



## Design and Construction of a Liquefied Petroleum Gas (LPG) Leak Detection System Based on the Internet of Things

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### Abstract

The use of LPG as an energy source in the community carries the risk of leakage that can endanger the safety of life and the environment. This research aims to design and build an LPG gas leak detection system based on the Internet of Things (IoT) using MQ-2 sensors and NodeMCU ESP8266. The methods used are Research and Development (R&D) with the hardware design stage, programming using the Arduino IDE, and integration with the Blynk application for monitoring and notifications. The MQ-2 sensor is used to read the gas level, while a buzzer and virtual LEDs are used as warning indicators. The test results showed that the system was able to detect gas levels above the 400 ppm threshold, providing real-time alerts through buzzers and app notifications with a quick response. Gas level data is also displayed in the form of a graph for easy monitoring. The system works stably as long as it is connected to a Wi-Fi network. Thus, this system has been proven to be effective, accurate, and can increase awareness of the potential danger of LPG leaks.

**Keywords:** Gas Leaks, LPG, IoT, MQ-2, NodeMCU ESP8266, Blynk

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### 1. Introduction

With the development and advancement of technology, human needs for natural resources and energy are increasing. These resources are very much needed, both for daily needs and other needs. Although natural resources on earth are abundant, some are renewable and some are not. One of the natural resources that cannot be renewed and used by humans to meet daily needs is LPG (Liquefied Petroleum Gas) [1]. Since the issuance of Presidential Regulation No. 104 of 2007 by President Susilo Bambang Yudhoyono regarding the transition from kerosene to LPG gas, the government aims to reduce fuel subsidies (BBM). This regulation encourages people to switch to using LPG. Until now, LPG has become an important need for society, both on a small scale such as households, and on a large scale such as restaurants, industry, and the medical sector [2].

As time goes by, the need for LPG gas is increasing and increasing from time to time, especially for 3 Kg LPG gas, each year continues to experience an average increase of 4.5%. The government is converting subsidized kerosene into subsidized LPG gas because fuel oil is predicted to run out if used continuously, so LPG gas was created [3]. LPG has many advantages when compared to other natural resources such as kerosene. However, LPG also has disadvantages in its use, such as it can cause fires because it has very high pressure when in the air [4]. One of the main risks in using LPG is the potential for fires caused by gas leaks. LPG leaks are often difficult to detect, especially because the smell of gas can be blocked by several factors, such as absorption into water pipes, carpets, or in rooms that use air conditioning. This situation can increase the risk of fire if the leak is not immediately anticipated. Therefore, special attention and solutions are needed to detect gas leaks effectively and in a timely manner [5].

The application of the Internet of Things (IoT) includes features such as information sharing, remote control, and data processing from sensors installed on various objects. These objects include food, electronic devices, collections, equipment, and even living things. All of these are connected to local or global networks through continuously active sensors [6].

To address these challenges, utilizing Internet of Things (IoT) technology is an effective alternative solution for detecting and monitoring LPG gas leaks in real time. Through IoT, remote monitoring can be performed using sensors capable of identifying changes in gas concentration in the air and sending alerts via automatic alarms or mobile devices. Therefore, this research aims to design and build an IoT-based LPG gas leak detection system as an effective preventative solution.

One of the main risks of using LPG is the potential for fires caused by gas leaks. LPG leaks are often difficult to detect, especially because the gas odor can be obscured by several factors, such as absorption into plumbing, carpets, or air-conditioned rooms. This situation can increase the risk of fire if leaks are not promptly addressed. The aim of this research is to design and build an IoT-based LPG gas leak detection system that is capable of detecting leaks in real-time and providing early warnings to users.

## 2. Literature Review

As a basis for the preparation of the research, a literature review was carried out on articles in the form of journals that had been written by previous researchers, namely in the form of LPG, IoT, gas leaks, and several research results related to this research. Research conducted by Dissa Margaretha Panjaitan, Valentina Febriyanti Naibaho and Afritha Amelia about “Rancang Bangun Sistem Pendeteksi Kebocoran Gas LPG Menggunakan Sensor MQ-2 Berbasis NodeMCU ESP8266”, The system was successfully realized to detect LPG gas leaks, provide real-time leak level information, and send notifications to users, even though it is not equipped with a control system after leak detection [7].

The research was conducted by Bayu Riyadi and Hendriyawan Achmad about “Rancang Bangun Sistem Keamanan Rumah Berbasis Piranti Raspberry Pi 3 Menggunakan Internet Of Things”, The results obtained were that the system successfully detected LPG gas leaks in real-time and sent notifications to users, even though they were not equipped with a power control system after leak detection [8]. Research by Sirmayanti et al, about “Rekayasa Mitigasi Kebocoran Gas LPG dengan Sistem Monitoring Telegram Bot Berbasis Internet of Things (IoT)”, The results of the design show that this tool successfully detects LPG gas leaks effectively and can provide notifications to users via Telegram, as well as visually monitor the state of the kitchen using CCTV [9].

The research was conducted by Intan Nur Fauziah, Harliana dan Muhamad Bagas Gigih about “Rancang Bangun Alat Pendeteksi Kebocoran Gas LPG Menggunakan Sensor MQ-6 Berbasis Arduino”, The results of the study show that this tool can detect gas leaks well. The buzzer and LED will illuminate when the detected gas level reaches the 500 ppm threshold. In addition, it can also stop the buzzer and LED when the ppm level is less than 500 ppm, indicating that the leak has been resolved [10]. This research has similarities with several previous studies that also developed a system to detect LPG gas leaks and send alerts automatically to users. However, what is different from this study is that it displays the concentration of gas size in the form of a graph so that it is easy for users to understand in more detail regarding the leak rate.

### 2.1. Theoretical Foundations

1. Liquefied Petroleum Gas (LPG)  
Liquefied Petroleum Gas (LPG) is a hydrocarbon gas produced in oil and gas refineries, the main components of which are propane and butane gas in packages. Liquefied petroleum gas is commonly used as fuel, especially for cooking. LPG is also used as a raw material for the aerosol industry and is environmentally friendly [11].
2. Internet of Things  
The concept of IoT is generally interpreted as the ability to connect objects or smart objects so that they can interact with other objects, environments, and even other smart computing devices through the Internet network. IoT is used in a variety of ways in various situations in human life [12].
3. MQ2 (Sensor Gas LPG)  
The MQ2 sensor is a sensor that detects flammable gases such as LPG (liquefied petroleum gas), i-butane, propane, methane, alcohol, hydrogen, and smoke. The way the MQ2 sensor works is that the windborne gas is captured and converted into an analog voltage by the MQ2 sensor. The MQ-2 sensor can detect a wide range of gases and fumes in the concentration range of 300 to 10,000 ppm [13].
4. NodeMCU ESP8266  
NodeMCU is an open source ESP8266 based platform that can connect objects and enable data transfer using Wi-Fi protocols. The common features of this board include; easy to use, programmable with Arduino IDE or IUA language, available as an access point or station, practical in API applications and has a built-in antenna [14].
5. Jumper Cable  
Jumper cable, a cable that serves as a link between a sensor device or breadboard and a microcontroller with a transmission medium that carries power and signals from the sensor and is converted by the microcontroller itself [15].
6. Arduino IDE  
Arduino IDE is a software that allows programs containing commands to be inserted into a microcontroller and uploaded for use in applications [15].
7. Adaptor  
According to the IEEE (Institute of Electrical and Electronics Engineers), it is often defined as a connecting device that regulates and converts power to meet the specific voltage needs of the device, and in the context of an adapter, means providing a power supply to low-power electronic devices such as the Arduino or NodeMCU.
8. Buzzer  
An electronic component that can convert electrical signals into sound vibrations. Generally, buzzers are often used as alarm devices [16].
9. Blynk  
BLYNK is a mobile operating system application platform (iOS and Android) aimed at controlling Arduino, Raspberry Pi, ESP8266, WEMOS D1 and similar modules over the Internet. The app is a creative platform for creating a graphical interface for your projects, which can be easily implemented using the drag-and-drop widget method [16].
10. Research And Development  
Research and Development (R&D) is a process or steps to develop a new product or improve an existing product. Development research is a type of research that can be a link or bridge between basic research and applied research. From this description, it can be concluded that Research and Development is a research method that aims to produce certain products. Through research on educational problems, solutions can be found so that they can develop and apply more innovative education, one of which is Research and Development (R&D) research or research and development research [17].
11. Parts per Million  
Parts Per Million (ppm) is a unit of measurement used to express the proportion or concentration of a substance or component in a mixture or solution by referring to the ratio of that part to one million parts of the mixture or solution [18].

### 3. Research Methodology

This research uses the Research and Development (R&D) method to design and develop a prototype of an IoT-based LPG leak detection system. The developed prototype is tested to ensure its functionality in detecting gas leaks in real-time. The results of this research are expected to be the basis for the development and application of a wider system in the future. The flow of the research is shown in Figure 1.

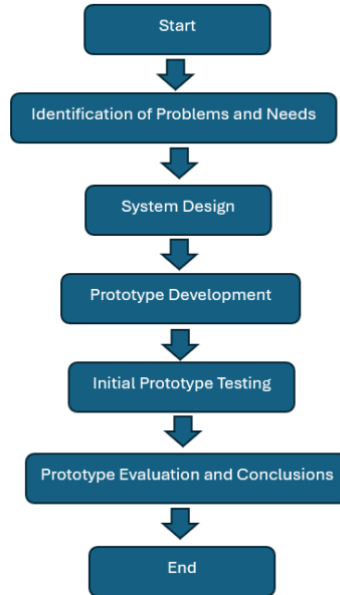


Fig. 1: Research and Development (R&D) Method

#### 3.1. Identification of Problems and Needs

This stage aims to identify potential hazards from LPG gas leaks that can threaten the safety of life and the environment. In general, people only realize a gas leak when they smell the gas directly. In addition, there are still many systems that are not equipped with automatic leak detection or early warning. This condition shows the need for a system that is able to detect gas leaks in real-time and provide alerts through alarms and digital notifications. Therefore, an IoT-based LPG gas leak detection system was designed to improve safety and respond quickly to potential leaks in various environments. The research instruments featured several devices used in this study, such as:

1. Microcontroller
2. Gas Sensor
3. Buzzer
4. Adaptor
5. Jumper Cable
6. Smartphone
7. Laptop/PC
8. Arduino IDE
9. Blynk App

#### 3.2. System Design

At this stage, the researcher describes the system's workflow, starting from receiving data by sensors to notifying users. The system's workflow is designed to ensure each component is working as it should, detecting leaks quickly and providing timely alerts. The system workflow can be seen in Figure 2.

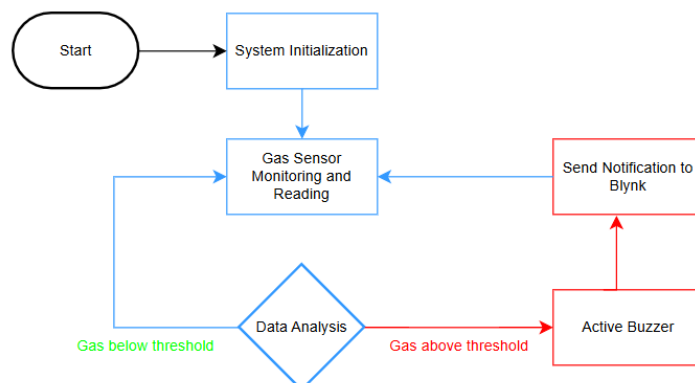


Fig. 2: System Workflow

1. System Initialization – The system starts working by activating all components, such as the MQ-2 Sensor, Buzzer, and connecting the NodeMCU to the Wi-Fi network as well as the Blynk application.
2. Gas Sensor Monitoring and Reading – The MQ-2 sensor reads LPG gas levels at regular intervals, and the readings are displayed in real-time via the Blynk app.
3. Data Analysis – The detected gas values are analyzed and compared to a predetermined threshold of 400 ppm.
  - If the gas is below the threshold → the System Return monitors and reads the gas sensor.
  - If the gas exceeds the threshold → the System activates the buzzer and sends a notification to the Blynk app.

This system works automatically, real-time, and is IoT-based, so it is able to provide direct warnings to users both through alarms and remote notifications when a gas leak occurs.

At this stage, the researcher also made an electronic circuit scheme of the gas leak detection system to show the relationship between the components. The Electronic Network Schema can be seen in Figure 3.

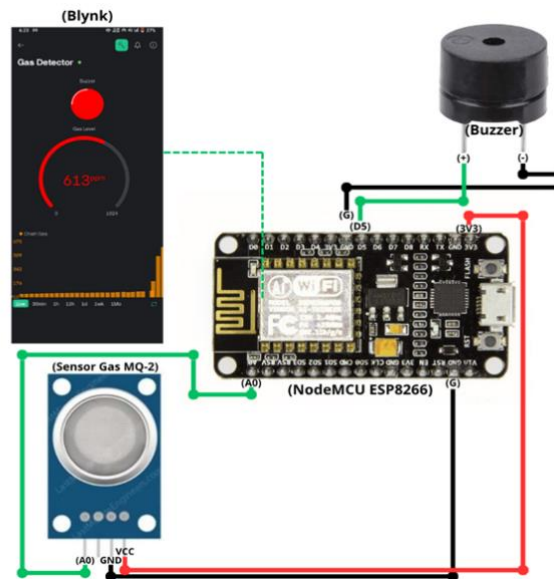


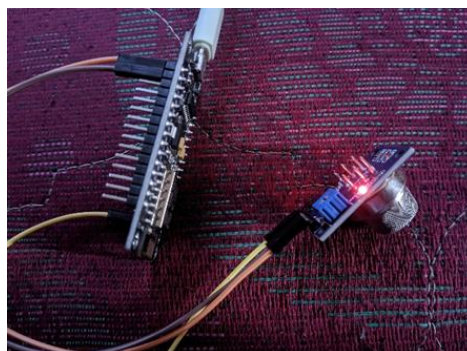
Fig. 3 Electronic Network Schematic

1. NodeMCU ESP8266 as the primary microcontroller for reading sensor data and controlling the output.
2. The MQ-2 Gas Sensor detects the presence of LPG gas and sends data to the NodeMCU via the data pin (A0).
3. The buzzer connects to the digital pin (D5) of the NodeMCU to provide an alarm when gas is detected exceeding the threshold.
4. The Blynk app on smartphones receives data from the NodeMCU over a Wi-Fi connection to display the sensor status and control the system remotely.
5. Electrical connection:
  - The 3V3 (3V) and GND sensors and buzzers are connected to the NodeMCU.
  - The sensor data path enters the analog pin A0 NodeMCU.
  - The buzzer is controlled by the NodeMCU digital pin (D5)).

### 3.3. Prototype Development

The leak detection system prototype was developed by assembling all electronic components based on the design that has been made. This development is carried out in stages to ensure that all components work according to their functions. This gas leak detection system uses a variety of hardware modules. The main components include the NodeMCU ESP8266, MQ-2 Gas Sensor, Buzzer, Jumper Cable, and micro USB cable.

The initial stage in the prototype development process begins with the assembly of all components. The connection between the gas sensor and the microcontroller can be seen in Figure 4.



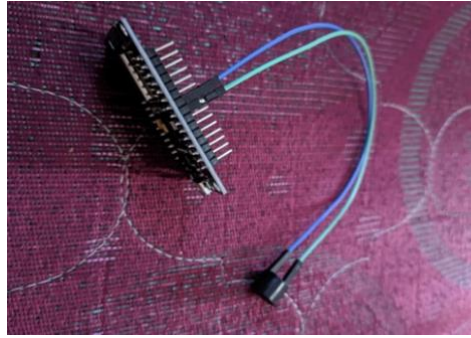
**Fig. 4:** ESP8266 to Gas Sensor

A crucial aspect to consider in the assembly process is ensuring proper connectivity between the pins in the MQ-2 Gas Sensor with the ESP8266 NodeMCU microcontroller. The pin relationships between these components can be seen in Table 1.

**Table 1:** Connection ESP8266 to Gas Sensor

Pin ESP8266	Pin MQ-2
A0	A0
G	GND
3V3	VCC

The next step is the connection between the NodeMCU and the Buzzer, which acts as an alarm for early warning. The connection between these two components can be seen in Figure 5.

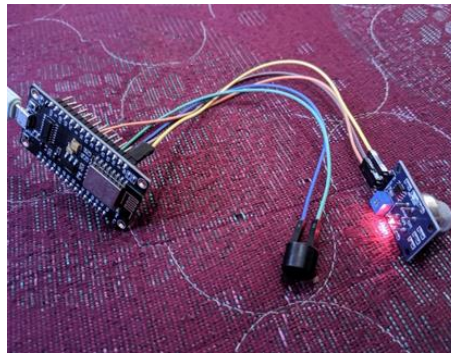
**Fig. 5:** ESP8266 to Buzzer

The pin relationship between the microcontroller and the buzzer can be seen in Table 2.

**Table 2:** ESP8266 connection to the Buzzer

Pin ESP8266	Buzzer
D5	+
G	-

The entire range of gas leak detection systems, which have been described in stages in the previous section, can be seen in full in Figure 6, which illustrates the integration of all components as a whole.

**Fig. 6:** Entire Network

### 3.4. System Coding

The programming process is a crucial stage in the development of an IoT-based gas leak detection system. The program is written using an Arduino IDE and uploaded to the NodeMCU ESP8266. The initial configuration includes setting up the MQ-2 Sensor for gas detection, a buzzer as a sound alarm, as well as a Wi-Fi connection to send data in real-time to the Blynk app. The program assigns pins D5 for the buzzer and A0 for the gas sensor, as well as sets the gas detection threshold (`GAS_THRESHOLD = 400`). Wi-Fi credentials are stored in `ssid` and `pass` variables, while auth tokens are used for secure connections to Blynk. All these elements support a stable and accurate monitoring system, as can be seen in Figure 7.

```
// AKSES BLYNK DAN WIFI
char auth[] = "_EikCDBGVivSwB4ut6hdSX7EmUkAg9nn";
char ssid[] = "Kajumen";
char pass[] = "00009898";

// DEFINISI PIN
#define BUZZER_PIN D5
#define SENSOR_PIN A0

// VARIABEL
BlynkTimer timer;
const int GAS_THRESHOLD = 400;
```

Fig. 7: Wifi, Blynk and gas limit connections

To support the system, a number of libraries and key functions are used in the program code. The library is used to enable Wi-Fi connectivity and integration with the Blynk platform, while the functions in the program are in charge of regulating the system's work logic, from reading the gas sensor, activating the buzzer, to sending data and notifications to users.

### 3.5. Application Interface Design

The main interface of the IoT-based gas leak detection application is designed with a simple yet informative interface, and is capable of presenting data in real-time. The Gauge widget functions to display the gas sensor value in a visual form resembling a circular meter, making it easier for users to monitor the gas concentration level. The SuperChart is used to present a continuous graph of the movement of gas levels, providing an overview of changes in sensor values over time. As an indicator of dangerous conditions, the red Virtual LED will automatically illuminate when the gas level exceeds the threshold. In addition, the system is also equipped with a notification feature to send direct alerts to users. An illustration of the application interface can be seen in Figure 8.

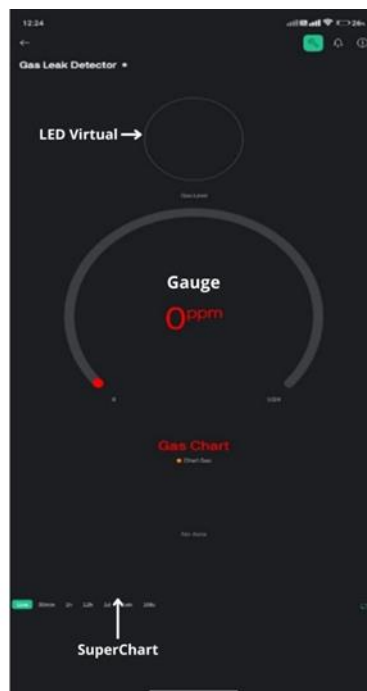


Fig. 8: Blynk Interface Display

To realize these functions, a number of widgets are used that are configured using virtual pins in the Blynk application. Details of the configuration of each widget are presented in Table 3.

Table 3: Widget Configuration on Blynk

Widget	Virtual Pin	Function
Gauge	V1	Visually displays the sensor value in the form of a meter circle (such as a speedometer).
Super Chart	V2	Displays a real-time gas level graph.
LED Virtual	V3	Illuminates if the gas exceeds the limit (indicator).

### 3.6. Initial Prototype Testing

After the prototype is completed, testing is carried out in a simulated environment to ensure the system can accurately detect LPG leaks. This test involves measuring sensor sensitivity, notification response speed, and detection accuracy.

### 3.7. Prototype Evaluation

The final stage of the research is the evaluation of the prototype's performance based on the test results. This evaluation is conducted to determine if the prototype can perform as expected and provide input for system improvement. Conclusions are drawn from all stages that have been carried out to assess the success of the research in achieving the goals.

## 4. Results and Discussion

### 4.1. Initial Prototype Testing

Before an IoT-based gas leak detection system can work, the first step to take is to connect the device to a WiFi network and integrate the NodeMCU with the Blynk app using the registered Auth Token. This process ensures that the device can transmit real-time gas sensor reading data to the Blynk app installed on the user's smartphone. During this stage, users also need to verify that all components such as the MQ2 gas sensor, buzzer, and virtual indicator on the app are connected and working properly. Once the initialization process is complete, the system is ready to provide accurate and timely notifications in the event of a gas leak.

### 4.2. Gas Sensor Sensitivity Testing

At this stage, tests were carried out on the MQ2 gas sensor to measure the sensor's ability to detect gas leaks. Test gas (lighter without flame) is used to test the sensor at a certain distance. The test was carried out with several variations in gas levels to determine the detection limits of the sensor. From these results, it can be concluded that the MQ-2 sensor is effective in detecting gases at very close distances (1-5 cm) but its effectiveness decreases significantly when it is 6-10 cm away. This can happen because the materials used for testing only use matches, not LPG Gas itself. Details of the test results can be seen in Table 4.

Table 4: Gas Sensor Sensitivity Test

Distance from Gas Source (cm)	Readable gas rate	Buzzer	Indikator Virtual
1-5 cm	400-1250 ppm	Active	Turn on
6-10 cm	30-50 ppm	Inactive	Not Flame

### 4.3. Gas Leak Warning Notification Feature

The gas leak warning notification feature has been successfully implemented to provide real-time information to users. Whenever the sensor detects a gas level that exceeds the threshold, the system automatically sends a notification via the Blynk app. The implementation of this notification feature is shown in Figure 9.

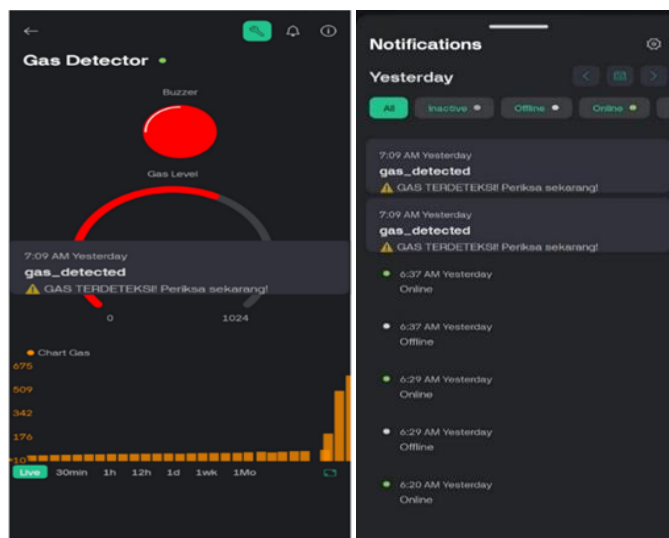


Fig. 9: Leak Notifications

Based on the test results, the system is proven to be able to send notifications quickly and accurately without experiencing technical problems. This shows that the system has a good response in delivering alerts to users in real-time. Details of the time when notifications are sent from the system to the user's device can be seen in Table 5.

Table 5: Gas Sensor Sensitivity Test

No	Reading Time	Notification Delivery Time	Level Gas	Information
1	06.23	-	31 ppm	Secure, Notifications not coming in
2	06.25	-	176 ppm	Secure, Notifications not coming in
3	07.09	07.09	613 ppm	Dangerous, Notifications sent

4	07.12	-	27 ppm	Secure, Notifications not coming in
5	07.15	07.15	509 00m	Dangerous, notifications are sent

#### 4.4. Buzzer Response Testing and Digital Indicators

To test the accuracy of the system's detection and response, tests were carried out on buzzers and virtual indicators connected to the Blynk application. The results of the digital indicator test can be seen in Figure 10.

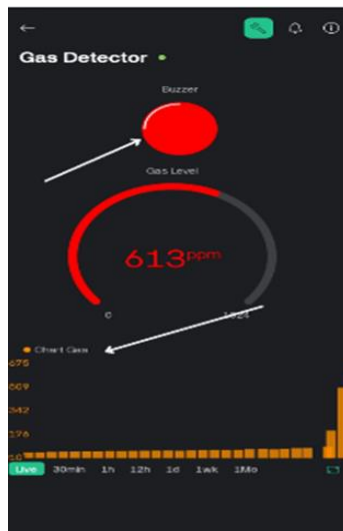


Fig. 10: Virtual Buzzer Indicator and Gas Level Chart

When the MQ2 gas sensor detects a gas in excess of the threshold (400ppm), the buzzer will activate as a warning alarm, and the virtual indicator on the Blynk app will illuminate to signal a red flag. This test aims to ensure that the system provides a fast and appropriate response when a gas leak is detected.

#### 4.5. Gas Sensor Test Results

To determine the system's performance in detecting the presence of gas, a series of tests were carried out by recording the reading value of the MQ2 gas sensor at regular intervals. The data from these readings is sent in real-time to the Blynk application and is displayed in the form of a graph that can be seen in Figure 11.



Fig. 11: Graphics Chart Gas

In addition, for documentation and further analysis purposes, the data is also recorded in Table 6.

**Table 6: Gas Sensor Sensitivity Test**

No	Reading Time	Level Gas	Status
1	06.23	31 ppm	Safe
2	06.25	176 ppm	Safe
3	07.09	613 ppm	Hazardous Gas
4	07.12	27 ppm	Safe
5	07.15	509 ppm	Hazardous Gas

#### 4.6. Prototype Evaluation

The evaluation was carried out after the IoT-based gas leak detection system was designed and tested. The prototype has gone through a functional testing stage, including testing sensor sensitivity, system speed in providing notifications, and accuracy in activating buzzers and virtual indicators through the Blynk application. The test results show that:

- The MQ2 gas sensor is capable of detecting the presence of LPG gas at a predetermined threshold (analogue value above 400ppm).
- The system sends data in real-time to the Blynk app and displays an accurate graph of gas levels.
- A warning notification is successfully sent to the Blynk app when gas is detected, accompanied by the activation of a buzzer and a virtual LED indicator.
- Communication between NodeMCU and applications runs stably as long as the device is connected to a WiFi network.

## 5. Conclusion

Based on the results of research and tests that have been carried out, it can be concluded that an IoT-based LPG gas leak detection system designed using MQ-2 sensors, NodeMCU ESP8266, and the Blynk application can function well in detecting gas leaks in real-time and providing alerts to users, MQ-2 sensors are able to effectively detect LPG gas at a distance of 1–5 cm with levels above the threshold of 400 ppm. However, effectiveness decreases at a distance of 6–10 cm. This is likely due to the fact that the test material is a gas from a lightless lighter instead of pure LPG gas, so the gas concentration is lower and spreads quickly in the air, making it difficult to detect at longer distances, Gas concentration data is displayed in real-time in the form of a graph using the SuperChart widget, making it easier for users to monitor gas levels and visually detect potential hazards and the System successfully performs its functions stably during the connect to a Wi-Fi network, with no technical issues during the testing process. For future development, the system can be further developed by adding automation features such as gas flow breakers or relays to minimize the risk of fire when a leak is detected and the use of a stable internet connection is essential for the notification system to work optimally. Therefore, it's a good idea to also equip your system with local storage features or alternative notifications (such as SMS) if Wi-Fi is lost.

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## References

- [1] R. Inggi and J. Pangala, "Perancangan Alat Pendeteksi Kebocoran Gas LPG Menggunakan Sensor MQ-2 Berbasis Arduino," *Simkom*, vol. 6, no. 1, pp. 12–22, 2021, doi: 10.51717/simkom.v6i1.51.
- [2] M. Efan, K. A. Santoso, and C. Mufit, "Rancang Bangun Sistem Deteksi Kebocoran Gas Lpg Pada Rumah Tangga Berbasis Iot," *J. Kaji. Tek. Elektro*, vol. 8, no. 2, pp. 65–73, 2023, doi: 10.52447/jkte.v8i2.6751.
- [3] I. W. M. Fadhilah Bakri, Askar Patahuddin, "Penjualan Liquefied Petroleum Gas Subsidi kepada Masyarakat Selain Kategori Miskin Perspektif Syariah (Studi Peraturan Presiden Nomor 104 Tahun 2007) Sales," *J. Kaji. Islam AL-FIKRAH*, vol. 1, no. 1, pp. 201–220, 2024, doi: 10.36701/fikrah.v1i1.1675.
- [4] S. Putri Pratiwi and T. Nurhastuti, "Rancang Bangun Alat Pendeteksi Kebocoran Gas LPG Menggunakan Wemos D1 R1 Dengan Notifikasi Peringatan Whatsapp dan Telegram Berbasis IoT," *J. Teknol. Inf.*, vol. 9, no. 2, pp. 97–105, 2023, doi: 10.52643/jti.v9i2.3766.
- [5] A. G. S. Akbar, J. Maulindar, and R. Susanto, "Rancang Bangun Kelebihan Internet of Things Untuk Mendeteksi Kebocoran Gas," *INFOTECH J.*, vol. 9, no. 1, pp. 223–231, 2023, doi: 10.31949/infotech.v9i1.5409.
- [6] C. Y. Pratiwi, A. Satria, U. Christanto, and R. Palupi, "Efisiensi Penggunaan Internet of Thing (IoT) dan Dampak Sistem dalam Rumah Pintar," *J. Solo Teknol.*, vol. 1, no. 2, pp. 45–49, 2025.
- [7] D. M. Panjaitan, V. F. Naibaho, and A. Amelia, "RANCANG BANGUN SISTEM PENDETEKSI KEBOCORAN GAS LPG MENGGUNAKAN SENSOR MQ-2 BERBASIS NodeMCU ESP8266," ... *Konf. Nas. Soc. ...*, pp. 113–121, 2021, [Online]. Available: <http://ojs.polmed.ac.id/index.php/KONSEP2021/article/view/592%0Ahttps://ojs.polmed.ac.id/index.php/KONSEP2021/article/download/592/203>
- [8] B. Riyadi and H. Achmad, "RANCANG BANGUN SISTEM KEAMANAN RUMAH BERBASIS PIRANTI RASPBERRY Pi 3 MENGGUNAKAN INTERNET OF THINGS," *J. Tek. Elektro, Fak. Teknol. Inf. dan Elektro Univ. Teknol. Yogyakarta*, pp. 1–10, 2018, [Online]. Available: <http://eprints.uty.ac.id/3349/>
- [9] S. Sirmayanti, L. Halide, I. F. Lestari, and E. D. Melda, "Rekayasa Migitasi Kebocoran Gas LPG dengan Sistem Monitoring Telegram Bot Berbasis Internet of Things (IoT)," *Pros. Semin. Nas. Tek. Elektro dan Inform. 2023-Teknik Telekomun.*, pp. 223–228, 2023.
- [10] I. N. Fauziyah, H. Harliana, and M. B. Gigih, "Rancang Bangun Alat Pendeteksi Kebocoran Gas LPG Menggunakan Sensor MQ-6 Berbasis Arduino," *J. Ilm. Intech Inf. Technol. J. UMUS*, vol. 2, no. 01, 2020, doi: 10.46772/intech.v2i01.185.
- [11] Y. A. Hasan, M. Mardiana, and G. F. Nama, "Sistem Pendeteksi Kebocoran Tabung Gas Lpg Otomatis Berbasis Arduino Uno Menggunakan Metode Prototype," *J. Inform. dan Tek. Elektro Terap.*, vol. 10, no. 3, 2022, doi: 10.23960/jitet.v10i3.2671.
- [12] F. Trisnawati, "SEMUDIK : Selamat Mudik Menggunakan Helm Berbasis Internet of Things (IoT)," *J. ICTEE*, vol. 1, no. 1, pp. 6–10, 2020, doi: 10.33365/jictee.v1i1.696.
- [13] L. Khakim, I. Afriliana, N. Nurohim, and A. Rakhman, "Proteksi Kebocoran Gas LPG Rumah Tangga Berbasis Mikrokontroler," *Komputika J. Sist. Komput.*, vol. 11, no. 1, pp. 40–47, 2022, doi: 10.34010/komputika.v11i1.4977.
- [14] H. Husny, F. Kurniawan, and L. Lasmadi, "Pengembangan Sistem Pemantau Kebocoran Gas Elpiji dan Peringatan Dini Bahaya Kebakaran Berbasis Internet of Things," *Avitec*, vol. 4, no. 1, p. 61, 2022, doi: 10.28989/avitec.v4i1.1181.
- [15] F. S. Nurul Fauziah, Akhlis Munazilin, "Rancang Bangun Sistem Pengontrol Irigasi Otomatis Menggunakan Mikrokontroler Arduino Uno," *G-Tech J. Teknol. Terap.*, vol. 8, no. 3, pp. 1464–1473, 2024, [Online]. Available: <https://ejournal.uniramalang.ac.id/index.php/g-tech/article/view/1823/1229>
- [16] N. K. Jumaa, Y. M. Abdulkhaleq, M. A. Nadhim, and T. A. Abbas, "IoT Based Gas Leakage Detection and Alarming System using Blynk platforms," *Iraqi J. Electr. Electron. Eng.*, vol. 18, no. 1, pp. 64–70, 2022, doi: 10.37917/ijeee.18.1.8.
- [17] Okpatrioka, "Research and development (R&D) penelitian yang inovatif dalam pendidikan [Innovative research and development (R&D) in education]," *Dharma Acariya Nusant. J. Pendidikan, Bhs. dan Budaya*, vol. 1, no. 1, pp. 86–100, 2023.
- [18] H. Sastrohamidjojo, "Kimia Dasar," no. June, 2005.