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Monitoring Carbon Monoxide Emission in the Air Using Wireless Application

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Abstract - **In 2008 a total of 22,971 industrial sources were identified to be subjected to Environmental Quality (Clean Air) Regulations, 1978. The highest number of stationary pollution sources was in Johor (8,141: 35.4%) followed by Selangor (4,127: 18.0%) and Perak (2,956: 12.9%). As for the past years, motor vehicles remain the major contributor of air pollution especially in urban areas [1]. It is estimated that in 2008 the combined air pollutant emission load was 1,451,746 metric tonnes of carbon monoxide (CO); 409,972 metric tones of nitrogen oxides (NO_x); 161,913 metric tones of sulphur dioxide (SO_2) and 31,672 metric tones of particulate matter (PM) [1]. Concerning due to very high load of carbon monoxide emission in the air, this study is to monitor the CO emission load via wireless application. Earlier research done showed that the Potential Health Hazards of Air Pollution especially carbon monoxide (CO) give various unhealthy effects. At low concentrations, it can fatigue in healthy people and chest pain in people with heart disease. While at higher concentrations, it can impair vision and coordination; headaches; dizziness; confusion; nausea also can cause flu-like symptoms and the worst effect is fatal at very high concentrations.**

I. INTRODUCTION

A. *Carbon Monoxide (CO) & the Effects*

Carbon monoxide (CO) is a gas that can build up to dangerous levels indoors when fuel- burning devices are not properly operated, vented, or maintained. A significant amount of the pollution that enters the atmosphere is generated by road transport. The burning of fossil fuel to generate motion and power is not a clean technology, and although some may argue that reserves of oil will not last long, at the present time society relies upon them. One such reliance is for road transportation [2].

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Carbon monoxide is a colorless, odorless, tasteless and toxic gas produced as a by-product of combustion. Any fuel burning appliance, vehicle, tool or other device has the potential to produce dangerous levels of carbon monoxide gas. Examples of carbon monoxide producing devices commonly in use around the home include:

- Fuel fired furnaces (non-electric)
- Gas water heaters
- Fireplaces and woodstoves
- Gas stoves
- Gas dryers
- Charcoal grills
- Lawnmowers, snow blowers and other yard equipment
- Automobiles

Carbon monoxide can bring effects to the human beings. It's silent, deadly and lurks in the home while your family sleeps. Dubbed the "silent killer," the colorless, odorless and poisonous gas - carbon monoxide (CO) - kills 500 people and sends 20,000 more to the hospital each year. Carbon monoxide inhibits the blood's ability to carry oxygen to body tissues including vital organs such as the heart and brain. When CO is inhaled, it combines with the oxygen carrying hemoglobin of the blood to form carboxyhemoglobin (COHb). Once combined with the hemoglobin, that hemoglobin is no longer available for transporting oxygen.

How quickly the carboxyhemoglobin builds up is a factor of the concentration of the gas being inhaled (measured in parts per million or PPM) and the duration of the exposure. Compounding the effects of the exposure is the long half-life of carboxyhemoglobin in the blood. Half-life is a measure of how quickly levels return to normal. The half-life of carboxyhemoglobin is approximately 5 hours. This means that for a given exposure level, it will take about 5 hours for the level of carboxyhemoglobin in the blood to drop to half its current level after the exposure is terminated [3,4].

Table 1 Concentration & Time of Exposure table – parts per million (ppm).

9 ppm	EPA residential standard - not to exceed 9 ppm in 8 hours.
35 ppm	EPA residential standard - not to exceed 35 ppm in 1 hour.
50 ppm	OSHA workplace standard - not to exceed 50 ppm in an 8 hour period.
200 ppm	Slight headache, fatigue, dizziness, nausea after 2-3 hours.
400 ppm	Frontal headaches within 1-2 hours. Life threatening after 3 hours.
800 ppm	Dizziness, nausea and convulsions within 45 minutes. Unconsciousness with 2 hours. Death within 2-3 hours.
1600 ppm	Headache, dizziness and nausea within 20 minutes. Death within 1 hour.
12,800 ppm	Death within 1-3 minutes.

B. Wireless Sensor Network

Early designs were basically a white pad which would fade to a brownish or blackish colour if carbon monoxide were present. Such chemical detectors are cheap and widely available, but only give a visual warning of a problem. As carbon monoxide related deaths increased during the 1990s, audible alarms became standard.

The alarm points on carbon monoxide detectors are not a simple alarm level (as in smoke detectors) but are a concentration-time function. At lower concentrations (e.g. 100 parts per million) the detector will not sound an alarm for many tens of minutes. At 400 parts per million (PPM), the alarm will sound within a few minutes. This concentration-time function is intended to mimic the uptake of carbon monoxide in the body while also preventing false alarms due to relatively common sources of carbon monoxide such as cigarette smoke.

There are four types of sensors available and they vary in cost, accuracy and speed of response. The latter three types include sensor elements that typically last up to 10 years. At least one CO detector is available which includes a battery and sensor in a replaceable module. Most CO detectors do not have replaceable sensors [5,6].

Wireless home safety solutions are available that link carbon monoxide detectors to vibrating pillow pads, strobes or a remote warning handset. This allows those with impediments such as hard of hearing, partially sighted, heavy sleepers or the infirm the precious minutes to wake up and get out in the event of carbon monoxide in their property [7, 8, and 9].

C. Design Software

This project involves the hardware and software, which must be working properly. In order to test the circuit and software in right condition, simple software must be test and observe to ensure no error occurs. Software programming will be written and tested by MPLAB IDE. LED is used o indicate ‘1’ or ‘0’ at the port. The MPLAB is very useful to run the assembly language because its allow checking of the content of port, special function register during simulation. The LED will indicate the value at the port B and A.ON mean ‘1’ and OFF mean ‘0’ at the port.

II. METHODOLOGY

Generally this system starts when the sensor measures the gas level emitted in the corresponding area (analogue signal), then the data measured will be collected and transform to the digital signal via microprocessor. In this section, the collected data will be sent to the GSM module and then the GSM will transmit the data to the corresponding receiver via the SMS. Figure 1 shows the block diagram of the gas monitoring system.

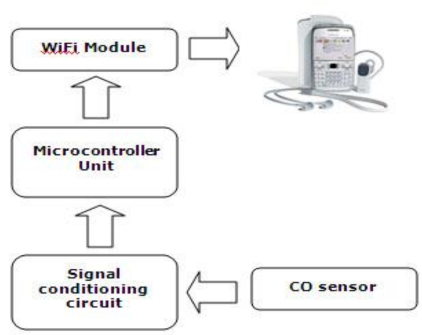

Fig. 1. Block diagram of the gas monitoring system

A. Hardware

Fig. 2 shows the block diagram used in the transmitter part. The input of the transmitter is the TGS 800 as to measure the CO gas sensor. UART pin of PIC16F887 will send the output signal which then converted to RS232 through the GSM modem.

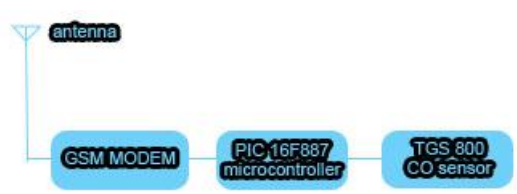

Fig. 2. Transmitter block diagram

On Fig. 3 it shows that the sensor TGS 800 is connected directly to the I/O port on the microcontroller's port A (RA0/pin 2) while the output port is connected to the GSM modem transceiver UART port in pin T_x and R_x which is (pin 17) and (pin 18).

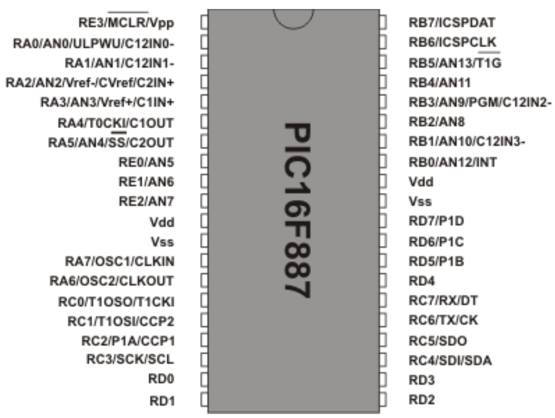

Fig.3. Pin configuration port of PIC16F887 (micro – controller)

The hardware part consists power supply and also for the microcontroller. The microcontroller is loaded with a program using programmer board (MPLAB IDE version 8) to read the data collected from the sensor and send it accordingly via GSM modem to the respective user.

In this project, 9 volt voltage was used. Voltage regulator LM7805 is used to convert 9 volt to supply 5 volt for the micro controller (PIC 16F887), CO sensor (TGS 800) and GSM modem as shown in Fig. 4.

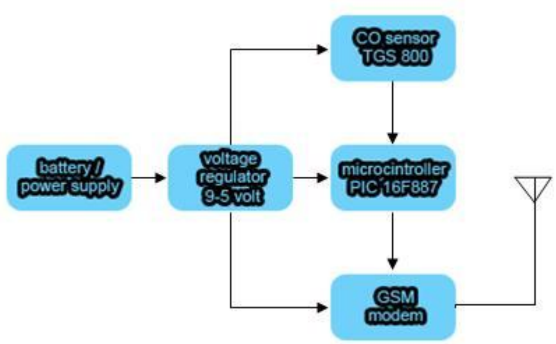

Fig. 4. Block diagram of transmitter's system

Figaro TGS 800 is the carbon monoxide CO sensor used since its produce an analog data at operating voltage of 5 volt.

The GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. From the mobile operator perspective, a GSM modem looks just like a mobile phone. GSM modems are most frequently used to provide mobile internet connectivity, also can be used for sending and receiving SMS and MMS messages. In this project GSM modem is connected to allow the data collected can be sent to the respective subscribers via SMS system. With GSM modem the data collected can be provided and transmitted easily by communicate over the mobile network. The GSM modem WAVECOM used in this project require 7 volt to operate. The GSM Modem is already designed with capabilities and features of RS232 function and 7 volt input voltage. UART data from the microcontroller will converted to RS232 signal by MAX232 Driver circuit. Fig 5 shows the block diagram of the transmitter and receiver of the system.

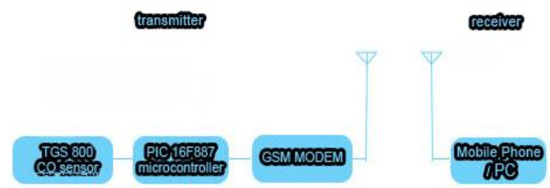

Fig. 5. Transmitter and receiver block diagram system

A few additional hardware also has been assembled together as a value added as project advantages such as in serial circuit programming (ICSP), 16x2 display for displaying the current gas reading, real time clock (RTC), push button and also max 232 as (RS 232 driver).

B. Software

The memory of microcontroller is used to store and execute the program code. The program is written by using MPLab IDE and uploaded into the processor by using PIC2 kit. This type of memory is programmable and erasable. The microcontroller will operate regarding the executed program that installed inside it. The language code being used in this program is assembly code. Fig. 6 shows the flow chart of the program of the microcontroller. It consists of sensor programs such as data calculation, measurement analog to digital conversion and defines where the data need to be sent. The output of the microcontroller is the GSM modem as the transmitter to the user or subscriber.

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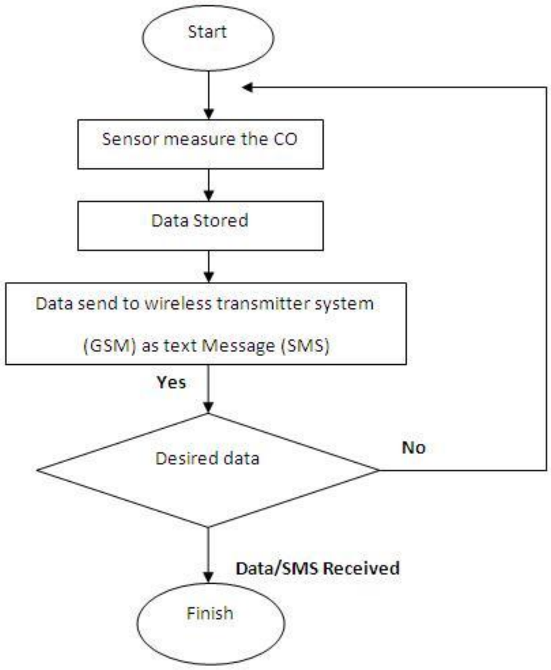

Fig. 6 flow chart program of the microcontroller

III. RESULT AND DISCUSSION

A. Hardware

Fig. 7 shows the completed assembled hardware of the CO gas monitoring system. The data is collected in three different places indoor (living room/working room) and outdoor (smoking area & car exhaust).

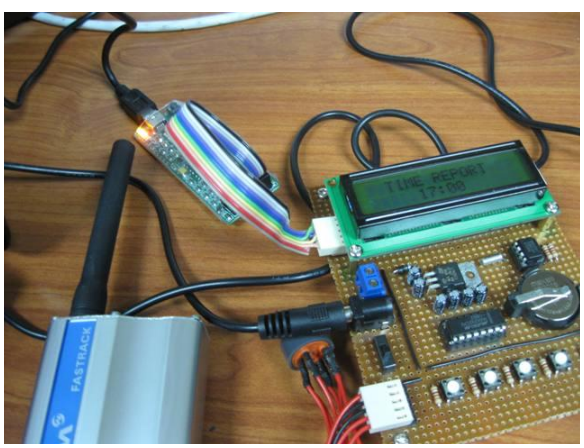

Fig. 7. The completed assembled hardware

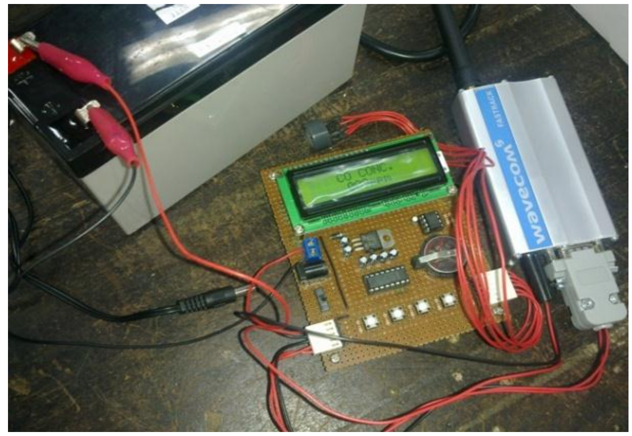

Fig. 8. The indoor data collection

Fig. 9. The outdoor data collection of smoking room

Fig. 10. The outdoor data collection from car exhaust.

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B. Display

Subscribers or users mobile phone is used as the display medium for the data collected from the sites. Table 2 below shows the average result collected from the three experiment sites as per shown in Fig. 8, Fig. 9 and Fig. 10.

Table 2 The average result of the collected data

Sites tested	1	2	3	4	5	Average (ppm)
Indoor	9	9	10	9	8	9ppm
Smoking room	39	37	36	36	37	37ppm
Car exhaust	46	50	52	44	48	48ppm

From the results it shows that Carbon Monoxide (CO) is very high obtained from the car exhaust, followed by the Carbon Monoxide in the smoking room and lastly indoor area.

Fig. 11 shows the sample SMS data collected displayed on the user or the subscriber mobile phone. While Fig. 12 shows the alert SMS send immediately after the gas reading reached the safety limit indicator.

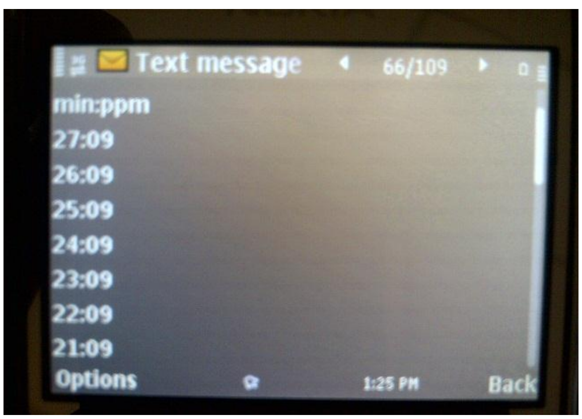

Fig. 11. The sample of SMS data collected (indoor)

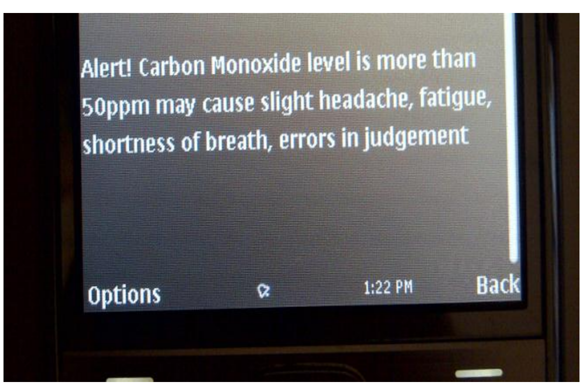

Fig. 12. The alert SMS sent to the subscribers

IV. CONCLUSIONS

By completion of this project it will show that a chemical sensor can be successfully integrated into a wearable platform and provide wireless monitoring of a hazardous gas Carbon Monoxide (CO) in the environment. Therefore, the user can monitor the CO emission in the respective area without having to be present at the test spot.

Thus, with this project it should show that with the continuous emission monitoring of the Carbon Monoxide via wireless system is very flexible, cost and time savings, and early warning or action can be taken especially for the Industrial and Urban area in Malaysia.

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