International Journal of Civil Engineering and Technology (IJCIET)
Volume 10, Issue 03, March 2019, pp. 464–469, Article ID: IJCIET_10_03_047
Available online at http://www.iaeme.com/ijmet/issues.asp?JType=IJCIET&VType=10&IType=3
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

DESIGN AND CONSTRUCTION OF CARBON MONOXIDE (CO) DETECTOR

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ABSTRACT

Carbon monoxide (CO) generally referred to as the silent killer, arises from combustion of fuel with limited oxygen. This gas is a lighter than air and could be dangerous if inhaled in high quatity by humans. There is increase in the death rate yearly as a result carbon monoxide (CO) poisoning. To prevent this poisoning, it is important to build a detector that will assess the level of CO levels the room/environment so as to inform people of the CO concentrations level. The contructed device in this study was assembled using TGS 2442 sensor. It uses PIC16F917 microcontroller as the processor, in the configuration perform the task of converting the analogue input into a digital output which was shown on the LCD as the CO concentration in the room. The constructed circuit was used to determine the output voltage of CO emitted from petrol car, candle, diesel generator and petrol generator. Highest output voltage was obtained from candle light.

Key words: Carbon Monoxide, Detector, Concentration, Microcontroller.

Cite this Article: Usikalu M. R, Umoren I., Ndubuisi A. O and Olawole O. F, Design and Construction of Carbon Monoxide (CO) Detector, *International Journal of Civil Engineering and Technology* 10(3), 2019, pp. 464–469.
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1. INTRODUCTION

Carbon monoxide is produced in the environment where combustion is done with limited oxygen. It is a colourless and odourless gas as such it can not be identified or sensed with our sense organs. It can emanate from two sources which are: natural and man-made origin. On worldwide basis largest contribution comes from natural source due light and chemical reactions going on in the atmosphere which produce about 5×10^{12} g in just one year (Weinstock *et al.,* 1972), volcanoes eruption and incessant bush burning are other natural sources of CO.

The most common souce of CO to the public is tobacco smoking. The quantity of it received by the lung depends on the depth of inhalation, type of tobacco consumed and the pattern of smoking. CO absorption is significant in upper airways and mouth (Raub *et al.,* 2000). CO is produced naturally as a secondary product in conversion of protoporphyrin to bilirubin. The product of the reaction is carboxyhemoglobin when non toxic CO reacts with

the hemoglobin. Goldfrank *et al.* (2002); Akinyemi and Usikalu (2013) reported in their studies that CO high concentration can be gotten from anthropogenic (man-made) sources.

It is a poisonous gas, which can produce effect even with concentration as low as 0.1% (1000 ppm). Ayres and Ayres (2009) reported that CO toxicity is as a result of its afinity to react with transition metals for instance iron located in the middle of a haemoglobin molecule. CO absorption happens through inhalation into the blood system by gaseous interchange in the lungs (Roth *et al.,* 2011, Akinyemi and Usikalu, 2010). Table 1 presents some effects of CO exposure. In many countries CO poisoning is one of the common source of natural deadly air poisoning. Other types of common symptoms/effects of the gas include the following; fatigue, nausea, vomiting, feeling of weakness, headache, dizziness etc. It can also lead to poor feeding and irritation in infants. Some of its neurological symptoms include confusion, disorientation, visual disturbance fainting and seizures (Blumenthal, 2001; Usikalu, 2009).

A CO detector is a device that is sensitive to detect the invisible CO gas. It can be powered by DC or AC backup or linked to a setup using an authorized control panel. The constructed CO detector will recognize the presence of the carbon monoxide (CO) gas and raise an alarm in order to create awareness of the increased level of CO in that particular vicinity. Figure 1 is the block diagram of constructed CO. CO detectors are patterned to quantify CO levels over time and trigger an alarm before getting to deadly limits of CO built-up in an environment, thereby creating awareness and warning for thosed living in the vicinity to increase the ventillation or vacate the vicinity. This study aims at constructing CO detector that can be used indoor monitoring using TGS 2442 sensor for the CO. The contructed detector was used to measure the concentration of CO emission when candle was lighted, and when petrol car, petrol generator and diesel generator were ignited.

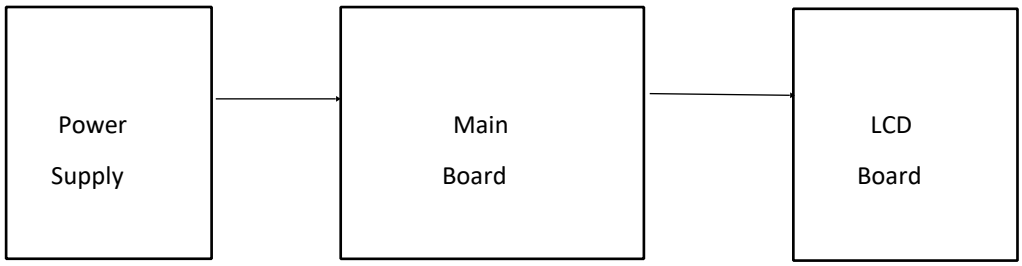

Figure 1 Block diagram of the CO detector

2. METHODOLOGY

The PIC16F917 microcontroller was used for the construction. It has the following features:

- 96 LCD segments
- 32kHz to 8MHz oscillator
- Low-power nanoWatt Technology
- 25mA Source/Sink current I/O
- Two 8-bit Timer
- One 16-bit Timer (TMR1)
- Extended Watchdog Timer (EWDT)
- Wide Operating Voltage (2.0V – 5.5V)
- Brown-Out Reset (BOR) with Software Control

- In Circuit Serial Programming (ICSP)
- Programmable Low Voltage Detect (PLVD)
- Wake on change
- I2C, SPI, AUSART

TGS 2442 Sensor configured as shown in Figure 2 was used as the detector for carbon monoxide which has the following features:

- Low power consumption
- High sensitivity/selectivity to
- carbon monoxide (CO)
- Miniature size
- Low sensitivity to alcohol vapor
- Long life and low cost
- Low humidity dependency

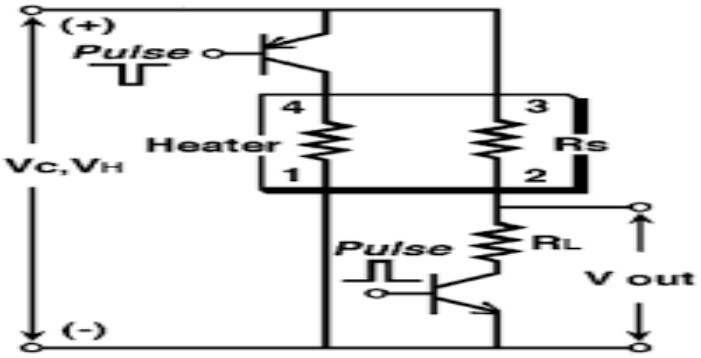

Figure 2 Basic measuring circuit and pinout configuration for TGS 2442

LM7805 regulator was used as voltage regulator for the constructed device. It is designed to automatically maintain a constant voltage level. A voltage regulator may be a simple feed-forward design or may include negative feedback control loops. It may use an electromechanical mechanism, or electronic components. All the components were coupled together on three printed circuit boards (PCBs). Two electrolytic caps, alarm buzzer and power supply chip were soldered on one of the PCBs. The second auxiliary board was put in place so as to reduce the load on the first by housing the Liquid Crystal Display unit (LCD). LCD serves to display the gas levels on the front panel. All other components which include resistors, transistors, the microcontroller and the sensor are mounted on the main PCB (Nwoye *et al.,* 2017; Ayara *et al.,* 2017). The implementation of the circut was done using Peripheral Interface Controller (PIC16F917) and TGS 2442 sensor as shown in Figure 3.

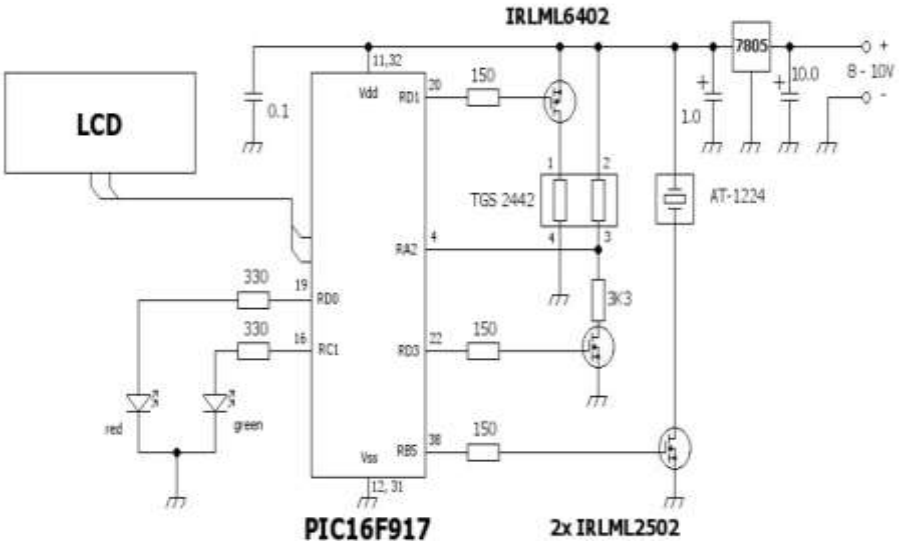

Figure 3 Circuit diagram of the carbon monoxide detector

Table 1 Effects of CO exposure (U.S. Consumer Product Safety Commission, 2016)

CO Level (ppm)	Signs
35- 40	No significance effects within first 8 hours
200 – 205	Headache after exposure for few hours
400 – 405	Nausea and headache and few hours
800 - 805	Dizziness, headache and nausea after few minutes; fainting in some hours
1000 - 1005	Loss of consciousness after anhour
3200 - 3205	Headache, nausea and dizziness after 5-10 minutes; unconsciousness after 30 minutes
12800 - 12810	Death after few minutes

3. RESULTS AND DISCUSSION

The constructed CO detector is very sensitive and able to measure and select CO perfectly when the sensor temperature is less than 100˚C. Though, when the temperature is lower than 100^{o}C, other contaminants and humidity may affcet the sensor, hence constant heat cleaning is improrttant when the temperature of the sensing element is greater than 300˚C. The conductivity incereases as the concentration of the gas increases in the presence of CO depending on the sensor used. The output voltage from CO emission from different source in 60 s was measured using the constructed circuit which was then converted to the concentration level. The result obtained from constructed device is displayed in Figure 4. Figure 5 is the constructed device on the bread board. It was found that candle produced the highest output voltage while the lowest output voltage was recorded from diesel generator, this is in accordancance with report of Akinyemi and Usikalu (2013). Here are the measured parameters from the device.

Input voltage to the power supply is 8.9 V

Output of the regulator is 4.99 V

Voltage going into sensor is 4.98 V

Voltage from sensor to the microcontroller is 4.98 V

The device after being tested gave a maximum voltage of 4.9 V.

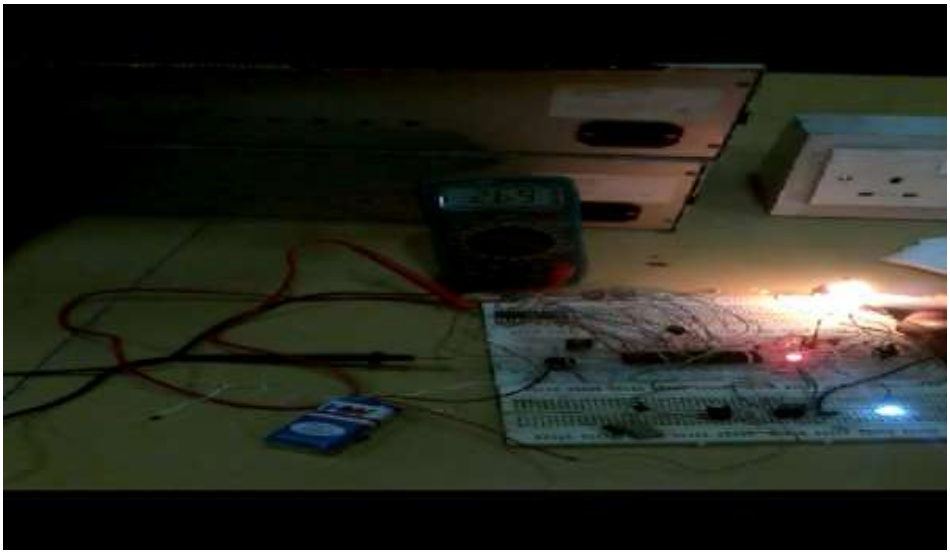

Figure 5 Constructed device on bread board

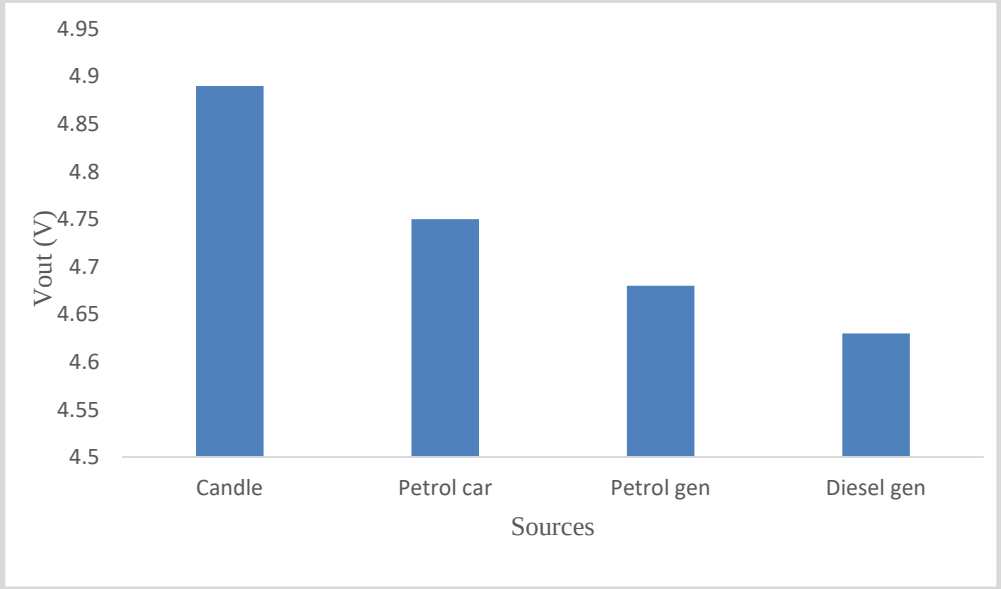

Figure 4 Variation of Vout against CO sources

4. CONCLUSIONS

TGS 2442 served as the sensor for the constructed carbon monoxide detector. It has two LEDs (green and red) as indicator and visual alarm for CO level and a buzzer. If a value greater than the threshold level is selected this would trigger the buzzer and

LEDs. The CO concentration in the environment is displayed on the LCD. This constructed detector has a good preference for CO and able to select the gas than for other gases. It was observed that other contaminants and humidity can affect the temperature of sensing element most especially if the temperature is lower than 100^{o}C. The constructed device work perfectly, it is sensitive to select CO gas in the environment when the sensor temperature is less than 100˚C.

ACKNOWLEDGEMENTS

Support of Covenant University Centre for Research, Innovation and Discovery (CUCRID) is acknowledged.

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