Smart LPG Leakage Monitoring and Control System Using Gas Sensor (MQ-X), AWS IoT, and ESP Module

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ABSTRACT

Purpose: *Nowadays, LPG is used in almost every kitchen for cooking. It has lots of advantages over other cooking fuels. We need to maintain compliance when we cook using it. The gas flows through a couple of equipment like a regulator, pipe, knob, and burner. If equipment got damaged or the regulator was kept on after cooking, it emitted the gas. This event is dangerous and destructive. So, once it is emitted, it should be detected immediately, and emissions should be stopped. There are several sensors available to detect the gas. We demonstrate using this sensor to build an intelligent gas monitoring system here. When the gas is detected, we regulate the valve and stop the gas emission using the control mechanism.*
Design/Methodology: *There are two approaches to designing the LPG detector for the researcher. One approach is to create from scratch, using the raw sensor, creating the schematics, and then building the PCB. After that, the components are assembled and tested in a natural environment. Finally, it would be best if we pack within a suitable enclosure. It takes time to make a testable product. The other approach is for rapid prototyping. Here, we followed the fast procedure. To minimize the hardware overhead, we purchased one complete gas detector system, which is available in the market, and then we added our intelligence to it.*
Findings/Result: *We tested the prototype in a natural environment. The result was found as expected and very promising. We inject the LPG into the sensor. After a couple of seconds, the built-in relay got energized. The ESP module sends the message to the predefined mobile number.*
Originality/Value: *Several projects have already been done to detect LPG leakage. Most of the project monitors gas; it produces an alarm if leakage happens. But here we added a couple of facilities. One is when gas leakage is detected instantly; it triggers the close of the regulator valve. The second one is the incident time, which will be uploaded to the cloud, not local device memory. It will help for audit purposes. Once a leak is detected, we can send the message to the What's App. These features provide value to the user.*
Type of Paper: *Experimental-based Research.*
Keywords: Intelligent LPG leak detector, IoT-based LPG leakage alarm.

1. INTRODUCTION :

Problem statement: The abbreviation of LPG is liquefied petroleum gas, the prime fuel used in kitchens to cook food. It has a lot of facilities than other sources of fuel for the kitchen. The only caveat is that we need to handle it with care. The mishandling can lead to life-threatening accidents. Worldwide, so much research is carried out to prevent the accident from LPG leakage. The problem is that we often forget to consider the practical scenario, so the project or product fails to comply in a natural environment.
Indication of methodology: here, we use the MQ-X series LPG detector. When it is ready, it senses the LPG in the air. Once it is present for a long time with sufficient amount, it triggers the output for alarm or triggering protection. It provides a potential free contact. Using that contact, we switch off

the regulator immediately and send the message to the mobile through WhatsApp. It paralley triggers the local audio-visual alarm.

Essential findings of others in this field: several research works are found over the net. Hasibuan et al. (2019). [1] demonstrate a project where LPG is detected using an intelligent system, and once it is detected, it sends the notification as an SMS to the mobile. The researchers (Hussien et al. (2020). [2]) next year improve the system and make it deployable for the hospital. The researcher (Zinnuraain et al. (2019). [3]) attached an automatic safety system to take immediate action on gas leakage in their research work. The researcher (Keshamoni et al. (2017). [7]) included gas booking as well as detection in their research work. They interact over the IoT for communication when the leakage happens. The Patchmuthu et. Al. (2023). [15] notify the user in the mobile application over IoT.

What study is done in this paper: We study several research documents to understand the actual scenario, as well as the pros and cons of designing a usable, robust, and consistent LPG detector that can run for a long time. We realize that several factors affect the system's performance. In this paper, we demonstrate a practical, feasible gas leakage system that accounts for several techniques to prevent major accidents from gas leakage.

Principal conclusion: LPG is suitable for cooking. The available system suffers from several cons, which make it an unreliable solution for LPG leakage detection incidents. A few factors demand special attention when designing a reliable LPG detector system. The kitchen smoke and dusty and oily environment degrade the sensor performance. Regular checks, system cleaning, and self-tests within predefined intervals can create a reliable system. Robust protection is an excellent solution to using LPG safely.

2. REVIEW OF LITERATURE/ CURRENT STATUS :

Much research has been carried out on LPG leak detection and immediate action. Here, we included some research projects where we found noticeable work already done. Table 1 lists a couple of research works and used technology.

Table 1: Llists research work and technology used in LPG leak detection.

S. No.	Focus/Subject	Technology/Algorithm/ Module/Components	Reference
1	Intelligent LPG gas leak detection tool with SMS notification	LPG Sensor, Mobile network for SMS notification	Hasibuan et al. (2019). [1]
2	A smart gas leakage monitoring system for use in hospitals	Gas Sensor, controller	Hussien et al. (2020). [2]
3	Smart gas leakage detection with monitoring and automatic safety system	Gas Sensor, controller, safety attachment	Zinnuraain et al. (2019). [3]
4	A Smart Approach of LPG Monitoring and Detection System Using IoT	LPG sensor, IoT	Mahfuz et. Al. (2020). [4]
5	A Critical Review on LPG Gas Leakage Detection and Monitoring System	Gas Sensor, controller	Subri et. Al. (2021). [5]
6	Design and Fabrication of a Smart Monitoring System for Liquefied Petroleum Gas-Operated Cars Based on Global System Mobile	LPG Sensor, Mobile Network.	Salman et. Al. (2023). [6]
7	Smart gas level monitoring, booking & gas leakage detector over IoT	Smart gas level sensor, IoT	Keshamoni et al. (2017). [7]
8	A LabVIEW based remote monitoring and controlling of wireless sensor node for LPG gas leakage detection	LabVIEW software, LPG Sensor	Deshmukh et. Al. (2016). [8]
9	LPG Leakage Detector with Smart SMS Alert using Microcontroller	LPG Sensor, Microcontroller	Nivetha et. Al. (2021). [9]

10	Microcontroller Based Monitoring and Controlling of LPG Leaks Using Internet of Things	LPG Sensor, Microcontroller, IoT	Anuradha et al. (2020). [10]
11	Development of LPG leakage detector system using arduino with the Internet of Things (IoT)	LPG Sensor, Arduino, IoT	Hannan et al. (2018). [11]
12	Smart Gas Booking and LPG Leakage Detection System	LPG Sensor, IoT	Patil et. Al. (2017). [12]
13	IOT based smart gas monitoring system	Gas Sensor, IoT	Anandhakrishnan et al. (2017). [13]
14	Smart Detection System for LPG Gas Leakage using IoT	LPG Sensor, Microcontroller, IoT	Ravisankar et al. (2022). [14]
15	Smart LPG usage and leakage detection using IoT and mobile application	LPG Sensor, Microcontroller, IoT, Mobile application	Patchmuthu et. Al. (2023). [15]
16	IOT based automatic LPG gas booking and leakage detection system	LPG Sensor, Microcontroller, IoT	Kodali et. Al. (2019). [16]
17	IoT based LPG cylinder monitoring system	LPG Sensor, Microcontroller, IoT	Srivastava et. Al. (2019). [17]
18	An IoT Based Framework of LPG Real Time Gas Leakage Detection and Controlling	LPG Sensor, Microcontroller, IoT	Bhatia et. Al. (2022). [18]
19	Home and industrial safety IoT on LPG gas leakage detection and alert system	LPG Sensor, Microcontroller, IoT	Soh et. Al. (2019). [19]
20	IoT-based LPG Gas Leakage Detection and Prevention System	LPG Sensor, Microcontroller, IoT	Kumar et al. (2021). [20]

In the table below, we included several research works based on communication technology. The below research works are practical references to design any IoT-based project for the new researcher for their research work.

Table 2: Llists the author's research on IoT and Data saving to the cloud over the IoT.

S. No.	Focus/Subject	Technology/Algorithm/ Module/Components	Reference
1	Let Us Create Multiple IoT Device Controller Using AWS, ESP32 And C#	AWS, ESP32 And C#	Chakraborty et al. (2023). [21]
2	Let Us Create An IoT Inside the AWS Cloud	AWS Cloud	Chakraborty et al. (2022). [22]
3	Let Us Create a Physical IoT Device Using AWS and ESP Module	AWS, ESP Module	Chakraborty et al. (2022). [23]
4	Let Us Create an Alexa Skill for Our IoT Device Inside the AWS Cloud	Alexa Skill, AWS Cloud	Chakraborty et al. (2023). [24]
5	Let Us Create A Lambda Function for Our IoT Device In The AWS Cloud Using C#	AWS Cloud, Lambda Function	Chakraborty et al. (2023). [25]
6	Let Us Create Our Desktop IoT Soft-Switchboard Using AWS, ESP32 and C#	AWS, ESP32 and C#	Chakraborty et al. (2023). [26]

7	Alexa Enabled IoT Device Simulation Using C# And AWS Lambda	C#, AWS Lambda	Chakraborty et al. (2023). [27]
8	IoT-Based Switch Board for Kids Using ESP Module And AWS	ESP Module, AWS	Chakraborty et al. (2023). [28]
9	Let Us Create an Alexa-Enabled IoT Device Using C#, AWS Lambda and ESP Module	C#, AWS Lambda and ESP Module	Chakraborty et al. (2023). [29]
10	IoT-Based Industrial Debug Message Display Using AWS, ESP8266 And C#	AWS, ESP8266 And C#	Chakraborty et al. (2023). [30]

3. OBJECTIVES OF THE PAPER :

Description for Objectives:

1) To study the LPG leak detection and accident prevention procedure.
2) To review research carried out on the LPG leak detection procedure.
3) To analyze the performance of the MQ-X sensor performance.
4) To test the LPG leak detection performance in a real scenario.
5) To design and develop a functional LPG leak detection system.
6) To interpret the complete feasible procedure in the LPG leak detection mechanism field.
7) To create a robust and failsafe LPG leak detection device.

4. METHODOLOGY:

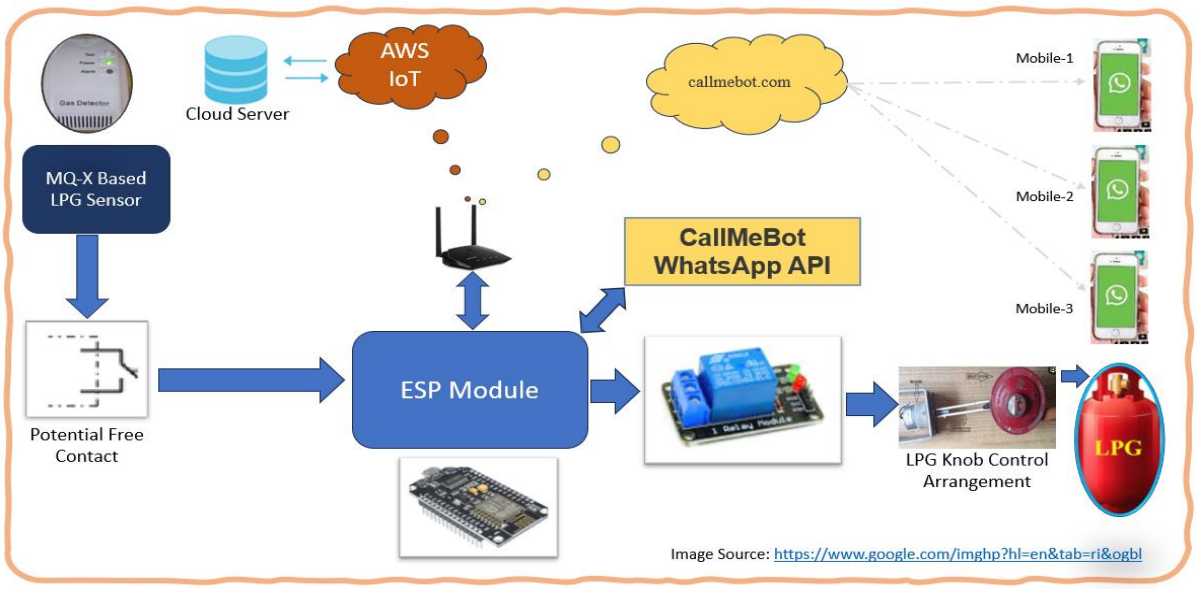

Fig. 1: The project block diagram

Figure 1 depicts the project block diagram. The central unit is the MQ-X-based LPG detector module. It has potential free contact. When the LPG detects, the contact will close. The possible free contact is fed to the input of the ESP module, which is the coordinate part of the complete system. When the system is powered up, it will try to connect with a Wi-Fi router. For this, we need to provide the Wifi credentials. Once connected, it will connect with the AWS IoT cloud server. Now, the ESP module is ready to receive the input trigger. It stays in an infinite loop. Once the digital input senses that the gas sensor has detected the leakage gas, the ESP module sends the event time stamp to the AWS cloud. It instantly triggers the motor to close the LPG regulator. And finally, it sends the What's App message to the preset mobile number. The mobile user gets the message for the gas leakage incident in their messaging app. Figure 2 depicts the front face of the detector device. Figure 3 depicts the components of the LPG detector device.

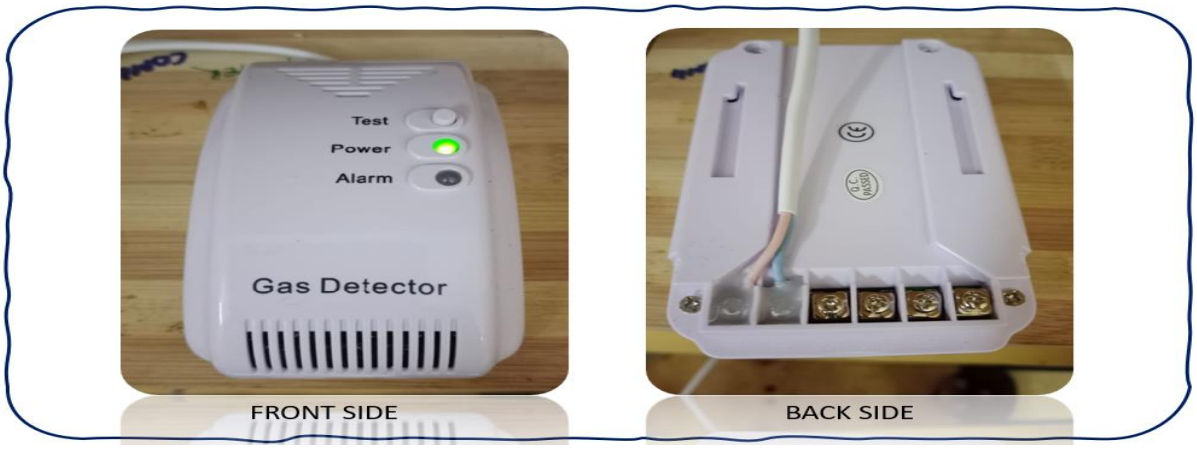

Fig. 2: The LPG detector with enclosure

Fig. 3: The internal components assembly inside the LPG detector

5. SUGGESTIONS :

We recommend executing a couple of tasks that provide a better experiment result.

1) The sensor placement is critical. The proper height should be maintained before the device is in action. Otherwise, the device will not detect the leakage of the LPG.
2) The wifi network should send messages to mobile phones as fast as possible and upload the incident to the cloud server.
3) We need to clean the sensor windows occasionally. We need to create a schedule and maintain it.
4) With that gas-checking device installed, we can also use several other monitoring procedures like knob status monitoring, etc.
5) The details to send the message to what app from the ESP module: https://randomnerdtutorials.com/esp8266-nodemcu-send-messages-whatsapp/#:~:text=After%20uploading%2C%20open%20the%20Serial,should%20receive%20the%20ESP8266%20message.

6. CONCLUSION :

The LPG is used in the kitchen to cook our daily foods. Sometimes, for mishandling, we face terrible accidents. To protect this or prevent massive accidents, research is going on to prevent accidents.

Here, we provide a review and design of a sound system that can be a feasible solution in our daily lives to avoid major accidents due to early detection of LP leaks. First, we introduce the problem statement on the subject. In the literature review, we added a couple of research works on this field. In the methodology, we demonstrate the architecture of the project. We added a couple of suggestions or recommendations for the researcher. Finally, we added the reference from where we got much information on the project field.

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8. LIMITATIONS :

There are a few limitations present in this procedure:

- In most scenarios, the sensor is placed near the LPG cylinder. This place is full of fumes, oil, and smoke present. For the time being, the sensor became less sensitive to LPG. So, when the system needs to detect the gas leakage, it will not be effective.
- The current system is run on AC230 volts. It might create sparks when leakage happens. The best way is to use a small potential battery.
- The complete system should be encapsulated (except the sensor windows) so that it can not create any issues when the gas reaches the Sensor window when gas starts leaking.

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