## Journal of Electrical Engineering, Electronics, Control and Computer Science – JEEECCS, Volume 6, Issue 22, pages 23-28, 2020 Development of a Gas Leakage Detection System

<sup>1</sup>C.C. Nnokwe, <sup>2</sup>B.C. Ubochi, <sup>1</sup>K.V. Onwuzuruike

<sup>1</sup> Department Electrical and Electronic Engineering, Imo State University Owerri, Nigeria
 <sup>2</sup> Department Electrical and Electronic Engineering, Federal University of Technology, Akure, Nigeria Email: <sup>1</sup> amakannokwe@gmail.com; <sup>2</sup> Brendan.ubochi@gmail.com; <sup>1</sup> vikelllydon@gmail.com

Abstract – Liquefied Petroleum Gas (LPG) is a fundamental source of fuel in urban areas as a result of its comparatively higher calorific value and reduced impact on the environment. Due to the flammable nature of the gas, care must be taken in order to guarantee its safe use. In this work, a microcontrollerbased gas leakage detection system is developed. The system detects leaked gas using MQ-6 gas sensor whose calibrated outputs are used to trigger an alarm and display gas levels on a liquid crystal display (LCD) for ambient gas concentrations above 100 PPM. Additionally, the system is configured to send an "EMERGENCY ALERT" message to a user's mobile device in emergency situations.

Keywords - Gas leakage detection; Liquefied Petroleum Gas; Atmega328P-PU Microcontroller; MQ-6 gas sensor.

## I. INTRODUCTION

Liquefied Petroleum Gas (LPG) has a very high caloric value and is widely applied for both industrial and domestic use. Due to its non-negative impact on the environment, it is used in homes as a cooking gas and automobile engine fuel (auto gas) [1] and has even been suggested as an alternative to R-12 in domestic refrigerators [2] among others. A study in India suggests that about 7.2 million tons of fuel wood has been saved between 2001 and 2011 due to the increased LPG access [3]. However, the increased utilization of LPG has its drawbacks. The occurrence of fire accidents as a result of LPG leakage has been on the increase [4]. In Nigeria alone, there are over 2.346 reported cases of fire accidents between 2010 and 2014 [5]. Till date, the reported cases of fire outbreak have been on the increase with its associated losses and impact on the economy [6]. A reason for the rise in the reported cases over the years could be due to the absence of an effective alert system.

A number of sensor-based fire alert systems have been developed. Most of these systems are able to monitor and detect gas leakage but have limited alert systems [7, 8]. Thus, these systems are unsuitable for use as early warning systems in facilities either in close proximity to the user or remotely located. In [9, 10, 11], an automatic LPG refill booking and detection system is designed to detect and display the gas leakage level on a liquid crystal display (LCD). While the system has limited gas leakage alert systems, it is able to send a booking message to the LP gas distributor whenever the gas cylinder weight goes below 2kg.

An important parameter affecting the effectiveness of a gas detector system is the location relative to the leak source/s. A coverage-based risk assessment procedure for gas detector placement [12, 13] was used to optimise the location of the gas detector system. Also, [14] suggests a risk-based point-type gas detector placement methodology suitable for either single or mixed gas leakages with an explicit guidance in optimizing gas sensor placement.

Even though significant progress has been made in the development of gas leakage detection systems, key issues still need to be addressed. In this work, a fast gas leakage detector with a buzzer and a text alert system is developed to accurately detect leakage from a single leak source. It uses MQ6 gas sensor placed close to the gas cylinder in order to trigger the alert system when the measured gas concentration goes higher than 100 PPM.

### II. METHODOLOGY

Fig. 1 shows the operation of the gas leakage detection system. The system is powered by means of series-connected rechargeable batteries of 4V each. The rechargeable battery supplies a DC to the gas sensor and the Atmega328 P-PU microcontroller directly. The LCD, GSM Modem and the buzzer are interfaced with the microcontroller [15]. The gas sensor detects gas leakages and transmits an analog voltage, corresponding to the measured gas concentration, to the microcontroller. The microcontroller has an inbuilt analogue to digital converter (ADC) which converts the analogue output voltage signals from the MQ6 gas sensor to corresponding digital voltage signals. The output of the sensor is calibrated and configured to have a threshold of 100 parts per million (PPM). For gas concentrations above this threshold, the microcontroller simultaneously activates the GSM module, triggers the buzzer and displays the measured value on the LCD. The circuit is simulated using Proteus simulation software [16] and the wiring connection is as shown in Fig. 2.



Figure 1. The wiring diagram of the system showing how the sub-components are interfaced with the microcontroller

## III. THEORY AND CALCULATION

The MQ-6 gas sensor in Fig. 3 is used in this work. This sensor is capable of detecting LPG, iso-butane and propane at varying sensitivity levels respectively. Its detection is measured in PPM (parts per million) which is a measure of the concentration of the gas in the vicinity. A microcontroller, Atmega328P-PU, is used to perform processing and control operations. It has an analogue to digital converter (ADC) which is used to convert the analogue output voltage from the MQ-6 to a digital signal for further processing. If the Atmega328P-PU determines that the concentration of the gas in the room is too high i.e. above 100ppm, it activates the GSM module. The Atmega328P-PU communicates with the GSM module using the "AT" cellular commands. A 7805 regulator is used in the system power supply unit. The 7805 regulator ensures an output of +5V and it is connected to the microcontroller.



Figure 2. Block diagram of the gas leakage detection system showing the interconnections between the sensor, the microcontroller and the various controlled devices

### A. MQ6 Gas Sensor

The MQ6 gas sensor used has high sensitivity to LPG, iso-butane and propane [17]. Tin dioxide is the sensitive layer and its resistance varies according to the nature and concentration of the gas. The sensor resistance reduces by about 15% at 20°C when the relative humidity is varied from 33% to 85%. Also, variations in the sensor resistance at a high relative humidity of 85% from temperatures between 20°C and 30°C are less than 6%. While it is suggested to calibrate the sensor by determining the sensor resistance (RO) in 1000PPM of LPG gas at 20°C and a relative humidity of 85%, we have performed the calibration by determining the sensor resistance in clean air. According to the datasheet, RS/RO in clean air is 10, where RO is the sensor resistance in 1000PPM of LPG gas and RS is the measured sensor resistance in clean air. The measured resistance is used to extract an approximate value of RO at similar values of temperature and relative humidity. The output voltage can thus be calculated from:

$$VRL = (RL / (RS + RL))VC$$
(1)  
Where: RS = Sensor resistance  
VC = Supply voltage to the load  
RL = Load resistance  
RL = Output voltage



Figure 3. LPG Gas Sensor Module [18]

## B. GSM Module

GSM module as shown in Fig. 4 is used to send SMS alert message in order for emergency measures to be taken by the home owner. The home owner's phone number is programmed into the microcontroller. The module functions with a voltage ranging from 3V-3.9V. The GSM Module is interfaced with the microcontroller through the AT cellular command and an external subscriber identity module (SIM) card [19].



Figure 4. A GSM Module showing the SIM800L cellular chip and the pins for communication with a microcontroller [20]

#### C. System Flow Chart

This program was written in C++ language following an optimized algorithm for gas processing. This algorithm is represented in the system flowchart in Fig 5.



Figure 5. System flow chart of the Gas Detection System

# IV. SYSTEM IMPLEMENTATION, RESULTS AND DISCUSSION

The system is housed in an aluminum box as shown in Fig. 6. It has a power switch to turn the device on and off. The LCD is located at the top of the casing for easier viewing of the display.





Figure 6. System assembly showing the key sub-components

When in operation, the system displays on the LCD the measured gas concentration. A small amount of gas is expected in a kitchen where LPG is used for cooking. This amount should ideally be less than 100 PPM. When the concentration of gas exceeds 100 PPM, the microcontroller communicates with the GSM module using "AT" cellular command. The microcontroller instructs the GSM module to send SMS to a pre-programmed phone number.

The tests were conducted in the kitchen on different days and time of day. Some of the results are shown in Table 1. Although, the detected gas concentration is known to vary with respect to changes in humidity [21], our results do not show this dependence since variations in humidity in the test environment are not significant.

The tests have shown that the detected gas concentration varies as a function of the distance from LPG containers/cylinders according to the relation:

$$T_{100} = 5(DLC - 1) \tag{2}$$

Where  $D_{LC}$  is the separating distance from the cylinder and  $T_{100}$  is the time for gas concentration to rise above 100PPM.

For instance, the farther away the gas leakage detection system is from the LPG gas cylinder, the lower possibility of detecting gas leakages and vice versa (see Fig. 7). It was observed that SMS messages are received at a short time interval of 5 seconds immediately after the MQ6 gas sensor detects leaked gas beyond the set gas concentration threshold.

Figure 7. Gas concentration variation as a function of the distance from LPG containers.

TABLE I. RESULTS SHOWING THE ACCURACY OF THE DEVELOPED GAS LEAKAGE DETECTOR IN DIFFERENT TEST CONDITIONS

Gas Concentration Threshold (PPM)	Measured Gas Concentrati on (V)	Detected Gas Leakage ?	Date	Time
100	77	No	05/10/ 2019	10.09a.m
100	86	No	05/10/ 2019	11.57a.m
100	107	Yes	05/10/ 2019	5.16p.m
100	128	Yes	08/10/ 2019	1.29p.m
100	64	No	08/10/ 2019	4.38p.m

#### CONCLUSION

This paper has highlighted the enormous benefits of LPG as an energy source. It has also pointed out the human safety and economic risk in its use in the absence of safe monitoring systems. As a result, it has shown a methodology for the development of a Gas Leakage Detection System. This system uses such major components as the MQ-6 gas sensor, Atmega328P-PU microcontroller and the GSM module in the design. It is capable of detecting leaked gas and notifying the user through an alarm and a mobile text message. A main feature of the system is the reduction in the time interval of about 5 seconds to detect leaked gas and send SMS alert messages. Due to its detection accuracy and ease of installation, it is expected that a wide deployment of this system in homes will result in a significant reduction in fire outbreaks and consequently, huge savings to the individuals and the economy.

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