

ESP32 Based Lab Enhance Safety & Gas Leakage Detection Using IOT

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Abstract: *In this paper we introduce a novel approach to elevating gas safety standards through an ESP32-based detection system integrated with the Blynk IoT platform. The proposed system is designed to meet the growing need for reliable and adaptable gas leak detection across various environments, including residential and commercial settings. By connecting individual detection units to a centralized hub, the system offers real-time monitoring, instant notifications, and automatic safety responses, such as triggering alarms and cutting off the gas supply. The integration of the Blynk platform enhances user interaction, providing a customizable mobile app and server interface that can be tailored to specific user preferences. This flexibility not only improves the user experience but also ensures the system's scalability, allowing it to be easily deployed and managed in diverse settings. The findings highlight the system's effectiveness in detecting gas leaks and mitigating potential hazards promptly. The ability to monitor gas levels remotely and respond quickly to leaks represents a significant advancement in gas safety technology. By empowering users with the tools to monitor, analyze, and respond to gas-related risks, this system offers a promising solution for enhancing safety and peace of mind in various applications.*

Keywords: Gas leakage detection, ESP32 microcontroller, Blynk IoT platform, Real-time monitoring, Automatic gas cutoff, Mobile application, User-friendly interface, Scalable system, Safety measures, Remote monitoring

I. INTRODUCTION

Liquefied Petroleum Gas (LPG) is a widely used fuel for domestic, industrial, and commercial purpose due to its efficiency and easy storage. But due to the high flammability of LPG it's important to handle the cylinders with proper care and avoid leaks to prevent incidents such as fires, explosions, and health risks. The leak detection traditionally was done by simple alarms or manual observations which often failed to provide real-time monitoring. Due to this the users also face inconvenience and interruptions in their daily activities due to unexpected depletion of gas cylinders. Recently many advancement were done using sensors combined with IoT connectivity, these have opened many ways for improving the system safety and efficiency. In this paper we have presented the design and development of smart leak detection and weight monitoring system which integrates an MQ sensor, a load cell and GSM module for alerts. This system is controlled by ESP32 microcontroller which processes the sensor data and activate the local alerts system when the weight of cylinder falls below a certain defined level or a leak is detected. This system ensures user safety by alarming early leak detection and also provides timely notifications for cylinder refilling, this reduces manual monitoring efforts. On addition to this the integration of IoT connectivity allows the system to be extended for remote monitoring and making a way for future smart home integration. This paper explains the methodology, hardware and



software implementation, testing results and potential improvements to show the feasibility and effectiveness of the developed system.

Problem Statement:

Gas leakage remains a significant safety challenge in residential, commercial, and industrial environments. Leakage of combustible gases such as LPG often goes undetected until it reaches dangerous levels, leading to accidents like fire outbreaks, explosions, and health hazards. Existing conventional gas detection systems primarily rely on standalone sensors with local alarm mechanisms, which are insufficient in situations where immediate human intervention is not possible. Moreover, traditional systems lack real-time monitoring, remote alert capabilities, and automated safety responses. In many cases, users are unaware of gas leakage when they are away from the location, increasing the risk of severe damage. Additionally, delayed detection and response can result in critical consequences, including loss of life and property. Although modern solutions exist, they are often expensive, complex, or not easily scalable for widespread use. Therefore, there is a need for a cost-effective, reliable, and intelligent system that can continuously monitor gas levels, provide instant alerts, and enable remote monitoring. This paper addresses these challenges by proposing an IoT-based gas leakage detection system using the ESP32 and the MQ-6 Gas Sensor. The system aims to detect gas leakage in real time, alert users both locally and remotely, and initiate automatic safety measures to minimize risks.

Objective of System:

The primary objective of the proposed system is to develop a smart and reliable gas leakage detection solution using IoT technology. The specific objectives are as follows:

- To design and implement a gas leakage detection system using the ESP32 for efficient processing and communication.
- To detect the presence of hazardous gases such as LPG using the MQ-6 Gas Sensor with high sensitivity and accuracy.
- To provide immediate local alerts through a buzzer and visual indication to ensure quick response in case of gas leakage.
- To enable automatic activation of safety mechanisms, such as controlling an exhaust fan using a relay module to reduce gas concentration.
- To implement IoT-based remote monitoring by transmitting real-time data to cloud platforms or mobile applications.
- To send instant notifications to users in case of gas leakage, even when they are away from the location.
- To develop a cost-effective, scalable, and user-friendly system suitable for both domestic and industrial applications.
- To enhance safety by minimizing the risk of accidents such as fire, explosions, and health hazards caused by gas leakage

II. LITERATURE SURVEY

In Journal titled "Automation of LPG Cylinder Booking and Leakage Monitoring System," P. Bharath et al. [2] proposed an automated system for gas booking and leakage detection. The system automatically books the cylinder before the LPG supply is fully utilized and alerts the owner in case of a leakage. Continuous monitoring of the cylinder's weight is carried out using a weight sensor, and if the weight decreases below a preset amount, the technology automatically books the cylinder and notifies the owner via message.

In the research titled "Kernel Approach on Detection of Ethanol Connection Using ZnO Gas Sensor," L. Shaw et al.[3] examined the clustering of various ethanol gas concentration levels. It was demonstrated that kernel principal component analysis could be employed to cluster data in this scenario. Different gas concentrations were detected and displayed using the proposed technique on the LabView front panel. The sensitivity of ZnO thick film resistors for sensing ethanol gas. It mentions that the sensor is a zinc oxide gas sensor with a thick film base. Additionally, it states that the sensor incorporates an inside heating coil capable of reaching temperatures between 75°C and 300°C. The



essay notes that ZnO reacts promptly to even very low gas concentrations and demonstrates significant sensitivity, along with acceptable stability and responsiveness.

In a project proposal by V. Ramya et al.[4] the focus is on an embedded system designed for hazardous gas detection and warning. The project aims to modify the current safety paradigm used in industries and extend its applicability to homes and workplaces. The primary objective of the project is to design a hazardous gas detection and alerting system using a microcontroller. The system includes an LCD display that continuously monitors and displays dangerous gases such as LPG and propane. Additionally, if these gases exceed the normal levels, triggering an alarm, an alert message (SMS) is sent via GSM to the appropriate individual. The automatic detection and warning system offer advantages over the manual approach, including fast response times and precise detection.

In a project proposed by T. Kiran et al.[5] a "Gas Leakage Detection System" utilizing FPGA and GSM technology was introduced. The study suggested a system for detecting gas leaks, wherein the first response team would receive wireless notifications containing information about the leak. This enables prompt preventive measures to be taken, even in the absence of individuals. The detection system automatically places a warning call via GSM to identify the leakage using FPGA. LPG was utilized to test and develop a prototype of the gas leakage detection system. According to trial findings, the system can detect leaks in less than a minute.

The topic of a project offered by Luay Fraiwan et al. [6] was "A wireless gas leak detector for house safety." They proposed utilizing a wireless safety gadget to locate gas leaks, particularly in homes where the use of heaters and appliances powered by liquefied petroleum gas (LPG) and natural gas may raise safety concerns. It was suggested that this device could also be applied to other natural gas and LPG-based industrial or plant processes. The system architecture comprises two main components: the detection and transmission module, and the reception module. The detecting and transmitting module utilize a special sensor circuit designed for this purpose to identify changes in gas concentration.

P.S. Murvay et al. [7] presented a research proposal concerning a survey on gas leak detection and localization methods. The primary objective of their study was to identify the most advanced leak detection and localization methods. Furthermore, they aimed to evaluate the capabilities of various techniques to ascertain the advantages and disadvantages of implementing each leak detection technique. Several organizations had conducted studies on the incidence of gas leak-related incidents and had generated statistics on the reported occurrences.

Fabien Chraim et al. [8] proposed the project titled "Wireless Gas Leak Detection and Localization." In their study, they suggested a method for locating and identifying wireless gas leaks. They utilized a monitoring system consisting of 20 wireless devices covering a 200-meter radius to track 60 propane releases. Following the application of the suggested detection and localization algorithms to the collected concentration data, they evaluated the methodology. They achieved a detection rate of 91% with seven false alarms over three days and an average detection latency of 108seconds. The localization results indicated a 5-meter accuracy. They recommended and discussed future designs for explosive gas sensors. Leaky compressors, valves, seals, and connectors were identified as the primary causes of most of these losses.

III. EXISTING SYSTEM

It was mentioned that the world has been evolving rapidly to embrace the latest technologies and interconnect everything. Various flammable gases such as carbon dioxide, ammonia, and others find applications in settings like hotels, canteens, and businesses. While the utilization of these gases has undoubtedly advanced technology, it also poses risks to human life and well-being. Consequently, safety emerges as a critical concern. In the existing method, Arduino reads the output of the sensors. Considering the Internet of Things (IOT) as a futuristic technology, it is suggested that physical items be connected to the internet. Safety being of utmost importance, the suggested gas detection system utilizes IOT to detect leaks and alert users promptly to take necessary actions. Monitoring of these gases is essential due to their harmful nature, enabling the identification of any changes in their levels and facilitating



appropriate actions to be taken. Overall, the project aims to mitigate the negative impacts of industrial pollution, create a safe working environment for employees, and reduce human intervention in monitoring pollution levels.

IV. SYSTEM ARCHITECTURE

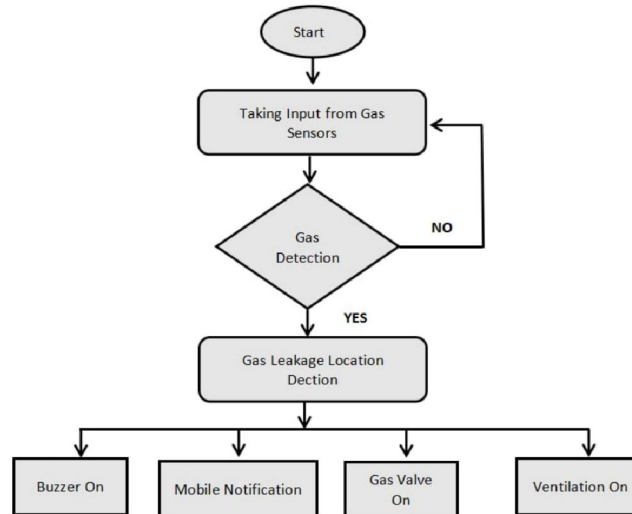


Fig. 1. Flow Chart of Working

The IoT-enabled gas leakage detection system operates through a sequence of sensing, processing, alerting, and communication stages. The system is built around the ESP32, which acts as the central controller for all operations. Initially, the MQ-6 Gas Sensor continuously monitors the surrounding environment for the presence of combustible gases such as LPG. The sensor outputs an analog signal proportional to the gas concentration in the air. This signal is fed into the analog input pin of the ESP32. The controller processes the incoming signal and compares it with a predefined threshold value programmed into the system. Under normal conditions, when the gas concentration is below the threshold, the system remains in monitoring mode, and the LCD displays a safe status message. When gas leakage is detected and the sensor value exceeds the threshold limit, the system immediately transitions into alert mode. In this condition, multiple actions are triggered simultaneously:

- A buzzer is activated to provide an audible warning
- A relay module is energized to switch ON the exhaust fan for ventilation
- A warning message is displayed on the LCD screen

Simultaneously, the IoT functionality of the ESP32 comes into operation. The controller connects to a Wi-Fi network and transmits real-time data to cloud platforms such as ThingSpeak or mobile applications like Blynk. This enables remote monitoring and ensures that users receive instant notifications about gas leakage, even when they are not present at the location. Once the gas concentration returns to safe levels, the system automatically resets to normal monitoring mode, turning OFF the buzzer and exhaust fan. Overall, the working of the system ensures continuous monitoring, quick detection, immediate response, and real-time communication, thereby significantly enhancing safety and reliability.

A. Hardware Component:

The gas leakage detection system utilizes an ESP32 microcontroller [11] connected to three gas sensors, a buzzer and a light. We use ESP32 because it comes with an integrated WiFi module that supports 802.11 standards. It can also reduce memory usage and computational overhead in environments where resources are constrained, such as embedded systems or low-power devices. Each ESP32 communicates with the Blynk server over WiFi, displaying gas levels for monitoring on a mobile app. Upon gas detection, the server triggers notifications. Additionally, a servo motor is employed to cut off gas supply. This scalable system enables multiple ESP32 units, each with its set of components, to



monitor distinct rooms. The collective data provides a comprehensive overview of gas levels, enhancing safety by risks in various locations through a centralized Blynk server.

B. Web Server Analysis:

In our initial investigation into the Arduino cloud infrastructure, we encountered several challenges that prompted a reevaluation of our approach. Notably, issues such as sluggish data updates and the absence of a default mobile application for notifications were identified. Furthermore, a noteworthy limitation surfaced in the Arduino cloud's capacity to concurrently receive data from multiple ESP32 devices – a constraint wherein only two ESP32 devices could transmit data to the Arduino cloud at any given time. In our pursuit of an alternative solution, we explored the utilization of ThingSpeak [12], an IoT analytics platform service, for monitoring data via WiFi through ESP32 devices. However, an inherent drawback became apparent as realtime data transmission to the ThingSpeak server incurred a minimum 10-second delay. Additionally, akin to the Arduino cloud, ThingSpeak lacked a dedicated mobile application, necessitating reliance on the ThingSpeak server or third-party applications such as MIT App Inventor [13] for mobile data presentation. Consequently, the decision to adopt Blynk emerged as a strategic response to these challenges. Blynk not only effectively addresses the shortcomings encountered in the Arduino cloud and ThingSpeak but also introduces a heightened level of scalability and responsiveness to our system. This choice proves integral to the seamless and comprehensive monitoring of gas levels across multiple locations. The shift to Blynk is motivated by its ability to surmount the limitations witnessed in both the Arduino cloud and ThingSpeak. Its robust features promise to enhance the system's scalability, providing a platform that can effectively manage the complexities associated with gas monitoring in diverse locations. By selecting Blynk, we anticipate not only mitigating the issues identified in our initial exploration but also elevating the overall performance and responsiveness of our gas monitoring system.

C. Mobile App Development:

In the implementation of our mobile application, we opted for the Blynk IoT mobile app, a cost-free solution that aligns with our project requirements. The design of the Blynk [14] application interface closely resembles the illustrative Fig. 2. Within this interface, users gain the capability to monitor gas levels in individual locations within a room, as well as an aggregated view of gas levels across different rooms. The inclusion of a status bar contributes to a comprehensive overview of the overall home environment. The Blynk application is intelligently designed to promptly notify users of any gas detection within a room. In such instances, the application visually highlights the specific room where gas leakage is detected, offering users precise information regarding the source of the issue. Simultaneously, a notification alert is triggered, providing immediate notification to the user's mobile device. This proactive approach ensures that users are promptly informed, even if they do not actively engage with the Blynk IoT app, facilitating swift and informed decision-making.

V. CONCLUSION

In conclusion, the development and implementation of automated gas detection systems represent a significant stride towards enhancing safety measures in various environments, particularly in industrial settings. This system is a smart and practical way to integrate LPG leak detection and weight monitoring into a single compact IoT platform. The system will enhance user awareness and safety by installing the weight tracking, gas leak alarm and automated warning, thereby diminishing accidents. Weight monitoring by means of the load cell provides accurate measurements of the level of gases, whereas the MQ-2 sensor responds to gas leakage in 3 seconds. This system is a dependable solution to users across various sectors because of its cheapness and ease of installation. The suggested system will properly fill the gap between safety, convenience, and automation, minimizing risks and maximizing gas use. As it evolves and improves, the given IoT-based LPG monitoring solution can become the new standard of kitchen and industrial safety. Additionally, the inclusion of prevention mechanisms, such as dynamic environmental control systems, underscores the proactive approach towards mitigating gas-related risks. By leveraging these advancements,



industry authorities can gain invaluable insights into gas detection patterns, enabling pre-emptive measures to be implemented, thus minimizing potential hazards and ensuring the safety of personnel and assets. Moving forward, continued research and development efforts in this field are crucial for advancing the effectiveness and reliability of automated gas detection systems, ultimately contributing to safer working environments and the protection of lives and property.

VI. FUTURE SCOPE

In future developments, enhancing the automated gas detection system could involve the integration of advanced machine learning algorithms to analyze data patterns, enabling predictive insights into potential gas leakages before they escalate. This predictive capability not only strengthens the system's proactive response but also empowers industry authorities with valuable foresight to implement preemptive measures. Additionally, research efforts may focus on advancing sensor technologies to develop more specialized sensors tailored to the diverse needs of industrial environments. These advancements aim to optimize sensitivity and accuracy in gas detection, further fortifying risk mitigation measures. Furthermore, expanding the prevention mechanism to include dynamic environmental control systems, such as automated exhaust fans triggered upon surpassing gas concentration thresholds, represents a promising avenue for future work. By implementing these enhancements, the automated gas detection system can effectively safeguard industrial facilities against gas-related hazards, elevating safety protocols to new levels of efficiency. The proposed IoT-enabled gas leakage detection system can be further enhanced by incorporating advanced technologies and additional safety features. Some potential areas for future improvement are as follows:

Integration of GSM Module: Adding GSM capability will enable SMS and call alerts, ensuring notification even in the absence of Wi-Fi connectivity.

Automatic Gas Valve Shut-Off System: The system can be extended to automatically close the gas supply using a solenoid valve when leakage is detected, preventing further hazards.

Multi-Gas Detection: Incorporating additional sensors can allow detection of multiple gases such as carbon monoxide (CO), methane (CH₄), and smoke, improving system versatility.

AI-Based Prediction and Analysis: Machine learning algorithms can be used to analyze gas patterns and predict potential leakage before it becomes critical.

Mobile Application Development: A dedicated mobile application with a real-time dashboard, historical data analysis, and alert management can enhance user interaction and control.

Integration with Smart Home Systems: The system can be integrated with home automation platforms, enabling centralized monitoring and control along with other smart devices.

Improved Sensor Accuracy: Using advanced and calibrated sensors can increase detection accuracy and reduce false alarms caused by environmental factors.

ACKNOWLEDGMENT

It gives us great pleasure in presenting the paper on "ESP32 Based Lab Enhance Safety & Gas Leakage Detection System using IOT". We would like to take this opportunity to thank our guide, Prof. Priti Sudhakar Gund Pujari, Professor, E&TC Department, Adsul's technical Campus, Ahlyanagar, for giving us all the help and guidance we needed. We are grateful to her for her kind support, and valuable suggestions were very helpful.

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