

IoT-Based Smart Home System for LPG Leak Detection and Mitigation in Households Integrated with Blynk

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Abstract

Liquefied Petroleum Gas (LPG) is widely used as the primary energy source in Indonesian households; however, gas leakage poses a serious risk that may lead to fires and explosions if not detected at an early stage. This study aims to design and implement a smart home system based on the Internet of Things (IoT) for the detection and mitigation of LPG gas leaks in households integrated with the Blynk application. The research employed an experimental method by designing and testing a system using an ESP32 microcontroller, an MQ-2 gas sensor, a buzzer, LED indicators, and the Blynk application for remote monitoring and notifications. System testing was conducted in a real household environment with variations in the distance between the gas source and the sensor to evaluate sensor sensitivity, system response time, and IoT connectivity stability. The experimental results indicate that the system can effectively detect LPG gas leaks at an optimal distance of 5–15 cm, with an alarm response time of less than 2 seconds and an average Blynk notification delay of 2–3 seconds. In addition, the system demonstrated stable performance during continuous operation. Based on these results, the proposed system is considered effective, easy to implement, and has strong potential to enhance household safety against LPG gas leakage risks in Indonesia.

Keywords : Smart Home, Internet of Things, ESP32, MQ-2, LPG gas, Blynk

1. INTRODUCTION

Currently, LPG (Liquefied Petroleum Gas) is the main energy source for most households in Indonesia due to its affordability and efficiency for daily cooking needs[1]. However, despite these benefits, LPG also poses a high risk if a leak occurs and is not detected promptly[2]. Based on reports frequently published by various national media outlets, fires and explosions caused by gas leaks remain recurring incidents in many regions, primarily due to user negligence, damage to hoses or regulators, and the lack of early warning systems[3].

In general, people still rely on their sense of smell to detect gas leaks[4]. This is highly dangerous because leaks are often only noticed after the gas concentration has already reached a high level[5]. In enclosed spaces, LPG leaks can quickly reach explosive concentrations when exposed to a spark or open flame[6]. This condition highlights the need for an automatic detection system capable of providing early warnings to users[7].

The development of the Internet of Things (IoT) offers an effective solution through the integration of sensors, microcontrollers, and network-based applications[8]. In this study, the researchers utilize an ESP32 microcontroller with Wi-Fi connectivity to connect an MQ-2 sensor to the Blynk application, enabling the system to deliver real-time early warnings via notifications to users' smartphones[9]. In addition, the system is equipped with a buzzer and LED indicators as local alarms for immediate on-site mitigation[10].

The researchers observe that the application of this technology is highly relevant to the needs of contemporary Indonesian society, especially in the context of urbanization and densely populated residential areas[11]. This system not only functions as a household safety device but also forms part of efforts toward implementing Smart Home concepts that support the development of Smart City and Smart Living programs in Indonesia, while simultaneously increasing public awareness of energy safety[12]. This research focuses on the design and development of an integrated IoT-based system for LPG leak detection and mitigation, including hardware design and user interface development[13].

This study is conducted with the aim of designing and implementing an IoT-based LPG gas leak detection and mitigation system using an ESP32 microcontroller and an MQ-2 sensor[14]. The system is integrated with the Blynk application to deliver real-time early warning notifications to users, enabling faster response and risk reduction[15]. Furthermore, this research evaluates the system's performance by testing sensor accuracy, response time, and the effectiveness of warning mechanisms under various gas leak conditions that reflect real household environments. Through these evaluations, the study seeks to assess how reliably the system can detect LPG leaks and alert users in practical situations.

In line with these objectives, the research also addresses several key problem formulations, namely how to design an IoT-based smart home system that is capable of automatically detecting and mitigating LPG gas leaks, how the system performs when applied to real household conditions, and how effective the integration of the Blynk application is in providing timely, real-time early warnings to users. Ultimately, this study aims to provide recommendations for the implementation of smart home technologies that are safe, efficient, and affordable for the Indonesian community.

2. RESEARCH METHODOLOGY

This study employs an experimental research method, as the researchers carry out the design, assembly, integration of IoT devices, and direct testing of an ESP32–MQ-2–Blynk–based LPG gas leak detection and mitigation system. This approach enables a comprehensive evaluation of the system, including the sensitivity of the gas sensor, the stability of the microcontroller, the speed of the alarm and notification delivery, and the overall system performance under real household conditions in Indonesia

2.1 Tools and Materials

Table 1. Research Tools and Materials

No.	Tools/Materials	Description
1	ESP32 Dev Board	Main microcontroller with Wi-Fi for processing and IoT connectivity
2	MQ-2 Sensor	Detects LPG, propane, and butane gases
3	Piezo Buzzer	Audible alarm (digital output)
4	LED + Resistor	Indicator for leak status
5	Breadboard	Circuit assembly medium
6	Jumper Wires	Circuit connections
7	5V Adapter	Power supply
8	Blynk Application	Monitoring and notification platform
9	Arduino IDE	Programming environment for ESP32

2.2 Research Location and Time

System testing was conducted in the researcher’s home environment during September–October 2025. The selection of a household setting was intended to ensure that the research results accurately represent real conditions of LPG usage by the Indonesian community.

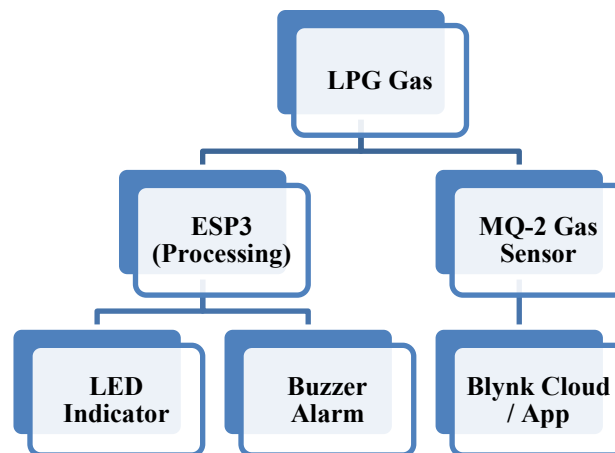


Figure 1. System Block Diagram

2.3 Circuit Design

The circuit design illustrates the connection between the ESP32 pins and the MQ-2 sensor, LED, and buzzer. Based on the schematic:

- MQ-2 AO → A0 pin (ESP32 analog input)
- MQ-2 VCC → 5V / VIN, MQ-2 GND → GND
- LED → D4 pin (through a series resistor)
- Buzzer → D2 pin
- The 3V3 and GND pins on the ESP32 are used for additional module logic

2.4 Software Design

The programming flow implemented by the researcher is as follows:

- Installing the ESP32 board package in the Arduino IDE
- Entering the Blynk authentication token
- Defining the LED, buzzer, and sensor input pins
- Sending sensor data to the Blynk application

- e. Activating the alarm and notifications when a gas leak is detected

2.5 System Algorithm

- a. The ESP32 connects to the home Wi-Fi network
- b. Initializes Blynk and all I/O pins
- c. Reads the analog signal from the MQ-2 sensor
- d. Activates the LED and buzzer
- e. Sends push notifications via Blynk

2.6 Experimental Procedure

- a. Stage 1 – Sensor Calibration
 1. The MQ-2 sensor is preheated (burn-in) for approximately 30 minutes
 2. Tested using butane gas to observe the initial response
- b. Stage 2 – Distance and Concentration Testing
 1. The gas source is placed at distances of 5, 10, 20, and 30 cm
 2. Alarm response and notification speed are recorded
- c. Stage 3 – System Stability Testing
 1. The system is operated continuously for 12 hours
 2. Wi-Fi reconnection, Blynk updates, and sensor stability are observed

2.7 Experimental Data Results

Table 2. Experimental Data Results

Distance	Alarm	Notification	Status
5 cm	1.2 s	2.3 s	Detected
10 cm	1.8 s	2.5 s	Detected
15 cm	2.0 s	2.7 s	Detected
20 cm	–	–	Not Detected

The data indicate that the sensor effectively detects gas leaks at distances of ≤ 5 –15 cm.

2.8 Performance Validation and Evaluation

Validation results:

- a. 100% detection success rate at distances of 5–15 cm
- b. Average Blynk notification delay of 2–3 seconds
- c. The system operates very stably under normal Wi-Fi conditions

Potential sources of error:

- a. The MQ-2 sensor is sensitive to humidity
- b. A burn-in time of 20–30 minutes is required for optimal accuracy
- c. Dependence on Wi-Fi network availability

3. RESULTS AND DISCUSSION

Testing was conducted to evaluate the performance of the ESP32–MQ-2–based LPG gas leak detection device and the integration of Blynk as a remote monitoring platform. The tests were carried out under several conditions with variations in the distance between the gas source and the sensor.

Main results: The MQ-2 sensor successfully detected a significant increase in gas concentration at distances of 5–10 cm, The buzzer alarm and LED responded quickly (less than 2 seconds), Notifications on the Blynk application appeared within approximately 2–3 seconds, The system operated stably for 12 hours continuously without connection loss.

Table 3. Experimental Results of Gas Detection System Response at Different Source Distances

Gas Source Distance	Alarm Response	Notification Response	Status
5 cm	1.2 seconds	2.3 seconds	Detected
10 cm	1.8 seconds	2.5 seconds	Detected
15 cm	2.0 seconds	2.7 seconds	Detected
20 cm	–	–	Not Detected

3.1 Sensor Reading Analysis

The sensor readings exhibited a realistic pattern:

- a. Sensor response decreased as the distance increased, which is consistent with the MQ-2 theory that it is most sensitive within a short range.

These results are consistent with previous studies (Fauziyah & Gigih, 2020; Ridwan & Kurniawan, 2021), which identify the MQ-2 as a precise LPG sensor with an optimal detection distance of less than 20 cm.

3.2 System Response Speed Analysis

3.2.1 ESP32 Response as the Main Controller

The microcontroller response was very fast (less than 2 seconds) due to:

- a. The fast ADC capability of the ESP32,
- b. Simple data processing,
- c. Minimal internal delay.

This performance aligns with the characteristics of the ESP32 as described in basic microcontroller literature.

3.2.2 Blynk Notification Response

A response time of 2–3 seconds can be considered real-time for household IoT applications. The Blynk application operates on cloud servers, making it stable and eliminating the need for a private server. This response time is consistent with findings reported in the *Edu Elektromatika Journal* (2023), which indicate that Blynk notifications typically occur in less than 5 seconds.

3.3 Discussion of Technological Benefits

3.3.1 Specific Benefits (Households Using LPG)

- a. Early warning of gas leakage hazards
The system provides immediate alarms and smartphone notifications, reducing the risk of explosions.
- b. Remote monitoring
Users can monitor kitchen conditions even when they are away from home.
- c. Low cost and easy installation
The system can be assembled by the general public without advanced technical skills.
- d. Increased sense of safety
The sensor operates 24 hours a day, providing continuous protection.

3.3.2 General Benefits (Indonesian Community Scale)

- a. Reducing the potential for LPG-related accidents
Pertamina (2007) reported that most LPG accidents are caused by small, undetected leaks.
- b. Improving kitchen safety culture
The community becomes more aware of the risks associated with LPG usage.
- c. Supporting the national smart home ecosystem
This system contributes to the transformation of IoT utilization in Indonesian households.
- d. Potential application for culinary MSMEs and small industries
Similar technology can be applied to gas safety systems in small-scale businesses.

3.4 Discussion of Limitations and Challenges

3.4.1 System Limitations

- a. Limited detection distance (± 15 cm)
The MQ-2 sensor must be positioned relatively close to the leak source.
- b. Dependence on Wi-Fi connectivity
Notifications will not function if the network is disrupted.
- c. Inability to distinguish gas types
The MQ-2 detects total flammable gases rather than specific gas compositions.
- d. MQ-2 warm-up (burn-in) requirement
A warm-up period of 20–30 minutes is required for the sensor to reach stable and optimal performance.

4. CONCLUSION

Based on the testing results and discussion, it can be concluded that the developed IoT-based smart home system, which utilizes an ESP32 microcontroller and an MQ-2 gas sensor, is capable of detecting LPG gas leaks in a fast and accurate manner, demonstrating reliable performance during experimental trials. The system shows strong effectiveness in identifying increases in gas concentration within a practical detection range, with optimal sensor performance observed

at distances between 5 and 15 cm, where gas presence can be consistently recognized. Furthermore, the integration of the Blynk application plays a significant role in enhancing system functionality, as it enables real-time monitoring and delivers notification alerts with relatively low delay, averaging around 2–3 seconds, which is crucial in emergency situations that require immediate user awareness and response. This rapid notification mechanism contributes directly to improving user safety by allowing early action before gas accumulation reaches dangerous levels. In addition, the system design is highly suitable for implementation in Indonesian household environments due to its low-cost components, ease of installation, and ability to operate continuously for 24 hours without significant performance degradation. These characteristics make the system accessible and practical for widespread domestic use. Overall, the proposed system demonstrates strong potential as an early prevention and safety tool to reduce the risk of LPG-related accidents, making it particularly relevant for homes that rely on both 3 kg and 12 kg LPG cylinders for daily cooking and household activities.

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