Poisonous Gas Detector with Electrochemical Nose

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ABSTRACT: Poisonous Gas Detector is used to detect the harmful gases in an area for safety purposes. The proposed device is used to detect the various poisonous gas leakages and alert people so that they can be evacuated immediately to save the life. This device uses the electrochemical sensor which is sensitive to poisonous and flammable gases such as CH_4 (Methane), CO (carbon monoxide), H2S (Hydrogen sulfide), C_3H_8 (Propane), LPG (Liquefied Petroleum Gas). Already there are devices existing in the market for the same purpose but they are costly. Also they fail to detect many gases. The proposed model in this paper is cost effective and efficient. Moreover, the rate of response is high. Hence this device may be used as a multi gas detection apparatus. The proposed device is designed and controlled with the help of Atmel Atmega 328p_pu micro controller. It is programmed and tested with Atmel ICE and Arduino IDE. The circuit is tested with LPG gas which resulted in quick response. This device is used to detect the poisonous gases in sewage, LPG leakage in home, leakage of poisonous gas in industries, formation of poisonous gas in Mines, and cleaning the hazardous leftovers. A DC motor is connected to the device which is used into the sewage manhole to detect gases at different level thereby avoiding human usage in manholes.

KEYWORDS: Multi gas detection, Electro chemical sensor, Atmel Atmega 328p, Atmel ICE, DC motor, poisonous gas detection, LPG gas detection.

I.   INTRODUCTION

Human lives are more important than anything in the world. People lose their lives mainly due to carelessness. Many accidents occur due to negligence and without following safety rules. Sometimes, the accidents are due to the standard of living of people. Many people in India are below poverty line and they adopt sub standard work to lead their day today life. This makes them to ignore the safety measures. Quite a many times they work near the road or place where there are many manholes. Lack of standby worker outside the manhole for communication for emergency purpose also leads to accidents. Drainage cleaning people are not aware of risk of sudden attack of poisonous gas; if the gases are odourless they will be exposed to it for a long time which may cause serious health problems. Gases like CO (carbon monoxide) are odourless which with concentration above 350ppm cause confusion and fainting, above it will surely kill individual [1]. Each gas has its own physical and chemical properties, which make them difficult to analyse without any instrument. Toxic gases present in various levels depending on the concentration and density of it. For example H2S (Hydrogen sulfide) gas is heavier and it is present at the lower surface, while the CO (carbon monoxide) is bit heavier than Hydrogen sulfide. Hence it stays above the H_2S; the CH_4 gas is lighter than the above mentioned gases and stays near the sewage man hole. There are many gas detecting sensors discussed in the literature. The air particles diffuse through the electrochemical sensor to the electrode and chemically oxidised or reduced depending upon the property of gas. The methane is oxidised when it passes the electrode and heat the sensor. The heat is directly proportional to the amount of gases present there. Though instruments available in market for detecting the toxic gases they are not affordable by poor drainage cleaner whose monthly earning is less than the detectors available [2].

People dying due to poisonous gas leakage is daily news nowadays. Few that can be listed in India are:

- 7 died in KVR Mills Erode
- 3 died due to Sewage gas attack in Kozhikode
- 4 died due to poisonous drainage gas attack
- 19 year old teen died in villupuram
- 4 people died in villupuram while cleaning drainage

An embedded system is planned and tested to reveal the presence of toxic gas inside a vehicle cabin using ATMEL 89C51 microcontroller. The designed system provides a warning signal through alarm and sms based on the amount of CO and oxygen gases leading to the provision for immediate ventilation in the cabin [3]. An industrial safety design incorporating fire and gas detection has been suggested using Computation Fluid Dynamics (CFD). A sonic modeling is chosen as a best method after comparing the same with the existing models and gas dispersion simulations are carried out for a typical process unit of a petroleum refinery and 6 gas detectors are placed to avoid 32 leak portions [4]. By means of appropriate intelligent method (controlling of sensitivity and selectivity of the sensor) and using new materials for the setup of electrodes and electrolytes, an effort has been made to develop a sensor to measure minimum of four gases [5]. The extensive availability of commercial amperometric gas sensors, application of ionic liquids and microelectrode encourage the progress of intelligent gas sensors which can measure the local temperature and humidity and give data for an increasing variety of considered gases [6]. In one of the literatures, the electrochemical behaviour of methylamine and hydrogen chloride gases is investigated on platinum screen printed electrodes (Pt SPEs) in an ionic liquid. There is no abnormal behaviour on the SPEs. This indicates that the materials in the paste/polymeric binder of SPES do not react with the toxic gases in a harmful way. It is suggest that the SPE/RTIL platform can be applied to sense the highly lethal gases at low level in actual atmosphere [7]. A nonwoven sheet for the colorimetric film sensor is used as main device in finding leakage gases and a study has been made to develop some coating methods of hydrophilic polymer solution containing water soluble dye on the sensor. The chemically toxic gases are found based on the change of colour of coated dye [8]. Smart removable wireless sensing system has been designed to sense the toxic gases. The flexibility of sensors proposed enables the operation in different operating modes. The sensor is detachable and MEMS based sensors can also be implemented to have more sensing efficiency [9]. A system with wireless gas sensing network technology is applied to identify the oozing of toxic gas. The presence of hazardous gasses like Liquefied Petroleum Gas and Propane are sensed and exhibited in Liquid Crystal Display. An alarm is produced instantly if the level of these gasses goes beyond normal level. LED indicators are also used to envisage the status of system. In this system MQ-6 gas sensor used to sense poisonous gas and GSM Technology is used to send an alert message during leakage [10]. A remote wireless real-time monitoring of information on different types of gases in an industrial field using wireless finding system with multi-sensor recognition having integrated toxic gas detection technology, communication technology, and data analysis is proposed [11].

The aim of this project is to save innocent life, and to have toxic gas detectors in every home and industry which is affordable in cost, fast in response and accurate. This paper discusses the details related to the project. The design, hardware and software requirements and the experimental details are discussed in the following sections.
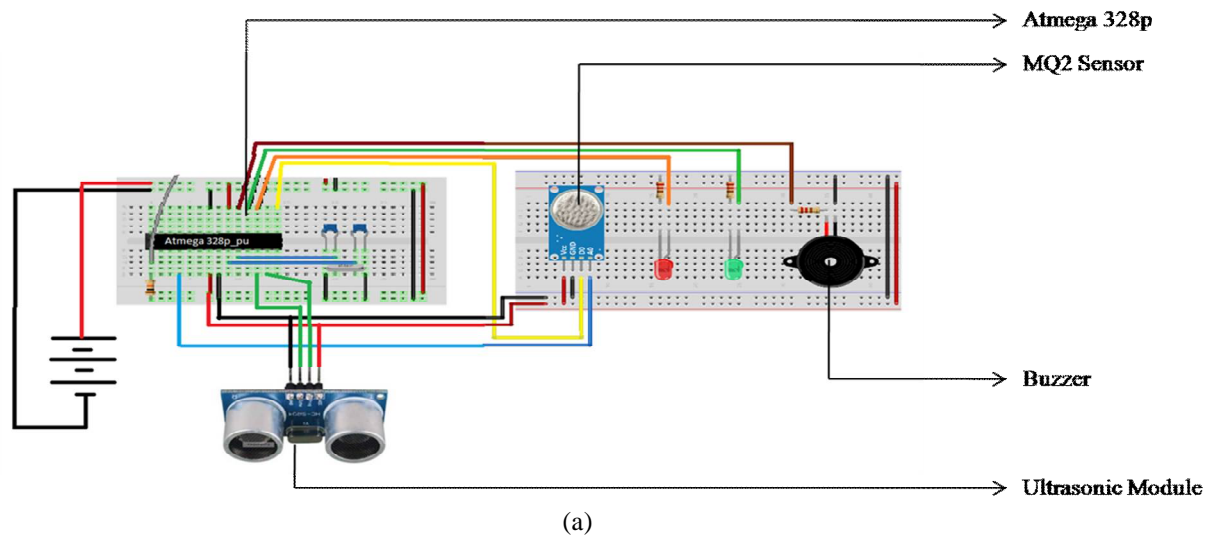
II. SYSTEM ARCHITECTURE

The main components of the design include an ultrasonic module, Atmega 328p controller and MQ2 sensor. Buzzer is used to provide alert by giving annunciation and LEDs are used to give visual indication during leakage. Arduino IDE and Atmel ICE software is used to design and simulate the poisonous gas detector. The circuit of the same is shown in Fig. (a).
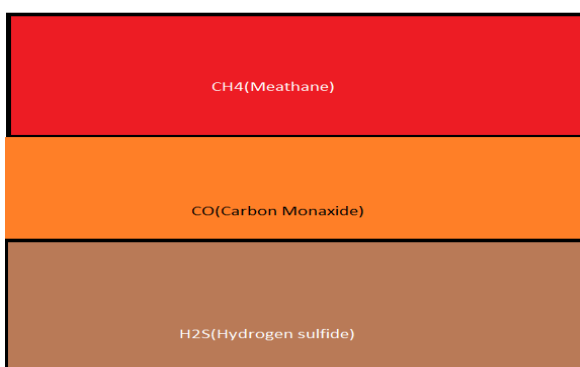
(a)

The ultrasonic module shown in Fig. (a) helps in measuring the distance of the sewage manhole. The distance of the manhole is usually a variable depending on the place. Hence this distance can be programmed in the microcontroller. The device moves down till the programmed distance with the help of dc motor (to be attached with the above circuit) and measures the presence of toxic gases. The indication to the operating person may be provided by two ways viz. visual and alarming. If toxic gases level is not harmful the green LED will glow otherwise the red one will glow followed by the warning alarm through buzzer. The presence of gases varies based on their concentration and density [1]. One such model in the sewage manhole is depicted as a block and as a setup device in Fig .(b) and Fig. (c) respectively. The setup contains a supporting rod in with the device is attached. When the device is placed above the manhole and turned on, the dc motor present in the setup works by getting signals from the ultrasonic module. The speed of the motor is proportional to the frequency generated by the ultrasonic module. The distance is derived from the accumulated gas by the ultrasonic module to produce a particular frequency.

(b)   (c)

If the poisonous gas present there in the sewage manhole, it will diffuse into the MQ2 sensor and settle on the electrochemical sensor, the sensor is either oxidised or reduced according to the chemical properties of the gas. The methane gas is oxidised and hence the sensor produces heat. Safe methane concentration for workers is 1,000 ppm (0.1 percent). Methane is considered an asphyxiant at extremely high concentrations and can displace oxygen in the blood [7].
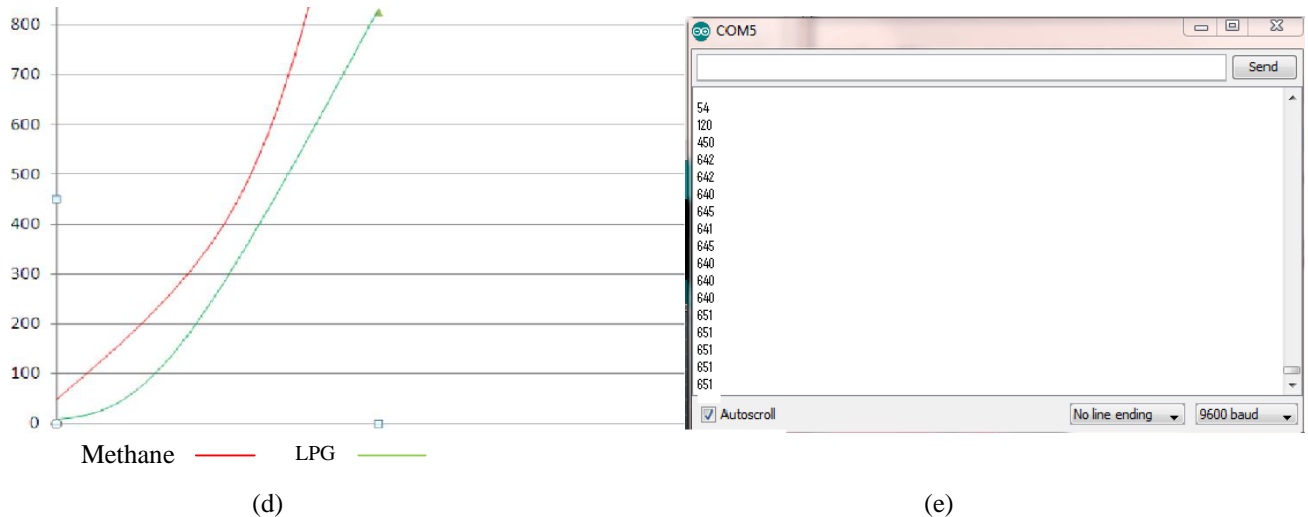
Exposing to 100ppm of H_2S causes coughing, eye irritation, loss of smell after 2-15 minutes (olfactory fatigue), altered breathing, and drowsiness after 15-30 minutes of prolonged exposing leads to death. Exposure to 2,000 ppm of LPG is hazardous to health, as it will blow up at any time. Meanwhile 800ppm of CO will cause death in hours [5].

III. HARDWARE INTEGRATION AND SOFTWARE IMPLEMENTATION

The requirements for the accurate operation and quick response of the proposed device are:

1. If the concentration of the toxic gases is less a warning sign is to be issued. When the safety level is exceeded alarm signal is to be issued to evacuate the persons nearby. These conditions and associated decision are programmed using the microcontroller. The inbuilt timer is used to offer quick response. Atmega 328p is used for this purpose. It is an 8 bit ACR-RISC based micro controller with 32KB flash memory; it is an read while write controller. It has 1024B EEPROM, 2KB of RAM, which contains 5 analog i/p pins and 13 digital i/p pins. This contains 32 general purpose working registers with 3 timers. It also includes a programmable watchdog timer with internal oscillator which operates between 1.8 – 5.5 volts.

2. The microcontroller is provided with the pure air level. So that the device must first get the level of pure gas (safety level). Gases are measured in ppm (parts per million). This device can work even at high temperature like 80 degree celsius.

3. The testing of poisonous gases is very dangerous so it should be done in a safe environment by wearing all the safety equipments.

4. The ultrasonic module used here is HC-SR04 which can measure distance with ranging accuracy 3mm. It contains both ultrasonic transmitter and receiver module. The transmitter releases a high frequency ultrasonic noise, which bounce off any nearby solid items. This sound is reproduced and perceived by the receiver on the sensor. The return signal is then processed by the control circuit to compute the time difference between the transmitted and received signals. It sends 40 kHz signals (8 times per second) and detects whether there is a pulse signal back, and uses the formula distance=(high level time * velocity of sound) . It is approximately 340 m/s.

5. MQ2 sensor is an electrochemical sensor which acts as nose for the device. It comprises of an electrochemical electrode which senses the toxic gases by oxidising or reducing the toxic gas. It then measures the poisonous gases based on their concentration using the controller. It has 3 pins namely, Vcc, ground and output. The output of this sensor is given to the microcontroller used (Atmega 328p).

6. The power supply requirement of the proposed device ranges from 2.2 volts to 5.5 volts. A 9 volt battery with regulator makes it function smoothly. This device consumes less power compared to the other commercially available products in market.

7. Atmel ICE tool is much easy to program the microcontroller as it supports programming and debugging of all Atmel AVR UC3 8-bit microcontrollers with operating voltage from 1.62V to 5.5V. It draws 3mA from target voltage reference when using debug WIRE interface and less than 1mA for all other interfaces. It is made of working with clock frequencies from 32 kHz to 7.5 MHz. The compiling and uploading of programs to the microcontroller is simple with this tool.

8. L293D is a Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. With the help of this, the DC motor can be controlled to move the device in either upward or downward direction.

IV. EXPERIMENTAL RESULTS

(d)   (e)

The above graph (d) shows the exposure of device to the two gases such as CH_4 (Methane) and LPG(liquefied petroleum gas). Both LPG and Methane gases were flammable gases which will burn or explode if the concentration is high. The device response to different gases varies according to their property. This picture clearly shows that the toxic gas (methane) level which that is experimented with the device. The level of concentration of methane shown in Fig. (d) is not dangerous while that of LPG is harmful and hazardous.

The gas leakage can be tested for various gases like LPG, Methane, H_2S and CO. The screen shot of LPG testing alone is presented in Fig. (e). It can be inferred from the graph (e) that there is a sharp increase in the level of concentration of LPG gas (54-651) when tested for gas leakage. 100 ppm of CO (carbon monoxide) is hazardous for health. More than 400 ppm of H_2S (Hydrogen sulfide) will kill humans. Toxic gases such as H_2S and CO are yet to be tested.

V. CONCLUSION

A low cost poisonous gas detector which detects multiple harmful gases to the human and living beings is proposed. The Atmel microcontroller which is cheap and better in performance is used to control this device. This device is not only designed for detecting the gases in sewage but also for detecting LPG leakage in home, toxic gas leakage in industry, poisonous gas formation in mines. The presence of many such harmful gases can be detected at a time with this proposed device. Atmel ICE software is used to simulate the leakage of LPG and methane gases. The presence of H_2S and CO can also be tested in the same simulation platform. A DC motor is used to travel through the manhole during leakage thereby avoiding human involvement. The direction and speed of the DC motor is controlled using an ultrasonic module. An alarm is used to give indication during harmful situation. In future an LCD monitor can be attached to show the ppm of the toxic and flammable gases present in the area where it is necessary. A GSM module can also be attached to notify the LPG leakage in home, which will send messages to people if they are out for work.

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