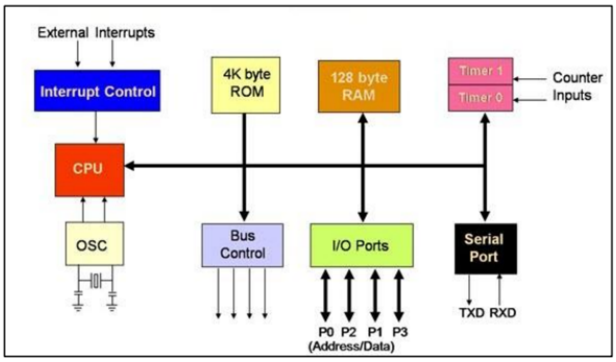


Figure 2.1 Block diagram of microcontroller

### 2.3.1 Arduino

Arduino is an open-source physical computing platform based on software and hardware that is easy to use and designed for immersive project development. It is composed of two main elements: a microcontroller (physically programmable circuit board) and an IDE (Integrated Development Environment) computer programme. Using the C and C++ programming languages, it is used to write and transfer code to a physical board. This programme is compatible with a wide range of computer operating systems, including MAC, Windows, and Linux.

Beginners will find this Arduino app to be simple to use, but advanced users will find it to be flexible. The Arduino UNO is a microcontroller module based on the ATmega328 microcontroller. It features 14 optical input/output pins (6 of which can be used as PWM signals), 6 analogue inputs, a 16 MHz crystal oscillator, a USB port, a power jack, an ISCP header, and a reset button. It can be started by connecting a USB cable to a computer and powering it with a battery or an AC-to-DC adapter.

The elements of this Arduino board's unique interfaces that allow the CPU board to connect to the shield set it apart from any other board or device. Different interchangeable parts can be connected to the shield in this situation. Some shields interact directly with the Arduino board via pins, while others bind to the I2C serial bus. The shield would be mounted next to the stakes if the shields were directly attached to the I2C serial bus. Arduino uses a variety of processors, the most of which have a linear 5V regulator and a 16 MHz crystal oscillator.

The Arduino UNO's ATmega328 CPU has 32 KB of flash memory for code storage, 0.5 KB for the bootloader, 2 KB of SRAM, and 1 KB of EEPROM. This operates at a 16MHz clock speed. Software memory and information memory are the two types of memories. It means that the programme code is kept on the hard drive's storage, while the application text is kept in the computer's memory. The pin diagram for the Arduino UNO ATMega328 is shown in Figure 2.2 [11].

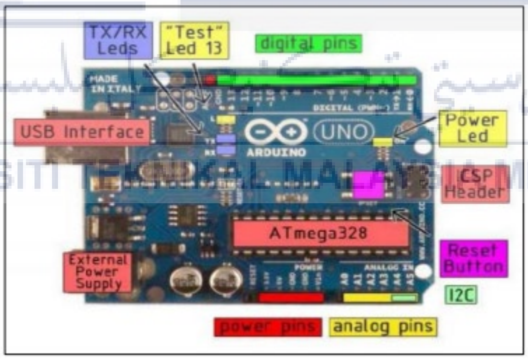


Figure 2.2 Pin diagram of Arduino UNO ATMega328

### 2.3.2 Raspberry Pi

The Raspberry Pi is a low-cost, general-purpose computer that can be plugged into a standard keyboard and mouse. It is sometimes referred to as a microcomputer due to its limited size. It is capable of providing more for personal computers with better 3D graphics than a modern game console, as well as its gaming performance. Scratch and Python are the programming languages used by Raspberry Pi.

The Raspberry Pi comes in two varieties: Model A and Model B. There are several differences between these two models. Model B is more expensive than Model A, but it has significant advantages. It has twice the memory of 512 MB of RAM on the inside. The pin diagram for the Raspberry Pi Model B is shown in Figure 2.3 [7].

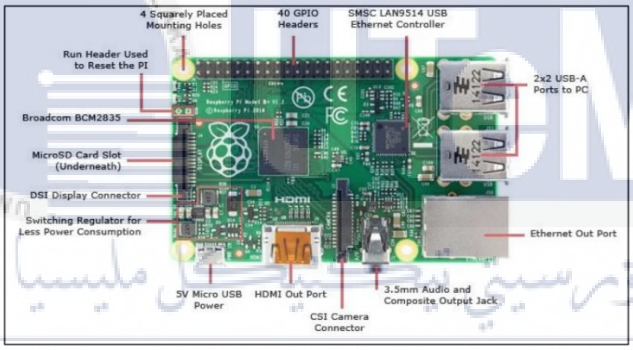




Figure 2.3 Pin diagram of Raspberry Pi model B

The board of the Model B has two USB ports, which are mainly used to connect the keyboard and mouse to other USB devices. The specification is based on the Broadcom BCM2835 SoC, which has an ARM1176JZF-S 700MHz CPU, Video Core IV GPU, and 256MB of RAM. Instead of a hard disc or solid-state drive, the model relies on an SD card for booting and long-term backup. This board is designed to run a Linux kernel-based operating system. The Raspberry Pi Model B microcontroller board's specifications are shown in Table 2.3 [12].

Table 2.3 This is a sample caption for table. Please push tab once after the table number before you type the caption.

| Specification | Details |
| --- | --- |
| Processor | ARM11 |
| Chip | Broadcom BCD2835 |
| Clock speed | 700 MHz |
| Power Source | 5V |
| Digital I/O Pins | 700mA (3.5W) |
| Analog Input pins | 8 |
| DC Current per I/O Pin | - |
| DC Current per I/O | 40 mA |
| Flash Memory | SD CARD |
| SRAM | 512 MB |
| Ethernet | 10/100 |
| USB 2.0 | 2 |
| Video Out | HDMI, Composite |
| Audio Out | HDMI, Analog |

### 2.3.3 Contrast of Arduino and Raspberry Pi

Arduino can also be used to control and influence the physical world. Raspberry Pi, on the other hand, is more software-based than hardware-based. Many programmes rely on software enhancements, graphics, and multimedia because it is just a Linux application. Table 2.4 shows the relationship between the Arduino UNO and the Raspberry Pi Model B [12].

Table 2.4 The relationship between the Arduino UNO and Raspberry Pi Model B

| Feature | Arduino UNO | Raspberry Pi Model B |
|---|---|---|
| Size | 2.95" x 2.10" | 3.37" x 2.125" |
| Processor | ATMega328 | ARM11 |
| Clock Speed | 16 MHz | 700 MHz |
| ROM | 32 KB | External SD |
| RAM | 2 KB | 512 MB |
| EEPROM | 1 KB | - |
| Minimum Power | 42 mA (0.3W) | 700 mA (3.5W) |
| Input Voltage | 7-12 V | 5 V |
| Digital GPIO | 14 | 8 |
| Analog Input | 6 | - |
| PWM | 6 | - |
| TWI/12C | 2 | 1 |
| UART | 1 | 1 |
| SPI | 1 | 1 |
| Dev IDE | Arduino Tool | Linux, Squeak, IDLE |
| USB | 1 USB 2.0 | 2 USB 2.0 |
| Ethernet | - | 10/100 |
| Audio | - | HDMI, Analog |
| Video | - | HDMI, Composite |

## 2.4 Carbon Monoxide (CO) Gas Sensor Technologies

Several new methods for detecting carbon monoxide emissions have been developed in recent years. In addition, there are four carbon monoxide gas detector systems that are suitable for use in residential settings. Colorimetric, metal oxide, electrochemical, and infrared sensors were among the four sensor systems used.

### 2.4.1 Colorimetric Sensor

Where only a small amount of energy is available and a low-cost sensor is needed, colorimetric sensors are widely used in passive Carbon Monoxide (CO) gas detectors. These sensors use a chemical method to catalyze the reaction of CO gas and change color. The colorimetric gas sensor has the advantage of detecting only one gas. A chemical reaction between the gas and the dye causes the selectivity. The reaction is dependent on the amount of chromogenic material present.

Colorimetric CO detection system with a 1 ppm tolerance limit, a 500-ppm dynamic range, and high CO selectivity over all common air pollutants including CO2, NO2, SO2, and O3. By using external chemical sensor probes, the visual sensor system may be applied to several other air contaminants [13].



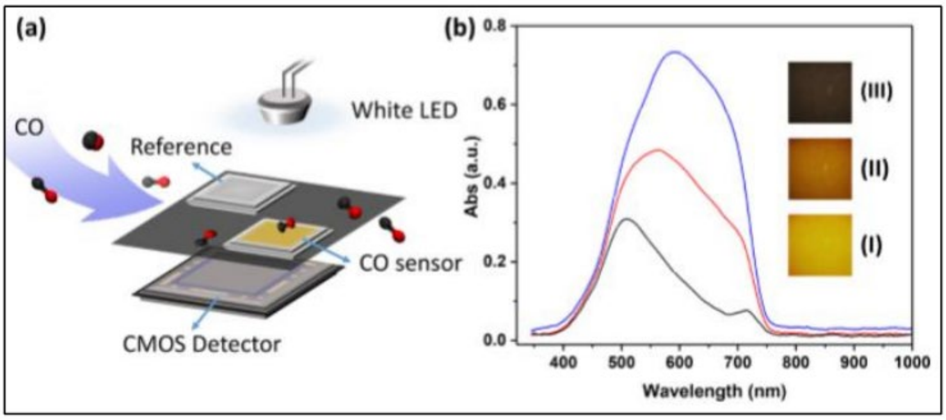


Figure 2.4 (a) Schematic of the setup for CO sensing. (b) UV−vis the sensing spectrum of the silica paper probe during sustained exposure to CO.

The CO test gas must be transferred at 1 L/min from the Tedlar airbag to the sensor cable network where the reference chip (grey) and the CO sensor module (yellow) are located, according to Figure 2.4 (a). The white LED illustrates the sensor chip, and the CMOS imager senses the transmitting signal, as shown in Figure 2.4 (b). Insets (I), (II), and (III) show images of the CO sensor chip at different doses of CO radiation, from low to high [13].

Furthermore, one of the disadvantages of colorimetric sensors is the reaction's slower reversibility. In the absence of CO gas, this sort of sensor usually takes longer to recover. Temperature can also affect reversibility, making it more difficult to rapidly reset the detector. These sensors are unable to detect CO gas concentrations in real time.

### 2.4.2 Metal Oxide Semiconductor Sensor

There are two groups of metal oxide CO sensors: p-type (positive type) and n-type (negative type). An excess of electrons or negative charges that contain a negative charge is referred to as N-type, while an excess of positive charges that lack an electron is referred to as p-type. Fresh air is highly insensitive to n-type CO metal oxide sensors. When exposed to CO gas, however, resistance will quickly deteriorate. The most common metal oxide in this group is tin oxide (SnO2), and tin oxide sensors make up the majority of today's metal oxide sensors. P-type metal oxide CO sensors, on the other hand, have a low resistance in clean air and raise it until completely exposed to CO gas [14].

Metal oxide sensors detect CO gas by measuring the resistance of the metal component, which is reduced when CO gas is oxidized to carbon dioxide ($CO_2$). Long lifespan, fast electrical analysis, and micro-manufacturing capabilities are some of the current advantages over competing technologies. They have been in use for the longest time and are among the most accurate in long-term records. Metal oxide sensors, on the other hand, have many disadvantages, including high input power, low resolution, high humidity, and temperature sensitivity.

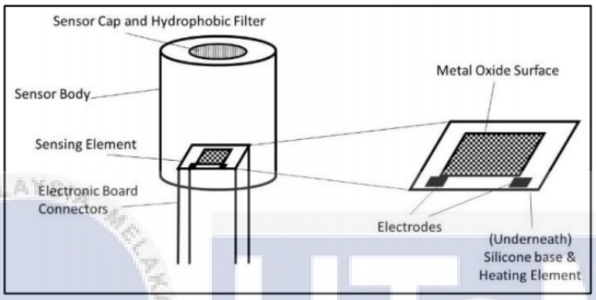


Figure 2.5 Metal Oxide semiconductor CO sensor structure.

### 2.4.3 Electrochemical Sensor

CO-gas electrochemical sensors are often simple electronic devices. When exposed to CO gas, they can generate a small amount of electricity. They have always been used to regulate the environment in factories and gas chambers. It is made up of two or three electrodes that are separated by an electrolyte. The electrode and pins are enclosed in a plastic housing with a narrow capillary tube to allow gas to pass through them.

The electrodes interact with an electrolyte, which can be liquid, gel, or solid, according to the specification. These electrodes must allow CO gas to diffuse into the cell while maintaining electrolyte consistency. To provide a precise comparison with other sensors, the third electrode (calibration electrode) is combined. This function allows the sensor's output to be improved and its range to be extended. Electrochemical CO sensors are shown in Figure 2.6.


Figure 2.6 Electrochemical CO sensor.

#### 2.4.3.1 Sample paragraph of subtopic level 3

The TL in distribution feeder is caused by heat generated due to current flow through feeder resistance. This are sometimes referred to as "I^2 *R* losses" (also known as "copper losses" or "joule losses"). The fact that this type of TL depends on the square of the current, means that demand profiles containing large peaks lead to significantly more TL than flat demand profiles, even if the average power usage is the same.

Electrochemical sensors are widely regarded as the best choice for CO gas detection in social housing. Higher resolution (down to 1ppm), linearity and selectivity, and low energy consumption all contribute to their fair quality. Low-cost electrochemical sensors, on the other hand, can lose a significant amount of sensitivity in a few months if exposed to very low humidity (approximately 10%) [15].

### 2.4.4 Infrared Sensor

The NDIR (Non-Dispersive Infrared) sensor is a basic spectroscopic sensor that is often used as a gas detector. An infrared transmitter (lamp), a sample chambers or light tube, a light filter, and two infrared detectors are the basic components of the NDIR (measuring detectors and reference detectors). In the presence of CO gas, infrared light absorption occurs in this system. By calculating differences in infrared radiation, the volume of CO gas can be measured [16].

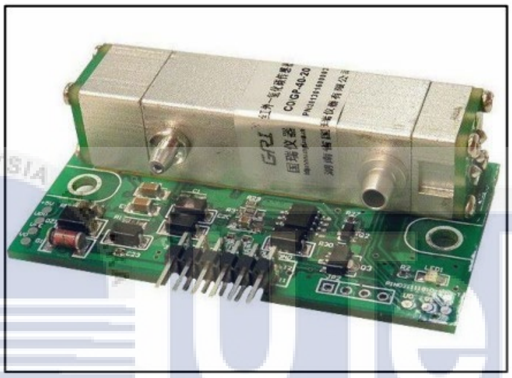

Figure 2.7 NDIR sensor.

### 2.4.5 Comparison of Sensor Technologies



According to the findings, the colorimetric CO sensor has the lowest cost, the metal oxide CO sensor has the longest life, and the electrochemical CO sensor has the highest overall cost and efficiency combination. A list of four sensor technologies is shown in Table 2.5.

Table 2.5 List of four sensor technologies for domestic applications

| Sensor Technology / Sensor Property | Colorimetric | Metal oxide | Electrochemical | Infrared |
|---|---|---|---|---|
| Short-term stability | Difficult to access | Fair | Good | Excellent |
| Lifetime | >5 years (Data being collected) | 5 – 10 years | >5 years (Data being collected) | >5 years |
| Resolution | Fair | Fair | Good | Excellent |
| Immunity to false alarm | Fair | Good | Good | Excellent |
| Immunity to false negative | Good | Good | Good | Excellent |
| Immunity to poisoning | Good | Good | Good | Excellent |
| Humidity dependency | Fair | Fair | Good-to-excellent | Excellent |
| Temperature dependency | Fair | Fair | Fair | Excellent |
| Sensitivity drift | Unknown | Moderate | Moderate | Low |
| Response time | Fair | Fair | Good | Excellent |
| Selectivity | Good | Good | Good | Excellent |
| Power consumption | Low | High | Low | Medium |
| Cost of sensor | Low | Low | Low | High |

Even if the CO level is low, a false alarm signals a warning detector. As a result, a negative result indicates that the detector was unable to detect a high CO level. The response time, on the other hand, is the amount of time it takes for the sensor to reach 90% of its maximum output. Finally, selectivity is described as the ability to distinguish between CO and other gases.

## 2.5 Power Window Motor

Automobile motors and mechanisms mounted inside the car door that regulate the movement of the window glass, allowing windows to roll up and down, are known as power window motors. Power window motor are special types of DC motors. They work in the same way as any other DC motor. In fact, a DC motor has two electrical wires, known as the positively and negatively terminals, which must be differentiated.

As the positive cable of the motor connects to the positive terminal of the power supply and the negative cable connects to the negative terminal of the power supply, the motor rotates clockwise. If the wire polarity is reversed, the motor can rotate in the opposite direction [17].



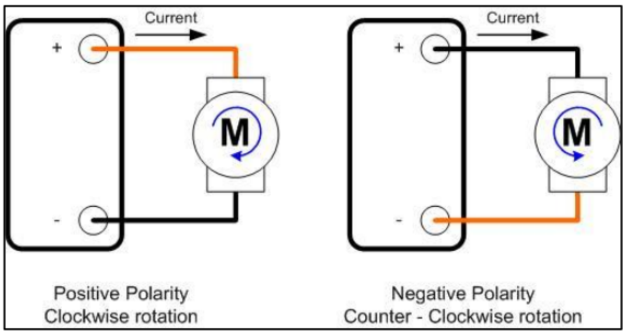


Figure 2.8 Basic DC motor connection.

The stator and the rotor are the two main parts of a DC motor (armature). Electrical interaction between the rotor and the stator rotates the armature. The voltage applied to the armature corresponds to the rotational velocity. The voltage of the engine terminals could be adjusted to control the motor's rpm. PWM (Pulse Width Modulation) is a straightforward method of achieving voltage modulation.

The PWM speed control principle is to run a DC motor using a sequence of ON and OFF voltage pulses to adjust the duty cycle while maintaining a constant frequency. The mean voltage is small and the motor speed is high if the service cycle is maintained short. The average voltage will only be high as the duty cycle decreases, and the motor speed will also be low.

Power window motors can also be powered by a variety of switches. By pressing this button, the motor's speed can be increased or decreased, and the motor's direction can be decided. Inside the door of a vehicle, they are often used to monitor and enable the window to roll up and down. The power window motor configuration and proportions are shown in Figure 2.9, and the power window motor specifications are shown in Table 2.6.



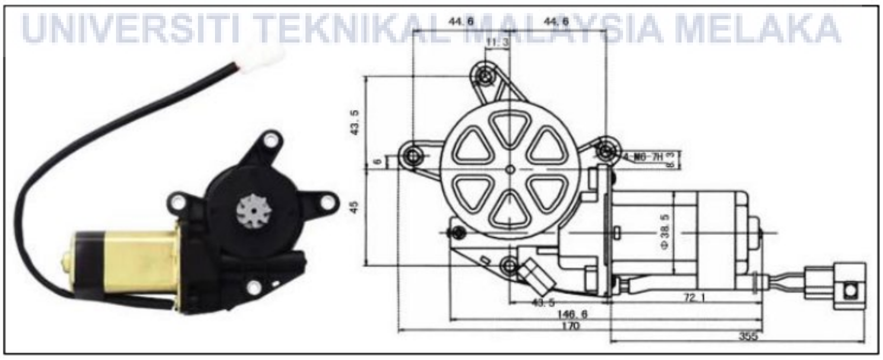

Figure 2.9 Structure and dimensions of power window motor.

Table 2.6 Specifications of power window motor

| | | |
|---|---|---|
| Voltage Rating (V) | | 12 |
| No Load Rating | Speed (r.p.m) | 85 ± 25 |
| | Current (A) | ≤ 3 |
| | Torqum (Kgf.cm) | 30 |
| | Speed(r.p.m) | 70 ± 20 |
| | Current (A) | ≤ 7 |
| Locked Torque (Kgf.cm) | | 85 ± 125 |
| Locked Current (A) | | ≤ 20 |

## 2.6 Liquid Crystal Display (LCD)

The LCD module is a fully assembled circuit board from the manufacturer. The objective is to display the numerical and character information on the screen. Serial communications are used to communicate between both the LCD module and the microcontroller. Character displays in various dimensions are available, including 8x2, 16x2, and 20x4 characters. The aim of nearly all LCD module dimensions is the same, and they are entirely dependent on the consumer's application specifications. The feature of the LCD module pin number is shown in Figure 2.01.



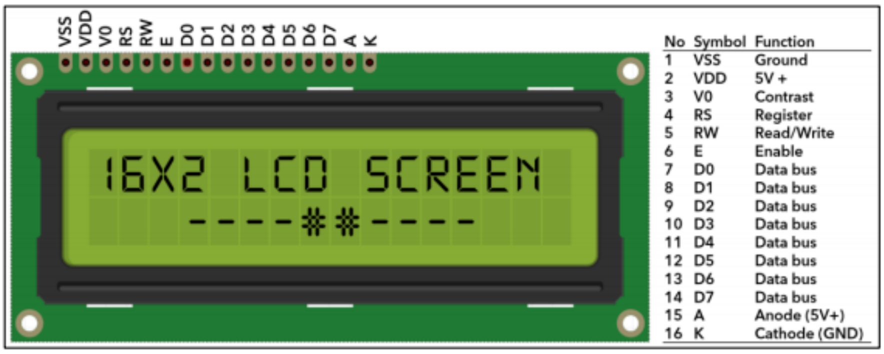


Figure 2.10 LCD pin diagram.

## 2.7 Summary

The Arduino UNO is being proposed as a microcontroller to operate the entire network of this project, as it requires the regulation of the rotation of DC motors in the system, for the monitoring of vehicle cabin air quality. The Arduino microcontroller is a hardware-based microcontroller that can control a variety of devices like sensors, LCDs, DC motors, and more. Small-scale, longer-lifetime sensors have been used to monitor metal oxide sensors, allowing the sensor to be calibrated for CO gas in a practical manner. The methodology for this project will be discussed in the following chapter.

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

This chapter explains the method used to develop this project. Block diagram and flowchart are most often used to explain further information on this project. This project is divided into two main components, hardware and software development which will be covered in this chapter. Figure 3.1 shows the flowchart of the Sarjana Muda Project (PSM) or bachelor's degree Project (BDP) for the whole year and Figure 3.2 shows the flowchart of the project.

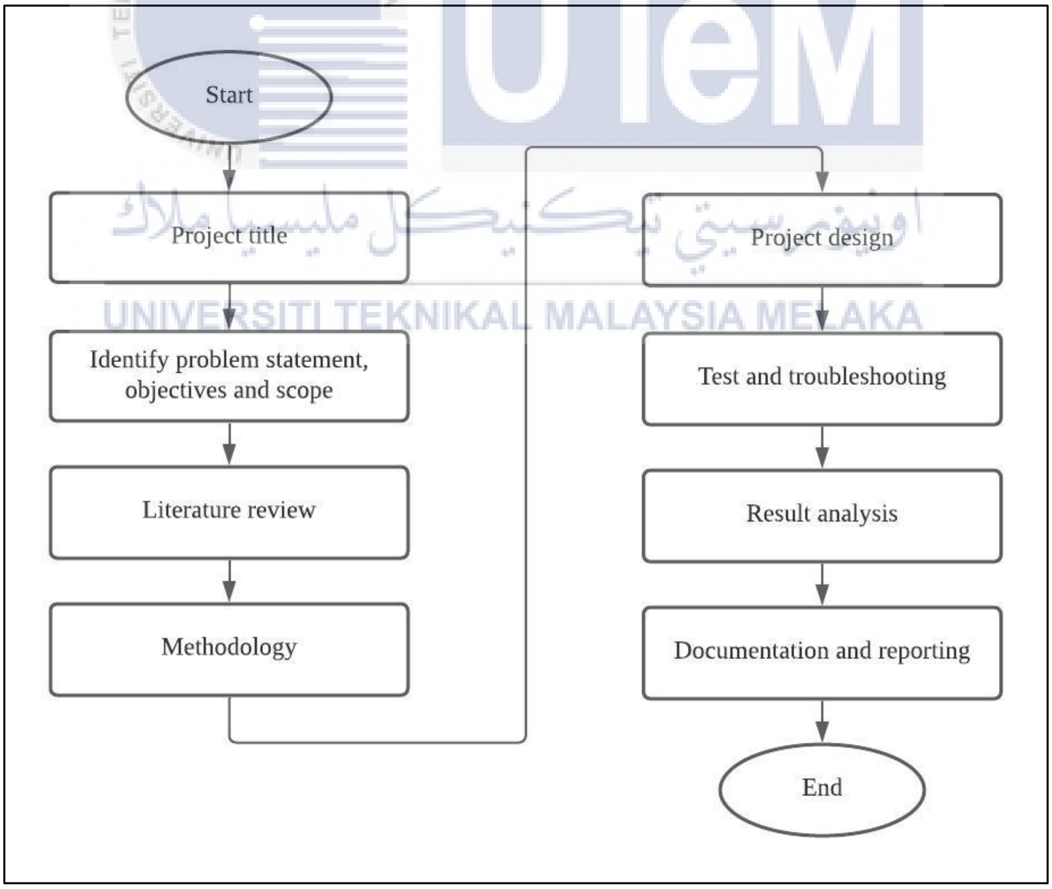


Figure 3.1 Overall flowchart of PSM.

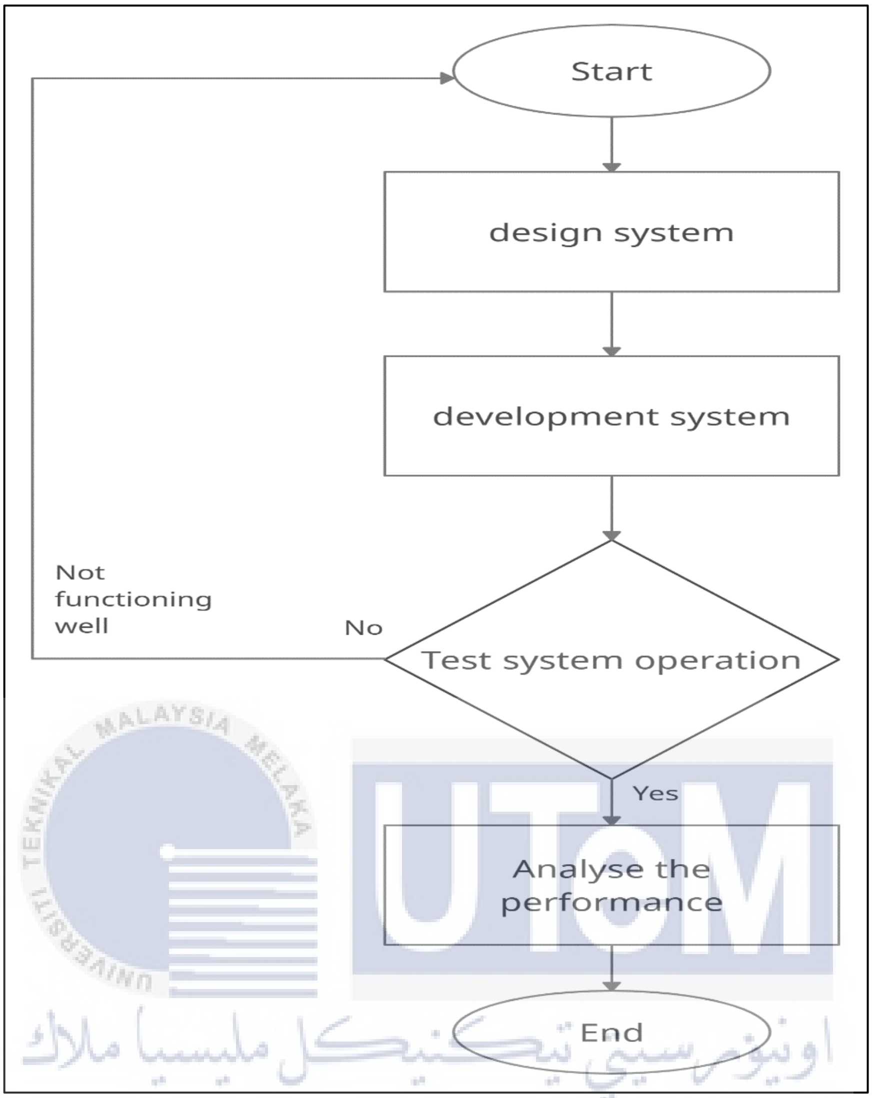


Figure 3.2 Overall flowchart of project.

## 3.2 Design of of Carbon Monoxide (CO) gas detection system

### 3.2.1 Circuit design

This system must be implemented in order to verify the feasibility of the proposed design simulations. This would also allow us to test the reliability of the control strategies previously discussed. A simulation of the proposed system's circuit model was performed using Proteus software. The Proteus simulation circuit for the MQ 7 sensor is shown in Figure 3.3.

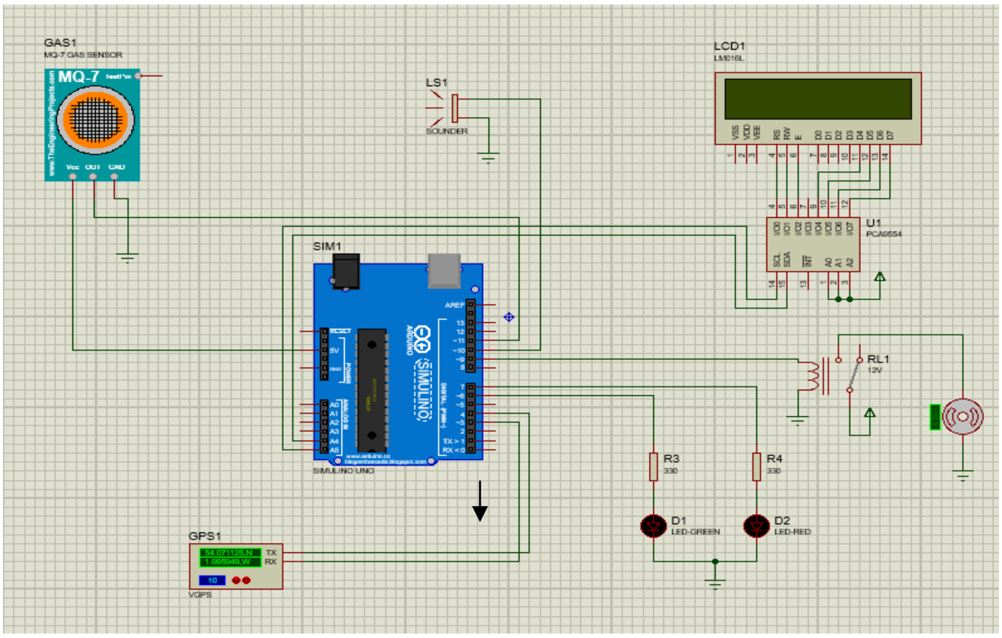


Figure 3.3 TL estimation general process flow.

Figure 3.4 shows the block diagram of this project that is used to clarify the system's flow and purpose.

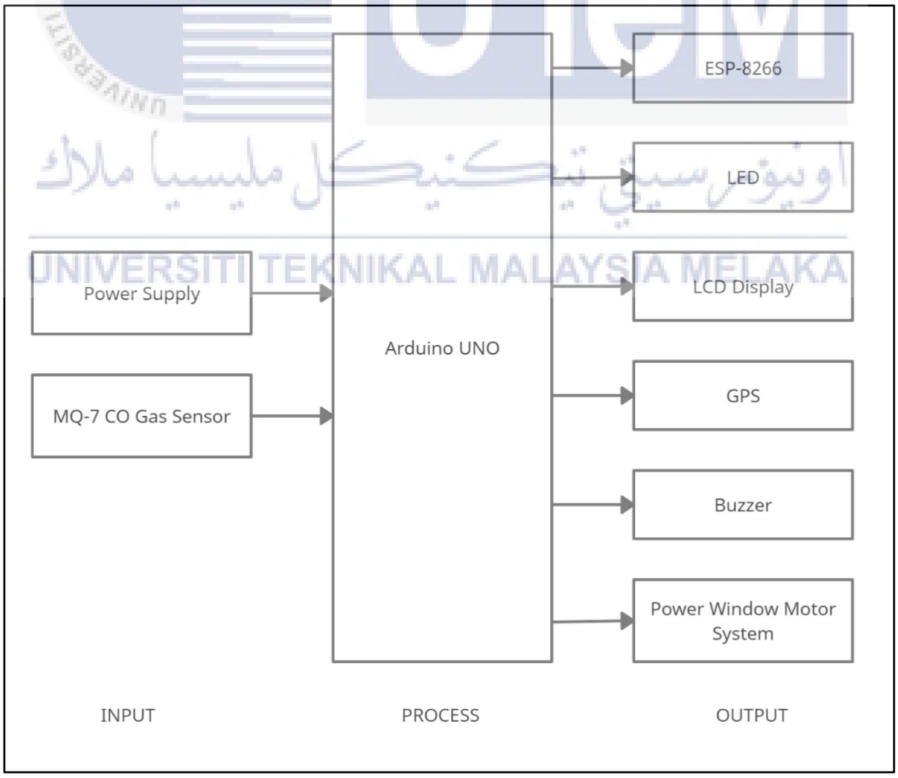




Figure 3.4 Block diagram of "Development of Carbon Monoxide Detection for Vehicle using IoT System".

#### 3.2.1.1 Program coding development

Programming is an important element for the overall running of the process. The Arduino IDE is a software tool that may be used to programme any Arduino board. This is a free software program that can be downloaded from the Arduino website. The flow chart for the entire procedure in the project is shown in Figure 3.5.

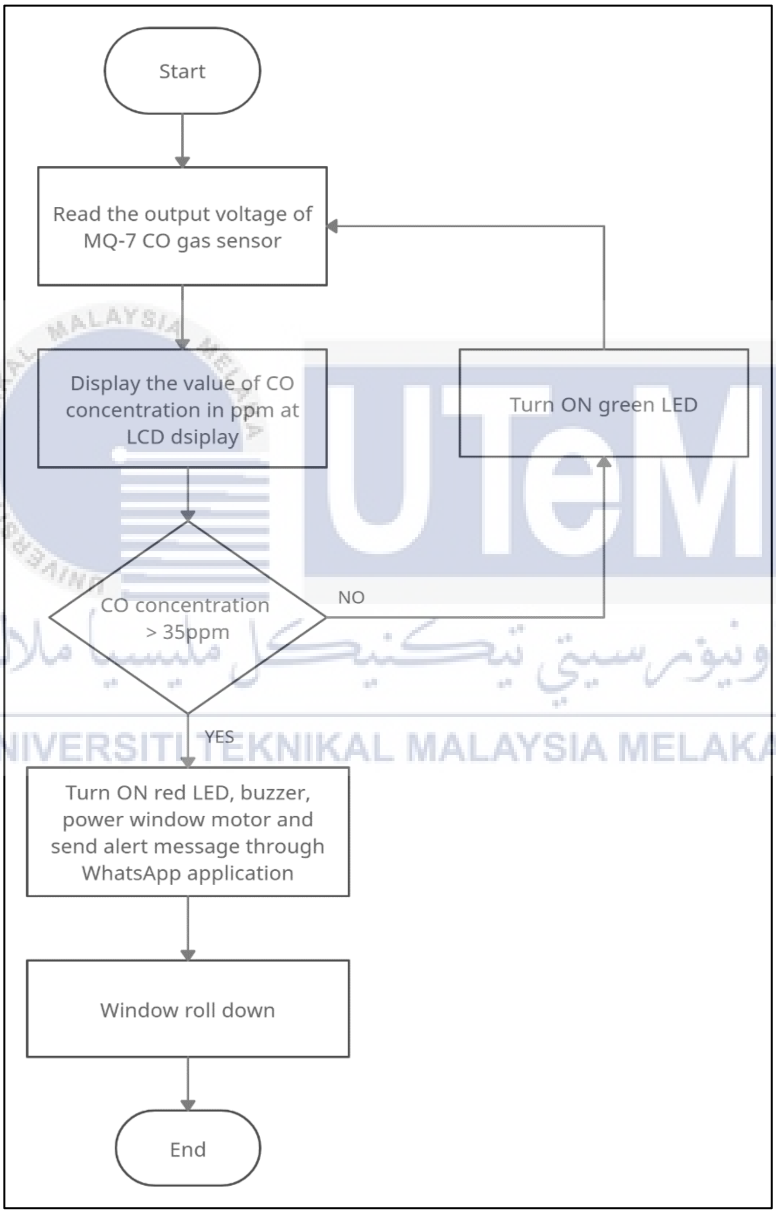


Figure 3.5 Flow chart of concentration of CO gas detection and vehicle window roll down algorithm.

The entire device is controlled by Arduino UNO programme that receives data from the MQ-7 CO gas sensor and interprets it to activate the gadget's functions, which include the LCD, LED, Buzzer, ESP-8266 and GPS, and the power window motor. The MQ-7 CO gas sensor detects the CO gas concentration at the start of the process. When the device is turned on, the LCD displays the CO gas concentration in ppm. If the CO gas concentration is less than 35 ppm, a green LED will illuminate, indicating that the CO gas concentration is safe. The buzzer and power window motor will stay in standby mode.

When the CO gas concentration is equal to or more than 35 ppm, on the other hand, the red LED will illuminate and the buzzer will emit a beep. To limit the amount of CO gas in the vehicle, the power window motor automatically rolls down the vehicle window. The authorised person will receive a warning message through WhatsApp application from ESP-8266 with the vehicle's location, and the ESP-8266 will send a signal once the CO gas concentrations have exceeded the specific value of the CO gas in ppm, alerting the driver inside the vehicle that the carbon monoxide gas concentrations were dangerous.

## 3.3 Development of an alert and monitoring system for the Carbon Monoxide (CO) gas detection

### 3.3.1 Hardware development

This section addresses possible equipment suitable for use in this system project. Basically, a lot of hardware input and output is used in this project, such as Arduino UNO, MQ-7 Gas Sensor, Limit Switch, LCD Display, GPS Module, Power Window Motor, LED, Buzzer and ESP8266 that will be used in this project will be described as below.

#### 3.3.1.1 Arduino UNO

The Arduino UNO is a microcontroller that may be used in a multidisciplinary electronics project or with an interconnected device. In this project, the Arduino UNO's primary function is to manage the entire system as well as to produce a power window motor to roll down or up the window. The Arduino UNO is approximately 68.6 mm x 53.4 mm in size and weighs only 25 grammes. The official Arduino UNO board is seen in Figure 3.6.

The Arduino UNO has the advantage of being able to use the device as a programmer without the need for an external programmer. The Arduino microcontroller has multiple I/O pins that can be used in other circuits. The Arduino UNO board, as previously stated, is a microcontroller based on the ATMega328. It features 14 digital input/output pins (6 of which can be used as PWM pins), 6 analogue inputs, a 16 MHz quartz crystal, USB connectivity, a power jack, an ICSP header, and a reset button.

To connect the board to the computer, you'll need a USB cable. In addition, the ATMega 16U2 (ATMega8U2 up to version R2) on this Arduino UNO is programmed as a USB-to-serial-converter. The Arduino UNO microcontroller's specifications are listed in Table 3.1.



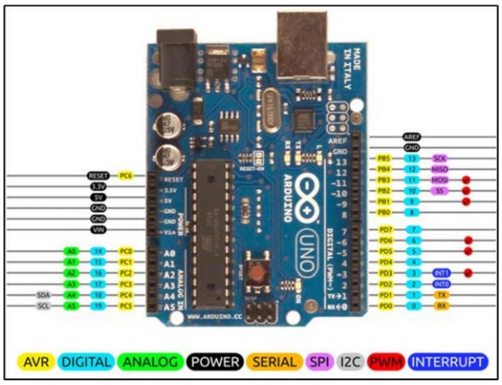


Figure 3.6 Arduino UNO board with pin labelling.

Table 3.1 Specifications of Arduino UNO.

| Specification | Details |
|---|---|
| Processor | ATMega328 |
| Operating Voltage | 5 V |
| Input Voltage (recommended) | 7-12 V |
| Input Voltage (limits) | 6-20 V |
| Digital I/O Pins | 14 (6 pins 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 (0.5 KB for boot loader) |
| SRAM | 2 KB |
| EEPROM | 1 KB |

#### 3.3.1.2 Rechargeble Battery

This project only requires one type of operational voltage battery, which is a 12 V 7 AH battery. This battery will power all of the Arduino UNO system's components, including the MQ-7 Carbon Monoxide (CO) gas sensor, the buzzer, the LCD, the LED, ESP-8266 and GPS system. A 12 V 7 AH rechargeable battery is shown in Figure 3.7.




Figure 3.7 12 V rechargeable battery.

#### 3.3.1.3 MQ-7 Carbon Monoxide (CO) Gas Sensor

The MQ-7 is a semiconductor gas detector that can accurately monitor carbon monoxide (CO) gas concentrations in the air. The CO gas sensor MQ-7 has a measurement range of 20 to 2000 parts per million. This sensor has a very high sensitivity, a fast reaction time, and a long lifetime. Tin Oxide, or $SnO_2$, is a reactive element used in this sensor that has a decreased conductivity in pure air. This sensor can function in temperatures ranging from -10 to 50 degrees Celsius and draws less than 150 milliamps at 5 volts. The carbon monoxide gas sensor is shown in Figure 3.8. (CO).

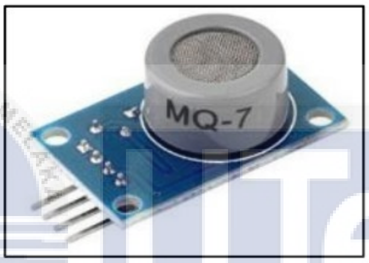


Figure 3.8 MQ-7 Carbon Monoxide (CO) gas sensor.

#### 3.3.1.4 Liquid Crystal Display (LCD)



A flat-screen display, such as a 7-segment digital clock and digit interface, displays arbitrary visuals. The 16 x 2-line LCD screen is used in this project to display the carbon monoxide (CO) gas concentration in ppm when the system is turned on. 16 x 2-line LCD displays are shown in Figure 3.9.

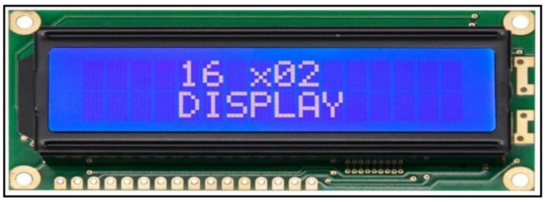


Figure 3.9 16 x 2 LCD display.

#### 3.3.1.5 Power Window Motor

Figure 3.9 shows the structure of a power window motor that can roll down a vehicle window when carbon monoxide levels are determined to be above a certain level. It will be powered by 12VDC. The torque of a power window motor is higher, which makes it easier to roll down the vehicle windows. When the polarity of the positive and negative terminals is adjusted, the power window motor rotates clockwise or counterclockwise. Figure 3.10 shows a simple schematic of the frame control window motor.

Figure 3.10Power window motor with frame.

#### 3.3.1.6 Buzzer module

When voltage is applied to a buzzer, it produces a beep sound to signify the presence of the voltage. It comprises of a piezo core and an oscillator that generates a frequency of 2-4 kHz. The transistor and the cable are connected through the buzzer. When the concentration of CO gas measured is higher than 35 ppm, the project's warning tool produces a persistent beep sound. The buzzer module's schematic is shown in Figure 3.11.

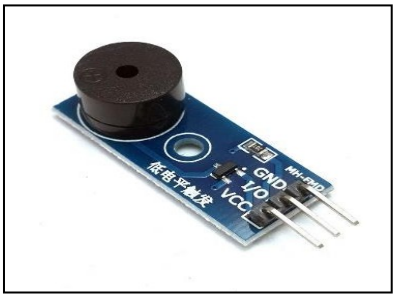


Figure 3.11 Buzzer module.

#### 3.3.1.7 Light-Emitting Diode (LED)

The main function of the LED in this project is to indicate if the concentration of carbon monoxide (CO) gas within the vehicle is safe or dangerous. If the CO gas concentration detected was greater than the set quantity, the LED would be triggered with the buzzer, and the power window motor would automatically roll down the vehicle window. The LED schematic is shown in Figure 3.12.

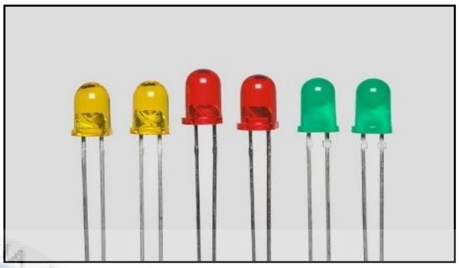

Figure 3.12 LED.

#### 3.3.1.8 Two-Channel Relay Module

The clockwise or counterclockwise orientation of the power motor window is controlled by the two-channel relay module. The device that manipulates the relay coil to regulate the movement of the power window motor as the positive and negative terminals of the power window motor are adjusted and the window is rolled up or down. This module's working voltage is 5 VDC, and the interface is suitable for operating current loads of 10A and 250VAC/15A. The schematic for the two-channel relay board is shown in Figure 3.13.

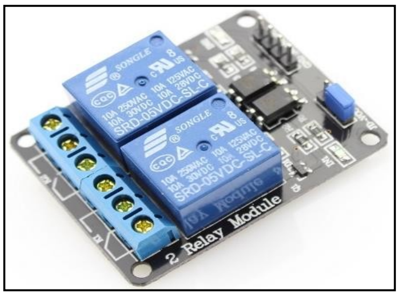


Figure 3.13 Two-channel relay module.

### 3.3.1.9 ESP8266

ESP8266 allows the microcontroller connect to a Wi-Fi. This module will send a alert message to an authorised person whenever the MQ-7 detects a concentartion of CO through WhatsApp application with a location of the car. The schematic for ESP8266 is shown in Figure 3.14.

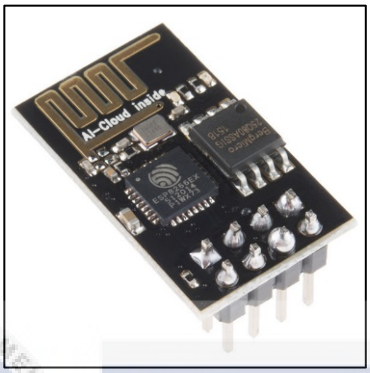

Figure 3.14 ESP8266.

### 3.3.1.10 NEO-6M GPS Module

The NEO-6M GPS Module is a self-contained GPS receiver with high positional accuracy. This module is developed for devices that use the battery as a low-cost, low-capacity resource, and it has been optimised for architecture, power, and memory, making it very simple to use. Longitude and latitude coordinates for the child's location are provided by the GPS module. It's also very compatible with any sort of microcontroller, making it a pleasure to connect. Figure 3.15 below shows the NEO-6M GPS Module.

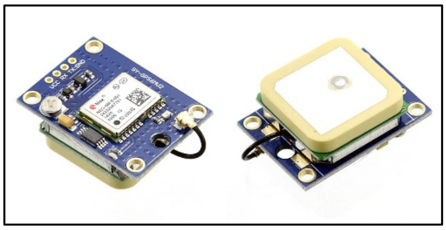

Figure 3.15 NEO-6M GPS Module.

### 3.3.2 Calculation of Carbon Monoxide (CO) Gas Concentration

The surface resistance of the sensor, Rs obtained by the voltage signal output of the load resistance, RL in the series of wounds. The relationship between surfaceresistance, load resistance and voltage output can be described as follows:

$$\frac{R_S}{R_L} = \left(\frac{V_C}{V_O}\right) - 1 \tag{3.1}$$

Where $R_S$ = surface resistance of the sensor

$R_L$ = load resistance

$V_C$ = source voltage (5V)

$V_O$ = analog output voltage of the sensor

Equation below is electrical resistance sensor:

$$R = \left(\frac{R_S}{R_L}\right) \tag{3.2}$$



The relationship between the resistance of the sensor and the concentration of the target CO gas generally follows the law of power. Over the large range of concentration of CO gas, the following can be defined:

$$R = K \cdot C^{-n} \tag{3.3}$$

Where $R$ = sensor resistance

$K$ = constant of sensor material

$C$ = CO gas concentration in PPM

$n$ = sensitivity according the change of gas concentration with the value 0.7

$$\boldsymbol{log\ R = log\ (K \cdot\ C^{-n})}$$

$$\boldsymbol{log\left(\frac{R_S}{R_L}\right) = log\ K + log\ C^{-n}}$$

$$\boldsymbol{log\left(\frac{R_S}{R_L}\right) = log\ K - n\ log\ C} \tag{3.4}$$

Considering the Normal Temperature and Pressure (NTP), equation (3.4) can be written as:

$$\boldsymbol{-1.4 + log\left(\frac{R_S}{R_L}\right) = \ -0.7\mathbf{log\ C}} \tag{3.5}$$

By comapring the equation (3.4) and (3.50 at NTP:

$$\boldsymbol{log\left(\frac{R_S}{R_L}\right) = log\ K - n\ log\ C}$$

$$\boldsymbol{-1.4 + log\left(\frac{R_S}{R_L}\right) = \ -0.7\mathbf{log\ C}}$$

$$\boldsymbol{log\ K = 1.4}$$

$$\boldsymbol{K = log^{-1}1.4}$$

$$\boldsymbol{K = 25.12}$$



From the power law at (3.83):

$$\boldsymbol{R = \ K \cdot\ C^{-n}}$$

$$\boldsymbol{\left(\frac{V_C}{V_O}\right) - 1 = \ K \cdot\ C^{-n}}$$

$$\boldsymbol{\left(\frac{5}{V_O}\right) - 1 = \ 25.12 \cdot\ C^{-0.7}}$$

$$\boldsymbol{C^{-0.7} = \left\{\left[\left(\frac{5}{V_O}\right) - 1\right] \div 25.12\right\}}$$

$$\boldsymbol{C = \left\{\left[\left(\frac{5}{V_O}\right) - 1\right] \div 25.12\right\}^{-1.43}}$$

$$C = 100.468 \times \left[\left(\frac{5}{V_O}\right) - 1\right]^{-1.43}$$

Therefore, the relationship between the sensor resistance, R and the concentration of Carbon Monoxide (CO) gas, Y as follow:

$$Y(PPM) = 100.468 \times \left[\left(\frac{5}{V_O}\right) - 1\right]^{-1.43} \tag{3.6}$$

## 3.4 Summary

Hardware such as an Arduino UNO microcontroller, MQ-7 Carbon Monoxide Gas Sensor, LCD module, power window motor, ESP8266 and GPS, LED and buzzer are used in the project. The flow chart in Figure 3.11 depicted the basic software implementation. The following chapter will include the performance and analysis of the project, as well as reflection on the results.

# CHAPTER 4

# RESULTS AND DISCUSSIONS

## 4.1 Introduction

This chapter explains about the result and troubleshooting for the problem that has been faced during the implementation of the project. Testing process also has been performed to test system performance and reported. The tabulated result and the analysed data will be explained in this chapter.

## 4.2 Project Implementation

The circuit prototype can be completed with several steps. The components used for circuit configuration are Arduino UNO, MQ-7 CO sensor, LCD, LED, buzzer, two channel relay module and power window motor. This system is powered by a 12V Direct Current (DC) battery. Precautionary steps are taken to prevent systematic and random errors from occurring prior to reading. As an initial stage, the MQ-7 CO sensor analog output voltage is required to convert the PPM value into CO concentration. The coding of the CO detection program is programmed into the Arduino UNO microcontroller. Before switching on the power supply, each connection between the components must be correct. The prototype case is designed and produced when the result is accurate and consistent. Figure 4.1 shows the overall simulation project circuit using proteus and figure 4.2 illustrates the completed prototype.

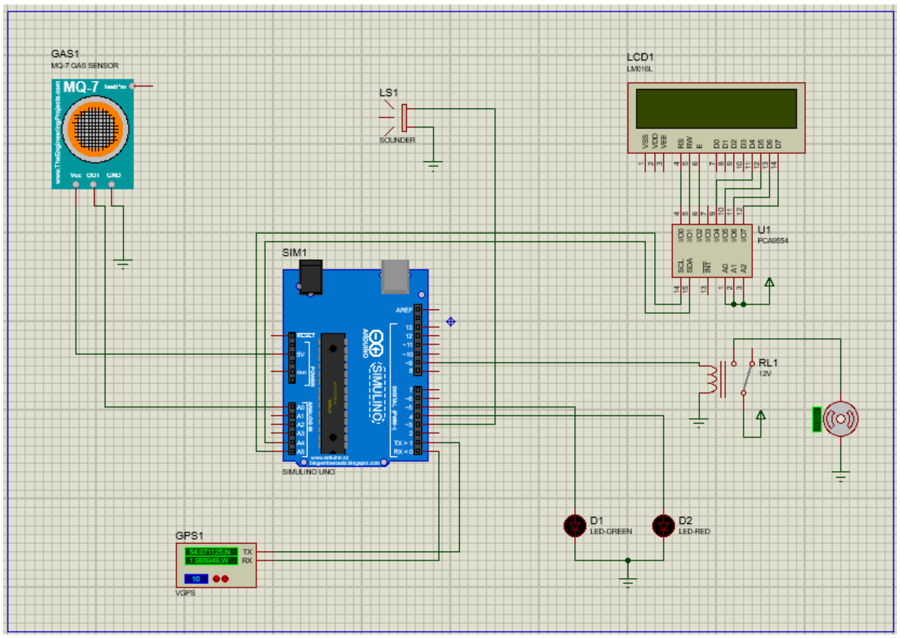


Figure 4.1 Overall simulation project circuit using proteus.

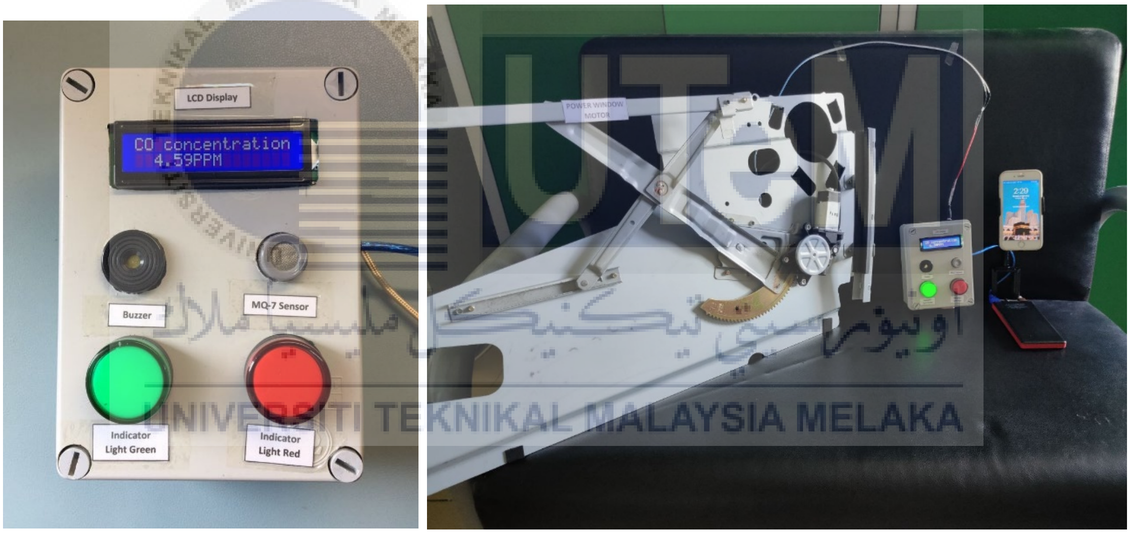




Figure 4.2 completed prototype

## 4.3 Analysis of Carbon Monoxide (CO) gas detector

### 4.3.1 Carbon Monoxide concentration (PPM) against Vout (V)

Analog output voltage from MQ-7 CO sensor, Vout is converted into Carbon Monoxide gas concentration in PPM value using formula of Equation (3.6). Series of the testing were being conducted with the power supply of 5V from Arduino UNO source pin by varying the output voltage from 0.4V to 3.8V with 0.2 increment by using potentiometer. The calculated result is tabulated in Table 4.1.

Table 4.1 Relationship between MQ-7 output voltage and CO concentration in PPM

| Vout (V) | $X = \left[\left(\frac{5}{Vout}\right) - 1\right] (V)$ | $Y = 100.468 \cdot X^{-1.43} (PPM)$ |
|---|---|---|
| 0.4 | 11.50 | 3.06 |
| 0.6 | 7.33 | 5.82 |
| 0.8 | 5.25 | 9.38 |
| 1.0 | 4.00 | 13.84 |
| 1.2 | 3.17 | 19.30 |
| 1.4 | 2.57 | 26.05 |
| 1.6 | 2.13 | 34.08 |
| 1.8 | 1.78 | 44.05 |
| 2.0 | 1.50 | 56.26 |
| 2.2 | 1.27 | 71.38 |
| 2.4 | 1.08 | 90.00 |
| 2.6 | 0.92 | 113.19 |
| 2.8 | 0.79 | 140.75 |
| 3.0 | 0.67 | 178.13 |
| 3.2 | 0.56 | 230.21 |
| 3.4 | 0.47 | 295.75 |
| 3.6 | 0.39 | 386.19 |
| 3.8 | 0.32 | 512.46 |

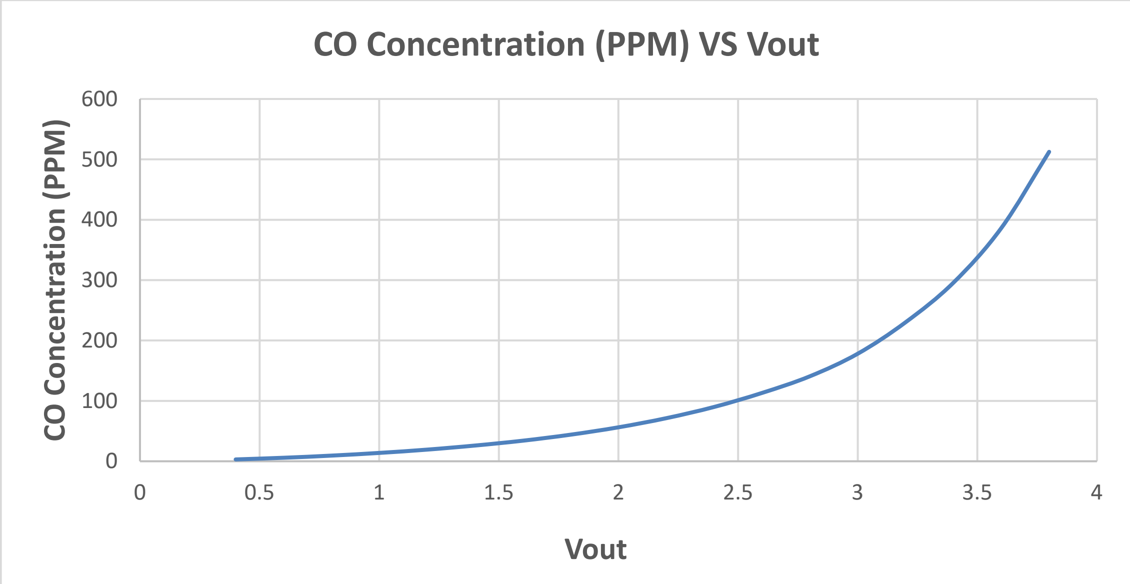


Figure 4.3 Graph of PPM against Vout

Figure 4.3 shows the graph of the CO concentration (PPM) against Vout based on the results in Table 4.1. The graph shows that the Carbon Monoxide concentration is directly proportional to the analog voltage output. The concentration of carbon monoxide also increases as the analog output voltage increases. The surface resistance, Rs of the sensor decreases as the CO concentration level increases and the source voltages, Vs also increases. The graph obtained and theoretical is slightly difference. Theoretically, carbon monoxide concentrations are directly proportional to MQ-7 CO gas sensor output voltage.



The implementation of this project was tested in three different conditions, including natural air condition, cigarette smoke condition and vehicle exhaust fumes, after the completion of the development and implementation of the software and hardware. The purpose of this test is to determine the achievement and results of this project in these three conditions, representing different levels of CO. Due to the unavailability of CO meter level reader to check the correct reading during the testing process, the test result was then compared with the literatures based on three different situations, and tabulated as shown in Table 4.2.

Table 4.2 Experiment result based on three condition

| Experiment condition | Result | References |
|---|---|---|
| Normal air | • CO concentration: 2.21 PPM<br>• Green LED turn ON | • Average level of normal air in between 0-9 PPM [17]. |
| Cigarette smoke | • CO concentration: 26.67 PPM<br>• Green LED turn ON | • A closed room that polluted by CO gs from cigarette smoke is 25 PPM [17]. |
| Car exhaust fumes | • CO concentration: 160.74 PPM<br>• Red LED turn ON<br>• Buzzer turn ON<br>• Power window motor roll down the window<br>• ESP8266 sent an alert message to an authorized person through WhatsApp application in the state of longitude and latitude | • CO gas concentration usually generated from exhaust fumes in between 100-200 PPM [17]. |

### 4.3.2 Carbon Monoxide gas concentration (PPM) against Time Taken (minutes) for normal air condition

The standard air quality in normal condition was tested by placing this project in a closed room with no presence of smoke or any incomplete combustion source and every 2 minutes readings for a duration of 10 minutes were recorded. The reading showed on LCD display is less than 35 PPM, and the green LED is turned on which represents a safe condition. For normal air condition, the standard level of CO concentration is about 0 PPM to 9 PPM. Table 4.3 shows the reading of CO concentration that has been recorded for 10 minutes and Figure 4.4 shows the graph of CO concentration (PPM) vs Time Taken (minutes) for normal air condition.

Table 4.3 The reading of CO concentration that recorded for 10 minutes under normal air condition.

| Time taken (minutes) | CO concentration (PPM) |
|---|---|
| 2 | 1.97 |
| 4 | 1.99 |
| 6 | 2.20 |
| 8 | 2.20 |
| 10 | 2.21 |

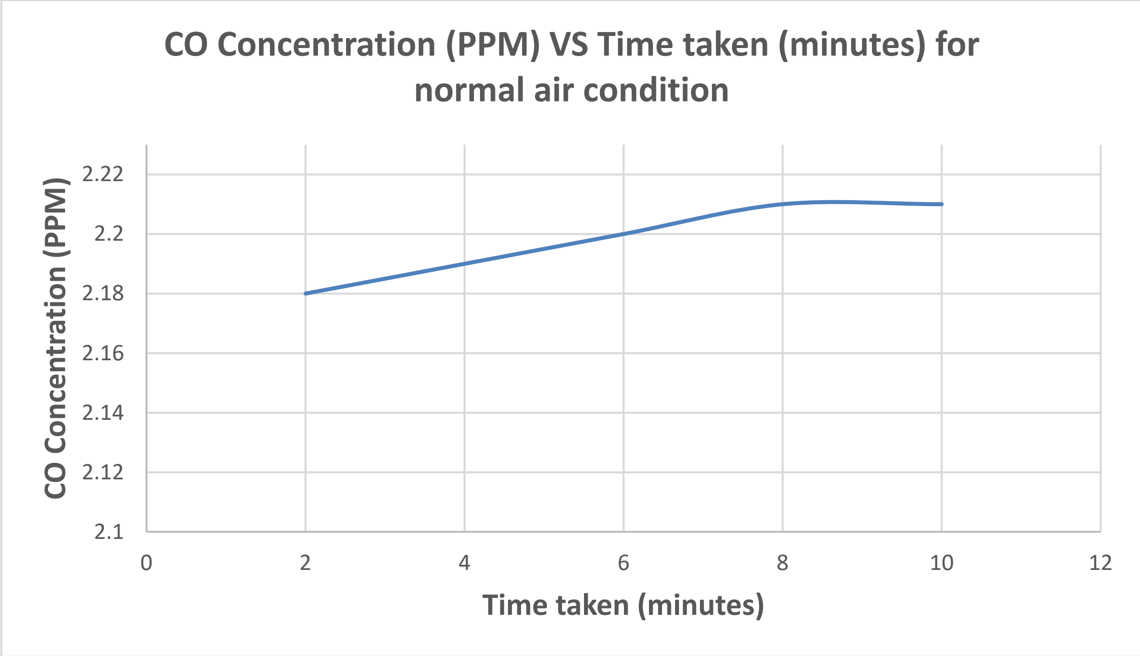


Figure 4.4 Graph of CO concentration (PPM) vs Time Taken (minutes) for normal air condition.

### 4.3.3 Carbon Monoxide gas concentration (PPM) against Time Taken (minutes) for cigarette smoke in a closed room.

For the second test, cigarette smoke condition was tested during a people smoking cigarettes inside a closed room and every 2 minutes readings for a duration of 10 minutes were recorded. All readings for CO concentration in PPM displayed on the LCD is less than 35 PPM and the green LED was turned on which indicates a safe condition. If the reading is 35 PPM or more, which marks the danger level, RED led will be turned on and buzzer will produce beep sound as well as the power window motor will roll down the window automatically. RED led and buzzer are used to give an alert that the air condition during this time is not in a safe condition. Table 4.4 shows the readings of CO concentration that have been recorded during the test with cigarette smoke in a closed room and Figure 4.5 shows the graph of CO concentration (PPM) vs Time Taken (minutes) for cigarette smoke in a closed room.

Table 4.4 The reading of CO concentration that recorded for 10 minutes for a cigarette smoke in a closed room.

| Time taken (minutes) | CO concentration (PPM) |
|---|---|
| 2 | 7.87 |
| 4 | 11.94 |
| 6 | 18.32 |
| 8 | 23.53 |
| 10 | 26.67 |

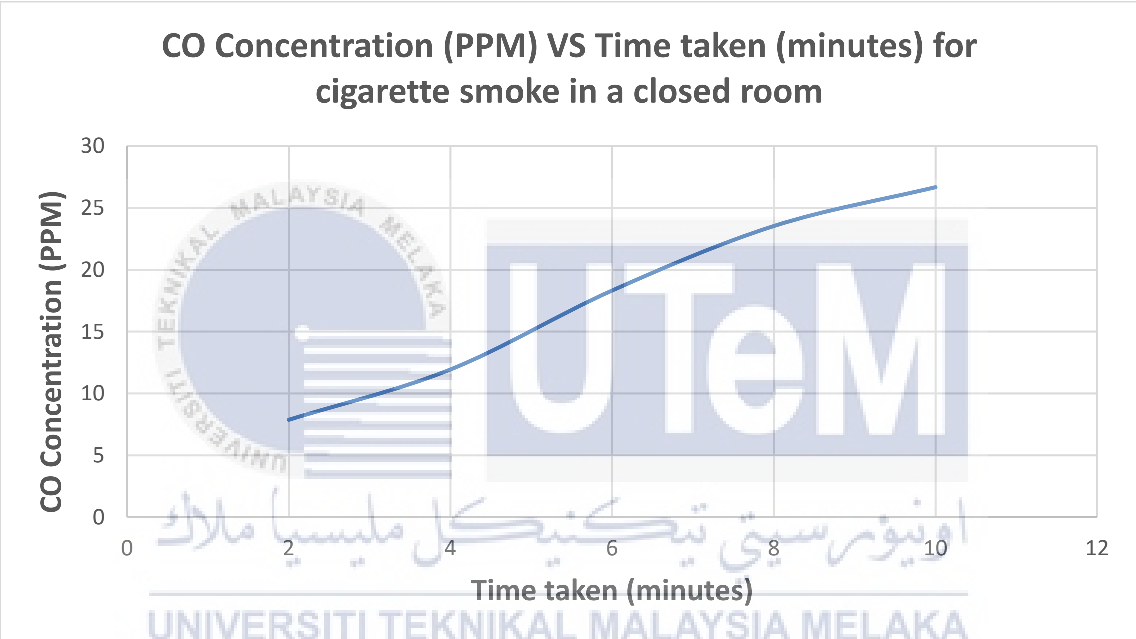



Figure 4.5 Graph of CO concentration (PPM) vs Time Taken (minutes) for cigarette smoke in a closed room.

### 4.3.4 Carbon Monoxide gas concentration (PPM) against Time Taken (minutes) for car exhaust fumes

For the third test, car exhaust fumes condition was tested in the garage by placing this prototype directly to the car exhaust for 10 minutes. The readings were recorded for every 2 minutes and the reading of CO concentration in PPM was displayed on the LCD as shown in Table 4.5. It showed that the condition was harmful. The system was triggered by lighting up the red LED and producing a beep sound from buzzer as well as activating the power window motor to roll down the window automatically. An ESP8266 sent an alert text message to the authorized person through WhatsApp application in the stated longitude and latitude. Table 4.5 shows the reading of CO concentration that recorded for 10 minutes during test with car fumes on a car exhaust, Figure 4.6 shows the graph of CO concentration (PPM) vs Time Taken (minutes) for car fumes on car exhaust.

Table 4.5 The reading of CO concentration that recorded for 10 minutes during the test with car exhaust fumes.

| Time taken (minutes) | CO concentration (PPM) |
|---|---|
| 2 | 29.43 |
| 4 | 44.75 |
| 6 | 84.92 |
| 8 | 116.36 |
| 10 | 160.74 |

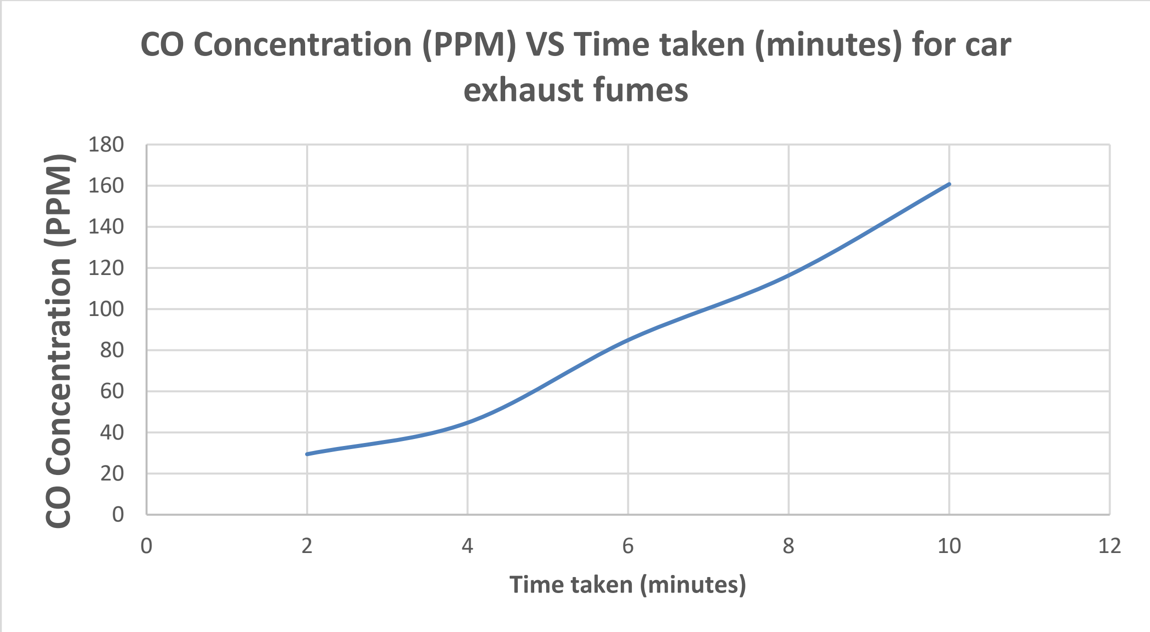


Figure 4.6 Graph of CO concentration (PPM) vs Time Taken (minutes) for car exhaust fumes.

### 4.3.5 Carbon Monoxide gas concentration (PPM) against Time Taken (minutes) for three conditions

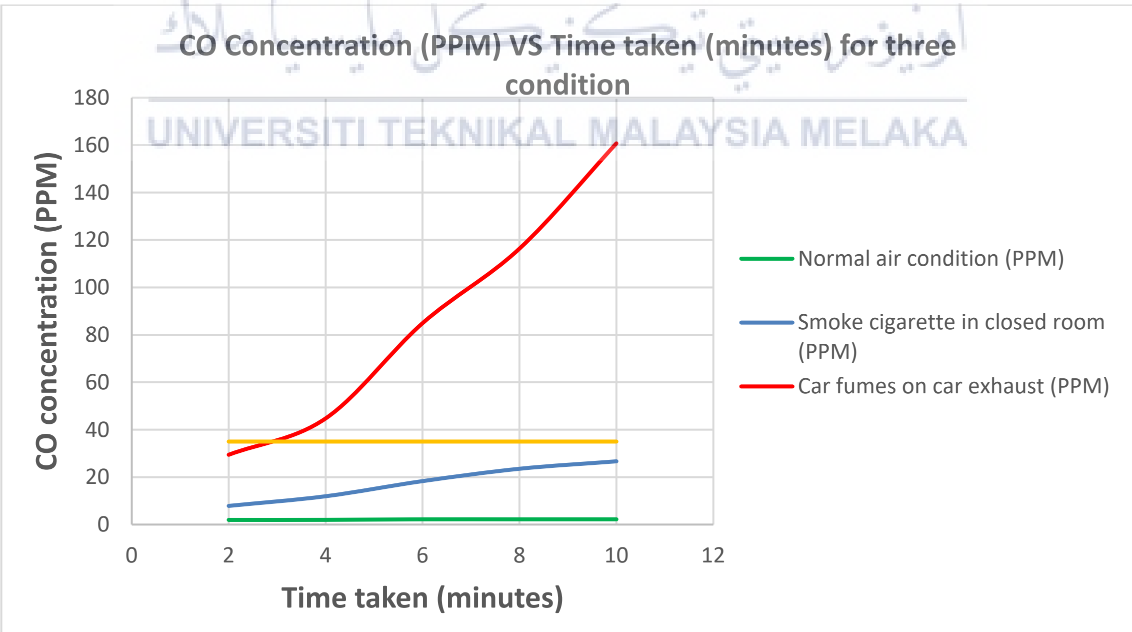




Figure 4.7 Graph of CO concentration (PPM) vs Time Taken (minutes) for three conditions.

Figure 4.7 shows the graph of CO concentration (PPM) vs Time Taken (minutes) for three conditions. It can be concluded that carbon monoxide (CO) sensor which is suitable for sensing CO concentrations in the air. The MQ-7 CO gas sensor can detect CO-gas concentrations anywhere from 20 to 2000ppm. The MQ-7 sensor has high sensitivity and selectivity of various natural gases such as Carbon monoxide (CO), Hydrogen (H2), Butane (LPG), Methane (CH4), Alcohol, and air. In this project, MQ-7 sensor is more sensitive to CO gas in the air. Based on the graph of Figure 4.7, carbon monoxide (CO) gas responses impressive among other gases. Therefore, the MQ-7 sensor can be treated as high precision carbon monoxide detector which has been embedded to this proposed system.

## 4.4 Internet of Things (IoT) alert monitoring system

The IoT components of this project is the alert monitoring system via WhatsApp application. The system will be triggered by lighting up the red LED and producing a beep sound from buzzer as well as activating the power window motor to roll down the window automatically. An ESP8266 wil then send an alert message to the authorized person through WhatsApp application in the stated longitude and latitude when the concentration of carbon monoxide (CO) gas exceeds the limit which is 35 PPM and above. In other words, the warning implies something must be adjusted to control the air inside the vehicle.

This condition happened during the third test when car exhaust fumes condition was tested in the garage by placing this project prototype direct to the car exhaust for 10 minutes. The reading of CO concentration in PPM was recorded and displayed on the LCD. An alert text message stating that the condition is harmful was sent. Figure 4.8 shows the alert text message from ESP8266 has already been sent to an authorized person in the stated longitude and latitude.

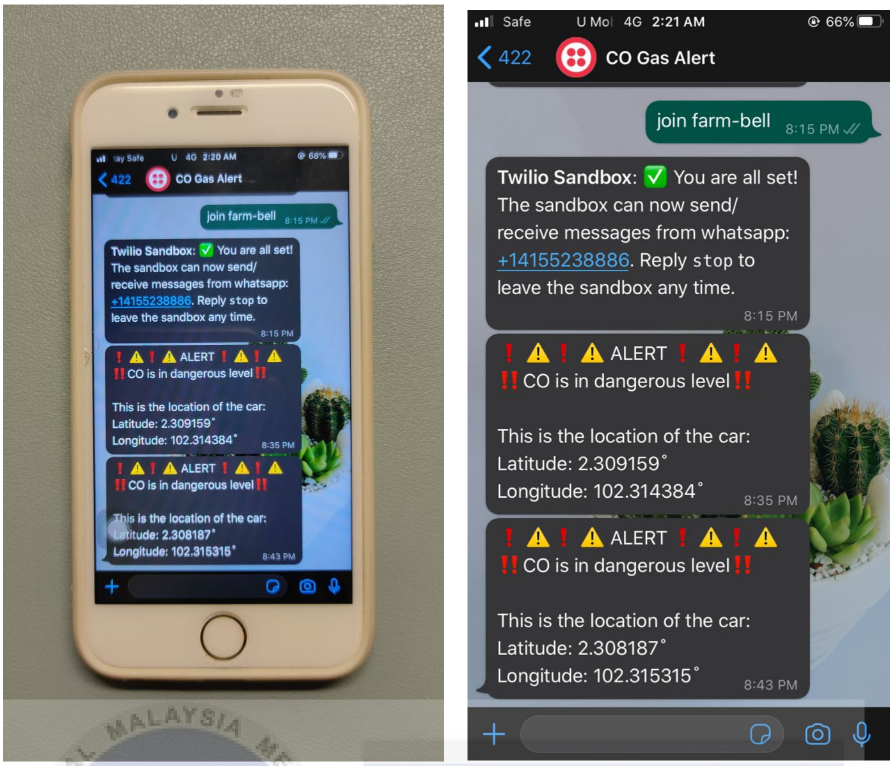


Figure 4.8 An alert text message from ESP8266 and GPS that has already been sent to the authorized person in the stated longitude and latitude.

## 4.5 Summary

The implementation, testing and results of the development of carbon monoxide detection for vehicle using IoT system project have been discussed. Several experiments and testings processes have been conducted to test the performance of the carbon monoxide detection system. The result gained from the experiment was satisfactory. Overall, the system meets the objectives and the carbon monoxide detection system for vehicle was able to work effectively.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATIONS

## 5.1 Introduction

This chapter concludes the overall of the implementation of the development of carbon monoxide detection for vehicle using IoT system project. With the rapid advancement of science and technology, the developments of a high-tech poisonous gas detection device with an implementation of IoT system are becoming popular to raise awareness among people about carbon monoxide as the "silent killer". The Consumer Product Safety Commission of the United States has affirmed that "carbon monoxide detectors are as critical to home safety as smoke detectors," and recommends that each residence have one or more CO detectors, as well as one CO detector for each building level. This highlights the importance of a poisonous gas discharge alarm system that is 100 percent accurate.

This chapter will revisit the objectives of the project that have been achieved. This chapter will also highlight some recommendations and potential work that can be used to enhance the project in future.

## 5.2 Project Objectives

The three main project objectives are briefly revised and discussed as follows:

### 5.2.1 To design a carbon monoxide gas detection system for vehicle using IoT system by using Arduino microcontroller

There is a few step to take in order to design a carbon monoxide gas detection system for vehicle. In chapter 2 have discussed the literature review part from other researchers on how other project systems were designed and fucntioned. Some components and methods comparing were made to find the best one to design this project.

### 5.2.2 To develop a warning signal and monitoring system for the carbon monoxide (CO) gas detection by using ESP8266 to send an alert message signal through WhatsApp Application

The objective of project developing system has achieved by employing an Arduino UNO as a microprocessor to control the complete system, which serves as a gas emission alert system. It will be able to detect CO in a car and notify the user if the CO level reaches a dangerous level, requiring an emergency evacuation. The IoT system was implemented to the system as an alert notification system to notify the authorized person when the CO gas concentration is in dangerous level. The power window motor will also roll down automatically to minimise CO concentration and prevent potential carbon monoxide poisoning.

### 5.2.3 To analyse the effectiveness of carbon monoxide (CO) detection system and waring signal to the user and an authorized person

The implementation of the development of carbon monoxide detection for vehicle using IoT system project has satisfied the design problem's objectives, according to the results and data analysis. Analysis has been made with three different condition. For the first condition, the project prototyoe was tested in a normal air condition. The second condition is the project prototype was tested during people smoking cigarettes inside a closed room and followed by the third condition which is the project prototype was tested directly to car exhaust fumes. The CO concentration readings value were recorded every 2 minutes for 10 minutes and the results shown differently as in chapter 4. As a result, the concentration of CO gas in the car can be controlled, preventing CO gas poisoning and death.

## 5.3 Future Works Recommendation

There is a few changes to this project that can be made. The following recommendation is described as follows:

i) By changing from using ESP8266 to GPRS. This is due to ESP8266 requires user to turn ON internet hotspot from smartphone to connect the internet to the system but GPRS already coonsists of Wi-Fi that will automatically turn ON when the system turn ON. Besides, ESP8266 can only use one internet hotspot at a time based on the username and password installed into the coding. GPRS is helpful as it is more easier for the user to handle the system.

ii) By inserting a breathing ventilator into the system that automatically turns on when the system detects carbon monoxide gas, the system may also be upgraded. The electric fan unit should be set to run until the gas sensor decides that the poisonous gas emission level has returned to a safe level.

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# APPENDICES

## Appendix A Coding of "Development of Carbon Monoxide Detector for Vehicles using IoT System"

```
//include library code
#include <MQUnifiedsensor.h>
#include <LiquidCrystal_I2C.h>
#include <SoftwareSerial.h>

//for 16x2 lcd display
LiquidCrystal_I2C lcd(0x27, 16, 2);

//output declaration
const int buzzer = 3;

//MQ-7 CO sensor declaration
float sensorValue;
const int analogPin = 0;
float Vout;
float CO;

//LED declaration
int ledPin1 = 5;
int ledPin2 = 4;

int value;
int digit;

void setup()
{

  //Set , buzzer and LED pins to outputs
  pinMode (buzzer, OUTPUT);
  pinMode (ledPin1, OUTPUT);
  pinMode (ledPin2, OUTPUT);

  //initialize serial communications at 9600bps
  Serial.begin(9600);

  //LCD display
  lcd.init();
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("WELCOME TO");
  lcd.setCursor(0, 1);
  lcd.print("CO DETECT.");
```

```
  delay(1000);
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("THANKYOU FOR");
  lcd.setCursor(0, 1);
  lcd.print("USING CO DETECT.");
  delay (1000);
  lcd.clear();

}

void loop()
{
  //Read the analog to PPM
  sensorValue = analogRead (analogPin);
  Vout = sensorValue * (5.0 / 1024.0);
  CO = 100.468 * pow(((5.00 / Vout) - 1), -1.43);

  //get the rounded CO ppm
  digit = 0;
  value = (int) CO;

  while (value != 0)
  {
    value = value / 10;
    digit++;
  }

  //when the reading is 1 digit
  if (digit == 1)
  {
    //set the cursor to column 0,line 1
    //(note: line 1 is the second row, since counting begins with 0)
    lcd.setCursor (0, 1);

    //print two blank spaces into display
    lcd.print("  ");
    lcd.setCursor (2, 1);

    //print the number into display
    lcd.print (CO);
  }

  //when the reading is 2 digits
  else if (digit == 2)
  {
    lcd.setCursor (0, 1);

    //print one black space into display
    lcd.print (" ");
```

```
    lcd.setCursor (1, 1);
    lcd.print (CO);
  }

  //when the reading is 3 digits and above
  else
  {
    lcd.setCursor (0, 1);
    lcd.print (CO);
  }

  //set the PPM to column 6, line 1
  lcd.setCursor (0, 0);
  lcd.print ("CO concentration");
  lcd.setCursor (6, 1);
  lcd.print ("PPM");

  //wait for half second before the next loop
  //for the analog-to-digital converter to settle after last reading
  delay (500);

  //determine alarm status
  if (CO > 35)
  {

    digitalWrite (buzzer, HIGH); //Buzzer sounds off continously
    digitalWrite (ledPin1, LOW); //Relay coil one trigger
    digitalWrite (ledPin2, HIGH);
    delay(10000);

  }

  else
  {

    digitalWrite (buzzer, LOW); //Buzzer sounds off
    digitalWrite (ledPin1, HIGH);
    digitalWrite (ledPin2, LOW); //Relay coil two trigger
    delay(5000);
  }
}

#include <ESP8266WiFi.h>
#include <ThingESP.h>
#include <TinyGPS++.h> // library for GPS module
#include <MQUnifiedsensor.h>
#include <SoftwareSerial.h>

ThingESP8266 thing("hilmihasnan", "gassensor1", "12345678");
```

```
TinyGPSPlus gps;  // The TinyGPS++ object
SoftwareSerial ss(1, 3); // The serial connection to the GPS device

//MQ-7 CO sensor declaration
float sensorValue;
const int analogPin = 13;
float Vout;
float CO;

float latitude , longitude;

int value;
int digit;

String lat_str , lng_str;


unsigned long previousMillis = 0;
const long INTERVAL = 6000;

void setup()
{
  Serial.begin(115200);
  ss.begin(9600);

  thing.SetWiFi("Hilmi Kacak", "000000000");

  thing.initDevice();

}


void loop()
{
   while (ss.available() > 0) //while data is available
    if (gps.encode(ss.read())) //read gps data
    {
      if (gps.location.isValid()) //check whether gps location is valid
      {
        latitude = gps.location.lat();
        lat_str = String(latitude , 6); // latitude location is stored in a string
        longitude = gps.location.lng();
        lng_str = String(longitude , 6); //longitude location is stored in a string
      }
    }

   //Read the analog to PPM
  sensorValue = analogRead (analogPin);
  Vout = sensorValue * (5.0 / 1024.0);
  CO = 100.468 * pow(((5.00 / Vout) - 1), -1.43);
```

```
//get the rounded CO ppm
digit = 0;
value = (int) CO;

while (value != 0)
{
  value = value / 10;
  digit++;
}

  if (CO > 35)
{
  String msg;
  msg = (String)"‼⚠‼⚠ ALERT‼⚠‼⚠\n" +
        (String)"!!CO is in dangerous level!!\n\n" +
        (String)"This is the location of the car: \n" +
        (String)"Latitude: " + lat_str + (String)"°\n" +
        (String)"Longitude: " + lng_str + (String)"°\n";

        thing.sendMsg("+60179462878", msg);
/* if (millis() - previousMillis >= INTERVAL) {
  previousMillis = millis() ;
  String msg = digitalRead(LED) ? "LED is OFF" : "LED is ON";

  thing.sendMsg("+60179462878", msg);

}*/
}


thing.Handle();

}
```

# Appendix B Gantt Chart of BDP1 and BDP2

| TASK / WEEK | ACADEMIC WEEK | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | STATUS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| **Analysis result and data** | PLAN | | | | | | | | S | | | | | | | | |
| | ACTUAL | | | | | | | | E | | | | | | | | |
| **Drafting result and discussion** | PLAN | | | | | | | | M | | | | | | | | |
| | ACTUAL | | | | | | | | E | | | | | | | | |
| **Drafting the conclusion and recommendation** | PLAN | | | | | | | | S | | | | | | | | |
| | ACTUAL | | | | | | | | T | | | | | | | | |
| **Compile report PSM 2** | PLAN | | | | | | | | E | | | | | | | | |
| | ACTUAL | | | | | | | | R | | | | | | | | |
| **Final report** | PLAN | | | | | | | | | | | | | | | | |
| | ACTUAL | | | | | | | | B | | | | | | | | |
| **Presentation PSM 2** | PLAN | | | | | | | | R | | | | | | | | |
| | ACTUAL | | | | | | | | E | | | | | | | | |
| **Report submission** | PLAN | | | | | | | | A | | | | | | | | |
| | ACTUAL | | | | | | | | K | | | | | | | | |

| TASK / WEEK | ACADEMIC WEEK | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | STATUS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| **Selection of PSM Title** | PLAN | | | | | | | | S | | | | | | | | |
| | ACTUAL | | | | | | | | | | | | | | | | |
| **Briefing on PSM 1** | PLAN | | | | | | | | E | | | | | | | | |
| | ACTUAL | | | | | | | | | | | | | | | | |
| **Study Background Project** | PLAN | | | | | | | | M | | | | | | | | |
| | ACTUAL | | | | | | | | | | | | | | | | |
| **Review of the Problem Statement** | PLAN | | | | | | | | E | | | | | | | | |
| | ACTUAL | | | | | | | | | | | | | | | | |
| **Explore the Information, Journals and Academic papers** | PLAN | | | | | | | | S | | | | | | | | |
| | ACTUAL | | | | | | | | | | | | | | | | |
| **Implementation of Literature Review** | PLAN | | | | | | | | T | | | | | | | | |
| | ACTUAL | | | | | | | | | | | | | | | | |
| **Identification of Hardware and Software of project** | PLAN | | | | | | | | E | | | | | | | | |
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| **Preparation Flow Chart for Methodology** | PLAN | | | | | | | | R | | | | | | | | |
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| **Implementation of Methodology** | PLAN | | | | | | | | B | | | | | | | | |
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| **Review on PSM 1 Report** | PLAN | | | | | | | | R | | | | | | | | |
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| **Presentation PSM 1 to panel** | PLAN | | | | | | | | E | | | | | | | | |
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| **Improvement and modify the report** | PLAN | | | | | | | | A | | | | | | | | |
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| **PSM 1 Report submission** | PLAN | | | | | | | | K | | | | | | | | |
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