ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 6, June 2017

Design and Implementation of Wearable Gas Detector using ATTINY85

[1] Chetanraj K Y, [2] Ravikumar S
R V College of Engineering, Bengaluru

Abstract: **Recently, there have been many developments in the area of gas detection. In this article, we design a compact wearable gas detector. The designed gas detector is implemented using ATTINY85 microcontroller, a gas sensor and the OLED display. The MQ-4 gas sensor senses methane, propane and butane which are the main constituents of natural gas. To notify the gas concentration to the user an OLED display is used. When the gas concentration reaches the specified threshold the user is notified by an alert message in the OLED display. The gas detector designed is smaller and cheaper and can be used in household, mining sector and industry.**

***Index Terms*—Wearable, Gas detector, Microcontroller, ATTINY85**

I. INTRODUCTION

Gases are generally classified into flammable and non-flammable gases. Flammable gases are dangerous and pose a serious threat to human life as the chances of explosion is high. Methane, Acetylene, Propane, hydrogen are few examples of flammable gases. When the flammable gas leaks into environment and the concentration reaches a certain threshold, it is likely to cause major accident such as explosion. Methane is commonly used as fuel in vehicles, and it is also used in residents and industry. Natural gas has high concentration of methane gas. Methane gas is found in underground petroleum reservoirs.

Methane gas doesn't have any odor or color. Hence detection of this gas is difficult for humans. Since natural gas is used in households, leakage of this gas poses serious danger. Gas detector detects and indicates gas leakage in surrounding area. Gas detector is a very important device in Oil industry, households and Gas industry.

Tae-Ho Nam et la [1], discusses about efficient method of detecting ammonia gas in refrigeration facility. Guaranteed durability of 5 years is assured by this technique and algorithms are suggested to improve the measurement accuracy. Bluetooth communication is used to send the data about concentration of ammonia to smartphones.

In [2], Zang discusses about combustible gas detector. This detector consists of STC12C5410AD microcontroller unit. Along with the microcontroller gas sensor and alarm is also attached to it. In this article, he discussed about hardware and software model and its implementation. The designed gas detector can able to operate in room temperature and fulfilled most of the requirements of the mining and other industries.

The issues like explosion of plants due to gas leakage poses a serious problem. So it must be avoided for the wellbeing of the company and employees. It is a very difficult challenge to sense a particular gas when there are lot of other gases in the surroundings. In [3], Nasaruddin has focused on eliminating the unwanted gases so as to detect only the wanted gases. There are both portable and fixed gas detectors available in the market. Fixed gas detectors are not mobile hence to cover a large area, more number of gas detectors are needed. Fixed gas detector senses only in certain fixed area surrounding it. Portable gas detectors on the other hand are mobile. Hence we can carry it anywhere we want. So portable gas detectors can be moved to any area where gas sensing is required. Portable gas sensors have limited battery capacity and also expensive. Portable gas detectors should as compact as possible so that they can be carried to any place conveniently. So there is a need to design compact and less expensive portable gas detector.

II. SYSTEM STRUCTURE

The designed system consists of microcontroller unit, OLED display and gas sensor unit. The system architecture of methane gas detector is as shown in figure 1. The description of each unit is as given below,

A. Microcontroller Unit

The microcontroller used here is ATTINY85. It is an 8-bit microcontroller with an operating voltage range of 2.7 to 5.5V. This enables the microcontroller to operate at very low voltage. The operating range of microcontroller is from 0 to 10MHz for the voltage of 2.7 to 5.5V. It has an in-system programmable memory of 8K bytes which enable storing of large program data. The microcontroller has 8-pins which makes it compact and easy to use in wearable devices. It has an internally calibrated oscillator. Hence there is no need for external crystal oscillator which reduces the system space.

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ISSN (Online) 2394-6849

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B. OLED display

In our design, we are using 0.96 inch OLED display with a resolution of 128×64. Even though the display size is less because of high resolution user can make out the displayed data easily. The operating voltage of OLED display is 3.3V to 5V which helps to operate in lower supply power. Compared to LCD display, the OLED display can operate in wide temperature range and are more durable.

C. Sensor Unit

The sensor unit used is MQ-4. This is an electrochemical sensor which uses Tin di-oxide as a sensing material. MQ-4 is highly sensitive to methane gas which is a main constituent of natural gas. In addition, the sensor unit can also sense propane and butane to a small extent. A simple flow chart of working of gas detector is shown in figure 2.

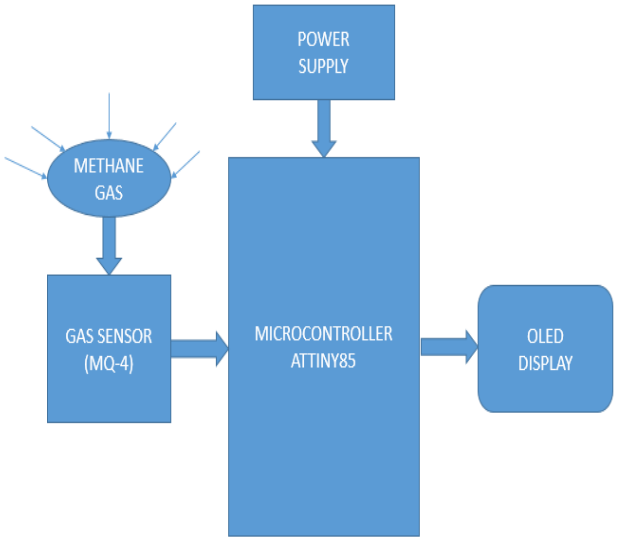

Fig 1: Block diagram of Methane Gas Detector

III. HARDWARE DESIGN OF THE GAS DETECTOR

The hardware design mainly concentrates on the miniaturization of the gas detector. Since the designed gas detector should be portable and compact, we have used 5cm×9cm generic PCB board to setup the components. In our approach we were able to set up all the components like OLED display, MQ-4 gas sensor and ATTINY85 MCU within the 5cm×5cm space on the PCB board as shown in the figure 3.

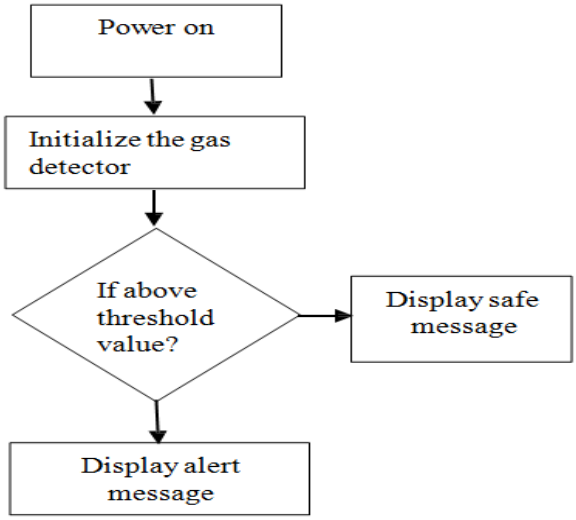

Fig 2: Software flowchart of the gas detector

IV. SOFTWARE DESIGN OF THE GAS DETECTOR

In gas detector system designed, when the system is powered on the sensing element i.e. SnO2 present in the gas sensor unit detects the methane gas in the environment. It then converts the methane gas concentration into corresponding electrical sign al and sends it to microcontroller. The microcontroller unit checks the analog values from the MQ-4 sensor. The program is designed such that when the values reaches above a threshold value it initializes the OLED display. The detected value, status of the gas in the atmosphere and the alert message are displayed in the OLED display. If the threshold value is not exceeded instead of alert message it show safe message in the display as shown in figure 3. If the threshold value of the gas exceeds the threshold value then display shows alert message as shown in figure 4.

Fig 3: OLED display showing safe message

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Fig 4: OLED display showing alert message

V. BATTERY LIFE

In our design of gas detector, we are using 5V supply. Since 5V supply is not available directly we are using 5V regulator to convert 9V supply from the zinc-carbon battery source to 5V. The voltage reading of the gas detector when is in power on state is 4.49V. The average current consumption of the gas detector calculated for the period of 5 minutes is 29 mA. Thus by using the zinc-carbon battery with capacity of 400mAh we would get the battery life as given in equation (1).

Time = (capacity/current) (1)

By using equation 1 we can calculate battery life and the obtained value for our case is 13.8 hours.

VI. TESTING OF THE GAS DETECTOR WITH METHANE GAS

The testing set up consists of glass tube, delivery pipe and gas chamber as shown in figure 5. First we place our gas detector inside the gas chamber. Then gas chamber is closed with air tight lock. In order to generate methane gas first we have taken certain quantity of sodium ethanoate and soda lime powder in the glass tube. After mixing the powder the tube containing the powder is heated gently and then strongly. The gas produced in the tube enters the gas chamber through the delivery pipe. When the methane gas enters the chamber and the concentration reaches above the threshold value the MQ-4 gas sensor which was already preheated for 3 minutes detects the methane gas and sends the signal to the MCU of gas detector. The MCU unit then shows the alert message on the OLED display.

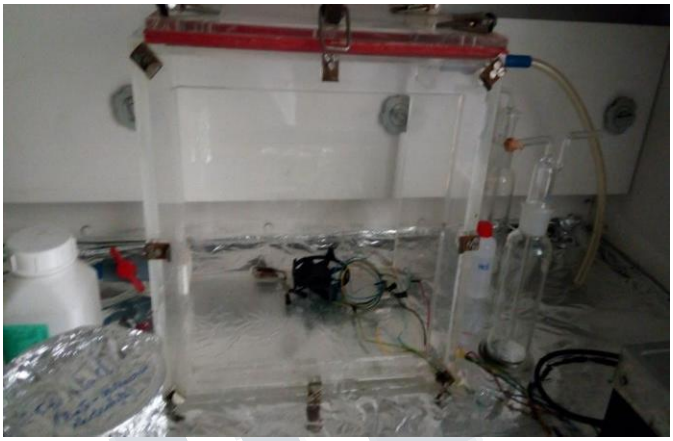

Fig 5: Setup of Gas Chamber

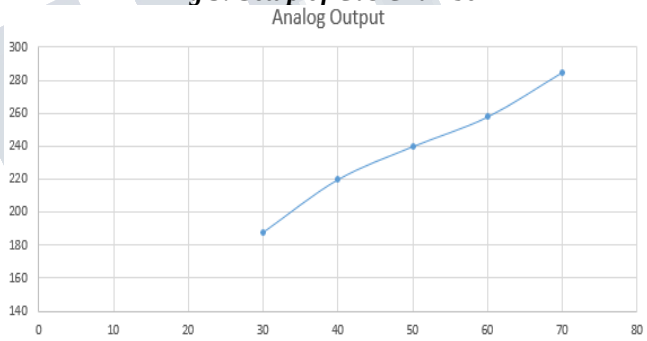

Fig 5: Plot of Analog output vs Gas concentration in ppm

The complete setup as shown in figure 5 is maintained at 28.6° and humidity 57%. Then testing is done and it is found that, as the gas concentration increases the analog output increases.

VII. CONCLUSION

In this paper, a methane gas detector is designed and implemented. The methane gas is highly combustible gas and it constitutes most part of the natural gas. Hence detecting methane gas is very important. The methane gas is generated in a gas chamber and the designed gas detector is exposed to methane gas inside gas chamber. The obtained results shows that the gas detector successfully detects the methane gas and also shows an alert message to the user in the OLED display. Further the design can be optimized using gas sensor that doesn't have heating element. Thus the device can be confined to a much smaller size. Also, by reducing the power consumption battery life of the gas detector can be increased.

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ISSN (Online) 2394-6849

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