LPG Leakage Detector Using Arduino and GSM Module with SMS Alert and Sound Alarm

Kyu Kyu Win

Faculty of Computer System and Technologies
University of Computer Studies, Taunggyi
Southern Shan State, Myanmar
kyukyuwin07@gmail.com

Abstract—Gas leakage is a major problem with industrial sector, residential premises, and gas powered vehicles like CNG Compressed Natural Gas buses, LPG, Liquefied Petroleum Gas cars etc. One of the preventive methods to stop accidents associated with the gas leakage is to install a gas leakage detection device at vulnerable places. The primary aim of this paper is to present such a device that can automatically detect and stop gas leakage in vulnerable premises. In particular gas sensor has been used which has high sensitivity for propane (C_3H_8) and butane (C_4H_{10}). The system detects the leakage of the LPG using a gas sensor and uses the GSM to alert the person about the gas leakage via SMS. When the LPG concentration in the air exceeds a certain level, the gas sensor senses the gas leakage and the output of the sensor goes LOW. The detection is done by ATmega328 microcontroller and the buzzer is turned ON. The system then alerts the user by sending an SMS (Short Message Service) to the programmed mobile number.

Keywords— Arduino , LPG, MQ-2 gas sensor, LCD, SMS, GSM module, Gas leaking

I INTRODUCTION

Liquefied petroleum gas is being used for the past decades as industrial fuel and for domestic purpose. It has a characteristic of smokeless burning in the air. The LPG is a highly flammable mixture of hydrocarbon gases like propane and butane [1].

The LPG is widely used for domestic purposes such as boiling, heating and cooking. An ideal gas sensor can be used to sense the leakage of an LPG from vehicles, industrial sectors, homes and other residential areas. If there is a leakage of LPG, it can be easily identified by the concentration of gas through the gas sensor [2].

Gas leakage detection in residential houses has become one of the fundamental issues in the recent times. Accidents mainly occur due to the negligence and technical fault. Some people may have a low sense of smell and in such cases they may not be able to respond for the gas concentration present [3].

Gas leakage detector unit can be easily integrated into a unit that can sound an alarm and give a visual suggestion of the LPG concentration. The gas sensor used in this project will have both admirable sensitivity and rapid response time. This sensor can also be used to sense other gases like iso-butane, propane, LNG, Liguefied Natural Gas and even cigarette smoke [4].

This proposed system is one of the embedded systems to detect the leagage of LPG based on Arduino and using GSM module with SMS alert and sound alarm. It is implemented by using Arduino UNO and Ardunio C program, and simulated using proteus 8 simulator before installation the circuit. And MQ-2 gas sensor is used to detect the amount of combustible gas present in the surrounding. When the LPG concentration in the air exceeds a certain level, the gas sensor senses the gas leakage and the output of the sensor will activate the system when the gas sensor senses any gas leakage. This is detected by ATmega328 microcontroller and buzzer is turn on. In this system, SIM900 GSM modem is used which alert the user by sending an SMS about the status of the gas leakage. 16×2 LCD, Liquid Crystal Display is used in this system to display the status of the sensor

detection upon the gas leakage. The main objectivs of the research are as follows:

- to detect gas leakage like LPG by using MQ-2 gas sensor and Arduino
- to activate the alarm to inform neighbor about the gas leakage
- to display the status on the LCD screen by using a 16×2 LCD module
- to inform the user about the leakage of gas via SMS
- to prevent the accidents and protect the fire disasters which are caused due to the gas leakage

II DESIGN METHODOLOGY

In this Arduino based LPG leakage detector, Arduino UNO board, MQ-2 Gas sensor module, 5V Buzzer, 16×2 LCD and SIM900 GSM module are mainly involved. The block diagram of this system is shown in Fig. 1.
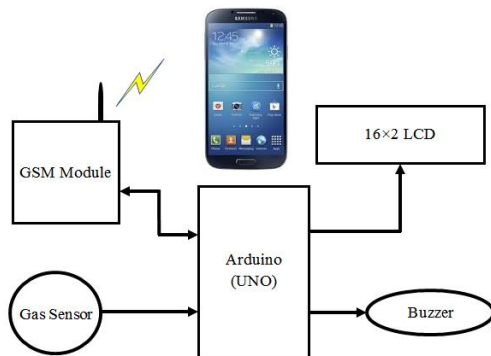

Fig. 1 Block diagram of the system

The functionality of system is divided into three main steps. In the initial step, the gas leakage is detected by the gas sensor. This detects the gas leakage and gives the signal to the microcontroller. After that in second step the microcontroller receives the signal, which sends by gas sensor. And then the microcontroller sends activation signal to other external devices attached such as buzzer, LCD display and GSM modem to send SMS alert [4].

The microcontroller in Arduino UNO sends the signal to the GSM module and if the GSM module is connected properly with the microcontroller, it sends an acknowledgement signal back to the microcontroller. Then if there is any gas leakage in the atmosphere it is detected by the gas sensor module using MQ-2 sensor. After tha sensor module detects the gas leakage, the signal is sent to the ADC unit of the microcontroller which then sends activation signal to other external devices connected to it such as buzzer, LCD and GSM module. A beep sound is generated when the buzzer receives the activation signal and the LCD display will show the status of the gas leak.

And then the GSM module gets the activatation which sends a warning SMS to the user. When the gas leakage is stopped, the whole system is made to reach its initial state.

A. Arduino

Arduino Uno is one of the microcontroller boards manufactured by the Arduino and based on the Atmel's ATmega328 microcontroller, It is a microcontroller board. "Uno" means one in Italian and the uno board is the latest in a series of USB, Universal Serial Bus. Meanwhile, Arduino board is a reference model for the Arduino platform.

Fig. 2 Arduino Uno

The Arduino Uno board has a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, a reset button, 6 analog inputs and also 14 digital input/output pins, in which 6 can be used as PWM outputs. It uses the

Atmega16U2 programmed as a USB-to-serial converter instead of FTDI USB-to-serial driver chip which was used in all the preceding boards. The board has 32 KB flash memory of which 0.5 KB is used by boot-loader, 2 KB of SRAM, 1 KB of EEPROM and 16 MHz clock speed [5]. Fig. 2 shows the Arduino Uno.

B MQ-2 Gas Sensor Module

MQ-2 is a semiconductor type sensor used to detect the gas leakage. MQ-2 gas sensor sensitive material used in the clean air low conductivity tin oxide (SnO_2). When there is the environment in which the combustible gas sensor, conductivity sensor with increasing concentration of combustible gases in air increases. Using a simple circuit to convert the change in conductivity of the gas concentration corresponding to the output signal. MQ-2 gas sensor high on gas, propane, hydrogen sensitivity of detection of natural gas and other flammable vapors are also very good. This sensor can detect a variety of flammable gas, is a low-cost sensors for a variety of applications. Fig. 3 shows the MQ-2 gas sensor module and Fig. 4 describes the typical sensitivity characteristics of MQ-2.
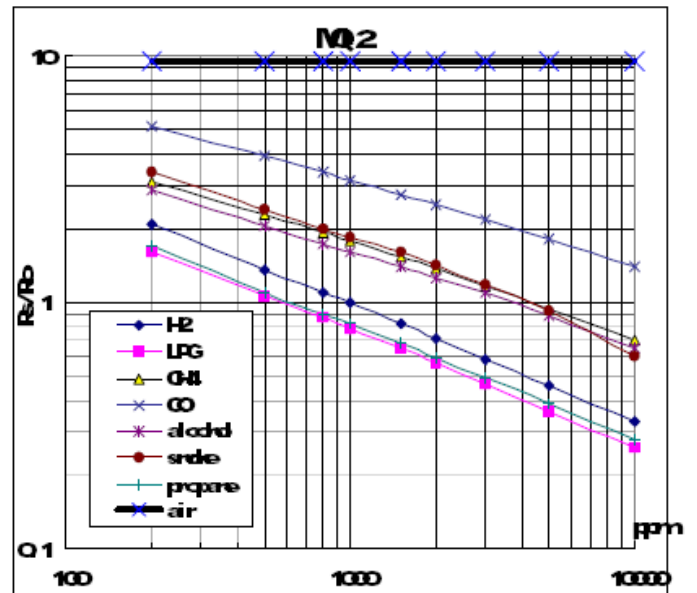

Fig. 4 Typical sensitivity characteristics of MQ-2

The MQ-2 gas sensor has a concentration sensing range from 20 to 2000ppm. It consists of four pins. The two pins are used for a power supply Vcc (5V) and GND. The third pin, D0 is TTL switching signal output and the fourth pin, A0 is analog signal output. The signal transmission pin, A0 is the one which sends the signal to the microcontroller if there is any increase in the concentration of gases in the air.

C. Buzzer

It is an electronic used to give alarm sound as it is programmed. Buzzer is used to generate a beep sound when the system is activated by the gas sensor.

Fig. 3. MQ-2 gas sensor module

Fig. 5 Buzzer

D. LCD

The LCD used here is 16×2 alphanumeric Liquid Crystal Display, LCD which means it can display alphabets along with numbers on 2 lines each containing 16 characters. It is used to display the the status of about the gas leak. It can be used to display the various options and all the readings that have been stored in the EEPROM.
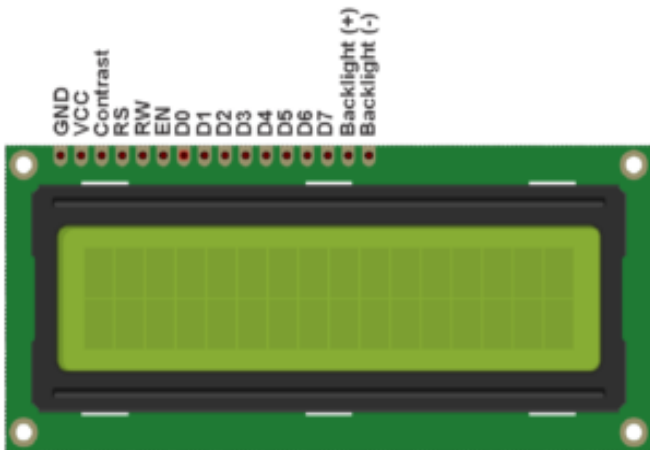

Fig. 6 16×2 liquid crystal display

E. GSM Module

There are different kinds of GSM modules available in market such as SIM900, SIM300, SIM800 etc. [link] Global System for Mobile communications modem is a highly flexible switch and a play quad band SIM900A. The modem can be used for direct and an easy integration to RS232 applications. The modem can be connected to a microcontroller through MAX232. The modem is used in this security system to send and receive SMS from and to the recognized user. The module can accept any GSM network operator SIM card along with its unique phone number. The status of the device can be indicated by LED.

Fig. 7 SIM900A GSM modem

The modem has a transmission rate of 22.8Kbps with an operating frequency of 890 to 915MHz. The modem can send SMS to a recognized user as soon as there is a leakage of gas. SIM900A GSM modem is used to send the warning message about the gas leakage to the mobile number when the modem gets the activation signal from the Arduino in this system.

F. Connection Between Arduino and GSM Module

There are two ways of connecting GSM module to arduino. In any case, the communication between Arduino and GSM module is serial. It is connected the Tx pin of GSM module to Rx pin of Arduino and Rx pin of GSM module to Tx pin of Arduino. The ground pin of arduino is connected to ground pin of gsm module. The voltage of power supply is depend on the type of GSM module it differs with manufactures. In this system, SIM900A GSM modem is used and DC 5V is supplied to V_{cc}. Another method in which two digital pins of arduino are used for serial communication. In this system two PWM enabled pins, 9 and 10 of arduino are choosed for this method.

If Tx pin of GSM module is connected to Rx pin of Arduino and Rx pin of GSM module is

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connected to Tx pin of Arduino, while programming Arduino uses serial ports to upload the program from the Arduino IDE to Arduino UNO board, the problem is occurred due to this connection. To avoid this difficulty, an alternate method in which two digital pins of arduino, 9 and 10 are used for serial communication in this system.
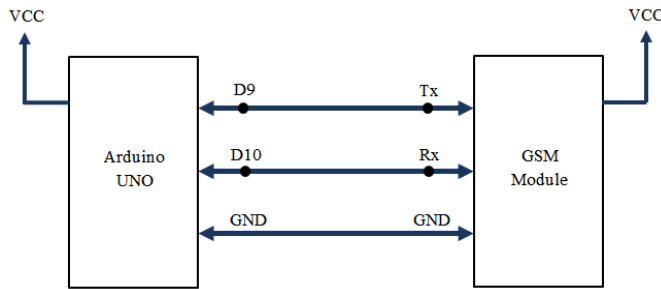

Fig. 8 Connection between Arduino and GSM module

III IMPLEMENTATION OF THE SYSTEM

This system is designed by using Arduino UNO, MQ-2 gas sensor module, 5V buzzer, 16×2 LCD module and SIM900 GSM module. Arduino UNO is important and the most useful part of the system. All the output devices are controlled by Arduino. And Arduino C program is uploaded to the ATmega328 microcontroller chip in Arduino UNO board to control the system. Fig. 9 shows the overall schematic diagram of the system that has been designed in this project to detect the LPG leakage.

MQ-2 gas sensor module is used as the input system of this project. This sensor detects the LPG gas molecues in the air. Analog out (A0) pin of MQ-2 gas sensor module is connected to analog pin 14 (A0) of Arduino and V_{cc} and GND pins are connected to V_{cc} and GND of Arduino. When the gas sensor detects the LPG gas, the sensor will activate the system. The output of the system goes into analog pin (14) A0 of Arduino. Through this connection, the Arduino can read the analog voltage, output from the sensor. Arduino board has a built-in analog-to-digital converter, so it is able to read analog values without any external ADC chip. Depending on the value (gas level) which is sensed by MQ-2 gas sensor that will occur with the circuit.
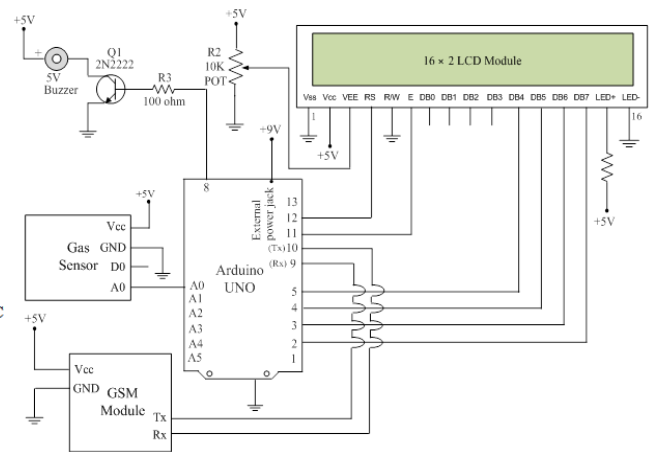

Fig. 9 Schematic diagram of LPG leakage detector using Arduino and GSM module with SMS alert and sound alerm.

DC 9V adapter is supplied to the external power jack of the Arduino UNO. Digital pin 8 of the Arduino controls the buzzer. Transistor Q_1 drives the buzzer and resistor R_3 limits the base current of Q_1. The anode pin of the buzzer is connected to V_{cc} (5V) of the Arduino. A beep sound is generated when the system is activated by the gas sensor.

A 16 × 2 LCD is connected with Arduino in 4-bit mode. And used to display the status to the user and the informative messages to the user like sending SMS, SMS Alert Send etc. Digital pins 5, 4, 3, and 2 of Arduino are connected to the pins 11 (DB4), 12 (DB5), 13 (DB6) and 14 (DB7) of the LCD module and Digital pins 11 and 12 of Arduino is connected to the pins 6 (E) and 4(RS) of the LCD module respectively. POT R2 is used to adjust the constrast of the LCD. Resistor R1 limits the current through the back light LED. V_{cc} and GND (R/W) pins of the LCD are connected to the V_{cc} (5V) and GND of the Arduino respectively.

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                 ┌─────────┐
                 │  Start  │
                 └────┬────┘
                      │
              ┌───────┴───────┐
              │   Power on    │
              └───────┬───────┘
                      │
             ┌────────┴────────┐
             │  Accept gas from │
             │   gas sensor     │
             └────────┬────────┘
                      │
             ┌────────┴────────┐
             │ System measure   │
             │ gas concentration│
             └────────┬────────┘
                      │
                  ◇───────◇
       No        Is gas sensor's O/P      Yes
    ┌──────────  value is greater  ──────────┐
    │            than 200 ppm                 │
    │            (threshold value)?           │
    │               ◇───────◇                 │
    │                                    ┌────┴────┐
    │                                    │  Alarm  │
    │                                    │activation│
┌───┴────┐                               └────┬────┘
│Display │                               ┌────┴─────┐
│"No Gas │                               │ Display  │
│Leaking"│                               │"GLD Alert│
│message │                               │  Sent"   │
│on LCD  │                               │message on│
└───┬────┘                               │  LCD     │
    │                                    └────┬─────┘
    │                               ┌─────────┴────────┐
    │                               │Send message to   │
    │                               │programmed mobile no│
    │                               └─────────┬────────┘
    │                               ┌─────────┴────────┐
    │                               │  Accept          │
    │                               │"Gas Leaking"     │
    │                               │message by mobile │
    │                               └─────────┬────────┘
    │           ┌─────────┐                   │
    └───────────│   End   │───────────────────┘
                └─────────┘
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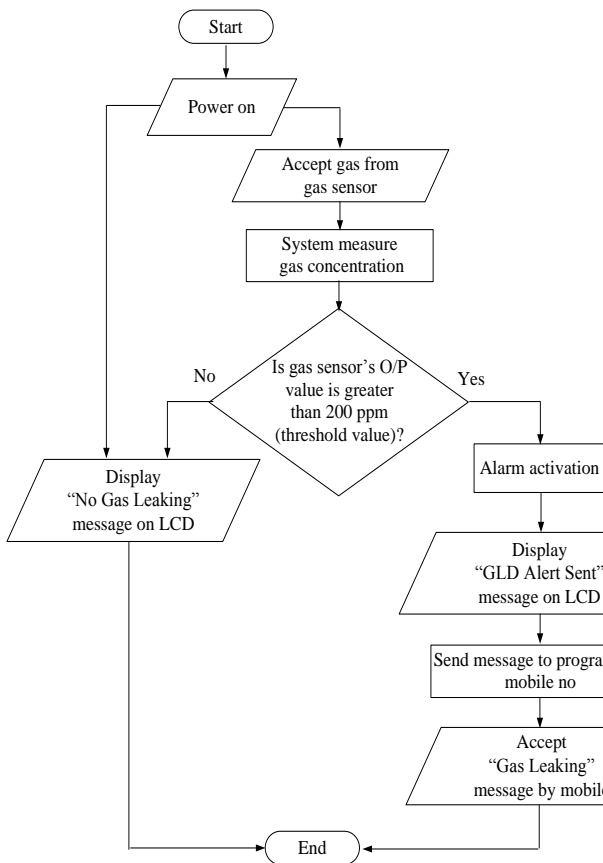
Fig. 10 Flowchart of the system

SIM900 GSM Module is used to send an SMS alert to the user when the gas leakage is detected by the gas sensor. Digital pins 9 and 10 which are PWM enable pins of Arduino are used for serial communication and they are connected to the Tx and Rx pins of GSM respectively. V_{cc} and GND of the GSM module is connected to V_{cc} (5V) and GND of the Arduino respectively. In this detector circuit, the control unit (Arduino) receives signals from the gas sensor and then sends the signal to the external devices, buzzer, LCD and GSM modem, buzzer generates a beep sound and LCD displays the status. After a few million seconds. And then the alert message "Gas Leaking" is sent to the cell phone which mobile number is specified in the program of this system. The flowchart of the system is shown in Fig. 10.

Arduino IDE, 1.8.1 is used to write the Arduino c program to interface to the Arduino UNO board. Before implementing the hardware circuit and interfacing this circuit to the software program of the system, proteus 8 simulator is used to simulate the system design of this interfacing circuit.

IV RESULT AND DISCUSSION

The prototype of leakage detector has been tested by sensing a small amount of LPG gas near to the sensor. MQ-2 gas sensor detects the LPG gas and sends the signal to the ATmega328 microcontroller in Arduino circuit board. After that microcontroller sends an active signal to other externally connected devices. As a result, the buzzer is activated to alert the consumer in case of gas leakage and the system displays the message on the LCD display. and the LCD display will show the status about gas leakge. GSM Modem is used to send an SMS alert to the user when the gas leakage is detected by MQ-2 gas sensor. The ststus of the system is described as the following table.

TABLE I

STATUS OF THE SYSTEM

Input	Output (Functional Performed)				State
Gas value	Alarm	Display Message on 16 × 2 LCD		Inform message to the user via GSM modem	
		Line 1	Line 2		
≤ 200 ppm	OFF	Gas Scan - ON	No Gas Leaking	-	Normal
> 200 ppm	ON	Gas Scan - ON	GLD Alert Sent	Gas Leaking	Warning

In this system, there are two states of the detection of gas sensor module to display on the LCD screen, the normal state and warning state. When the system is in normal state, the gas sensor does not sense any gas and LCD will show the status "Gas Scan-ON" and "No Gas Leaking". The implemented system of the normal state is described in Fig. 11.
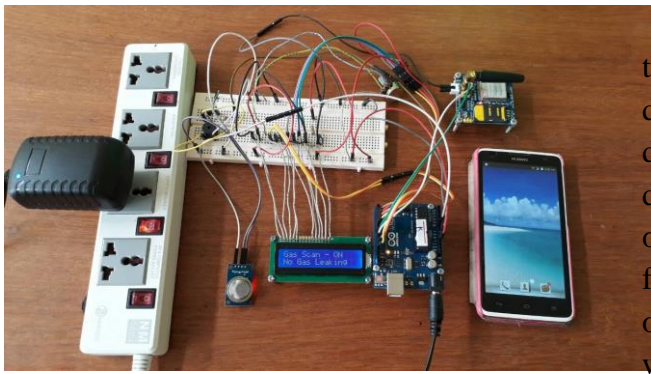
Fig. 11 The implemented system of the normal state

When the system is in warning state, there is any gas leakage in the atmosphere it is detected by the gas sensor module, MQ-2 sensor. And then the "Gas Scan-On" and "GLD Alert Sent" information is displayed on the LCD screen as illustrated in Fig. 12. After a delay of few milliseconds, the "Gas Leaking" message is sent to a pre-defined mobile number using GSM module as shown in Fig. 13.

Fig. 12 The implemented circuit of the gas leakage detector using arduino and GSM module with SMS alert and sound alerm when it is in wanring state.

Fig. 13 The implemented system of the warning state that sends "Gas Leaking" message to the pre-difined mobile number.

Testing was carried out by releasing LPG into the atmosphere around the sensor. This leakage detector was observed that when the LPG detector was test by placing it at different distances from the gas source, the response time of the LPG system decreased as the distance from the gas source increased. Also it was observed that the sensitivity of the gas sensor was very high in clean air. The gas gas sensor sensitivity varied with temperature while the reference voltage remained constant over time. It is small sensitive to smoke and alcohol, its sensitivity depends on humidity and temperature. This proposed system has excellent sensitivity to LPG with a quick response of time.

V FUTURE ENCHANCEMENT

The system can be expended to many applications in future. The sensor used to detect the gas leakage also used to detect alcohol consumed person and smokers in the petrol bunks. If the smokers found in the petrol filling stations they could be immediately send out from the place and along with the fire accident prevention public safety can be maintained .

It can be also incorporated the location detection feature for the gas leakage area for which SIM900 is purposely used as it comes with add feature of web interfacing by using some extra codes in the program and advanced Arduino board like Rasberry Pi.

VI CONCLUSIONS

This paper presents the design of the gas leakage detector using Arduino and GSM with SMS alert and sound alarm and discusses its implementation. This project is arduino based project. Gas leakage in households and industries cause risk to life and property. A huge loss has to be incurred for the accidents occurred by such leakage. A solution to such a problem is set up a monitoring system which keeps on monitoring the leakage of any kind of flammable gases and protects the consumer from such accidents. This proposed system avoids the accidents caused due

to the leakage of the LPG gas and used in domestic as well as in industrial purpose. The system enables to monitor the gas leakage in remote location and thereby leads to a faster response time in the events of leakage condition. The present paper provides a solution to prevent such accidents by not only monitoring the system but also activating an alarm as well as sends the message to the user.

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