# PIC-BASED CARBON MONOXIDE MONITORING SYSTEM

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**Sesi Pengajian** : 1 1 / 1 2

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Signature :
Supervisor's Name : ROSMAN BIN ABD RAHIM
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That was dedicated to my beloved dad, Mr.Imran Bin Daud, my mum, Mrs.Zawiyah Binti Johari and my siblings, Muhammad Suhaimy, Muhammad Hairy and Nurul Izween Soffia. Praise is to Allah s.w.t that I am part of this loving family.

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**ABSTRACT**

Carbon monoxide gas is a product of combustion of organic matter with insufficient oxygen supply to enable complete oxidation to carbon dioxide. It is often produced in domestic or industrial settings by motor vehicles and other gasoline powered tools, heaters, and cooking equipment. Exposures at 100 ppm can be dangerous to human health and it can be fatal if one is exposed up to 400 ppm. The fact that carbon monoxide cannot be detected by human senses makes it more dangerous. This project was created to solve this problem by detecting carbon monoxide using TGS 2442 gas sensor and generate an alarm signal when the detected gas reach its hazardous level. Powered by Microchip's PIC18F2550, this project enable users not only be alarmed when the carbon monoxide gas reach a dangerous level but also to be aware of the gas concentration level which will be displayed on the system's LCD. Built using a latest carbon monoxide sensor TGS 2442, the system can detect up to 1000 ppm of carbon monoxide level. The alarm signal system consists of LEDs, LCD and buzzer which will triggered according to the gas concentration level detected by the sensor. Through this project, a user-friendly yet reliable alarm system is achieved by using a cheaper yet powerful PIC18F2550 microcontroller. Testing the complete project is done at three different conditions, which is in normal air condition, cigarette smoke and car exhausts fumes.

**ABSTRAK**

Gas karbon monoksida merupakan produk pembakaran bahan organik dengan bekalan oksigen yang mencukupi bagi membolehkan pengoksidaan lengkap kepada karbon dioksida. Ia sering dihasilkan dalam persekitaran domestik atau industri oleh kenderaan bermotor dan alatan lain yang menggunakan kuasa petrol, pemanas, dan peralatan memasak. Pendedahan pada 100 ppm boleh membahayakan kesihatan manusia dan ia juga boleh membawa maut jika seseorang itu terdedah kepada 400 ppm dalam jangkamasa yang lama. Kita sedia maklum bahawa karbon monoksida tidak dapat dikesan oleh deria manusia, ini menjadikan ianya lebih merbahaya. Projek ini telah dicipta bagi menyelesaikan masalah ini dengan mengesan karbon monoksida menggunakan sensor gas TGS 2442 lalu menjana isyarat penggera apabila gas yang dikesan mencapai tahap merbahaya. Projek ini dikuasakan oleh microchip PIC18F2550 dan ia bukan sahaja mampu membuat pengguna peka apabila gas karbon monoksida mencapai tahap merbahaya malahan pengguna juga boleh mengetahui tahap kepekatan gas melalui sistem paparan pada skrin LCD. Projek ini dibina dengan menggunakan sensor gas karbon monoksida terbaru iaitu TGS 2442, sensor ini mampu mengesan mengesan sehingga 1000 ppm gas karbon monoksida. Keluaran sistem ini terdiri daripada LED, LCD dan buzzer yang akan dijana mengikut tahap kepekatan gas yang dikesan oleh sensor. Melalui projek ini, sistem penggera yang mesra pengguna mampu dicapai dengan menggunakan mikropengawal PIC18F2550 yang lebih murah dan berkesan. Setelah siap dibina alat ini akan diuji pada pada tiga keadaan yang berbeza, pertama dalam keadaan udara yang normal, kedua persekitaran yang menggandungi asap rokok dan akhir sekali udara sekitar asap ekzos kereta.

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## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| CO | - | Carbon Monoxide gas |
| ppm | - | Parts Per Million |
| PIC | - | Peripheral Integrated Circuit |
| LCD | - | Liquid Crystal Display |
| LED | - | Light Emitting Diode |
| RAM | - | Random Access Memory |
| CPU | - | Computer Processing Unit |
| RS | - | Register Select |
| R/W | - | Read/Write |
| E | - | Enable |
| ISR | - | Interrupt Service Routine |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Carbon monoxide is an odorless, tasteless, invisible gas. It is often produced in industrial area such as machineries, motor vehicles and other gasoline powered tools, heaters, and cooking equipment. Exposures at 100 ppm can be dangerous to human health and it can be fatal if one is exposed up to 400 ppm. The fact that carbon monoxide cannot be detected by human senses makes it more dangerous.

This project carried out in order to solve to this problem by monitoring carbon monoxide and generate an alarm signal when the concentration release of the unhealthy and hazardous level.

Powered by Microchip's PIC18F2550, this project enable users not only be alarmed when the carbon monoxide gas reach a dangerous level but also to be aware of the gas concentration level which will be displayed on the system's LCD. This project used TGS 2442 sensor because it is the most suitable sensor. TGS 2442 was displays good selectivity of carbon monoxide, it can detect up to 1000 ppm so making it ideal for carbon monoxide monitors.

For software implementation, Proteus 7 is used to create the circuit and MPLAB IDE is used to compile the c code to program the hex file into PIC18F2550. This monitoring system consists of LEDs, LCD and buzzer which will triggered according to the gas concentration level detected by the sensor.

## 1.2 Problem of Statement

In 2002, the United States Poison Centers found, each year, approximately 15.000 visits to emergency Departments (EDS) and around 500 deaths are caused by unintentional because of carbon monoxide exposures. Similar to other places with high concentration of air pollution e.g. industrial places, bus stations etc

This project – propose a device that can display the rate of air pollution has been put at the public area such as station bus so that public can be very aware of their surroundings

## 1.3 Objective of Project

- The purpose of the project is to design and develop PIC based carbon monoxide monitoring system that is capable of monitoring carbon monoxide gas level in toxic infested environment.

- The PIC based carbon monoxide monitoring system will be able to warn user of emergency evacuation if the toxicity of carbon monoxide exceeds 400 ppm.

## 1.4 Scope of Project

The scope of the project can be divided into two parts which are the hardware design and the software design.

For the hardware, it can be categorized into three parts:

1. PIC 18F2550 Microcontroller
2. The sensor system
3. Output system

For the Software, it can be categorized into three part:

1. Proteus 7 Professional Software
2. Microcontroller Programming Software
3. BootLoader's software

## 1.5 Summary of Works

The entire project is being done in two semester period continuously. During first semester, most of the works involve studying the microcontroller used for the project and learning the programming language. The components used for the project are identified in the first semester. This also involves ordering FIGARO TGS 2442 sensor at online market.

In the second semester, most of the works involved hardware and software implementation. This is when the hardware development process begins. The literature reviews work continues from the first semester to the second semester. After the software and hardware works is finished, the circuit testing work begins. Data is collected throughout the testing process. Finally the documentation of thesis is carried out.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter will discuss in detail about the meaning of carbon monoxide and the effect PIC18F2550 in general, about its pin functions and the memory organization of the microcontroller. This chapter also explains about the sensing system and the output system of the project. It also touches about the software that will be used for the programming, which is Proteus 7 Professional, MPLAB and there are a couple of past related works presented towards the end of the chapter.

## 2.2 Carbon Monoxide

Carbon monoxide (CO) is a poisonous, colorless, odorless, and tasteless gas. Although it has no detectable odor, CO is often mixed with other gases that do have an odor. CO is a common industrial hazard resulting from the incomplete burning of natural gas and any other material containing carbon such as gasoline, kerosene, oil, propane, coal, or wood. Forges, blast furnaces and coke ovens produce CO, but one of the most common sources of exposure in the workplace is the internal combustion engine.

Carbon monoxide is harmful when breathed because it displaces oxygen in the blood and deprives the heart, brain, and other vital organs of oxygen. Large amounts of CO can overcome in minutes without warning—causing to lose consciousness and suffocate.

Besides tightness across the chest, initial symptoms of CO poisoning may include headache, fatigue, dizziness, drowsiness, or nausea. Sudden chest pain may occur in people with angina. During prolonged or high exposures, symptoms may worsen and include vomiting, confusion, and collapse in addition to loss of consciousness and muscle weakness. Symptoms vary widely from person to person. CO poisoning may occur sooner in those most susceptible: young children, elderly people, people with lung or heart disease, people at high altitudes, or those who already have elevated CO blood levels, such as smokers. Also, CO poisoning poses a special risk to fetuses. [1]

### 2.3 PIC18F2550 Microcontroller

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1640 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "Peripheral Interface Controller". PICs are popular with developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability.

The PIC18F2550 belongs to the high-performance 8-bit microcontroller family of PICmicro® microcontroller devices. PIC18F2550 has 32 Kbytes of Flash memory and can store up to 16, 384 single-word instruction. The data memory contains 2048 bytes of SRAM and 256 bytes of EEPROM. The Analog-to-Digital converter module has 10 input channels with Programmable Acquisition Time. This module allows conversion of an analog input signal to a corresponding 10-bit digital number. PIC18F2550 has one 8-bit timer (Timer2) and three 16-bit timers (Timer0, Timer1 and Timer3).

#### 2.3.1 PIC18F2550 Functions

The PIC18F2550 microcontroller is available in a 28-pin DIL (Dual-In Line) package and a 28-pin SOIC (Small Outline Integrated Circuit) package. For the project, the 28-pin PDIP is used. The arrangement for 28-pin PDIP package is as shown in Figure 2.1.

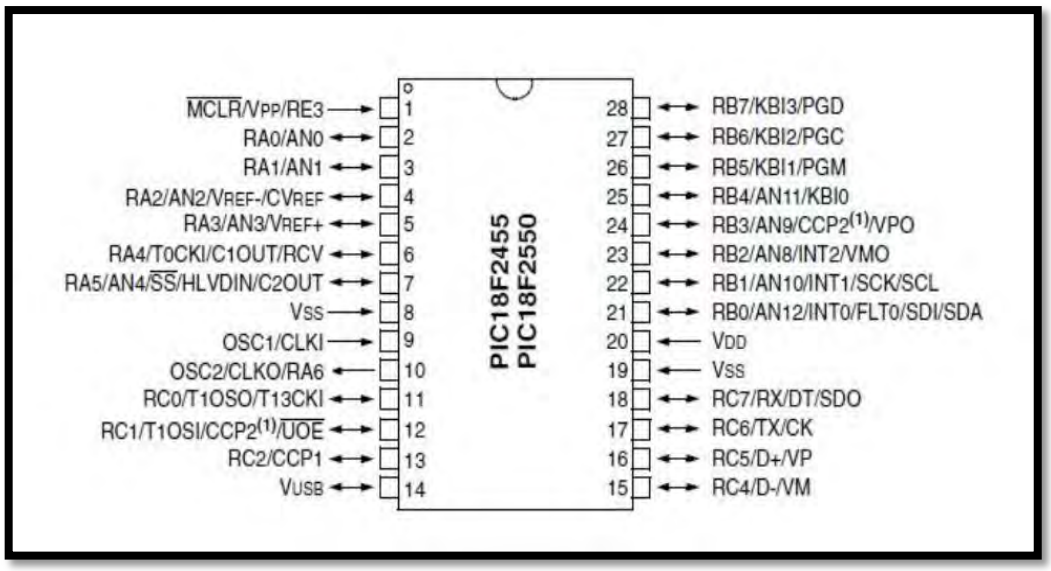


Figure 2.1: Pin Diagram of PIC18F2550

**i. Voltage supply and Ground reference (VDD and VSS)**

The device operates from one +5V supply connected to pin 20 (VDD) while pin 8 and pin 19 are (VSS) grounded.

**ii. I/O Ports**

There is a total of 24 I/O pins (Port A, B and C) where some pins of the I/O ports are multiplexed with an alternate function from the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin. A summary of the ports are as follow:

a. Port A and TRISA Register

PORTA is an 8-bit wide, bidirectional port, situated at pin 2-7. The corresponding data direction register is TRISA. Setting a TRISA bit (=1) will make the corresponding PORTA pin an input. Clearing a TRISA bit (=0) will make the corresponding PORTA pin an output.

b. Port B and TRISB Register

PORTB is an 8-bit wide, bidirectional port, located at pin 21-28. The corresponding data direction register is TRISB. Setting a TRISB bit (=1) will make the corresponding PORTB pin an input. Clearing a TRISB bit (=0) will make the corresponding PORTB pin an output.

c. Port C and TRISC Register

PORTC is a 7-bit wide, bidirectional port, placed at pin 11-13 and 15-18. The corresponding data direction register is TRISC. Setting a TRISC bit (=1) will make the corresponding PORTC pin an input. Clearing a TRISC bit (=0) will make the corresponding PORTC pin an output.

d. Port E

For PIC18F2550, PORTE is only available when Master Clear functionality is disabled (MCLRE = 0). In this case, PORTE is a single bit, input only port comprised of RE3 only.

**iii. OSC1/CLKIN and OSC2/CLKOUT**

The PIC18F2550 on-chip oscillator is driven usually from an external crystal. OSC1 provides an input to the internal clock generator circuits while the OSC2 is the output which has ¼ the frequency of OSC1, and denotes the instruction cycle rate. [2]

## 2.4 Carbon Monoxide Sensor (The Sensing System)

Figure 2.2: TGS 2442

There are several Carbon Monoxide (CO) sensors to choose from in the market but for the project, FIGARO TGS 2442 CO sensor is used. This is because TGS 2442 displays good selectivity of CO, making it ideal for CO monitors. In the presence of CO, the sensor's conductivity increases depending on the gas concentration in the air. A simple pulsed electrical circuit operating on a one second circuit voltage cycle can convert the change in conductivity to an output signal which corresponds to gas concentration. [3]

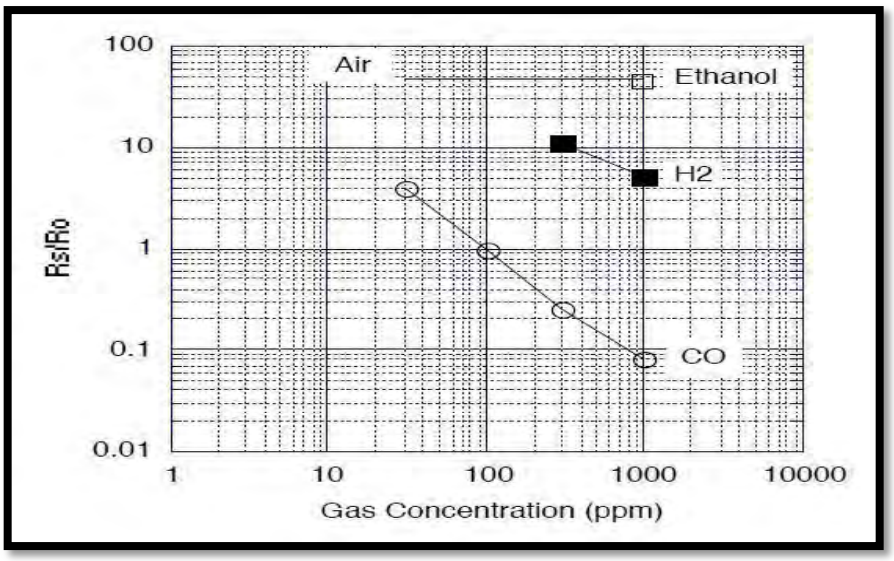


Figure 2.3: Sensitivity Characteristic for TGS 2442

Figure 2.3 represents typical sensitivity characteristics of TGS 2442 on three type of gas Hydrogen gas, Ethanol gas and Carbon Monoxide gas. The Y-axis is indicated as sensor resistance ratio (Rs/Ro) which is defined as follows:

Rs = Sensor resistance of displayed gas at various concentrations.
Ro = Sensor Resistance in 100ppm CO.

Based on figure 2.3, TGS 2442 sensitivity to ethanol gas is very low as evidenced by the relatively flat slope of its sensitivity curve and high resistance value while in Hydrogen gas TGS 2442 is slightly more sensitive compare to the previous gas. TGS 2442 is most sensitive in CO gas since the sensitivity curve to CO shows a sharp drop in sensor resistance as CO concentration increases.

**2.5 Output System**

The output system of the project is one of the vital parts of the project because it is necessary in order to achieve one of the project objectives which are to warn users of emergency evacuation when the CO toxicity exceeds dangerous level. The output system consists of three main components:

- Light Emitting Diode (LED).
- Buzzer

- LCD Display

### 2.5.1 Light Emitting Diode (LED)

A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are increasingly used for lighting. The LED is based on the semiconductor diode. When a diode is forward biased (switched on), electrons are able to recombine with holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the color of the light is determined by the energy gap of the semiconductor. An LED is usually small in area, and integrated optical components are used to shape its radiation pattern and assist in reflection. LEDs present many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved robustness, smaller size, faster switching, and greater durability and reliability. These advantages makes LED a suitable CO level indicator for the project. [4]

### 2.5.2 Buzzer

A buzzer is an audio signaling device, which may be mechanical, electromechanical, or electronic. Typical uses of buzzers include alarms, timers and confirmation of user input such as a mouse click or keystroke. The project uses an electronic type of buzzer which is a piezoelectric element may be driven by an oscillating electronic circuit or other audio signal source. The buzzer used for the project is So-Buzz by Cytron Technologies which has a voltage range from 3-12V and it produces beeping sound.

### 2.5.3 LCD Display

A liquid crystal display (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). LCs does not emit light directly. LCDs therefore need a light source and are classified as "passive" displays. Some types can use ambient light such as sunlight or room lighting. There are many types of LCDs that are designed for both special and general uses. They can be optimized for static text, detailed still images, or dynamic, fast-changing, video content.

LCDs are more energy efficient, and offer safer disposal, than CRTs. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an

electronically-modulated optical device made up of any number of pixels filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome. For the project, a 16 by 2 Hitachi JHD162A LCD display is used. The LCD has up to 192 characters available including Japanese and Greek characters.

### 2.6 Proteus 7 Professional Software

Proteus allows professional engineers to run interactive simulations of real designs, and to reap the rewards of this approach to circuit simulation and then, a range of simulator models for popular micro-controllers and a set of animated models for related peripheral devices such as LED and LCD displays, keypads, an RS232 terminal and more. It is possible to simulate complete micro-controller systems and thus to develop the software for them without access to a physical prototype. In a world where time to market is becoming more and more important this is a real advantage. Structurally, Proteus 6 Professional separated into two main components, which are ISIS Professional and ARES Professional. ISIS Professional mainly involved on circuit designing and simulation

#### 2.6.1 PIC16F877 Parameter Settings

The most important part of Proteus simulation is setting up the microcontroller. The configuration needs to be correct to cross out any setting error in time for program simulation. To edit the parameter for PIC, right click on the PIC to select the component and then left-click and Edit Component dialog will pop up. In this dialog, two things that need to set are Program File and Processor Clock Frequency