ISSN: 2456 - 3935

International Journal of Advances in Computer and Electronics Engineering
Volume 6, Issue 2, February 2021, pp. 1 – 9

A Multi-Sensor Gas Detection and Multi-Alert System

Patrick O. Olabisi
Academic staff, Department of Electrical, Electronic and Computer Engineering,
Bells University of Technology, Ota, Nigeria
Email: niyiolabisi@gmail.com

Abduljalil Abiri
UG Scholar, Department of Electrical, Electronic and Computer Engineering,
Bells University of Technology, Ota, Nigeria
Email: abduljalilabiri@gmail.com

Abstract: *Gas leakage particularly of Liquefied Petroleum Gas (LPG) has posed great dangers in homes and industry causing fire disasters and explosions due to its high flammability. The challenge of being able to effectively monitor leakage of LPG rests so much on gas sensors being positioned close to potential leakage points to allow for rapid detection. This prompted envisioning the design of a multi-sensor system which we called Rapid Detection Sensors Network (RDSN) built with MQ-5 gas sensors, as input into the overall safety device. On the output side is alerting the users of the gas facility for any LPG concentration greater-than-or-equal-to 400ppm using a multi-alert system that incorporates a 16-bit LCD unit built to display activities and sequence of operations within the safety device, a local sound (buzzer) alarm and a remote alert system that uses GSM messaging. A stepper motor was mounted on the cylinder to close the valve when gas leakage is detected. A prototype of the system was developed and tested by deliberately leaking some LPG from the cylinder.*

Keyword: *Please Gas Sensor, Sensors Network, Remote Alert, Inflammability, Explosion.*

1. INTRODUCTION

Combustible gases, which include hydrogen, propane, butane, methane, ammonia, and liquefied petroleum gas (LPG) used in both domestic, industrial, research and commercial environments have resulted in explosions and fire disasters over time when they leak into the environment without quick interventions, due to their high inflammability. They have caused severe harms to human health due to their toxicity and consequential oxygen deficiency they cause in the environment [1]. Major damage and/or destruction of lives and properties of great values have also been witnessed. Gas leakages in most cases result from use of fake and substandard materials and sealants, improper installation practice, lack of adequate and timely maintenance, worn out gas equipment and materials not replaced on time, faults in the gas facility, accidents and human errors. Despite the addition of odorous materials into LPG, sensitivity of the human nose as a natural safety mechanism cannot be relied upon to trigger quick intervention to leakage of LPG [2].

LPG as a highly inflammable and combustible gas has an explosive range of 1.8–9.5% volume of gas in air and the expansion is such that for every 1° rise in the temperature of LPG, the pressure inside the cylinder increases by 15 kg/cm^3 [3, 4]. It is therefore very important to have effective means of detecting its leakage at any point on the gas chain. By the gas chain, we mean the span from the gas storage tank or cylinder through the gas hose to the gas burner/dispenser in domestic, commercial and industrial premises. The process of detecting gas leakage is the process of identifying potentially hazardous gas leaks using a gas sensor [5]. The gas tank or cylinder in a lot of cases or places is positioned outside or away from the burner section. Selection of appropriate gas detection sensor, proper allocation and placement of the sensors along the gas chain is very important to building improved safety system that will effectively sense leakages of LPG gas and so be able to quickly avert disasters.

Different Gas leakage detection and monitor, particularly of LPG, have been designed and built using vari-

Cite this paper:

Patrick O. Olabisi, Abduljalil Abir, "A Multi-Sensor Gas Detection and Multi-Alert System", International Journal of Advances in Computer and Electronics Engineering, Vol. 6, No. 2, pp. 1-9, February 2021.

ISSN: 2456 - 3935

International Journal of Advances in Computer and Electronics Engineering
Volume 6, Issue 2, February 2021, pp. 1 – 9

ous gas sensor types, different controllers, different means of alerting users, different programming techniques and different approaches to putting the whole system together. In [2], MQ-5 gas sensor and a PIC18F1320 microcontroller were used, but it only incorporated audio-visual warning signaling of Display and a Buzzer Alarm. In [6] components used were MQ6 gas sensor, NodeMCU ESP8266 microcontroller which can connect to Wi-Fi for IoT features, with the alert systems being physical buzzer, email and smartphone notifications. Data obtained for both gas leakage and weight of the cylinder are uploaded into a type of IoT platform known as Blynk cloud in real-time. The monitoring system was developed using LabVIEW Graphical User Interface. Despite the versatility of the design in its control and monitor aspects, it is limited in the sensing range of the one sensor that was used.

The gas leakage detection system in [7] is a very efficient one, configured to detect gas leakage at 250ppm which is far less than the standard 1000ppm. The LPG booking and leakage detection system built by Jolhe et al [8] incorporates a gas weight sensor (L6D) built into it to continuously monitor the level of the gas in the cylinder. The weight sensor module is used with a load cell, which drives a relay circuit to give two levels pulses at Gas <=10kg when the cylinder has just been refilled and Gas <= 0.5kg when the cylinder is almost empty. The relay circuit is in turn connected to the microcontroller.

In a number of works that have been done on gas detection, multiple means of alerting the user(s) or owner(s) of the gas system have been deployed. These include alerting users both at local or immediate proximity and at remote or distant locations [9]. They incorporated different combinations of visual display, sound alert, remote GSM messaging, turning off the gas cylinder knob and in some cases turning on an exhaust fan to blow off the gas from the point of leakage. Other remote alert systems used include the Zigbee wireless technology. In [10], Zigbee wireless transceiver was used to transmit gas leakage data within a maximum distance of about 100m to monitoring computer system(s) that display the information on LabVIEW Graphical User Interface (GUI). The Internet of Things (IoT) has also been deployed to remotely alert user(s) of the gas facility [11, 12, 13]. For example, in [11, 13], ESP8266 Wi-fi module was used with IoT to send message through email to the user(s) with the use of Blynk applications with internet connection in place.

The overall problem with all previous designs is that they used one gas sensor for detection of gas leakage, which results in more quantity of gas leaking out before the sensor could detect the leakage, particularly if the leakage hole is a few more distance from the immediate sensor point than what the sensor could quickly detect. Such phenomenon thereby limits effectiveness of the process of detection of leakages.

2. MULTI-SENSOR NETWORK

2.1 The Rapid Detection Sensors Network

In this work, we designed multiple sensors into this safety system by locating gas sensors at the gas storage, somewhere along the connecting pipe or hose and at the point of the gas utilisation where the burner is located. This is meant to make the sensors closer to points of potential leakage and prevent the possibility of the gas spreading out so much when leakage occurs before it is detected, raising of alert and consequently nipping the leakage in the bud to adequately prevent a disaster to the gas facility and the users. The RSDN system shown Figure 1 therefore helps in improving detection performance. Lots of works have been done on detection of gas leakage and raising alerts, but the introduction of the RDSN makes much difference and provides a highly effective safety system.

The RDSN system is based on the principles of linear Multi-sensor array. It was developed to provide effective coverage of the gas chain. The multi-sensor designed into the system is such that at the gas storage location, basements, rooms and passages where gas hose, connections or joints and valves are positioned, and at the gas burner, all the gas sensors installed are connected into the same gas detection safety system. The major advantage of sensor array, which can be designed into different geometries of linear, circular, planar, and spherical arrays, was noted to be that new dimensions and range are added to the observation, which helps to improve the estimation performance [14]. These sensors are therefore centrally controlled to detect leakage at any point, so that users can be more quickly alerted and the gas supply stopped by the incorporated stepper motor or human interventions. Attempt at forestalling fire disasters resulting from different phenomena of smoke and leakages of various gases, necessitated the use of different sensors of Electrolyte, Thermal-Chemical, Gravimetric Chemical, Optical fibre, IR Spectrometry, and so on, in a sensor-array advanced gas detection system [15].

Beyond provisions of the RDSN system, this work made additional efforts at designing the system of alerting users more robust by increasing the methods of alerting the users to cover users at both local and remote locations. It also provides mechanism for prompt stopping of the gas supply when leakage is detected by automating the closing of the gas supply valve. The user or owner of the premises and/or gas facilities is alerted whether they

ISSN: 2456 - 3935
International Journal of Advances in Computer and Electronics Engineering
Volume 6, Issue 2, February 2021, pp. 1 – 9

are at home, on-site or afar off at work or have travelled at the time the leakage was detected. Also, with the leakage detected and the user alerted, the constraints and distance of his remote location should not pose a problem to quickly shutting down the gas supply and stopping the leakage before it results into a fire disaster. Gas leakage might even happen at night when people have closed or are asleep.

2.2 Types and Quality of the Gas Sensors

The size and type of sensors determine their sensitivities and the environments where they can cope with. Gas sensors are electronic noses and their general classification is based on the types of the sensing element they are made of, which also determine their areas of applications [16, 17]. They are classified into: Metal-Oxide semiconductor-based gas sensors, Optical gas sensors, Electrochemical gas sensors, Capacitance based gas sensors, Calorimetric gas sensors, and Acoustic based gas sensors [18]. Gas sensors measure the ambient gas atmosphere which alters the sensor properties in a characteristic way [16].

The gas sensor adopted for this work is the MQ5 sensor module, which is useful for detecting leakage of H2, LPG, CH4, CO, Alcohol. The MQ-5 gas sensor has

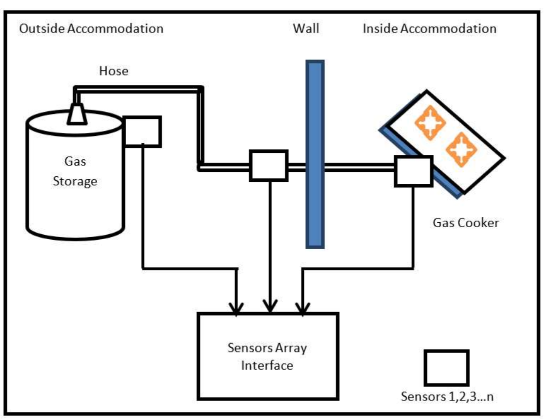


Figure 1: Rapid Detection Sensors Network (RDSN)

such features as high sensitivity to LPG and some other gases, fast response of less than 10 seconds, detection range of 100 – 10,000 ppm, stable and long life, operates with a heater voltage of 5volts and a simple drive circuit, therefore making the system very efficient at detecting LPG gas leakage anywhere. The sensor is composed of the Tin Dioxide (SnO_2) sensitive layer, micro AL203 ceramic tube, measuring electrode and the heater fixed into a crust made by plastic and stainless-steel net. It detects the presence of LPG in the air using a heated sensor element which increases in temperature when exposed to LPG [19]. The heater sets the necessary work conditions for the sensitive components. The output voltage generated by the sensor is directly proportional to the concentration of leakage LPG gas present around it. The fact of changes in the resistance of heated metal oxide sensors for example, in response to the atmosphere around them, is an approach that had been known for over forty years [20].

The MQ-5 has six pins, four are used to obtain signals and the other two provides heating current. The Out pins of the sensors communicate with the microcontroller through its PC's pins respectively. A toggle button is connected to the test pin of the gas sensors in the Proteus circuit design to simulate input signal to the microcontroller. The design specifications of MQ-5 are given in Table I.

Shown in Figure 2 is a chart of plots of the sensitivity characteristics of the MQ-5 for several gases including LPG, at Temp: 20°C, Humidity: 65%, O_2 concentration 21%, R_L=20KΩ. The graph is determined in controlled atmosphere and calibrated with a few known gas stated in the legend. Sensitivity calibration to 1000ppm of LPG concentration was done on the sensor because it has different resistance values for different types and concentration of gases. Load resistance (R_L) of about 20KΩ was also set, with the temperature and humidity of the environment put into consideration.

TABLE I: STANDARD WORK CONDITIONS FOR MQ-5 GAS SENSORS [21].

Symbol	Parameter name	Technical condition	Remarks
V_C	Circuit voltage	5V±0.1	AC OR DC
V_H	Heating voltage	5V±0.1	AC OR DC
R_L	Load resistance	20KΩ	
R_H	Heater resistance	31±10%	Room Temperature
P_H	Heating consumption	Less than 800mw	

By placing the sensor in fresh air and knowing the sensor supply voltage, V_s, the load resistance, R_L= 20 kΩ and by measuring the voltage V_{out} developed across the load resistance, the clean air sensor resistance parameter R_{SCA}, was computed using the formula [22, 23]:

$$R_{SCA} = R_L \frac{V_s - V_{out}}{V_{out}} \quad (1)$$

ISSN: 2456 - 3935
International Journal of Advances in Computer and Electronics Engineering
Volume 6, Issue 2, February 2021, pp. 1 – 9

Then the value of the reference sensor resistance, R_O, corresponding to a concentration of 1000 ppm H2 in fresh air, was determined using the formula:

$$R_O = \frac{R_{SCA}}{RatioAir} \quad (2)$$

where $RatioAir$ is a parameter of each MQ sensor. For MQ5, the $RatioAir$ parameter is given by:

$$RatioAir = \frac{R_{SCA}}{R_O} = 9.56 \quad (3)$$

The sensor output equation was solved using the nonlinear regression, such that:

$$ppm = a\left(\frac{R_S}{R_O}\right)^b \quad (4)$$

$$\log(ppm) = \log a + b \log\frac{R_S}{R_O} \quad (5)$$

$$ppm = 10^{\log a + b\, log\left(\frac{R_S}{R_O}\right)} \quad (6)$$

where R_S is the measured internal sensor resistance and ppm is the gas concentration in parts-per-million. R_S is computed from the measured output sensor voltage using:

The formula obtained for MQ5 sensor is given by:

$$log(ppm) = -2.5279 log\left(\frac{R_S}{R_O}\right) + 1.8771 \quad (7)$$

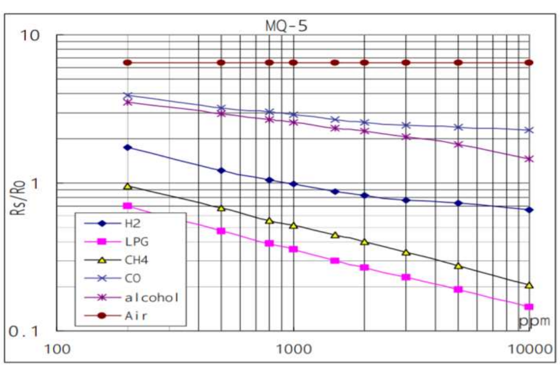


Figure 2: Typical sensitivity characteristics of the MQ-5 for several gases [14].

3. THE CONTROL UNIT

This unit controls the operation of all modules and parts of the system. It was implemented with Atmega 328p microcontroller and the accessories were a 16MHz crystal oscillator, two 22pF and one 10uF capacitors, a Toggle button, and a 10kΩ Resistor. The external 16MHz crystal oscillator was used to provide the desired clock speed to the microcontroller. The 10uF capacitor and 10kΩ resistor connected the toggle button provided Reset to the microcontroller at Power-On startup and at any point. The 22pF capacitors connected in series with the 11pF capacitor along with the 9pF stray capacitance of the 16MHz crystal equals 20pF capacitance required to properly oscillate the crystal.

Programming the system in Arduino code, C++ language was used which was then converted to a hex file and uploaded to the ATmega 328p microcontroller using an arduino hardware burner using programming software known as AVRDUDE.

4. MULTI-ALERT LPG DETECTION SYSTEM

A number of these output devices were incorporated into this work with improvements in the choice of devices and components for the implementation. This is coupled with the main innovation of this work in the development of the RDSN system at the input side of the whole system. This work incorporated the following devices to alert the gas user(s) of leakage: LCD display, Local Sound Alert, and GSM Remote Alert.

Shown in Figure 3 is the flow chart of the procedure of operation of the whole system to perform detection of LPG leakage from all sensor points, send out alert signals both as local sound and remote location alerts and lock the gas cylinder valve to cut supply.

4.1 Display Unit

This unit gives visual information of the operations going on in the system. It was made of: one 16x2 LCD Display run in 4-bit mode on D4-D7, two 10kΩ Resistors and one 10kΩ potentiometer connected to the V_{EE} for adjusting the brightness of the LCD. The LCD 16x2 is a 16 pin device which has 8 data pins (D0-D7) and 3 control pins (RS, RW, E). The remaining 5 pins are for supply and backlight for the LCD. The control pins help us configure the LCD in command mode or data mode. They also help configure read mode or write mode and also when to read or write.

4.2 Local Alarm Unit

This unit alarms the gas user of leakage through audible sound. It was made with a Buzzer and an LED that blinks along with the audible alarm when it is ON. The buzzer is connected to pin D6 and pin D7 of the microcontroller. The buzzer used is a SFM-10B High decibel 3-24V DC active buzzer.

4.3 Remote Alarm Unit

Users of the gas facility can be alerted remotely when at the time of gas leakage they happened not to be at home. The global system of wireless communication (GSM) was adopted because of the world-wide reach and uniformity of the technology all over the world. A GSM module shown in Figure 4 was used. It is powered by a 12V DC supply and connected to the microcontroller on the serial pins through a MAX232 IC that converts the RS232 (serial) data from the GSM modem (SIM 800A) to TTL required by the microcontroller.

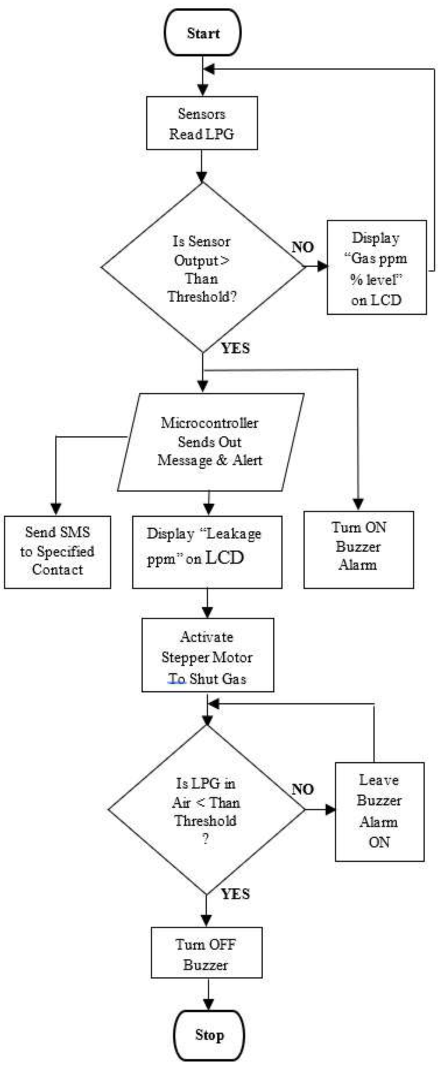


Figure 3: Flowchart of the Gas Leakage Detection System.

With communication established between the GSM modem and the microcontroller, AT commands from the microcontroller were used to send SMS text to the user phone. Three 10uF capacitors were used with the MAX 232 IC and fourth to remove disruptions with the micro-controller's supply voltage.

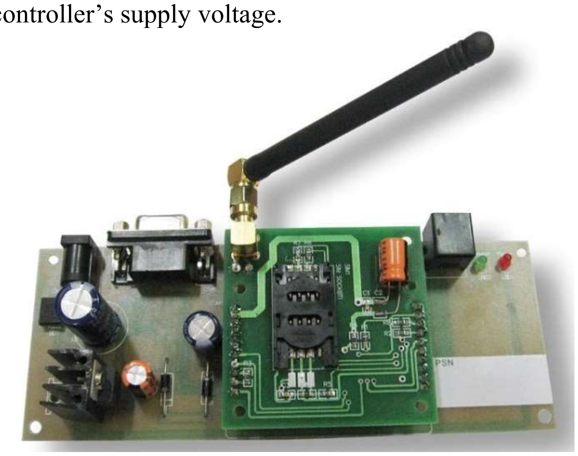


Figure 4: GSM Module Source: (http://www.andcircuit.com/product/sim800-gsm-module-arduino/)

4.4 Smart Leakage Control Unit

Smart control of gas supply from the gas cylinder or gas tank immediately leakage is sensed before the leakage becomes so much as to result in fire disaster or explosion is achieved with the use of a stepper motor to lock the outlet valve of the gas cylinder or tank. The objective is to make the smart lock sensitive enough by automatically implementing it even before the owner or user of the gas facility could get to the scene though he has been alerted by either sound alarm or GSM messaging alert.

A DC stepper motor, NEMA 17 Bipolar stepper motor, was used to shut the valve of the cylinder. Stepper motors though slow, its precise rotational steps, easy of control and setup, make it advantageous for positional controls achieved through its fractional rotational increments. Running the motor directly with the microprocessor will not provide sufficient torque to move the valve of the gas cylinder in order to shut gas supply, since the microprocessor output current is 50mA/pin. Therefore, a motor driver was used to supply more current and achieve sufficient torque. The stepper motor driver used in this work is the L2093D, with the configuration and connections are shown in Figure 5. It operates on the principle of Half H-Bridge, which makes the motor to run in either clockwise or anti-clockwise direction.

The number of steps required to shut the gas cylinder valve when fully opened is obtained from:

$$No\ of\ Steps = \frac{Angular\ Range\ of\ Valve}{(Angle\ of\ Each\ Motor\ Step)/2} \quad (8)$$

ISSN: 2456 - 3935
International Journal of Advances in Computer and Electronics Engineering
Volume 6, Issue 2, February 2021, pp. 1 – 9

$$= \frac{180^0}{45^0/2} = 8\ Anticlockwise\ Steps$$

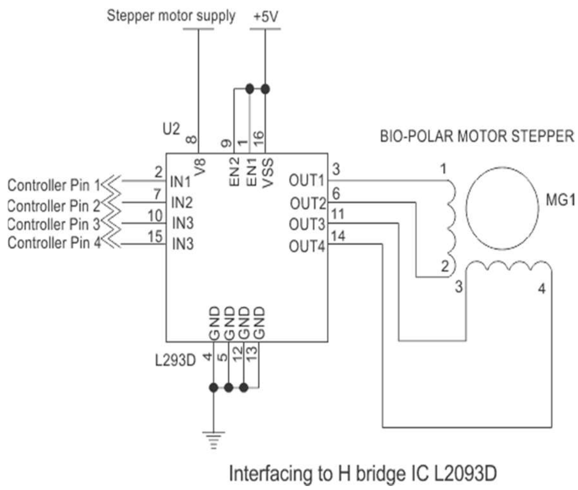


Figure 5: Stepper Motor Driver Circuit

5. TESTING AND RESULT ANALYSIS

5.1 Prototype Testing

Shown in Figure 6 is the complete system in a casing. Figure 7 shows the reading of the two sensors that were used in the prototype. Sensor 1 located close to the cylinder detects some LPG, while Sensor 2 mounted on the cooker is not sensing any LPG. This is because the LPG that was released into the air at the moment was right at the cylinder side and not at the cooker side. Figure 8 shows the system powered-ON and the LCD displaying LPG detection. When LPG was released into the air and it was detected by the system, the buzzer alarm sounded and only continued to sound for as long as it takes for the LPG ppm to go down below the concentration threshold of 400 ppm programmed into the system. This took varied time duration which depended on the following: (i) time it took the stepper motor to turn off the gas cylinder's valve; (ii) how airy the room/kitchen where the gas facility is located is, for air to blow out the leaked gas; (iii) the promptness of user(s) to attend to the gas facility when the alert buzzer was heard; and the overall sensitivity of the system, which in this case was meant to be more robust with the introduction of the multi-sensor system.

5.2 Result Analysis

Tables II and III show the average time taken for the MQ-5 gas sensors to detect 400 ppm of LPG gas released into the air at different temperatures. The Distance column stands for the Distance of the system from the gas leak source (in meters) while Td is the Time taken to detect the gas leak (in seconds) and T is the Total Time taken to detect and alert users to the gas leakage (in seconds).

Shown in Figure 8 is the plot of the Time taken to detect the gas, alert the user and stop gas leakage versus the Distance of the system from the gas leakage source.

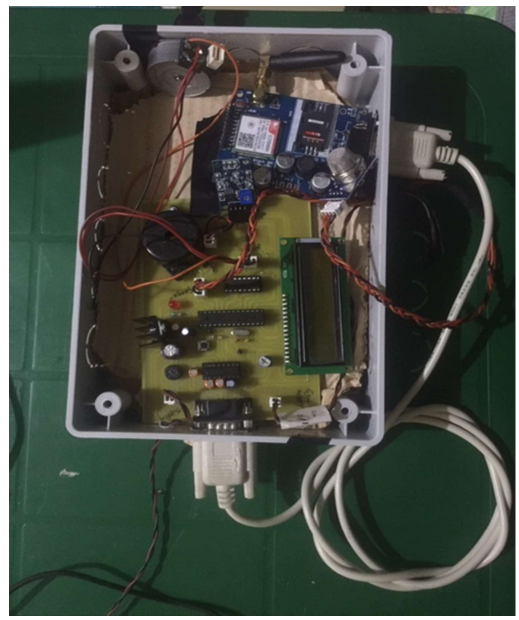


Figure. 6: Dual Alert Domestic Gas Detection System

5.3 Discussion

It was observed during testing at different distances from the gas leak source that the response time of the LPG system decreased as the distance from the gas source increased and vice versa. Also observed during testing is that the sensitivity of the gas sensor was higher in a warm environment and lower in cold environments.

These observations are reflected in the graph in Figure 9, where the time taken for the system to detect the gas, alert users and stop the gas leakage increase as the distance between the gas detection system and the gas leakage source increases. Also, the response time of the gas detection system decreases as the temperature of the surrounding environment increases. This is expected as the sensitivity of the gas sensors varies with changes in temperature. The gas detection system's stepper motor has a short iron rod attached to it to rotate the LPG gas cylinder valve anti clockwise.

ISSN: 2456 - 3935
International Journal of Advances in Computer and Electronics Engineering
Volume 6, Issue 2, February 2021, pp. 1 – 9

Figure 7: Gas % Levels At Ambient Conditions With Virtually No LPG Gas Present In Air.

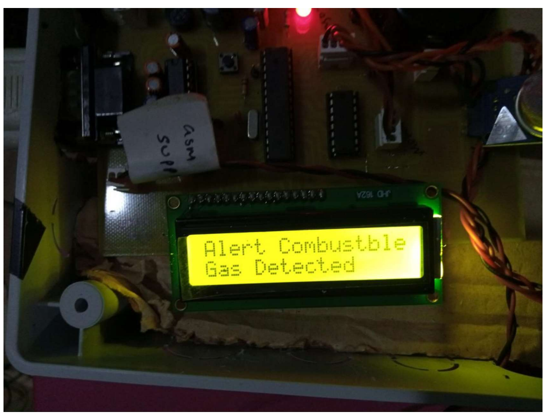


Figure 8: Information On The LCD Display When Gas Leakage Has Been Detected

TABLE II: DISTANCE VERSUS TIME TAKEN TO DETECT THE GAS LEAKAGE.

Distance (metres)	**Td(seconds)**		
	18℃	26℃	34℃
0.1	3.3	3.3	2.9
0.3	4.8	4.5	4.2
0.5	6.2	5.0	4.6
0.7	8.3	6.2	6.0
1.0	12.7	11.2	10.6
1.5	17.1	15.4	14.9
2.0	25.7	23.7	21.8

TABLE III: DISTANCE VERSUS TIME TAKEN TO DETECT AND ALERT USERS OF THE GAS LEAKAGE.

Distance (metres)	**T(seconds)**		
	18℃	26℃	34℃
0.1	3.5	3.5	3.1
0.3	5.0	4.7	4.4
0.5	6.4	5.2	4.8
0.7	8.5	6.6	6.2
1.0	12.9	11.4	10.8
1.5	17.3	15.6	15.1
2.0	25.9	23.9	22.0

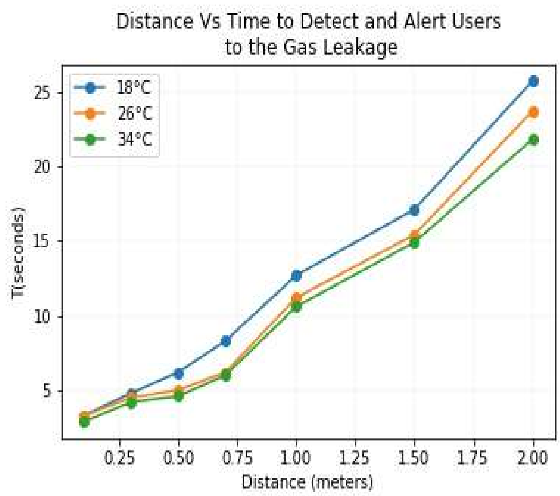


Figure 9: Graph of the time taken to detect the gas, alert the user and stop gas leakage versus Distance of the system from the gas leakage source

6. CONCLUSION

The system prototype design majorly focused on the introduction of multi-sensors array into the gas leakage detection system, wherein PLG detection sensors are installed at all the stages of the gas supply and utilisation chain. It is a portable and efficient system which aimed at nipping the possibilities of the hazards of fire disaster and explosion resulting from leakage of LPG gas into the air at any of the stages of gas storage, supply hose, and cooker/heater points. The prototype proved effective as shown in Figure 8, where two installed sensors detected LPG released into the air at a point/location closer to each of them. The threshold of the LPG concentration in air before alert could be raised was particularly set at 400 ppm because this is adequate enough to prevent a fire disaster or an explosion.

The multi-alert part of the system makes it more versatile. It is such that even if the user(s) could for whatever reason(s) not be able to attend to the gas facility to stop the leakage, the installed stepper motor will shut the gas cylinder valve before the leakage results in a fire disaster or explosion.

7. FUTURE WORK

This system is ultimately geared towards improving health and safety features of homes and all places where LPG is either being stored, sold or utilised. As a way of improving on the effectiveness of this system, more sensors could be added to the array to make the leakage detection more prompt. It could also be noting that the sensitivity performance of the gas sensors is affected by the temperature of the environment. So, a temperature sensor could be designed into it. This will enable the microcontroller to consider both the temperature of the environment and the concentration of gas within the space before making decisions on alerting the user(s) and/or shutting the gas supply.

REFERENCES

[1] Mohammad Hosein Beheshti, Somayeh Farhang Dehghan, Roohalah Hajizadeh, Sayed Mohammad Jafari and Alireza Koohpaei. "Modelling the Consequences of Explosion, Fire and Gas Leakage in Domestic Cylinders Containing LPG." Annals of Medical and Health Sciences Research. January 2018; Vol 8 Special Issue 1: 83-88.

[2] Mahalingam, A., Naayagi, R, T, and Mastorakis N. E. Design and Implementation of an Economic Gas Leakage Detector. Recent Researches in Applications of Electrical and Computer Engineering. 22 October 2015. P. 20-24.

[3] Solken W (2008). Lower and Upper Explosive Limits for Flammable Gases and Vapors. Retrieved from http://www.wermac.org/safety/safety_what_is_lel_and_uel.html

[4] [4] Hahn, E. (March, 2019). LPG Properties & LPG Composition - What Are the Properties of LPG. Retrieved from https://www.elgas.com.au/blog/453-the-science-a-properties-of-lpg

[5] Cory. (March 13, 2019). A Short History of Gas Leak Detection. Retrieved from https://www.dodtec.com/a-short-history-of-gas-leak-detection/#:~:text=The modern era of gas explosions in fuel storage tanks.

[6] Sitan, T. S. and AbGhafar A. S. 2018. Liquefied Petroleum Gas (LPG) Leakage Detection and Monitoring System.Journal of Science and Technology, Vol. 10 No. 3 (2018) p. 46-53.

[7] Enalume K. O., Obianke S. K. 2017. Design and Implementation of an Efficient LPG Leakage Detector. International Journal of Latest Engineering Research and Applications (IJLERA) ISSN: 2455-7137 Volume – 02, Issue – 06, June – 2017, PP – 20-26.

[8] B. D. Jolhe, P. A. Potdukhe, N. S. Gawai. "Automatic LPG Booking, Leakage Detection And Real Time Gas Measurement Monitoring System." International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 4, April – 2013. 1192 – 1195.

[9] Yadav, V., Shukla, A., Bandra, S., Kumar, V., Ansari, U, and Khanna, S. 2016. A Review on Microcontroller based LPG Gas Leakage Detector. MAT Journal of VLSI Design and Signal Processing. Volume 2 Issue 3.P..1-10.

[10] Huan Hui Yan and Yusnita Rahayu. "Design and Development of Gas Leakage Monitoring System using Arduino and ZigBee." Proceeding of International Conference on Electrical Engineering, Computer Science and Informatics (EECSI 2014), Yogyakarta, Indonesia, 20-21 August 2014. P.207 – 212.

[11] M. Abdul Hannan, A.S. Mohd Zain, F. Salehuddin,

[12] H. Hazura, S.K. Idris, A.R. Hanim, AM AH, NSS Mohd Yusoff. "Development of LPG Leakage Detector System using Arduino with Internet of Things (IoT)." Journal of Telecommunication, Electronic and Computer Engineering. Vol. 10 No. 2-7. P.91 – 95.

[13] Asmita Varma, Prabhakar S, Kayalvizhi Jayavel. "Gas Leakage Detection and Smart Alerting and Prediction Using IoT." IEEE 2nd International Conference on Computing and Communications Technologies (ICCCT), Chennai, India. 23-24 Feb. 2017. p.327 – 333.

[14] S.M. Zinnuraain1, Mahmudul Hasan2, and Md. Akramul Hakque3, and Mir Mohammad Nazmul Arefin. "Smart Gas Leakage Detection with Monitoring and Automatic Safety System." IEEE 2019 International Conference on Wireless Communications Signal Processing and Networking (WiSPNET), Chennai, India. 21-23 March 2019. 406 – 409.

[15] Wikipedia. Sensors Array. Retrieved from: https://en.wikipedia.org/w/index.php?title=Sensor_array&oldid=979630117. 21 September 2020.

[16] Kanakam, P., Hussain, S. M., and Chakravarthy, A. S. N. "Electronic Noses: Forestalling Fire Disasters A technique to prevent false fire alarms and fatal casualties. 2015 IEEE International Conference on Computational Intelligence and Computing Research. Madurai, India. 10-12 Dec. 2015

[17] Lilienthal A. J., Loutfi A. and Duckett T. Airborne Chemical Sensing with Mobile Robots. *Sensors* 2006, *6*, 1616 – 1678. ISSN 1424-8220 by MDPI http://www.mdpi.org/sensors

[18] Kanakam, P, Hussain, S.M., and Chakravarthy, A. Electronic noses: Forestalling fire disasters: A technique to prevent false fire alarms and fatal casualties. In Proceedings of the IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), Madurai, India, 10–12 December 2015 1–6.

[19] Digi-Key Electronics. Introduction to Gas Sensors: Construction Types and Working. 4 June 2019. Retrieved from https://components101.com/articles/introduction-to-gas-sensors-types-working-and-applications

[20] Figaro. *MOS sensor Operating principal* 21 August 2018, https://www.figaro.co.jp/en/technicalinfo/principle/mos-type.html

[21] Peterson, P. J. D., Aujla, A., Grant, K. H., Brundle, A. G., Thompson, M. R., Hey, J. V. and Leigh, R. J. 2017.Practical Use of Metal Oxide Semiconductor Gas Sensors for Measuring Nitrogen Dioxide and Ozone in Urban Environments. Sensors

ISSN: 2456 - 3935

International Journal of Advances in Computer and Electronics Engineering
Volume 6, Issue 2, February 2021, pp. 1 – 9

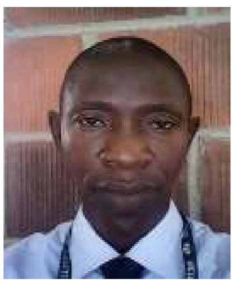
2017, 17, 1653; doi:10.3390/s17071653. ww.mdpi.com/journal/sensors.

[22] Technical Data MQ-5 Gas Sensor, HANWEI ELECTRONICS CO., LTD, http://www.hwsensor.com, p1-2.

[23] Popa, A., Hnatiuc, M., Paun, M., Geman, O., Hemanth, D. J., Dorcea, D., Son, L. H., and Ghita. S. 2018. An Intelligent IoT-Based Food Quality MonitoringApproach Using Low-Cost Sensors.Symmetry 2019, 11, 374; doi:10.3390/sym11030374. www.mdpi.com/journal/symmetry. P,1-18.

[24] Dorcea, D., Hnatiuc, M. and Lazar, J. 2018.Acquisition and Calibration Interface for Gas Sensors.*2018 IEEE 24th International Symposium for Design and Technology in Electronic Packaging (SIITME)* Iasi, Romania. 25-28 Oct. 2018.

Authors Biography



Dr Patrick Olabisi graduated with B.Eng (Electrical/Electronic Engineering) in 1989 from Federal University of Technology, Owerri, Nigeria. He obtained M. Eng (Electronic & Telecommunication Engineering) in 2010 from Federal University of Technology, Akure, Nigeria and PhD (Telecommunication Engineering) in 2020 from University of Ibadan, Ibadan, Nigeria. His areas of specialization include signal and speech analysis and processing, Telecommunication QoS Assessment and Optimisation, multi-sensor arrays and wireless sensor networks. He has worked at different levels in a number of companies in the fields of electronics, telecommunication and control. He was Acting Director of School of Engineering at Lagos City Polytechnic, Lagos, Nigeria. He is currently an academic staff at Bells University of Technology, Ota, Nigeria.

Adbuljalil Abiri is a young Electrical Engineering graduate who graduated with a Bachelor of Engineering (B. Eng) in 2020 from the Department of Electrical, Electronic and Computer Engineering of the Bells University of Technology, Ota, Nigeria.

Cite this paper:

Patrick O. Olabisi, Abduljalil Abir, "A Multi-Sensor Gas Detection and Multi-Alert System", International Journal of Advances in Computer and Electronics Engineering, Vol. 6, No. 2, pp. 1-9, February 2021.