Sensor Based Smart Automated Gas Leakage Detection and Prevention System

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***Abstract*— Liquefied petroleum gas (LPG) is commonly used for heating, cooking, automotive power, and various other uses worldwide. LPG is a particularly flammable gas, and LPG leaks cause significant incidents. The cause may arise from improper installation to the use of faulty gas cylinders. Since LPG is an extremely volatile and flammable gas, a reliable safety system has been designed and developed using IoT (Internet of Things) capable of detecting gas leakage, turning on the emergency alarm, tracking the location, and sending alerts messages to users and nearest helpline number. The proposed model sort out into four modules, such as Gas Detection Module (GDM) always detect the gas leakage to avoid unexpected incidents; Location Detection Module (LDM) track the gas leakage location and pass the value to NM; Notification Module (NM) is responsible for generating the message service to notify the nearest help center and user; In the case of a gas leak, the Alarm Module (AM) is responsible for activating an emergency alarm. The result shows the system successfully performed. It can be noted that the proposed can be embedded with any environment, including home, office, ship, industry, etc.**

Keywords*— *Automation, Internet of Things, Embedded system, Arduino Uno R3, Liquefied petroleum gas, Gas leakage, Breadboard, Gas Detection Module, Location Detection Module, Notification Module, Alarm Module

I. Introduction

Liquefied petroleum gas (LPG) leaks have been reported to cause major incidents that have cost millions of dollars in fatalities and property damage around the globe. Since LPG is one of the most widely used fuels in Bangladesh, caution is advised to avoid incidents such as fires and suffocation that are connected with its use [1].

Security is still a top concern in the home, office, and business. In this regard, less costly methods of avoiding accidents and catastrophes in the gas and oil business are often utilized, but these measures must be effective. The extent of defense against danger and destruction is referred to as security [2]. Early alarm warnings need the assistance of automation to guarantee that adequate time is sufficient to avoid possible hazards. This report illustrated gas leakage detection systems, along with troubleshooting instructions [3, 4]. Even though constructing a device with a gas sensor is not as simple as it might seem [5, 6], an alert system based on an ESP (WiFi) network has been created. The technology detects environmental methane gas and propane. When a gas leak is discovered, the circuit's sensors inform the user, the ESP modem is activated, and a customized dashboard sends a warning notice. The device sends out real-time notifications, allowing for urgent health and safety interventions and extending the time required to resolve the crisis [7, 8]. The same machine may be used in a variety of settings, including kitchens, oil and gas pipes, and gas storage facilities [4]. When gas is used, there is still the possibility of leakage, endangering human lives and property [9, 10].

Consequently, building a low-cost gas leak detector will contribute to the gradual reduction of this threat. Carbon (LPG or methane) leaks in households and factories have resulted in many collisions (mainly oil and gas industries). Several lives and assets have been lost as a result of these leaks, which have resulted in fires and blasts [11].

Gas leakage is unavoidable in pipeline gas transfer since joints and other transmission components are needed. Gas leakage can be overlooked up to a particular mass stage, so lifting an alert must be lifted once it exceeds specific threshold values [12]. The issue was primarily found in the home for irresponsible. The IoT enables real-time and remote detection of gas leaks [13]. The IoT is a linked device system that uses programming, sensors, and network connectivity to collect and exchange data. To stop the accidents that occurred by gas leakage, an intelligent embedded system is proposed [14]. Our proposed method can detect gas leakage and activate the emergency alarm, besides sending an alert message to emergency contact and nearest help center with the appropriate location.

The rest of the work is closely allied. This section outlines the significant developments in gas detection. Section II discusses the analytical methodology used to build the whole system. Section III explores the design and architecture of the proposed method, whereas Section IV analyses the resultant structure. Section V finishes with a discussion of observations and shortcomings and future development goals.

II. PROPOSED SYSTEM

The purpose of this paper is to enable people to take urgent action in the event of a gas leak. LPG gas leaks may happen because of a hose attachment that is not waterproof or because the hose itself is weak and can be infiltrated by gas due to poor hose construction. This may be due to the tube's valve not fitting on the stand, or it may be similar to what the writer has seen while cooking gravy food that has overflowed, causing the stove to catch fire. As a result, the gas gush continues unabated, filling the kitchen with gas. Since LPG is thicker than air, it would be very harmful if gas leaks in the kitchen. If the air weights one unit weight of LPG, the gas weighs two units weight. The quantity of gas might have accumulated naturally and is already present in the explosive mixes. Despite being lit or burned with such a spark plugs flame, a 1.8 percent LPG gas ratio to air would just not burst or combust. However, when there is no fire or electric static, and the gas level is between 1.8 and 10%, it will burn violently. It can only light up if there is 10% LPG in the tank. This is due to the essence of the LPG gas combination. LPG explosions with a volume of 1.8% to 10% are perfectly classified, resulting in a horrific loss of power lines, and the blast power is often dependent on the volume of the substance erupted. When a bomb explodes, all of the air in the world is used up, and the area becomes a void, causing those in the immediate area to suffer injuries and have trouble breathing. The nearby structures would be subjected to the brunt of the air movement. LPG erupted on a substance of 1.8% to 10%, but there was no fire. If there is a burn, it ensures that the gas content is still 10% on (flammable) and there would be no blast. This system is developed so that the system can detect the gas leakage immediately (gas in the air between 1.8% to 10%) and take action for ensuring safety.

Design the proposed system to detect or read the value (gas) from specific environment air and analyze the collected value for safety from unexpected incidents [15]. Firstly, it is required to set up the embedded system where LPG gas is used in home (Kitchen). Gas Sensor MQ2 will always monitor the air to detect the leakage gas (LPG), when LPG gas is mixed with the room air, the air becomes heavier. So, it's easy to detect the LPG gas from air for the sensor formula. This sensor is also capable to detect other gases (Like i-butane, nitrogen, gasoline, hydrogen, smoke). There's two led light (green, red) integrated with the system, green is always turn on mode when any leakage found the red light will turn on and the emergency alarm will be activated. Then Ublox NEO-6M GPS sensor will detect the home location and send it with an alert message to the nearest help center (Like Fire service) and emergency phone number (specific person) with the help of GSM SIM800L sensor, any type of help center number can be given here programmatically.

Fig. 1 illustrates the suggested embedded system's flowchart design.

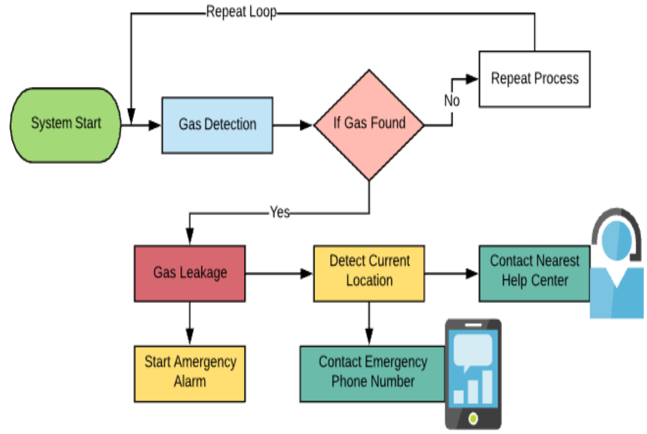

Fig. 1. The proposed system's flowchart diagram.

This research work aims to construct and build an algorithm based on an intelligent automated embedded system. Algorithm 1 depicts the system's overall flow.

Algorithm 1: The Complete System's Functioning Procedure

Input: Gas (From Scanning Environment)
Output: Safety Ensure

```
1:   Import Library;  [Python_Library]
2:   Scanning Gas ();  [Using_Smoke_Gas Sensor-MQ-2]
3:        While (Scan until gas found)
4:             If (found == gas)  [LPG, i-butane, nitrogen, gasoline,
                                   hydrogen and etc.]
5:                 Activate alarm (); [Using_Buzzer]
6:                 Track location ();  [Using_ Ublox_NEO-6M]
7:                 Send alert message ();  [Using_ SIM800L]
8:                         Call location function ();
9:                         Emergency contact (Location);
10:                        Help Center (Location);
11:                Break;
12:             Else
13:                Continue;
14:        End while
15:  Repeat step 2;
```

III. SYSTEM DESIGN AND ARCHITECTURE

The system under consideration is made up of four (4) components. These are as follows:

1. Gas Detection Module (GDM).
2. Location Detection Module (LDM).
3. Notification Module (NM).
4. Alarm Module (AM).

As seen in Fig. 2, the proposed system's overall circuit diagram comprises the modules GDM, LDM, NM, and AM.

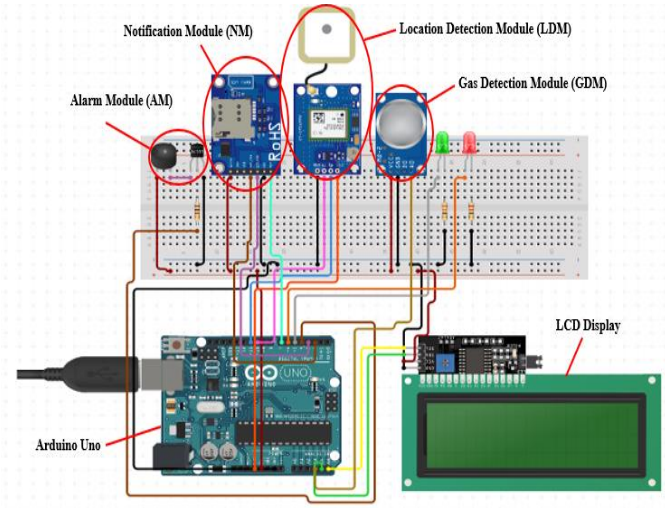

Fig. 2. Circuit Diagram for the Entire System.

In the GDM, the sensor detects the Gas from the environment. If any gas is found sensor will pass the value to Arduino After processing the data, the recommended method sends an emergency notification to urgent numbers and the nearest assistance center. MQ2 Gas Sensor was used to build this module. Gas Sensor (MQ2) is a handy module for recognizing gas leaks. Gases such as LPG, nitrogen, i-butane, gasoline, hydrogen, and smoke will be detected. Due to its fast response time. As quickly as possible, samples should be made. The MQ2 sensor will be connected to the breadboard and the Arduino Uno R3. Breadboard, MQ2 sensor, and Arduino Uno R3 Pins have been integrated. Bus POS/Arduino 5V to MQ2 5V, Bus GND/Arduino GND to MQ2 GND , and Arduino A3 to MQ2 AOUT have been connected.

The GDM's circuit design is seen in Fig. 3.

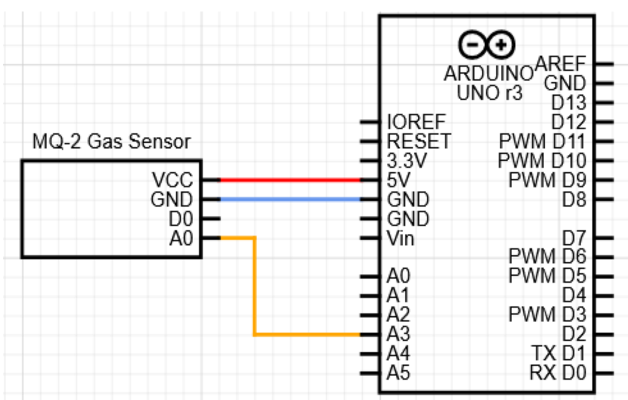

Fig. 3. Gas Detection Module (GDM).

In the LDM it will track and send the location details to the emergency contact number and nearest help center (Fire Service) if any gas leakage is found [16, 17]. Ublox NEO-6M GPS Module, a device that can map up to 22 satellites and pinpoint positions all over the planet is used. It may be an excellent starting point for those interested in learning all about GPS. Ublox NEO-6M GPS sensor will connect directly to the breadboard and Arduino Uno R3. Ublox NEO-6M GPS Module, breadboard, and Arduino pin GPSNeo6M GND to Bus/Arduino GND, GPSNeo6M TX to Arduino Uno 10, GPSNeo6M RX to Arduino Uno 11, and GPSNeo6M VCC to Arduino Uno R3 3.3v have been integrated.

The circuit schematic in Fig. 4 illustrates the usage of the LDM.

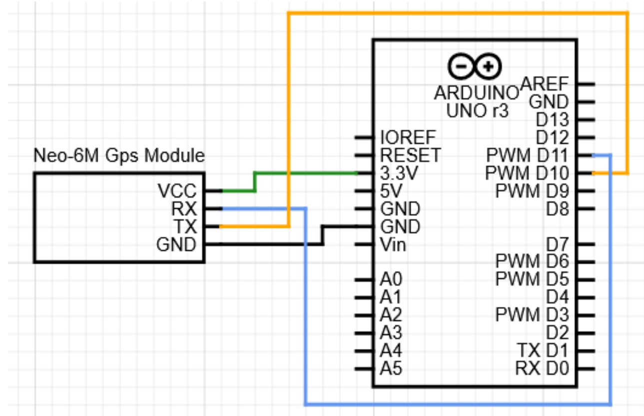

Fig. 4. Module for Location Detection (LDM).

The NM module is a robust approach that includes our proposed system [18]. It is responsible for notifying the nearest help center and sending alert messages to emergency contact (like homeowner) with the appropriate location. This module was constructed using a quadband GPRS-GSM SIM800L. If a gas leak is detected, it sends an alarm message to the emergency phone and support center with a location. The SIM800L is a small and lightweight quad-band GSM/GPRS system equipped with a quad-band antenna. A functional SIM card enables you to conduct phone calls, send text messages, and surf the web. The SIM800L quadband GPRS-GSM module will be directly coupled to the Arduino Uno R3 and breadboard. Arduino Uno R3, breadboard, and SIM 800L Module pinouts SIM 800L 5V to Bus POS/Arduino 5V, Arduino 2 to SIM 800L TXD , Arduino 3 to SIM 800L RXD, Bus/Arduino GND to SIM 800L GND, Arduino 7 to SIM 800L RST.

Fig. 5 shows the NM's circuit diagram.

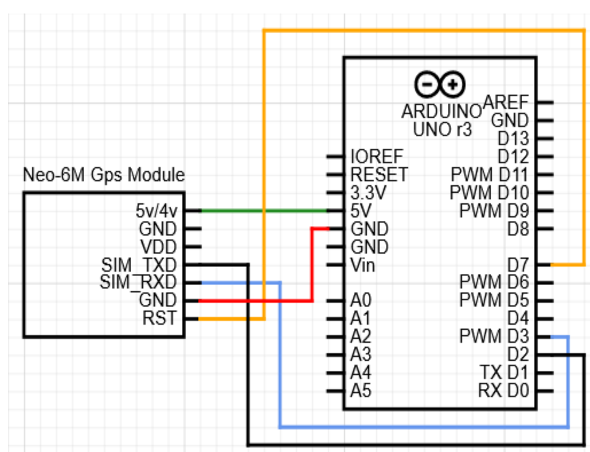

Fig. 5. Notification Module (NM).

The AM is responsible for triggering the alarm. When the gas sensor detects the gas, the proposed embedded system will turn on the red light and activate the alarm to alert the people there. Buzzer is used to build this module. This is a little buzzer that emits an extremely loud 2KHz beep. The buzzer will be wired to the Arduino Uno R3, the breadboard and the NPN BC337 transistor. Breadboard, buzzer, Arduino Uno R3 and transistor, pins Link the Buzzer POS to the Arduino Bus POS, the TSBC337 C/Arduino GND to the Buzzer neg, the Bus GND to the TSBC337 E, and the Arduino 4 to 1k ohm Resistor.

A circuit diagram depicts the usage of the AM in Fig. 6.

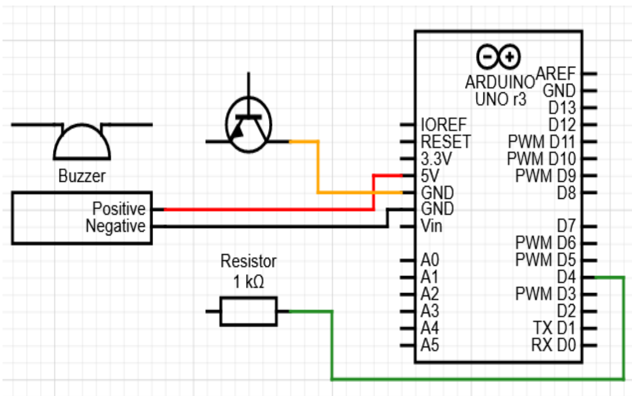

Fig. 6. Alarm Module (AM).

IV. Analysis and Implementation

Hardware has been embedded into the embedded computing gas safety system in order to build it. Arduino Uno R3, Breadboard, MQ-2 Smoke Gas Sensor, Ublox NEO-6M GPS Module, SIM800L QuadBand GPRS-GSM Module, Buzzer,LCD Display (20x4 12C), Basic Green LED (5mm), Basic Red LED (5mm), and Transistor (NPN BC337) are all required components.

Fig. 7 depicts the used components to build up the proposed system.

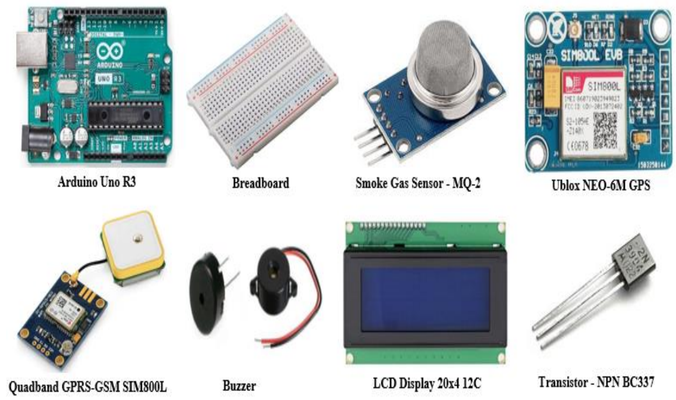

Fig. 7. These components are used to design and develop the gas leakage detection and prevention system.

All of these components have been combined to create the proposed embedded system. Fig. 8 depicts the overall system diagram.

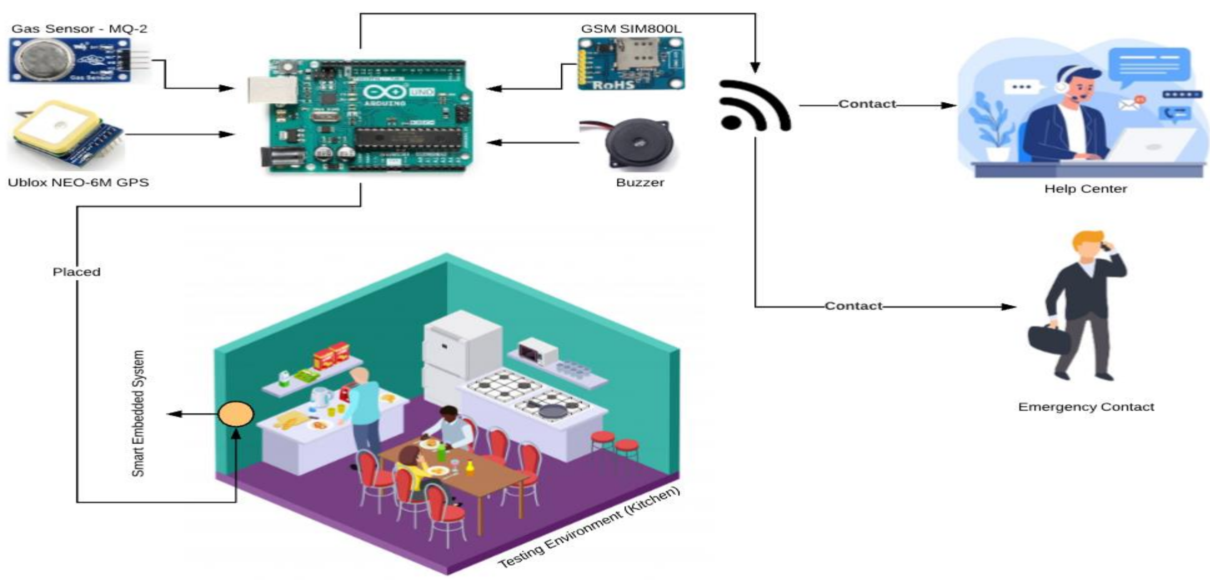

Fig. 8. The proposed smart embedded system's complete solution diagram.

Usually, 15 tests evaluate the proposed smart embedded system performance. A medium-size about 95 square feet kitchen room is selected to deploy the embedded system. The room is made airtight and the room temperature to 28 °C. Firstly, the device is set up near the stove, a distance of about 1.5m between the device and stove. Then the stove is turned on to leak out the gas. When the system detected the presence of gas, it required 0.5 secs to identify it, trigger the red Led bulb with an urgent siren, and send alarm messages to the phone numbers set on the device.

After that, in test phase 2, the device is set up to become more distant about 2m from the stove and the device successfully performed as well. Similarly, 15 tests are performed and tried to set up the device at the max distance from the stove, and our concern was the device could perform in any corner of the kitchen room. For the rest of the 13 tests, the distance is increased in every step. With more length, the device takes slightly more time to respond because when LPG gas leaks, it takes time to mix with the air, and when the device is far away from the stove, it takes time to reach the LPG mixed air. It is noted that the max response time of 5.2 seconds with a max distance of 8.5m. Table. I summarizes the outcomes of the experiments.

TABLE I. OUTPUT OF THE PROPOSED SYSTEM'S PERFORMANCE EVALUATION

Number of Tests	Stove Distance (m)	Response Time	Result
1	1.5	0.5	Pass
2	2	1.15	Pass
3	2.5	1.38	Pass
4	3	2.01	Pass
5	3.5	2.32	Pass
6	4	2.49	Pass
7	4.5	3.05	Pass
8	5	3.21	Pass
9	5.5	3.39	Pass
10	6	3.59	Pass
11	6.5	4.11	Pass
12	7	4.25	Pass
13	7.5	4.44	Pass
14	8	5.01	Pass
15	8.5	5.2	Pass

The suggested system response output is shown in Fig. 9. Overall, the device performs well, and the trendline demonstrates that response time grows proportionately with increasing distance.

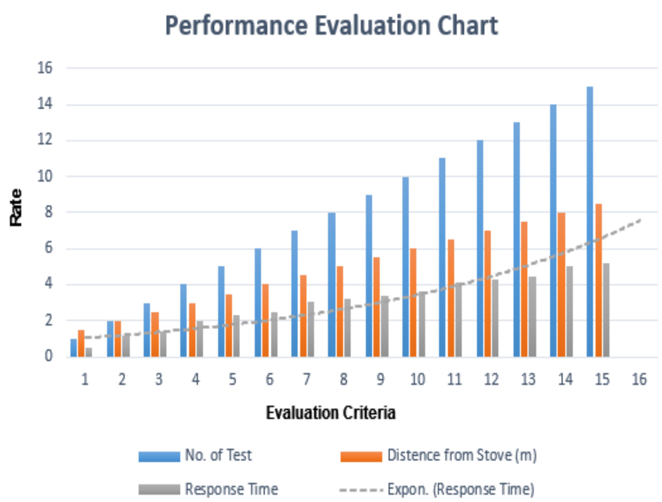

Fig. 9. Performance Evaluation Chart.

Table. II depicted the estimated cost of the proposed system. It can vary on the marketplace, country, and demand [19]. This work has been developed at a very low cost so that anyone can afford and ensure safety.

TABLE II. ESTIMATED COST FOR PROPOSED SYSTEM.

Hardware Components	Price
Arduino UNO R3	450 tk
Breadboard	90 tk
Ublox NEO-6M GPS Module	900 tk
MQ-2 Sensor	120 tk
SIM800L Quad-Band GPRS-GSM	900 tk
I2C LCD Display 20x4	200 tk
Basic Led light * 2	60 tk
BC337 NPN Transistor	20 tk
Resistor 1K Ohm	5 tk
330 Ohm Resistor	5 tk
220 Ohm Resistor	5 tk
Wires	80 tk
Total	2835 tk

V. CONCLUSION

After the setting was established, the model successfully recognized the gas leakages, and a warning was delivered over the Wi-Fi network. The notification was sent to the server to alert the recipient. The warning (Buzzer) is instantly activated to notify others of their presence and avert potential explosion and fire threats. This smart system has several safety advantages critical for detecting gas leaks early and responding to avoid LPG leaks. There will be no risk if the gas supply stops in the pipeline within a specified time. Additionally, the device may be utilized for a variety of functions, including gas leak detection, when combined with deep learning [20-22], transfer learning [23-25], and computer vision [26-30]. It will be attempted to combine them to provide the most effective product in future research.

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