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AUTOMATIC GAS LEAKAGE MONITORING SYSTEM USING MQ-5 SENSOR

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ABSTRACT

Safety plays a crucial role in today's world, and an automatic safety system must be employed in environments like institutions, hospitals, homes, factories, and workplaces. One of the precautionary measures that must be taken to avoid the danger associated with gas leaks is to install a gas leak detection system in places that are at risk. This paper presents a liquefied petroleum gas (LPG) leakage monitoring system. The gas detector MQ-5 used in the design is responsible for measuring the gas that is leaking. An Arduino microcontroller acts as the brain of the whole system, controlling all the components in the design. If the gas sensor detects a gas leak, it will sound an alarm by means of a buzzer and will send SMS messages to the registered mobile numbers with the help of the GSM module. A liquid crystal display is used in the study to display the presence or absence of gas leakage.

Contribution/Originality: To generate awareness of the security actions individuals can take in their day-to-day life in response to the rise in the outbreak of fire and explosions in the world today.

1. INTRODUCTION

Since the beginning of time, humans have used security systems of one form or another. To alert the community to a danger, signals were once given through shouting and sound. Later this was replaced with the clapping of hands and the introduction of signals to inform the community or transmit a certain message if there was an outbreak of fire, an abduction or a burglary, particularly during the early periods of some African societies, such as in Nigeria [1-3]. All such notification methods or warnings are by nature both necessary and undependable and unmethodical. The first fire alarm system was invented back in 1852 by Moses Farmer and Dr. William F. Channing. This system consisted of two fire alarm boxes which each had a telegraphic key and a handle. When a fire or explosion is noticed in an organization, factory, home, or place of business, somebody has to reach inside one of these boxes and crank the handle to dispatch a notification about the fire or explosion to the nearest alarm station. The operator at the station will then take the message and notify the fire department about the fire so that they can send assistance. The earliest electronic fire alarm system was invented almost four decades later, in 1890, by a scientist named Francis Robbins

Upton. He noted that, in most cases, people will not have time to stand and crank a handle inside a box when they are in the middle of a fire or explosion. Thus, the system he invented eliminates the need for this step. Altough the system was not that popular when he first introduced it, people later started to appreciate the need for a more progressive fire alarm system like the one he invented. Since that time, there have been a many developments in fire alarm systems, especially with the latest developments in technology, and today, business- and homeowners need not take any action, other than leaving the area during a fire, for the necessary action to be taken.

There is always a high risk of leakage whenever gas is used, threatening human properties and lives. Therefore, an affordable and low-cost gas leakage detector system can assist in decreasing the risk over several years. In the past years, several accidents have been caused by liquefied petroleum gas (LPG) or methane leakages in factories and homes. This leakage of gases has led to the loss of several lives and properties due to explosions and fire. Modern technology must be utilized to give early warning signs to assure that adequate time is available to mitigate probable danger. In this research, a gas leak detection system has been developed. This system will detect the presence of gases such as liquefied petroleum gas (LPG) and methane in our environments, factories, schools, and hospitals. If there is a gas leakage of any kind that can be a danger to society or the people living in that environment, the MQ-5 sensor used in the circuit design will automatically detect it, the GSM modem in the design will send a warning signal to the users whose numbers are registered in the system or to the monitoring company that is responsible for the building or organization. This system also includes a buzzer that will sound an alarm if a gas leakage is detected. This system can also be used in various other places, such as oil and gas pipelines, kitchens, and gas storage facilities.

2. RELATED WORKS

This research aims to design a gas detection system that will automatically detect gas leakage and send an alert. This device is expected to be used in household security where heaters and gadgets that make use of natural gas and LPG may be a cause of danger. This gas detector system can likewise be used for other functions in factories or plants that depend on LPG or natural gas for their operation. The gas leakage detector system will send a notification message to the registered mobile phones. An Arduino microcontroller is used as the brain of the system. The gas detector system is controlled and monitored through the web application ADAFRUIT. Once a leak is detected, the power supply is automatically cut off, and the buzzer is turned on. Using this web application, the system can be further controlled by the user, for example by switching on the fan or water pump [4]. This smart gas detection system is proposed for use in various hospitals. If there is a sudden leakage of gas, the gas sensor used in the design will send a signal to the Arduino. The Arduino will process the signal and then send a notification to other external gadgets involved in the design, such as the liquid crystal display, the magnetic buzzer, and the GSM module which stores the phone numbers of the individuals who are responsible for fighting fires in the hospital; the alarm will be sent repetitively until an acquiescent reply message is received [5]. The gadget was designed to be mounted either on the ceiling or wall. Once the system is mounted in a suitable place with a supply of electrical energy, it will be ready to automatically send a notification using short message service (SMS) or by calling the owners if there is a gas leakage. The detection system comprises an Arduino microcontroller, a MQ-5 gas sensor with ATmega328 microcontroller mounted on it, an active buzzer for raising the alarm, a SIM900A GSM/GPRS module to send the mobile message, a solenoid valve to close or open the gas provision, and a relay module, which is activated with the help of the digital signal sent by the Arduino [6]. Thus the design of this gas leakage sensor-based detection system, which can both notify and control, is low cost and innovative. The gas detection system is very proficient, portable, user-friendly, cost-effective, and small in size [7]. It features an analog to digital conversion (ADC) method based on electronic gadgets, which is used to detect gas leakage using mechanical devices in factories, households, gas stations, and vehicles. These are places where detection of gas leaks is an essential concern to evade any kind of danger. This gadget comprises a processing section, which receives the date inputs, processes the data, and then produces an output. Depending on the output information, it then starts a fan and activates a light-emitting diode; if the

concentration of the gas surpasses a certain level, it then activates the buzzer, while also switching off the gas power supply and informing the relevant parties by sending an alert message via the monitoring computer system. The gas concentration level for a particular operational area will be stored in the Mat lab "Database Explorer Tool" to make a summary of the gas eminence of this environment or area available for scrutiny, to inform any risk assessment [8]. There is an LPG leak detection and alert system. This system triggers the buzzer and shows the severity of the leak to notify persons once the LPG leak is detected. The system is exceptionally simple yet dependable [9]. The design of the gas detector is based on the Internet of Things. The gas detector sensor used in the design will capture the data and upload it into an information cloud. If there is gas leakage, the sensor will detect it and sound an alarm with the help of a buzzer. There is an LCD screen to display the leakage, notify the observer, and trigger the exhaust fan in the particular area or section where the gas is leaking, to then extract the leaked gas [10].

Table-1. Materials used in this research.

S/N	Name of components	Number used
1	Arduino Uno Board	1
2	MQ-5 Sensor Detector	1
3	Liquid crystal display	1
4	SIM900	1
5	Buzzer	1
6	Jumper wires	24
7	Number of connections	12

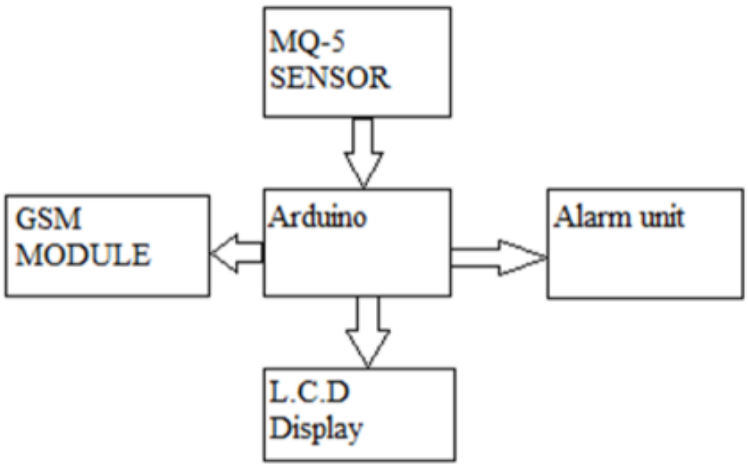

Figure-1. Block diagram of the whole system.

3. MATERIALS AND METHOD

3.1. The Materials Used in this Research

3.1.1. Liquid Crystal Display

The liquid crystal display (LCD) is now the common choice for alphanumeric, graphics, and video displays (Figure 2). These exist in many forms, but the small monochrome LM016L was selected for use in this research. The reason for choosing this particular LCD is its easy availability in markets. The small monochrome alphanumeric unit displays letters, numbers, and symbolic characters from the standard ASCII character set. The display is a standard LM016L, which can show two lines of 16 characters (16x2).

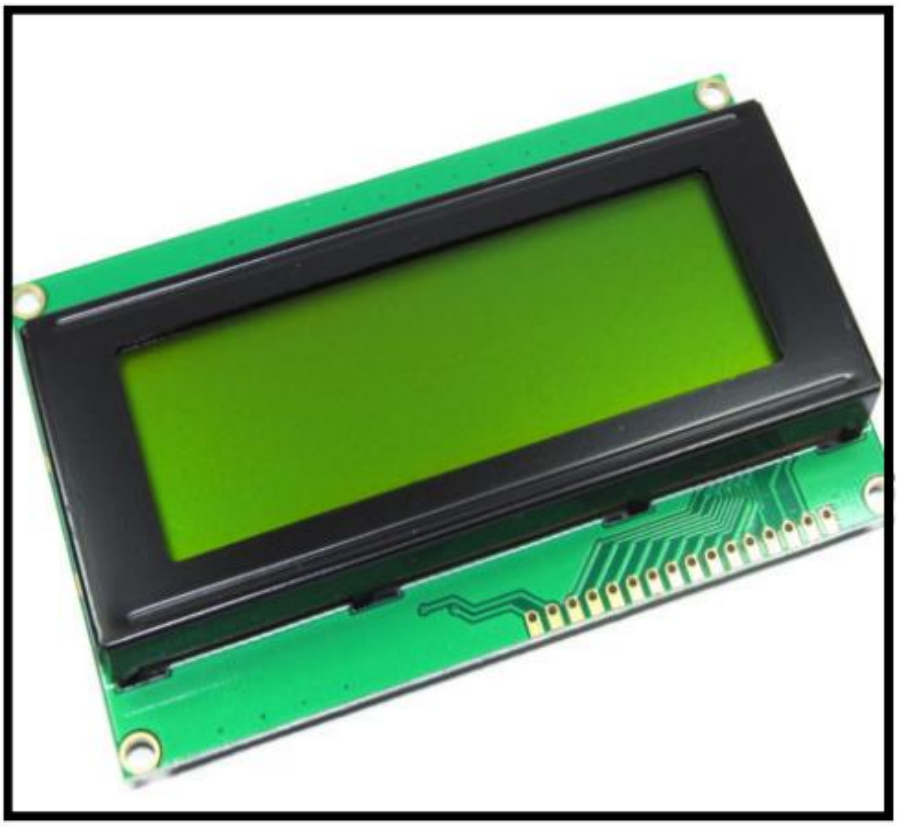

Figure-2. Liquid Crystal Display.

3.1.2. Alarm Unit (Buzzer)

The vibrating disk in the magnetic buzzer is attached to the pole by the magnetic field (Figure 3). When a fluctuating signal is transmitted through the coil, it produces a fluctuating magnetic field, which causes the disk to vibrate at a frequency equal to that of the drive signal. The magnetic buzzer is used as an alarming device within the design of the circuit; in case any form of gas leakage is detected, it will sound an alarm to notify the homeowner.

Figure-3. Magnetic buzzer.

3.1.3. MQ gas Sensor

MQ sensors are a type of gas sensor that is mainly used to detect a very wide assortment of gases, including smoke, alcohol, methane, liquefied natural gas, hydrogen, ammonia, propane, and benzene. An MQ sensor is usually

made up of an electrode which is coated in a sensing material, and is heated to make it more sensitive and reactive. When a gas reacts with these electrodes, its resistance will change, the higher the concentration of gas, the lower the resistance.

Figure-4(a). The TGS2442 gas detector sensor internal circuitry.

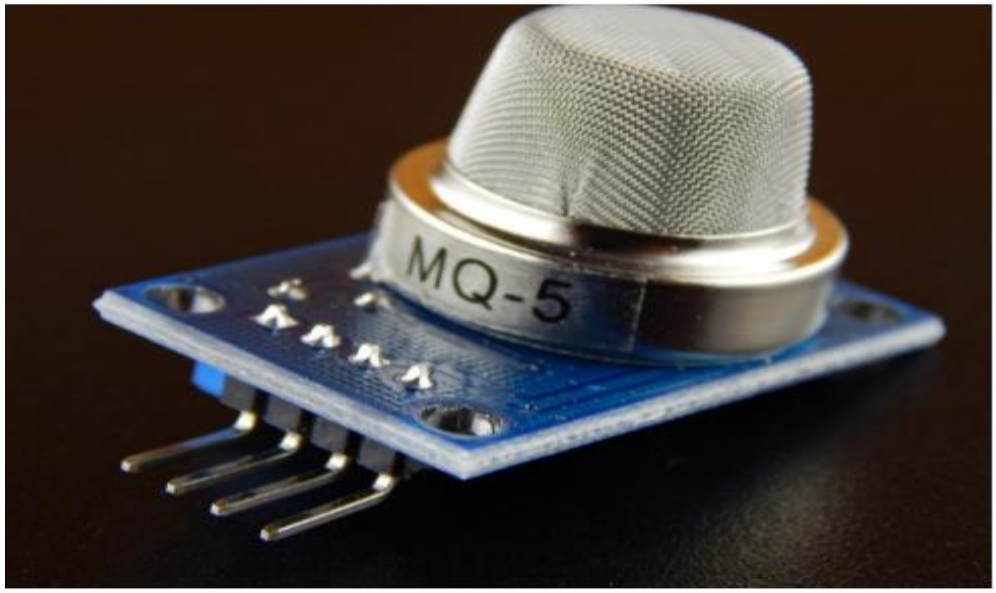

Figure-4(b). MQ-5 gas detector sensor.

3.1.4. Arduino

The Arduino is a microcontroller board based on the ATmega328P (Figure 5). The Arduino microcontroller has fourteen (14) digital pins for input and output; six (6) of these pins are used for pulse width modulation (PWM), another 6 are used as analog inputs. It also has a universal serial bus (USB) connection cable, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a power jack, a reset button, and an ICSP header.

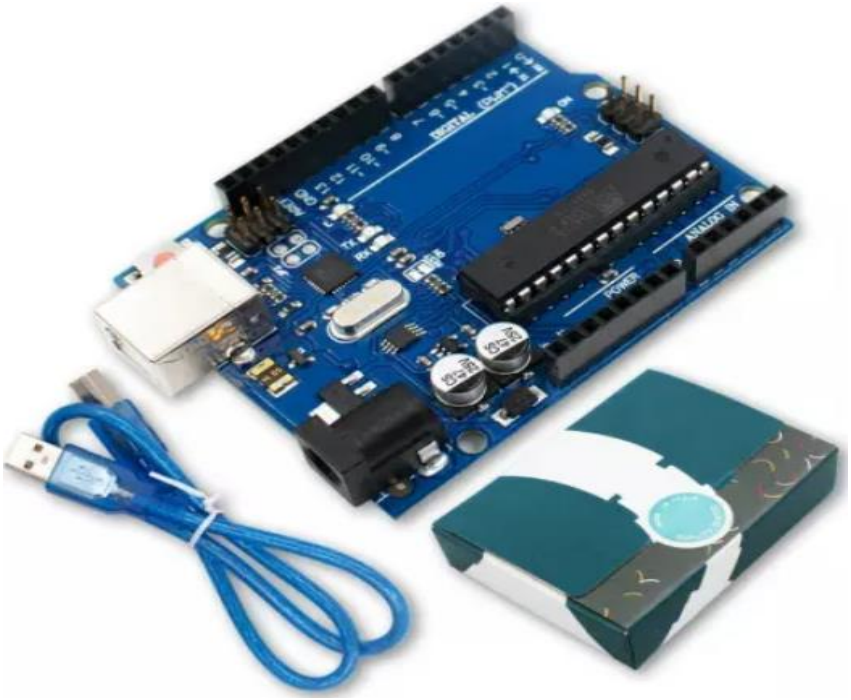

Figure-5. Arduino Uno board microcontroller.

3.1.5. The SIM900 GSM/GPRS Alert Module

The SIM900 GSM/GPRS shield is a GSM modem, which can be assimilated into a very large number of Internet of Things applications (Figure 6). There are usually three light-emitting diodes on the SIM900 GSM/GPRS shield which indicate its power status and connectivity and provide the observer with a brief overview of its status.

The PWR: This light-emitting diode is connected to the shield's power supply line. If this light-emitting diode is on, the shield is receiving power.

The status: This light-emitting diode indicates the SIM900's working status. If this light-emitting diode is on, the chip is in working mode.

Netlight: This light-emitting diode indicates the status of the cellular network the shield is connected to. It will blink at different rates to indicate what state it is in.

Figure-6. SMS Based Alert Module.

3.2. Method

This section of the study concerns the operation of the whole system (Figure 7). When the user activates the system, the Arduino will read the data transmitted bt the MQ-5 sensor when it detects a gas leakage. The Arduino will then activate the buzzer and send a signal to the LCD Display. The GSM modem gets information from the Arduino and sends a message to the designated mobile number registered in the system. Communication between the GSM modem and phone is conducted via AT command in this study. This is because the GSM modem can only comprehend AT command statements. Using this, it can communicate with phones, computers, and Arduino. To complete this study, the whole component must work together efficiently. The GSM modem acts as a medium, receiving the instructions from the Arduino and sending a message to the designated mobile number. C programming is used to develop the program for the Arduino application.

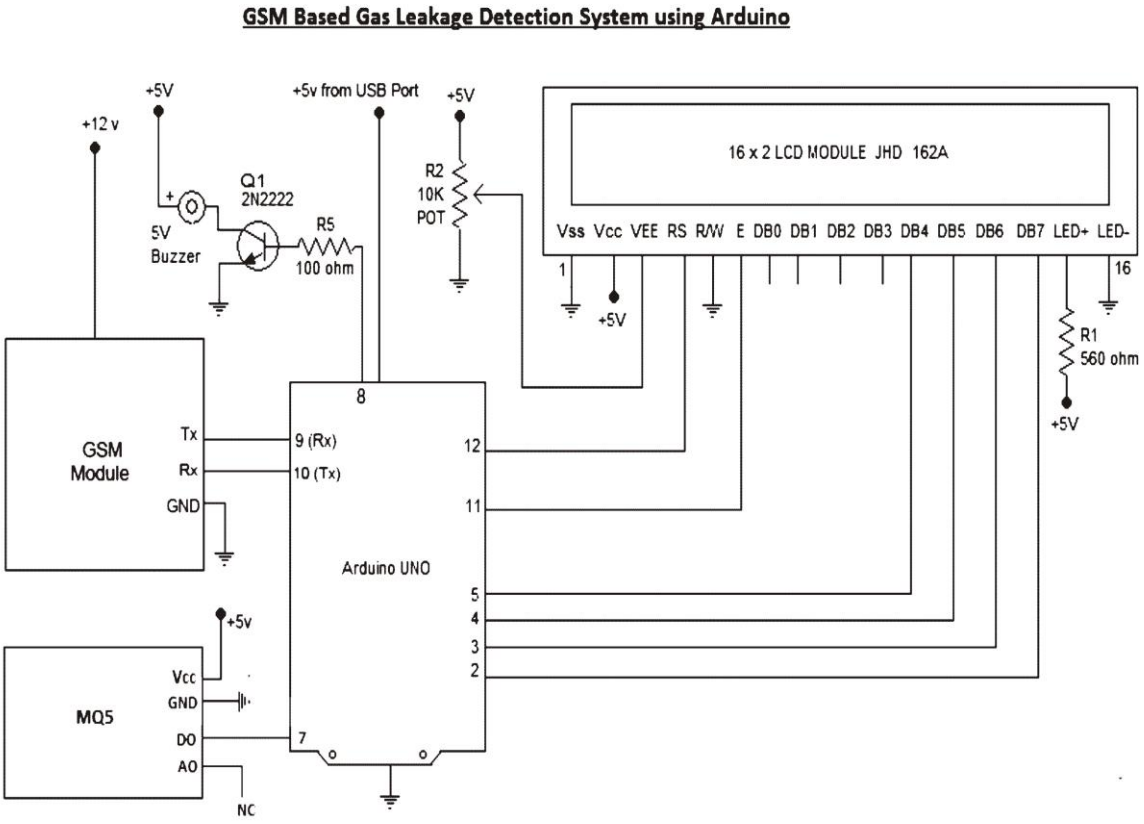

Figure-7. Circuit diagram showing all the connections between the components.

3.2.1. The Pin Assignment of the Whole System Connection is as Follows Below

LCD

The LCD RS pin to digital pin 12 of the Arduino.

The LCD enables pin to digital pin 11 of the Arduino.

The LCD D4 pin to digital pin 7 of the Arduino.

The LCD D5 pin to digital pin 6 of the Arduino

The LCD D6 pin to digital pin 5 of the Arduino.

The LCD D7 pin to digital pin 4 of the Arduino.

The LCD R/W pin to the ground of the Arduino.

The LCD V_{SS} pint to the ground pin of the Arduino.

The LCD V_{CC} pin to 5 volts of the Arduino.

The LCD V_O to 10KΩ resistor ends at +5V and ground the Arduino.

BUZZER

The ground of the buzzer is connected to the ground of the Arduino.

The V_{CC} of the Buzzer is connected to digital pin 8 of the Arduino.

GSM MODULE

The V_{CC} pin of the GSM module is connected to 5 volts of the Arduino.

The ground pin of the GSM module is connected to the ground pin of the Arduino.

The T_X pin of the GSM module is connected to R_X a pin of the Arduino.

The R_X pin of the GSM module is connected to the T_X pin of the Arduino.

MQ-5 SENSOR

The D_O pin of the MQ-5 sensor is connected to the digital pin 7 of the Arduino. In addition, the +5 volt of the Arduino is connected to the Vcc of the sensor. Finally, the ground of the Arduino is connected to the ground of the sensor (Figure 8).

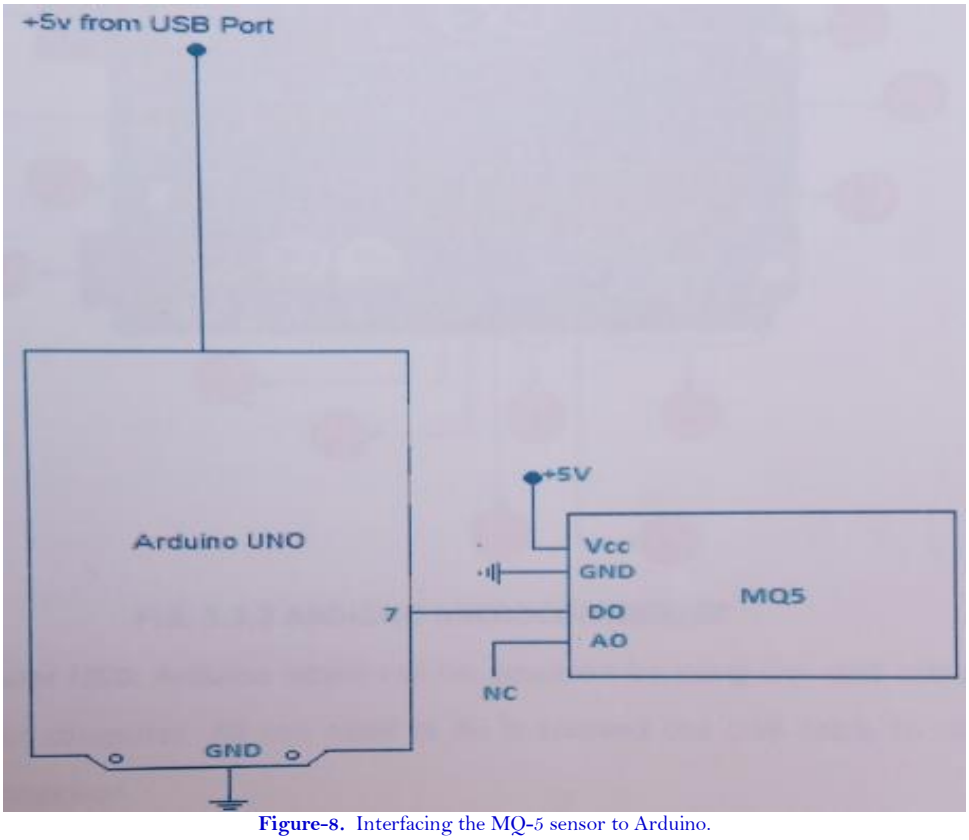

Figure-8. Interfacing the MQ-5 sensor to Arduino.

4. RESULTS

Table-2. Shows the simulation testing and results obtained.

S/N	Test conducted	Result obtained
1	System Activated	Initializing
2	After some seconds	No gas leakage, Relax please Figure 9 (a, b)
3	If there is gas leakage	Gas leakage detected in Figure 10 (a, b)
4	Message sent to the registered phone numbers	Hello boss, Gas is leaking Figure 11

Figure-9(a). Implementation result showing no gas leakage.

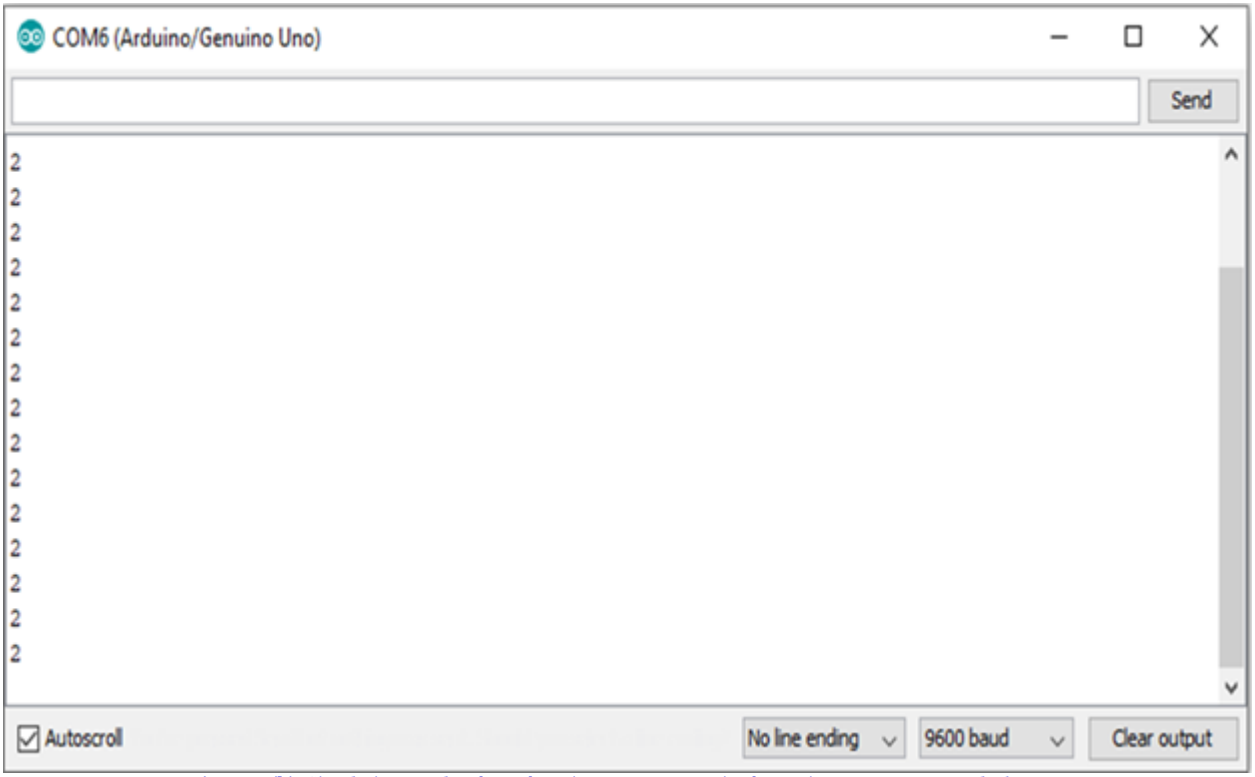

Figure-9(b). Simulation results show there is no gas present in the environment or no gas leakage.

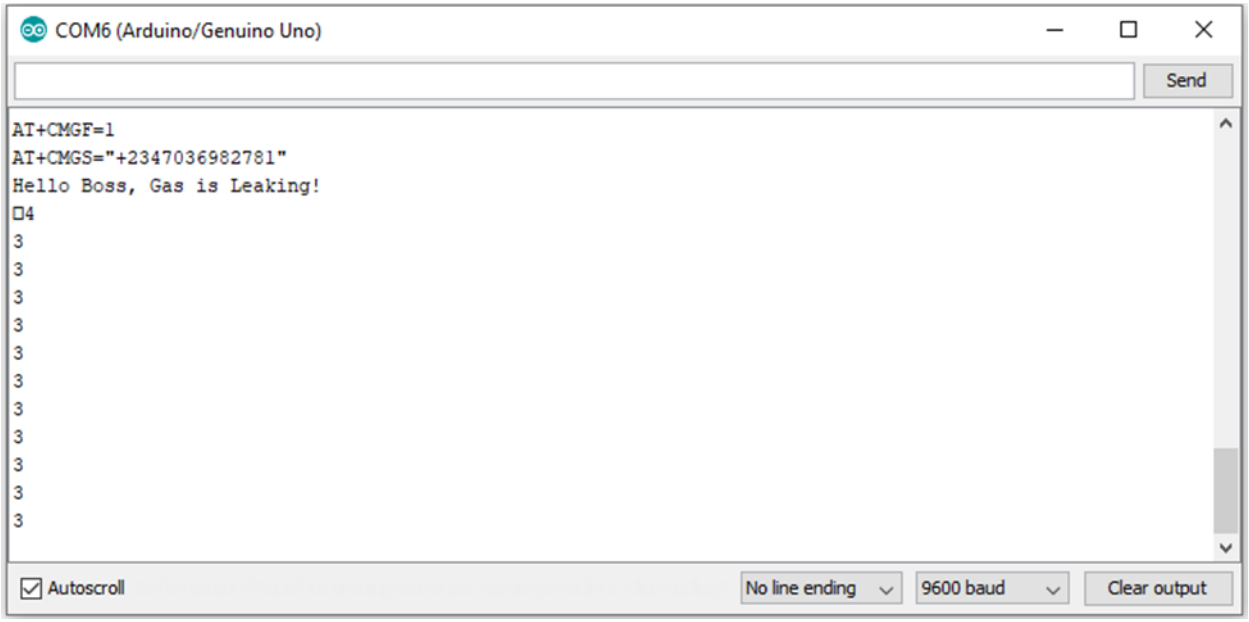

Figure-10(a). Simulation result showing there is gas present in the environment, Hello Boss, Gas is leaking.

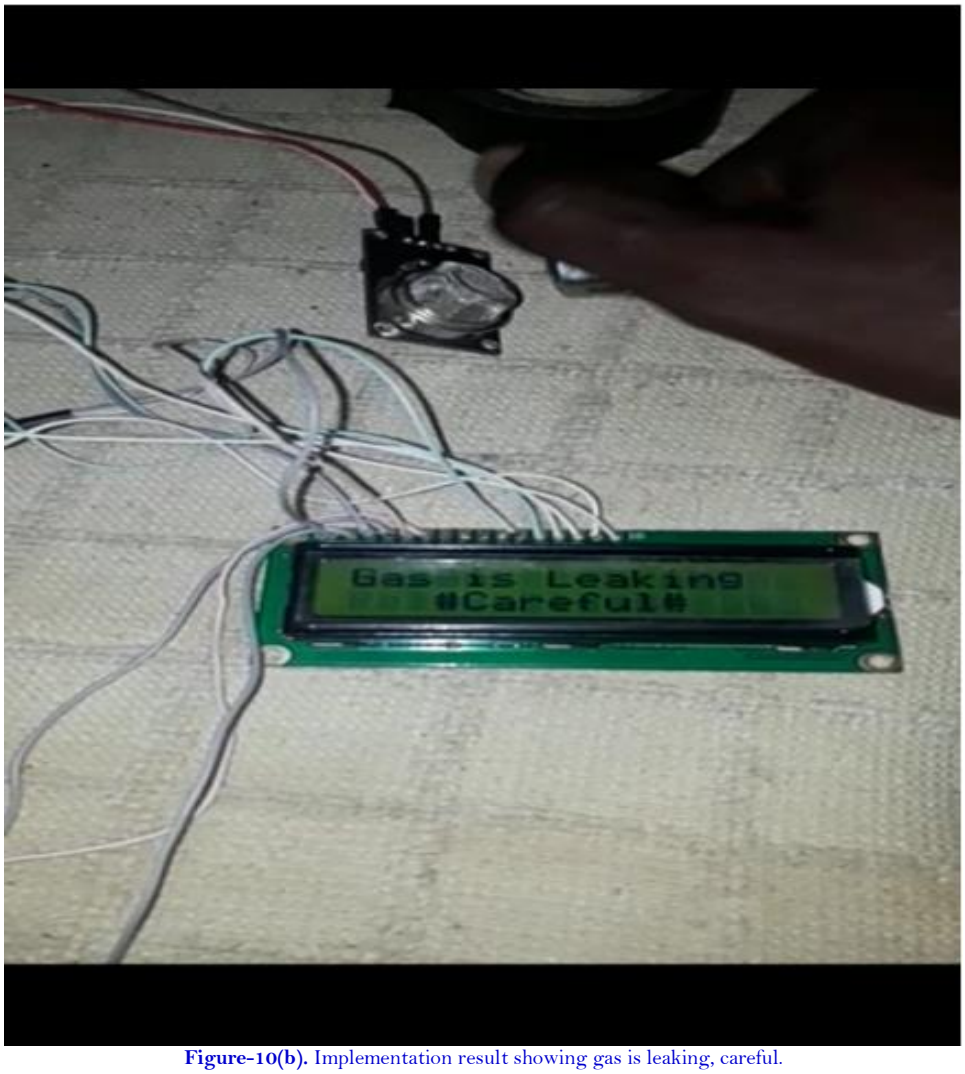

Figure-10(b). Implementation result showing gas is leaking, careful.

Figure-11. Message from the registered mobile phone showing, Hello Boss, Gas is leaking.

5. CONCLUSION

This research aimed to construct a system to detect gas leakage, when the concentration of gas is above the amount expected in the environment. When the user activates the system, the Arduino microcontroller reads the presence of gas in the environment. When it detects a concentration above the expected value, the GSM modem receives the data from the Arduino microcontroller and sends an SMS to the owner's mobile phone. To allow communication between the GSM modem and the mobile phone, AT command is used, because the GSM modem can only understand AT commands. Using this, it can communicate with a mobile phone, computer, and the Arduino microcontroller.

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Competing Interests: The authors declare that they have no competing interests.
Acknowledgement: All authors contributed equally to the conception and design of the study.

REFERENCES

[1] M. B. Ahmad, A. A. Abdullahi, A. S. Muhammad, Y. B. Saleh, and U. B. Usman, "The various types of sensors used in the security alarm system," *International Journal of New Computer Architectures and Their Applications*, vol. 9, pp. 50-60, 2019. Available at: https://doi.org/10.17781/p002618.

[2] A. M. Baballe and M. Cavas, "A review advancement of security alarm system using internet of things (IoT)," *International Journal of New Computer Architectures and their Applications*, vol. 9, pp. 38-49, 2019. Available at: https://doi.org/10.17781/p002617.

[3] M. B. Ahmad, A. S. Muhammad, A. A. Abdullahi, A. Tijjani, A. S. Iliyasu, I. M. Muhammad, I. Ibrahim, S. Tijjani, Y. Idris, and I. K. Dahiru, "Need for security alarm system installation and their challenges faced," *International Journal of New Computer Architectures and Their Applications*, vol. 9, pp. 68-77, 2019.

[4] D. Arulanantham, P. Divahar, E. Sanjana, V. G. Varshini, and K. K. Vasantha, "Automatic gas leakage detection and management," *International Journal on Engineering Technology and Sciences*, vol. 7, pp. 92-96, 2020.

[5] N. M. Hussien, Y. M. Mohialden, N. T. Ahmed, M. A. Mohammed, and T. Sutikno, "A smart gas leakage monitoring system for use in hospitals," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 19, pp. 1048-1054, 2020. Available at: https://doi.org/10.11591/ijeecs.v19.i2.pp1048-1054.

[6] S. Nazarov and B. Jumayevon, "Smart alarm system for gas leakages," *International Journal of Engineering Research & Technology*, vol. 9, pp. 973-976, 2020. Available at: https://doi.org/10.17577/ijertv9is050508.

[7] M. M. Khan, "Sensor-based gas leakage detector system," presented at the 7th Electronic Conference on Sensors and Applications, 2020.

[8] 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, pp. 13-24, 2015. Available at: http://dx.doi.org/10.14257/ijsh.2015.9.4.02.

[9] A. Manhas, N. Chambyal, M. Raina, S. Dutta, and P. Singh, "LPG gas leakage detection using IoT," *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, vol. 7, pp. 520-526, 2021. Available at: https://doi.org/10.32628/CSEIT2174121.

[10] B. F. Alshammari and M. T. Chughtai, "IoT gas leakage detector and warning generator," *Engineering, Technology & Applied Science Research*, vol. 10, pp. 6142-6146, 2020. Available at: https://doi.org/10.48084/etasr.3712.