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Design and Implementation of an Efficient LPG Leakage Detector

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Abstract: Liquefied petroleum gas (LPG) has become a very common source of cooking fuel at home. However, LPG leakage poses a serious threat to the user and others. To avert the danger associated with the use of LPG at home, this system was developed so that gas leakage can be quickly detected and notification of the user is immediately carried out. A GSM module is used to send SMS to the user if gas leakage is detected and the status is displayed on an LCD. The PIC18F2520 microcontroller carries out all the processing of the signal received from the MQ6 gas sensor and activate the GSM module and LCD to inform the user. To make the system very efficient it was configured to detect gas leakage at 250ppm which is far less than the standard 1000ppm and it was designed to be powered by the mains and from rechargeable battery. Test result carried out on the system were satisfactory indicating that it can be successfully deployed for domestic use.

Keywords: Gas leakage detection, GSM module, LCD, LPG, MQ6 sensor

1. INTRODUCTION

Liquefied Petroleum Gas (LPG) is a highly inflammable gas made up of the mixture of propane and butane, although butylene, propylene and other hydrocarbons are present in small quantities [1, 2]. The gas is used as fuel for domestic, automobile and industrial purposes, including several heating applications [2, 3, 4]. However it has gained considerable use as a cooking gas. Ethanethiol is added as a powerful odorant to give it its characteristic smell since LPG is odorless, so that when there is gas leakage it can be detected through smell [5]. It is very important that gas leakage is detected because of the flammable nature of the gas. If left undetected it can lead to fire outbreak, causing injuries, loss of property and sometimes death.

There are several factors that can lead to gas leakage such as carelessness on the part of the user, the personnel that refilled and/or service the gas cylinder/burner or faulty hose and cylinder. Although gas leakage as a result of faulty cylinder is very rare because the cylinder can last more than two decades before it expires, it sometimes happens [6]. To illustrate the danger of gas leakage, there was an incidence in Lagos, Nigeria where a gas explosion in an apartment in a storey building resulted in a serious injury to 24 persons [7]. This is just one of many examples showing the need for an efficient system of gas leakage detection.

Several work has been done on gas leakage detector. J Tsado et al. developed a system of gas leakage detection system that used 555 timer to interface the MQ 6 gas sensor with the microcontroller and then by means of relays activates the GSM module to alert the user [8]. N. Harshada and B. Pawar developed a system that directly interface the MQ 6 gas sensor with the microcontroller. In addition to the GSM module sending an SMS to the user when it detects gas leakage, there is a buzzer to sound an alarm, the exhaust fan would be switched on and the sprinkler activated, to reduce the concentration of gas in the air [9]. V. Ramya and B. Palaniappan also implemented a similar design but without the sprinkler [10]. Apart from detecting the gas concentration in the air, K. Abid, et al. included a means of booking a refill of the cylinder with their design so that the user would be automatically notified when the gas in the cylinder goes below a set threshold [11].

Others such as B. Didpaye and S. Nanda, T. Soundarya and J. Anchitaalagammai, S. Ashish, et al., and K. B. Vinoth, et al., implemented a system that detects the gas leakage and control the leakage by shutting off the source of the gas supply using either a solenoid valve or a stepper motor [12, 13, 3, 5].

In this paper we developed a system that can monitor the LPG concentration in the air and simultaneously alert the user through an SMS so that appropriate actions can be taken to avert the danger. A unique feature of this design is that it can also be powered by batteries so that whether there is supply from mains or not the system will be fully functional.

2. MATERIALS AND METHOD

Fig. 1 shows the block diagram of the system which consist of four units.

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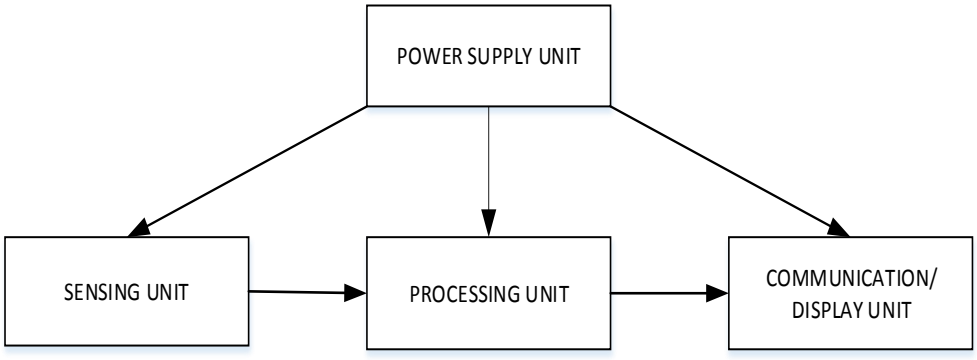

Figure 1: Block diagram of the system

2.1. Sensing Unit.

The efficiency of the gas leakage detector depends on the sensitivity of the sensor. For this reason MQ 6 gas was chosen. To calibrate the gas sensor for high sensitivity and to give its output in ppm instead of in volts, the following derivations were made.

Deriving LPG concentration from the sensor reading

The output of the sensor is measured in volt V_0

R_S= sensor resistance

R_L = load resistor value in ohms (10 k- 60k) from the MQ6 data sheet

To calibrate the sensor in clean air, R_0 must be determined. So we measured the values of the output voltage in clean air. Four reading were taken and the average was determined. 0.664mV 0.670mV 0.662mV and 0.657mV

$$\frac{0.664 + 0.670 + 0.662 + 0.657}{4} = 0.663mV$$

The sensor operated with current of 0.17mA.

$$V = I\,R \quad \cdots\cdots 1$$

$$R = \frac{0.663mV}{0.17mA} = 3.9$$

From the data sheet R ranges from 10k to 60k. Therefore at minimum value (clean air) R_0= $3.9\times 10k \cong 40k\Omega$

R_0= 40kΩ

Also from the MQ 6 data sheet:

$$R_S = (V_C - V_0) \times \frac{R_L}{V_0} \quad \cdots\cdots 2$$

$$Rs = (5 - Vo) \times 20000/V_0$$

$$Rs = (100000 - 20000V_0)/V_0$$

The data sheet provides a graph for LPG concentration in ppm versus $^{R_S}/_{R_0}$. The ppm versus $^{R_S}/_{R_0}$ curve was fitted for the values provided, which gives:

$^{R_S}/_{R_0} = 18.446 \times (LPG\ ppm)^{-0.421}$ Then:

$$LPG\ ppm = \left[\frac{^{R_S}/_{R_0}}{18.446}\right]^{\frac{1}{-0.421}} \quad \cdots\cdots 3$$

Substituting for R_S in the equation and assuming temperature and relative humidity to be constant equation 3 will become:

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$$LPG\ ppm = \left[\frac{\frac{(100000 - 20000\,Vo)/Vo}{R_0}}{18.446}\right]^{1/(-0.421)}$$

$$LPG\ ppm = \left[\frac{\frac{(100000 - 20000\,Vo)}{R_0 \times V_0}}{18.446}\right]^{-2.3753}$$

$$LPG\ ppm = \left[\frac{\frac{1}{(100000 - 20000\,V_0)}}{18.446 \times R_0\ \times V_0}\right]^{2.3753}$$

Where R_0 = 40kΩ

$$LPG\ ppm = \left[\frac{\frac{1}{(100000 - 20000\,V_0)}}{18.446 \times 40000 \times V_0}\right]^{2.3753}$$

Therefore the LPG concentration in ppm is given as

$$LPG\ ppm = \left[\frac{\frac{1}{(100000 - 20000\,V_0)}}{18.446 \times 40000 \times V_0}\right]^{2.3753} \quad \ldots\ldots\ldots 4$$

Where V_0 = the output voltage measured from the sensor.

To make the system very sensitive, a set point of 250ppm was chosen to detect the presence of LPG in the environment. This is highly sensitive because at 1000 ppm concentration, the gas is considered dangerous [10, 14].

2.2. The Processing Unit

The Microcontroller used was PIC18F2520. The gas sensor is connected to pins 2 and 3 of port A which is configured as an input port. The LCD is connected to port B which is configured as an output port. Port C configured as an output port sends signals to the GSM module. When the microcontroller receive the analog signal from the gas sensor, (measured in volts) it processes the signal and converts it to a digital signal using its ADC so that the status of the gas leakage can be shown in ppm. Based on the program of the microcontroller the GSM module and the LCD are activated. The program was written in embedded C programming language and burnt into the microcontroller

2.3. Communication/Display Unit

An important feature of this design is alerting the user of the gas leakage. This is done in two ways. One way is through the GSM module which is activated to send an SMS indicated that gas leakage had been detected. It also shows the concentration of the leakage in ppm. The second way is by displaying the status of the system and the gas concentration in an LCD. With these features the user can be notified of gas leakage whether he/she is at home or elsewhere as long as he/she is with the authorized mobile phone. Thus it is important that before using the cooking gas, its status should be checked on the LCD to forestall any danger.

SIM800L GSM module was used because it works on frequencies GSM 850MHz, EGSM 900MHz, DCS 1800MHz and PCS 1900MHz. While a 16x2 alphanumeric LCD was used since the message information to be displayed is not lengthy.

2.4. Power Supply unit (PSU)

There are two sources of power supply to the system. One is direct supply from the mains by plugging into a wall socket and the other through rechargeable battery. This is necessitated by the fact that stable power supply still remains a mirage in Nigeria. As a result, the system will reliably detect gas leakage whether there is supply from mains or not. Basically, the PSU consists of the 220/12V step down transformer, a bridge rectifier to convert the AC voltage to a pulsating DC voltage, a filtering capacitor to remove the AC ripples and an LM7805 voltage regulator to provide stable 5V voltage to the appropriate components.

2.5. Operational Principle

The system operates following the sequence shown on the flowchart in Fig. 2.

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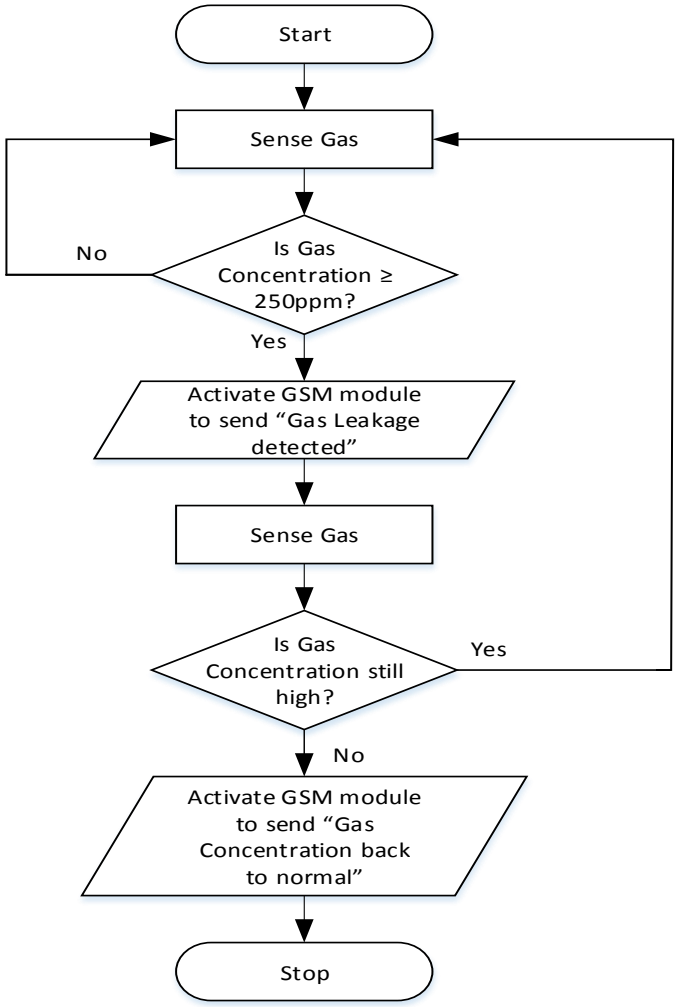

Figure 2: Flowchart of the system

Once the system is powered, the gas sensor starts sensing the gas in the environment and sending the information to the microcontroller which converts it to a digital form and instructs the LCD to display the result. The microcontroller is programmed to take appropriate action of notifying the user ones the gas concentration has exceeded a certain threshold value. This value is set at 250ppm. If the microcontroller receives this information from the gas sensor, it immediately activate the GSM module to send an SMS to the user and indicate the status on the LCD. After this continuous sensing is done to see whether the concentration level has gone to the safe limit. As long as the concentration of LPG in the environment is very dangerous, the user will keep on receiving the alert SMS. But as soon as the system detects that the LPG concentration is below 250ppm, it will also notify the user of this status and display the information on the LCD.

This system has high sensitivity to LPG detection in the kitchen. Fig. 3 shows the complete circuit diagram of the system. While Fig 4 and 5 shows the PCB layout of the design and the completed work respectively.

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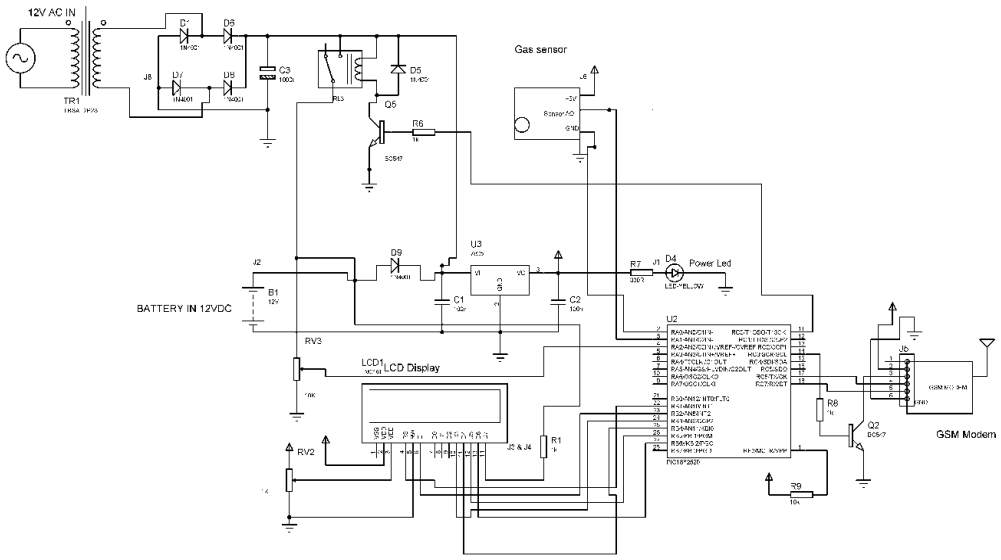

Figure 3: Complete circuit diagram of the design

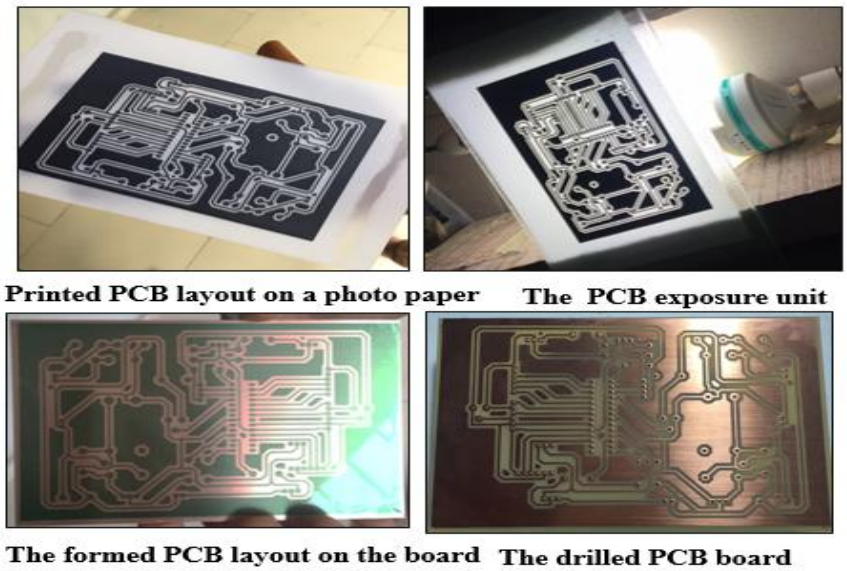

Figure 4: PCB layout design of the gas leakage detector

Figure 5: The completed LPG leakage detector

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3. TEST/RESULTS

Table 1 and figure 6 & 7 shows the result of the test that was carried out using the LPG leakage detector. The test shows that the system can quickly respond to gas leakage in the kitchen making it very efficient and enabling quick response to avert the danger. Based on the test carried out, it is advisable for the user to place the device 0.6m – 2.0 m from the gas source and 0.2m to 1m above the floor.

Table 1: Average of the Concentration and Distance Test

S/N	Distance From Burner	Detection	
		Time (sec)	Gas Concentration (ppm)
1	0.3m	39	1005
2	0.5m	46	350
3	0.7m	58	307
4	0.9m	69	290
5	1.1m	84	268
6	1.3m	99	268
7	2.5m	200	252

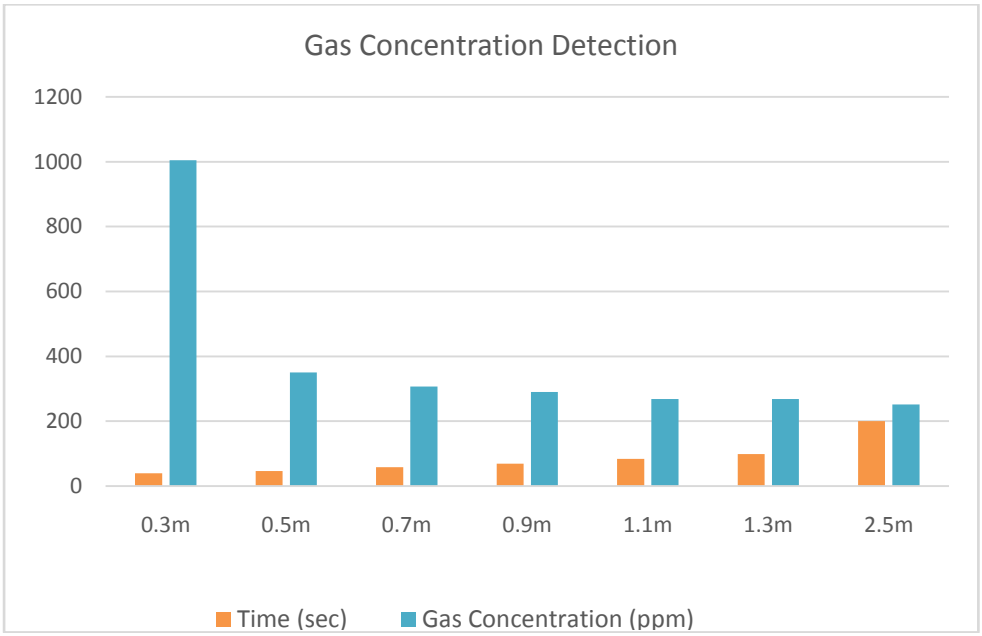

Figure 6: Chart showing the concentration of LPG detected, at a particular distance and the time taken.

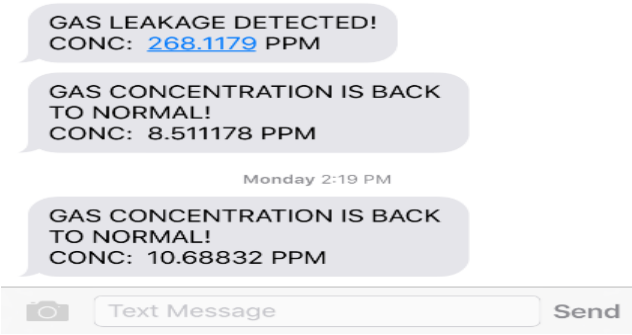

Figure 7: Snapshot of SMS sent by the device.

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4. CONCLUSION

The LPG detector was developed and tested and the results were satisfactory. This is an indication that the device can be installed in home and industrial kitchen to help forestall fire incidence that result from gas leakage that goes on undetected. This device when installed will efficiently help the user to know when there is gas leakage without relying solely on the sense of smell. Since the device can be powered from the mains and a battery, reliability of the system is guaranteed all the time.

REFERENCES

[1]. B. Hossain, S. J. Shourov, M. Rana and S. Anower, "Matlab Guidance Based Smart Gas Leakage Detection and Security System Using Analog to Digital Technique," *International Journal of Smart Home, vol. 9, no. 4,* pp. 13-24, 2015.

[2]. M. J. Kesavan, R. R. Kannan, V. S. Vishwanath and P. Sathya, "LPG Gas Leakage Detection, Monitoring And Control Using LabView," *International Journal Of Innovative Research In Technology (IJIRT), vol. 1, no. 10,* pp. 151 - 155, 2014.

[3]. S. Ashish, P. Ratnesh, K. Rajeev and V. Rahul, "GSM Based Gas Leakage Detection System," *International Journal of Technical Research and Applications (IJTRA), vol. 1, no. 2,* pp. 42 - 45, 2013.

[4]. B. Jolhe, P. Potdukhe and N. Gawai, "Automatic LPG Booking, Leakage Detection and Real Time Gas Measurement Monitoring System," *International Journal of Engineering Research & Technology (IJERT), vol. 2, no. 4,* pp. 1192 - 1195, 2013.

[5]. K. B. Vinoth, S. Kalaiyarasan, B. A. R. Denesu and T. Kanthavel, "Quadcopter Based Gas Detection System," *IOSR Journal of Electronics and Communication Engineering (IOSR-JECE), vol. 11, no. 1,* pp. 64 - 68, 2016.

[6]. E. EJOH, "DPR cautions users of gas cylinders," 26 september 2014. [Online]. Available: http://www.vanguardngr.com/category/DPR cautions users of gas cylinders.

[7]. P. Igbonwelundu, "24 Wounded In Cooking Gas Explosion In Lagos," 10 September 2014. [Online]. Available: http://thenationonlineng.net/24-wounded-in-cooking-gas-explosion-in-lagos/. [Accessed 01 May 2017].

[8]. J. Tsado, O. Imoru and S. Olayemi, "Design and Construction of a GSM Based Gas Leak Alert System," *International Research Journal of Electrical and Electronics Engineering (IRJEEE), vol. 1, no. 1,* pp. 2 - 6, 2014.

[9]. N. Harshada and B. Pawar, "Arm Based Gas Monitoring System," *International Journal of Scientific & Technology Research, vol. 3, no. 6,* pp. 43 - 45, June 2014.

[10]. V. Ramya and B. Palaniappan, "Embedded System for Hazardous Gas Detection and Alerting," *International Journal of Distributed and Parallel Systems (IJDPS), vol. 3, no. 3,* pp. 287-300, 2012.

[11]. K. Abid, r. K. Neju, K. D. Shailendra and S. R. Praveen, "GSM Based Automatic LPG Ordering System With Leakage Alert," *International Jpournal of Research in Enmgineering and Technology (IJRET), vol. 3, no. 12,* pp. 40 - 42, 2014.

[12]. B. Didpaye and S. Nanda, "Automated Unified System for LPG using Microcontroller and GSM Module," *International Journal of Advanced Research in Computer and Communication Engineering, vol. 5, no. 2,* pp. 234 - 237, February 2016..

[13]. T. Soundarya and J. Anchitaalagammai, "Control and Monitoring Sytem for Liquefied Petroleum Gas (LPG) Detection and Prevention," *International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), vol. 3, no. 3,* pp. 696 - 700, 2014.

[14]. OSHA, "United State Department of Labour,," 2010. [Online]. Available: http://www.osha.gov/dts/chemicalsampling/data/CH_26000.html.

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