Smart Gas Leak Management System

BMDP Rathnayake[1#], RMCP Ranasinghe[1], ERMCK Rajapaksha[1]

[1]*Faculty of Engineering, General Sir John Kotelawala Defence University, Ratmalana, Sri Lanka*
[#] *38-eng-0046@kdu.ac.lk*

Abstract— *Smart LP gas leakage management system is designed in a way to enhance residential safety. An intelligent system which is capable of timely detection and resulting in the best appropriate response is required as LP gas leaks pose a significant risk in households. The system utilizes two MQ-2 gas sensors positioned near the gas cylinder and the gas cooker for broad coverage. After detecting a gas leak, the system undergoes a few processes like activating an exhaust fan, opening windows for ventilation, cutting off the power supply of the whole house and a loud buzzer is triggered to alert the occupants. Moreover, the system is integrated with a mobile application via Bluetooth, allowing home users to remotely control any component in the system. More importantly the system has a notification feature, sending alerts to users' mobile phone when there is a gas leakage. The effectiveness of the system is demonstrated by the experimental results. The research contributes to the field of smart gas leak management systems, developing residential safety and enabling dynamic gas leak detection and response mechanisms.*

Keywords— **LPG, Real time response, GSM, Mobile alerting system, power control mechanism.**

I. INTRODUCTION

Liquified Petroleum gas which is also called as propane or butane is widely used for cooking and heating purposes. It is known to be a highly flammable gas. Therefore, leakage of this type of a gas can bring significant risks to households.

Meanwhile, 815 gas explosions have been reported in Sri Lanka in the period 01-11-2021 to 18-11-2021 (Amani, N., 2021). A gas cooker used to cook meals for patients at the Anuradhapura Teaching Hospital had caught fire this afternoon, and the News 1st correspondent reported that three gas cylinders were detached from the cooker and that gas leaks were identified in two of them. Meanwhile, a gas cooker had exploded at a house in Vihara Paalugama in Anuradhapura, with no injuries being reported. However, a youth was injured after a gas cooker had exploded in Udupussallawa. Additionally, a gas cooker had also exploded at a house in Welambada in Gampola, yet no one was injured in the explosion. Occupants of the house said the gas cylinder contained a tri-colour seal. More gas cookers have exploded in Raththota in Matale as well. Furthermore, the gas consignment that reached the country on the 'Pericles' tanker this week was allowed to be used in cylinders following tests. Tests were conducted for the second time on the standards of LP gas that reached Sri Lanka on the Epic Balta tanker on Saturday (18) (Amani, N., 2021).

Because of these incidents and having the potential to initiate fire, explosions and health hazards building of a smart gas leak detection and management system was required.

In this research paper, the design and implementation of the management system was presented. The system includes a series of safety measures to mitigate risks like measuring the gas level by two MQ-2 gas sensors, activating an exhaust fan when the gas leak is detected, a power supply control mechanism, a buzzer, a LCD display which shows all the commands including the gas levels, a mobile alerting system, opening all the windows of the relevant section and also incorporates system control via Bluetooth communication, allowing users to control all the system functionalities. The special function in power control mechanism is that it cuts off the electrical power of the whole house, mitigating the risk of accidental ignition caused by electrical sparks. This is done by short circuiting the live wire and the earth wire of the place. Moreover, this includes the option that the components of the system can be controlled using a mobile app via Bluetooth. This option is only available for home users. The whole circuit and all the other components in the system will be powered up by the external power sources.

In conclusion, the paper represents the comprehensive overview of smart LP gas management system featuring its key features, functionalities. The goal is to contribute to the field of IoT enabled safety systems, setting the stage for future developments in gas leakage management technologies and home automation.

II. LITERATURE REVIEW

Dorge, P. et al. (2023) suggested a system which is built on a Node MCU. This includes a buzzer, a MQ135 gas sensor. When a gas leak is detected, the sensor will alert the microcontroller. Then an emergency valve will be shut off. In here the leakage is found by monitoring the variations in the infrared radiation intensity. When the relevant

circumstances arise, both the alarm and the emergency shut off valve will be turned on.

Shrestha, S., Anne, V. P. K. and Chaitanya, R. (2019) describe about a gas leak detector which notifies the user with a SMS and call so that he/she can turn off the gas valve from anywhere he/she wants. The buzzers will be activated whenever the gas leakage is detected. This also has the facility to automatically book a gas cylinder whenever the load sensor detects the weight of the cylinder to be lower than the given threshold value.

Aman, F. et al. (2022) proposed a system which combines the gas leak detection with an IoT system which provides the mechanism to contain the severity of gas leakage and send real time alerts. In this system for the gas detection an MQ-6 sensor and NodeMcu with ESP8266 Wi-Fi module is used. Then an exhaust fan will be activated through a relay which instantly reduces the leaked gas concentration inside and a notification will be sent to the user through an app. All the information will be transferred over the internet to a database. That information will be accessed through an app configured specifically for the accessibility by the user.

Santiputri, M. and Tio, M. (2018) proposed a device, monitoring the area continuously. The data is provided to the NodeMcu and then the results are displayed as a warning to the user via an Android based smartphone.

Tasnim, Z. et al. (2022) proposed a model which sort out into four sections. The gas detection module (GDM) always detects the gas leakage, and the location detection module (LDM) tracks the gas leakage location and pass the value to notification module (NM) which is responsible for sending the notification to the nearest helping centre. the alarm module is responsible for activating an emergency alarm.

III. METHODOLOGY

Two MQ-2 sensors are used detect the gas leakage from the gas cooker and the cylinder and transmits the values to the microcontroller (Arduino ATmega328P). The gas values are continuously shown in an LCD display. when the threshold value is exceeded by the gas sensor the Arduino sends signals to all the other components in the system. The buzzer will be activated so that the home users can notify the gas leakage. The notification is sent to the users' mobile alerting the gas leakage. As the damage minimizing steps the windows of the relevant section will be opened as soon as the leakage is detected. An exhaust fan will be activated to suck all the air inside the section to the outside. At the same time power of the house will be cut off by short circuiting the live wire and the earth wire of the house through a relay. Then the trip switch of the house will be automatically turned off disconnecting the electricity supply.

Arduino uno is a microcontroller which is powered by ATmega328P microcontroller which is like the brain of the management system.MQ-2 sensor is used to detect gases like methane, butane, propane and more. Once this sensor is exposed to the environment it may have varying sensitivity levels with different types of gases. So, to calibrate the sensor accordingly we should expose this sensor to the known concentration of this gas and adjust the readings accordingly (ARDUINO, 2021). GSM 800L wireless communication. Which is used to send the notification to the user. To rotate the windows of the prototype 2 servo motors were used. The primary function of the exhaust fan is to remove unwanted air from the space.

The basic function of the relay module is to control the switching of electrical power between different components which was used to cut the power when the gas is leaked. The frequency of the buzzer can be customized and sounds when a gas leakage is detected. Typically consists of a trigger mechanism. HC-05 is widely used to enable wireless connection between devices. This supports data transfer rates up to 3 Mbps (Nasir, S.Z, 2019). LCD display consists of a layer of liquid crystals kept between two transparent electrodes and two polarizing filters. This is used in this system to show the gas levels and alert messages.

IV. SYSTEM FLOW CHART/SYSTEM BLOCK DIAGRAM

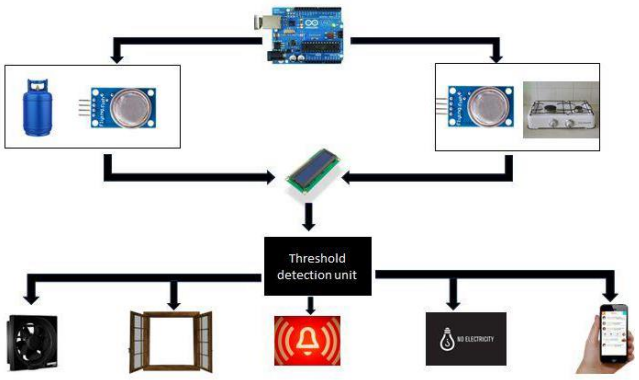

Figure 1: System block diagram

The system will be powered up by two external batteries. First, the user needs to turn on the system using the manual switch. The gas level will always be displayed in the LCD display. The system includes 2 gas sensors, one for the gas leakages happens from the gas cylinder while the second one for the gas leakages that could arise from the gas cooker. We can manually turn off the gas sensor 2 when the cooking is done using the gas stove as the LP gas concentration is usually high at that occasion. First the code displays the amount of gas(ppm) in the air using the LCD display while checking there is a gas leakage. If a gas leakage is detected by either one of the sensors or both sensors. The windows of the kitchen will be rotated by 90 degrees to the outside automatically, buzzer will be activated, exhaust fan will be activated, trip switch of the house will be turned off and a SMS will be sent using SIM 800L GSM module. The power

to the GSM module was given by the microcontroller through a buck converter. The required power by the GSM module was only 3.3V. supplying more power to the GSM module could damage it.

If there is no gas leakage detected the system will keep displaying the concentration of gas in this surrounding.

In here gas sensor near the gas cylinder (gas sensor 1) and gas sensor near the stove (gas sensor 2) is turned on all the time except when it comes to cooking gas sensor 2 is turned off.

In the cooking scenario,

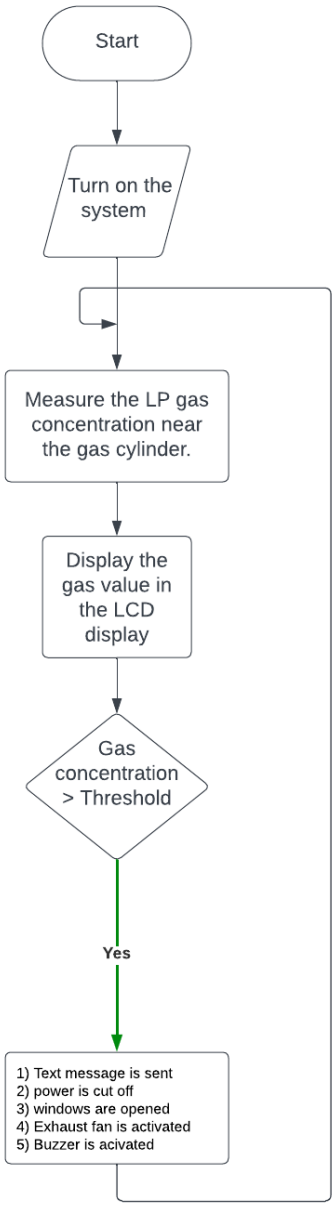

Figure 2: Flow chart 1

In the normal scenario,

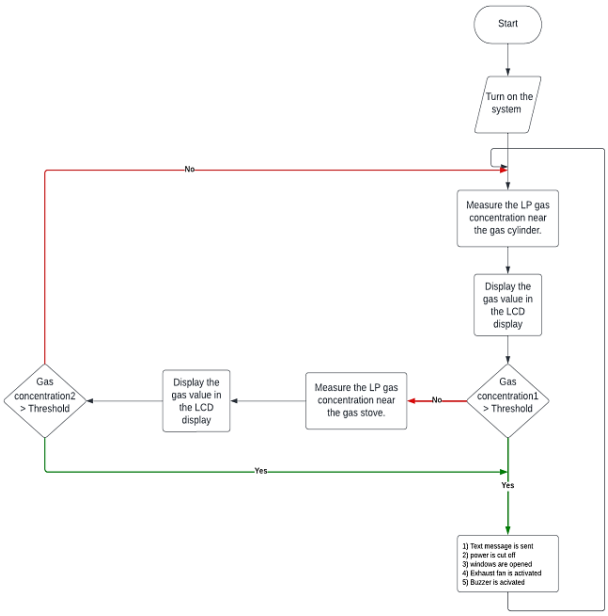

Figure 3: Flow chart 2

V. RESULTS

The experimental set up is shown in figure 8 and the system flow charts are indicated in Figures 2 and 3. The gas values will be displayed in the LCD display. This MQ2 sensor is suitable for detecting LPG, i-butane, propane, methane, alcohol, Hydrogen, smoke. According to the datasheet for the MQ2, it is sensitive to 300-10000 PPM., the estimated PPM of combustible gases is between 330 and 950 PPM. The Lower Explosive Limit (LEL) of propane for example is 2.1%, or 21000 PPM, so you are well below that threshold. To calibrate, you would need to enclose the sensor in some sort of chamber, and then introduce a known concentration of a gas into the chamber. The exposure limit of LPG should not exceed the acceptable value of 600ppm as per the safety standards.

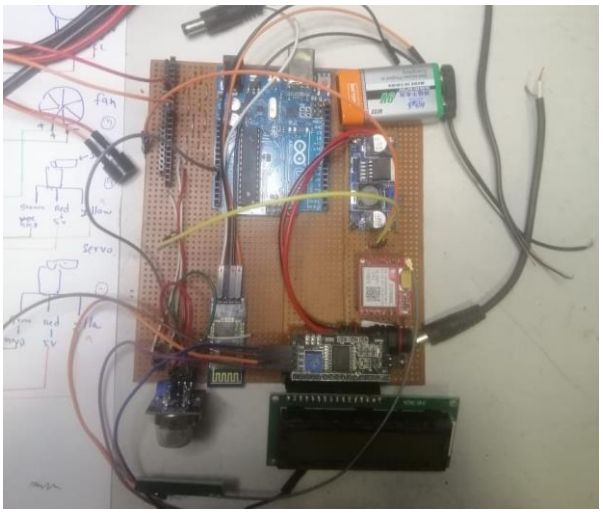

Figure 4: Circuit

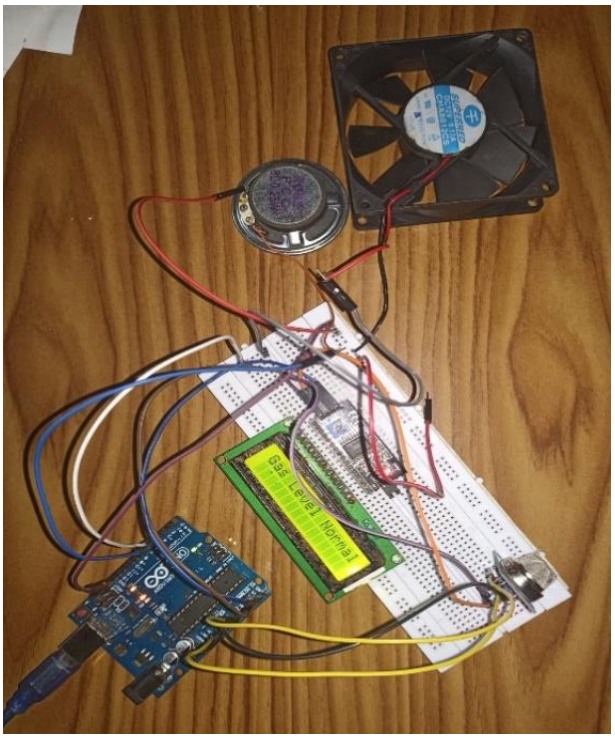

Figure 5: Testing connections

Table 01: Time taken for different actions.

Incident	Time taken(sec)
Time taken to warm up the gas sensor when it is turned on after a period of 8h or 9h	300 – 600s
Time taken to detect the 600ppm of LP gas	2-4
Time taken to send the notification after the detection	1-2
Time taken to cut off the power	1
Time taken to open the windows fully	2
Time taken to start the rotation of exhaust fan	2
Exhaust fan will rotate through	1
Time taken to start the alarm	1
Alarm will sound through	25

. VI. GAS SENSOR TEST

First the gas sensor was connected to the microcontroller using an analog pin. Then the values of LP gas concentration in the environment were displayed on the serial monitor were recorded. Then by releasing LP gas using an LP gas lighter, the changes of the gas values were observed. Then took the average of those values after lighting up the lighter as the threshold value for the system activation.

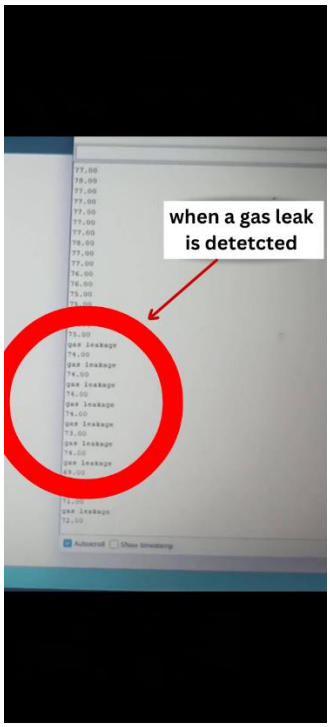

Figure 6: LP gas concentration in the environment

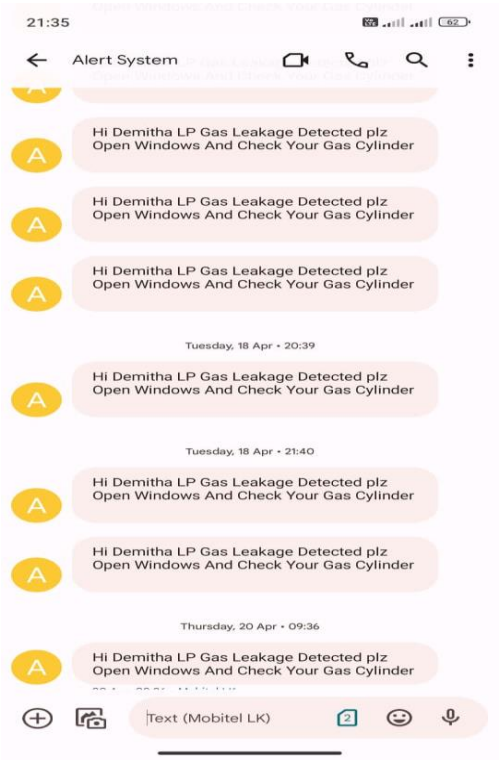

Figure 7: SMS alert on detection of gas leakage and fire

VI. FINAL OUTCOME AND DISCUSSION

A smart gas leak management system which can detect the gas leakages and take the necessary precautions to avoid the damage was implemented successfully.

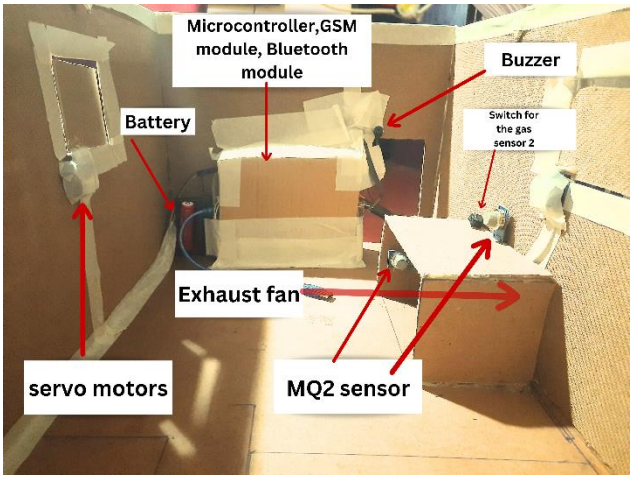

Figure 8: Prototype

VII. ENCOUNTERED PROBLEMS AND IMPLEMENTED SOLUTIONS.

The smart gas leak management system was first designed to detect the gas leakages using only one gas sensor. Slide modifications were designed to take the system to an effective and more accurate level. As LP gas can be leaked by the stove also It was decided to put another sensor near the stove to detect the gas leakage by the stove while cooking. Another thing in here was that this system needed a good power supply. To sort this out, it was decided to use a bike battery (12V/13A) which can be recharged and reusable. Furthermore, it has been decided to cut off the power of the house when a gas leakage is detected. This was decided to take place using a 5A relay by short circuiting the live and earth wires of the house once a gas leakage is decided. As LPG is a much heavier gas the exhaust fan had to be fixed to a lower level near the gas cylinder.

VIII. LIMITATIONS

Difficult to install the system for a house as lot of drilling through the walls and wiring should be done to install the exhaust fan and other components. Sometimes Bluetooth module shows a resistivity to be connected to the mobile phones when the whole system activates during a gas leak. The system was expected to be controlled by long distance users through his/her mobile phone, but the system was totally jammed when the two codes (code of the GSM800l module and the main code of the system) were integrated with each other. But the system still has the ability to send text messages to the users' mobile phone when a gas leakage is detected.

The cylinder is recommended to be stored in a closed chamber to catch the concentration when the gas is leaking. The dimensions of the chamber must be closer to 3 feet higher, 3 feet longer and 3 feet wider.

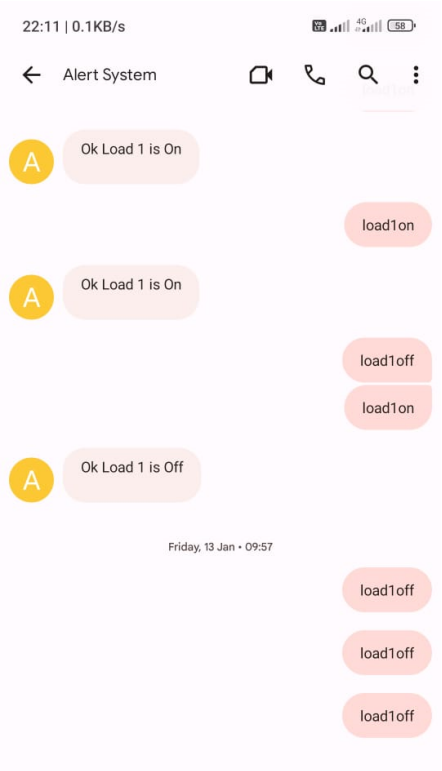

Figure 9: Controlling components in the system using text messages from the mobile.

IX. CONCLUSION

As a conclusion smart gas leak detector is a promising technology that can help prevent LP gas related accidents and improve safety in homes, business and other settings. This system uses a combination of sensors and wireless connectivity to detect gas leaks and alerts users in real time and takes the necessary precautions to prevent the harm or damage which could occur even when they are not in the respective premises. If we get the overall beneficiary of the system we can mention improved safety, convenience, cost savings and energy efficiency. However, there are also some potential drawbacks to consider. These include the cost of the devices and maintenance, as well as concerns about data privacy and security. Finally, the smart gas leak detector is a technology that can offer many benefits for users. However, like any new technology it is very important to carefully evaluate the costs and benefits before deciding about whether to invest in these devices.

X. FUTURE WORK

There are several modifications that can be done for this system to improve their functionality and performance. Some of these include:

- **Voice activation:** Adding voice activated commands to control the system can make it more convenient and more user-friendly, allowing users to activate or deactivate them without turning off the switch.

- **Multi gas detection**: some smart gas leak detectors can only detect one type of gas, such as LP gas. However, developments can be made to enable them to detect multiple types of gases, such as propane, carbon monoxide or methane.

- **Predictive analytics:** Analyze historical data and detect patterns which could indicate the instances that have the potential to have a gas leakage.

- **Remote monitoring and control:** ability to monitor and control the system through a web interface or a mobile app. This allows users to monitor the gas levels, remotely turn off the gas supply in case of a gas leak and receive alerts. The code for this relevant section worked perfectly without integrating with the main section but when integrating with the main section the system didn't function well.

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AUTHOR BIOGRAPHIES

BMDP Rathnayake is an undergraduate of General Sir John Kothalawala Defence University, following the B.Sc. in Electronic and Telecommunication Engineering.

RMCP Ranasinghe is a graduate of General Sir John Kotelawala Deference University with B.Sc. in Electrical & Electronic Engineering. He is currently reading a MSc in Telecommunication at University of Moratuwa. Also, he is an Associate Member of the IESL.

ERMCK Rajapaksha has a B.Sc. (Hons) in Electronic & Telecommunication Engineering from General Sir John Kotelawala Deference University, Sri Lanka and a M.Sc. in Communication & Information Technology from Universität Bremen, Germany. She currently serves as a Lecturer (Probationary) at the Dept of Electrical, Electronic & Telecommunication Engineering, Faculty of Engineering, General Sir John Kotelawala Deference University. Her research interests include wireless sensor networks, Opportunistic Networks and RF-Front-end Devices.