JRSSEM 2025, Vol. 05, No. 2, September
E-ISSN: 2807 - 6311, P-ISSN: 2807 - 6494

Design Of Gas Leakage Monitoring System and RFID-Based Door Security Access Control Using Blynk Application

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Abstract. Home safety remains a pressing concern, particularly regarding gas leakage risks and unauthorized access, both of which can endanger lives and property. Conventional gas detectors and door locks often operate independently, lacking integrated real-time monitoring and control features. This research addresses that gap by designing and testing an Internet of Things (IoT)-based system that integrates gas leakage monitoring with door access control to enhance household security. The objective of this study is to develop a cost-effective, reliable, and user-friendly solution capable of real-time detection, prevention, and remote supervision. The system was built using an ESP8266 microcontroller as the central controller, an MQ-2 gas sensor for leakage detection, an RFID sensor for door authentication, and the *Blynk* mobile application for remote monitoring. The system triggers a buzzer alarm and automatically shuts off the gas valve when gas concentrations exceed safe thresholds, while RFID authentication ensures that only registered users can access the door. Experimental testing demonstrated that the gas sensor achieved high sensitivity with minimal response delay, and the RFID module successfully restricted access to authorized users. Furthermore, alerts and system status were accurately displayed on the *Blynk* app in real time. These findings indicate that the proposed system provides a practical and efficient approach to enhancing home safety. The integration of IoT-based monitoring and control offers significant implications for developing smarter, safer, and more sustainable residential environments.
Keywords: Internet of Things, ESP8266, MQ-2, RFID, BLYNK

INTRODUCTION

Home security issues and the risk of gas leaks are now serious concerns in the community (Calabrese et al., 2024; Khudhur et al., 2022; Wang et al., 2024). Based on data from the Central Statistics Agency (2024), the number of domestic theft cases in Indonesia over the last three years has fluctuated. In 2020, 247,218 cases were recorded, decreasing slightly to 239,481 cases in 2021, but then sharply increasing to 372,965 cases in 2022. This trend indicates that home security systems, especially manual door access controls, remain vulnerable to break-ins. Additionally, gas leaks pose an equally dangerous threat. Data from the Jakarta Provincial Fire and Rescue Service recorded dozens of fire cases caused by LPG gas leaks in the last three years: 25 incidents in 2021, rising to 40 incidents in 2022, and decreasing to 27 cases towards the end of the same year. These facts confirm the need for an early warning system to prevent greater losses.

Several studies show that technology can effectively improve home security. Simanjuntak et al. (2023) developed a home security system combining an MQ-2 sensor and a GSM module to detect LPG gas leaks with a low error rate of around 1.6%, sending alerts via SMS immediately upon detection. Another study by Fuadi et al. (2024) designed a NodeMCU-based gas leak monitoring system (ESP8266) integrated with Android applications. This system detects gases in real time using MQ-2 sensors, transmits data to the Firebase cloud, and enables practical remote monitoring via mobile phones (Al-Okby et al., 2021).

The MQ-2 sensor, highly sensitive to flammable gases, is very suitable for gas leak warning systems (Ilham et al., 2022). Meanwhile, RFID technology, which can recognize tags of authorized users, complements an efficient access control system (Yusup, 2022). Research by Khairyansyah et al. (2024) also designed a gas leak detection system based on the WeMos D1 Mini microcontroller and MQ-2 sensor connected to the *Blynk* application.

The integration of ESP8266, MQ-2 sensors, RFID, and *Blynk* applications allows the creation of intelligent and responsive home security systems. According to Syukhron (2021), *Blynk* facilitates easier remote monitoring and control, especially on microcontroller-based devices. The ESP8266 microcontroller is ideal for Internet of Things (IoT)-based home security systems due to its built-in Wi-Fi, low power consumption, and flexibility for integrating various sensors (Putra & Nugraha, 2021). Additionally, *Blynk* offers an easy-to-use dashboard interface, enabling homeowners to monitor devices directly via smartphones (Wirawan et al., 2023). Leander et al. (2024) noted that *Blynk*-based security systems enhance both efficiency and comfort for residents.

Research by Fadillah et al. (2022) states that ESP8266-based IoT systems for household gas monitoring can accelerate emergency responses. Rachman et al. (2021) demonstrate that RFID systems with digital verification reduce risks of illegal access. Kurniawan & Handoko (2020) found that combining gas sensors with mobile application-based control can reduce gas leak-related accidents. Rahmawati & Anggraini (2023) added that using *Blynk* in smart homes not only facilitates supervision but also provides comfort and a sense of security for residents. Overall, technology-based home security systems have been proven to enhance residents' comfort while minimizing fire and crime risks.

Several studies have attempted to address these problems. Simanjuntak et al. (2023) developed a system combining MQ-2 sensors and GSM modules to detect LPG gas leaks and send SMS alerts with a 1.6% error rate. Fuadi et al. (2024) designed a NodeMCU ESP8266-based gas leak monitoring system integrated with an Android application for real-time monitoring via Firebase. While these studies demonstrate technological advances, they remain limited to single-function systems—either focusing on gas leak detection or remote monitoring—without integrating broader home security features. This reveals a research gap in designing multifunctional systems that not only detect gas leaks but also control home access through reliable authentication.

The novelty of this study lies in integrating ESP8266 microcontrollers, MQ-2 sensors, RFID authentication, and the *Blynk* application into a single IoT-based system that simultaneously monitors gas leaks and secures door access. Unlike previous studies focusing separately on safety or security, this system combines both aspects to enhance responsiveness and minimize risks.

The objectives of this research are: (1) to design and implement an IoT-based monitoring system for gas leakage detection and door access control, (2) to test the accuracy and reliability of the integrated sensors, and (3) to analyze the effectiveness of the system in providing real-time monitoring and alerts. The benefits of this research are twofold: academically, it enriches the literature on IoT applications for integrated home safety and security, and practically, it offers homeowners a cost-effective, user-friendly, and reliable smart home solution that enhances both comfort and protection.

MATERIALS AND METHOD

The design of this system involves the integration of several main components, namely the adapter as the power source, the sensor as the input, the microcontroller as the processing unit, and several actuator devices and the user interface as the output. The system will start working when the device obtains a power supply from the 12V 5A adapter. After obtaining the voltage, the ESP8266 NodeMCU microcontroller will initialize all connected hardware, namely MQ-2 sensors, RFID sensors, buzzers, and internet network connections. Next, the system will try to connect to the Wi-Fi network. If the connection is successful, then the NodeMCU starts reading data from the MQ-2 sensor to monitor the presence of gases, and the RFID sensor to verify door access based on the card affixed. The flowchart of the system can be seen in Figure 1.

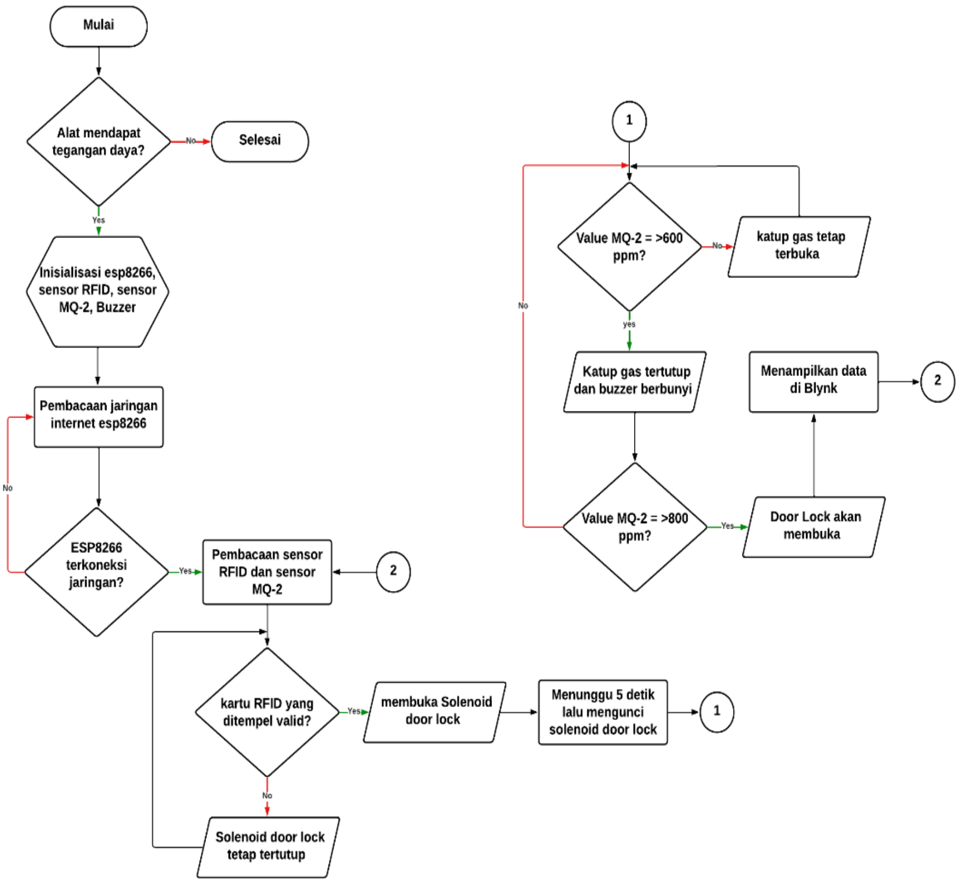

Figure 1. Flowchart of gas leak monitoring system and door access security

Based on the flowchart in Figure 1, it shows that if the MQ-2 sensor detects a gas value above the threshold of 600 ppm, the system will close the gas valve (solenoid valve) and activate the buzzer as a form of early warning. If the gas value increases to more than 800 ppm, the system will automatically unlock the solenoid door to provide evacuation access to the occupants. The door will be left open, then locked again automatically if the ppm has returned to low to maintain safety.

In addition to detecting gases, the system also verifies access through RFID card reading. If the card attached is valid and registered in the system, the solenoid door lock will open to provide access. On the other hand, if the card is not recognized, the door lock will remain closed. Each sensor reading status or system action will be displayed on the Blynk app in real-time to facilitate remote monitoring by users. The structure of the hardware relationships in this system is then made a block diagram. Figure 2 shows a block diagram of the design of the gas monitoring system and door security access control.

RESULTS AND DISCUSSION

Tool Testing

In the testing of this tool, it serves to find out the results provided by the MQ-2 sensor and RFID sensor in the gas monitoring system and door security access control which is tested for the effectiveness of this tool. In conducting tool testing, it is divided into two stages, namely testing each component and testing the whole.

Blynk App Dashboard View

The dashboard in the Blynk application is used to monitor the system condition in real-time. There are four main components displayed, namely the gas value indicator, buzzer, gas valve, and door lock. The gauge gas indicator shows the gas concentration value detected by the MQ-2 sensor, with a range of 0 to 1000 PPM. The Dashboard view can be seen in Figure 4.

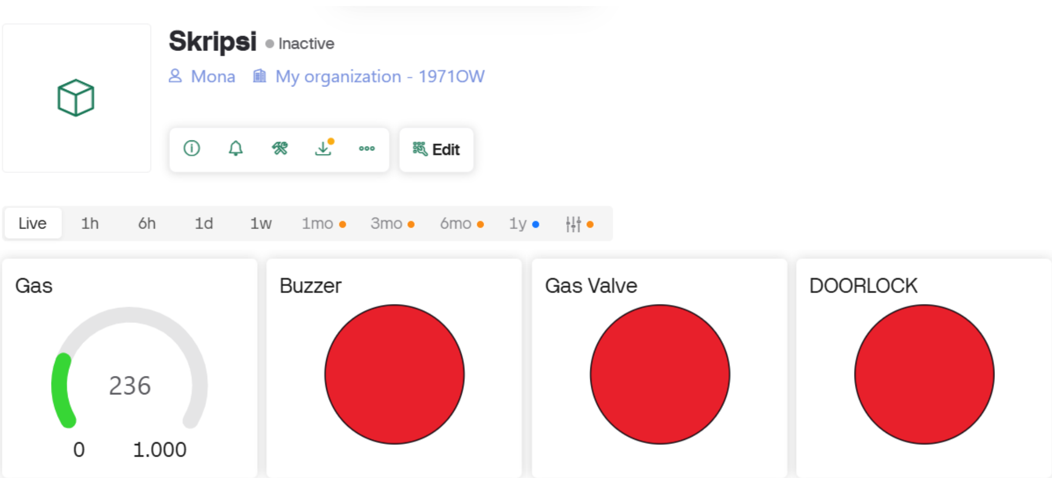

Figure 2. ***Blynk App*** **Dashboard View**

Figure 2 has three other indicators displayed in the form of red circle buttons, namely Buzzer, Gas Valve, and Doorlock, each of which indicates the condition of the device in an inactive state (OFF). The color of this indicator will change when the active device matches the program's logic. This display makes it easy for users to quickly and easily monitor the status of the system over an internet connection using ESP8266 microcontroller.

MQ-2 Sensor Testing

The test results of the MQ-2 Sensor were carried out in 5 experimental stages to evaluate the performance of the MQ-2 Sensor in detecting gas values and how the system responds to the values generated by the sensor connected to the Gas Valve, Buzzer, and Door Lock components. The results of the test data can be seen in Table 1.

Table 1. MQ-2 Sensor Test Results

Trial	Sensor MQ-2 Value	Valve Gas	Buzzer	Door Lock
1	0 - 200 ppm	Open	Off	-
2	201 - 400 ppm	Open	Off	-
3	400 – 599 ppm	Open	Off	-
4	>600 ppm	Closed	On	-
5	>800 ppm	Closed	On	Open

Testing Tag Cards on RFID

RFID sensor testing aims to ensure the system can distinguish between cards that have access permissions and those that do not. Each RFID card has a code for (UID) that is read by the sensor. Before testing, the UID of the card that is considered valid is first entered into the microcontroller program so that the system can recognize the card when it is tested. This process allows the system to allow access only to cards that have been previously registered.
In the trial, two different cards were used:

1. Card 1 (valid) with UID A3AAA5F8
2. Card 2 (invalid) with UID 63BBA113

In addition to testing based on card validity, testing is also carried out on the card reading distance. The RFID card is tested with distances ranging from 0.1 cm to 5 cm to determine how responsive the sensor is in reading the UID. This test is useful for determining the optimal limit of sensor detection distance under real-world conditions of daily use.

Table 2. RFID Sensor Testing

No	Reading Distance (cm)	UID card: A3AAA5FB	UID Card 63BBA113
1	0,1 – 1	Readable – Access Granted	Readable – Access Denied
2	1,5 – 2	Readable – Access Granted	Readable – Access Denied
3	2,5 – 3	Readable – Access Granted	Readable – Access Denied
4	3,5 – 4	Readable – Access Granted	Readable – Access Denied
5	4,5 - 5	Readable – Access Granted	Readable – Access Denied
6	5.5 >	Illegible	Illegible

Overall Testing of the Tool

At this stage, testing of the entire system is carried out to ensure that all components function according to the design. NodeMCU ESP8266 used as the main control center, which is in charge of processing inputs from the MQ-2 Sensor as a gas leak detector and the RFID Sensor as the door access control system.

The output components used include a buzzer as a sound warning device when gas is detected exceeding the threshold, a gas solenoid valve to automatically close the gas flow valve, and a solenoid door lock that functions to open the door when a valid RFID card is detected. In addition, the system is connected to the Blynk application via a Wi-Fi connection, which plays a role in real-time monitoring to users in real-time.
The components used in this system include:

1. NodeMCU ESP8266
2. Sensor MQ-2

3. Sensor RFID
4. Buzzer
5. Solenoid Valve Gas
6. Solenoid Door Lock
7. Blynk App

Table 3. Overall Tool Testing

No	Components Tested	Condition	Solenoid Valve Gas	Solenoid Door Lock	Buzzer
1	Sensor MQ-2	Gas value < 200 ppm	Open	-	Inactive
		300 – 500 ppm	Open	-	Inactive
		> 600 ppm	Shut	-	Active
		≥ 800 ppm	Shut	Open	Active
2	Sensor RFID	Valid card (UID A3AAA5F8	-	Open	Active sound 2 times
		Invalid card (UID 63BBA113)	-	Closed	Active 2 seconds

CONCLUSION

The gas leak monitoring system and RFID-based door security access control integrated with the *Blynk* application developed in this study demonstrated effective real-time gas leak detection using the MQ-2 sensor and automatic door access control via solenoid locks based on RFID authentication. The system successfully sends instant notifications through the *Blynk* app, ensuring timely user alerts. Testing confirmed that RFID serves as a reliable authentication method for door access control, and the overall system provides a practical and efficient solution for enhancing home safety. Future research could explore expanding this system by integrating additional sensors and smart home features, such as fire detection or video surveillance, to create a more comprehensive intelligent home security platform.

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