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Liquid Petroleum Gas (LPG) Cylinder Leak Detection Tool Using MQ-2 Sensor Based on Internet of Things (IoT)

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***Abstract*— The widespread use of LPG cylinders brings the risk of gas leaks that can cause serious hazards, including fires and explosions. Therefore, an effective system is needed to detect gas leaks and provide early warnings to users. This study aims to develop an LPG cylinder leak detection device using an MQ-2 sensor based on the Internet of Things (IoT). The system consists of an MQ-2 sensor capable of detecting LPG, a microcontroller module for data processing, and an IoT communication module to send alerts to user devices via the internet. When the MQ-2 sensor detects a gas concentration that exceeds the predetermined threshold, the system sends an alert in the form of a notification to the user's mobile application. Additionally, the system is equipped with an audible alarm for direct on-site warnings. Test results indicate that this system can detect gas leaks with high accuracy and send alerts promptly. The implementation of IoT technology allows for real-time monitoring and handling of gas leaks, thereby enhancing the safety of LPG cylinder users. Thus, this leak detection device is expected to reduce the risk of accidents due to gas leaks and provide a sense of security for users.**

***Index Terms*— gas detection; Internet of Things (IoT); Liquefied Petroleum; MQ-2 sensor; safety system.**

I. Introduction

Systems that connect computer devices, mechanics, digital machines, objects, or individuals equipped with a Unique Identifier (UID) are known as the Internet of Things (IoT). With this system, data can be sent over the network without human intervention. One important component of the IoT is that every item connected to the internet has a configurable internet protocol address. This protocol address allows items to send data to other artificial objects or over a network. Machine-to-machine communication solutions known as the IoT make it possible to view businesses in real-time[1]. Many aspects of human life have been influenced by advances in IoT technology in the current digital era, including household security and the industrial sector. This technology can be used to identify LPG leaks, which are a major problem that can endanger lives and property[2][3]. As a result, a robust and efficient system is required to detect gas leaks as quickly as possible. Natural gas leaks can be dangerous to the environment and human health. Even small particles leaking into buildings or other enclosed spaces can gradually build up to produce fatal levels of explosive or deadly gas. Leakage of refrigerant gas and natural gas into the environment[4]. LPG, which is a mixture of propane and butane, is used for various purposes, such as cooking and as generator fuel. LPG is highly pressurized and cold, so it is stored in cylinders even though it is often used as cooking gas. Ethanethiol is used as a powerful deodorizer to detect leaks. LPG leaks have increased to 10.74% of total kitchen accidents, up from 0.72% previously. Since rubber pipes can crack and cause leaks, small 5 kg LPG cylinders with a burner on top of the cylinder are considered safer[5][6].

A report by the Multiconsult Group by Norad (2020) states that LPG helps developing countries achieve the Development Goals (SDG) in a sustainable manner by facilitating access to environmentally friendly fuel and technology. However, the use of LPG poses risks because the gas is highly flammable and can cause explosions and fires if the gas leaks. This can cause injury or even death as well as property loss. This accident problem is usually caused by old gas regulators, damaged hoses, unmaintained or low-quality hoses, improper installation of the gas regulator, and poor hose connections to the gas stove[7][8].

When gas leaks, it can cause serious health problems such as headaches, dizziness, nausea, memory loss, vomiting, and even death. These consequences are preventable, showing how important a good detection system is. Using the MQ-2 sensor, we propose an IoT based LPG leak detection system. This sensor detects flammable gases and warns the user if the gas concentration exceeds safe limits. This system also has an automatic response mechanism with a servo motor to close the gas regulator if a leak occurs[9][10][11].

II. METHODS

A. System Block Diagram

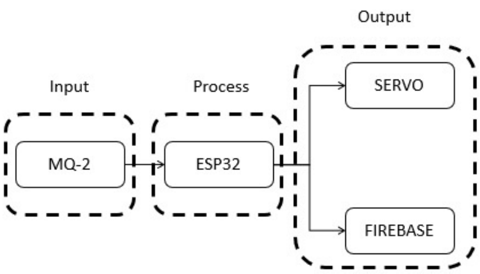

Fig. 1. System Block Diagram

As can be seen in Figure 1, this research uses 3 stages: input, process, and output. The input for this research uses the MQ2 Sensor, which is calibrated first to accurately read LPG parameters. The ESP32 microcontroller is used as the processor in this research, allowing the data to be connected and displayed in the code. There are two outputs used: a servo and a modular display for user monitoring. The servo is utilized to perform specific actions based on the detected gas levels, such as closing a valve or activating an alarm system to ensure safety. The modular display allows users to monitor real-time data and system status, ensuring they are informed about the gas levels and any potential hazards.

B. System Algorithm

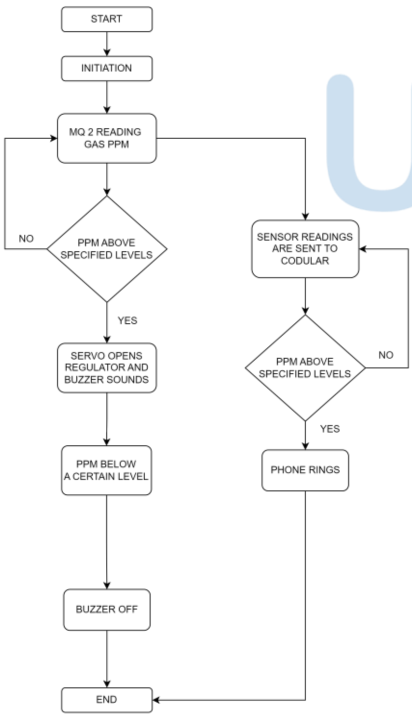

Fig. 2. System Algorithm

In the Fig. 2 above the system starts by initiating all components. After the initiation process was complete, the sensor read the LPG gas parameters and then the ESP32 sent the reading value to the modular application. When the LPG gas parameters were above the predetermined values, the ESP32 ordered the servo to rotate in order to open the regulator. The ESP32 also turned on the buzzer as an offline notification to offline users. Apart from offline notifications, Kodular also provided notifications to the user's cellphone in the form of danger warning notifications. When the LPG gas parameters were below the predetermined limit, the ESP32 gave a command to turn off the buzzer.

C. IoT Process

Fig. 3. IoT process

In this research, the IoT system is used to monitor LPG gas parameters. The IoT algorithm is implemented using ESP32, which is connected to a WiFi network and Firebase database. The connection process is carried out in stages with the initial stage being connecting the ESP32 to WiFi. When the ESP32 is connected to a WiFi network, it will connect to the Firebase that has been prepared. ESP32 is connected to the WiFi network and Firebase, so it can send MQ2 reading data to Firebase. Firebase, which has received the reading value, will send the data to Kodular. This process is illustrated in Fig. 3.

D. Quality of Service

QoS is used to measure the capacity of computer networks, such as network applications, hosts, or routers, to provide better network services so that they can meet the service needs of their users. QoS helps users get faster performance from network-based applications by using delay, jitter, packet loss, and throughput parameters. There are several parameters that need to be considered to determine QoS, including Throughput, Packet Loss, Delay, and Jitter.

In this research, QoS is used as one of the metrics because the effectiveness of the LPG leak detection system heavily depends on the network performance. Accurate and timely detection and notification of gas leaks are crucial for ensuring user safety. By analyzing QoS parameters such as throughput, packet loss, delay, and jitter, the reliability and efficiency of the IoT-based detection system can be assessed. This ensures that the system can consistently provide real-time alerts and minimize false alarms, thus enhancing the overall safety and reliability of the system.

1. Packet Loss

   Packet loss is a parameter that indicates how many data packets are lost during transmission, possibly due to collisions and network traffic[12]. Packet loss parameter categories can be seen in Table I.

TABLE I. PACKET LOSS

Category Lost Package	Package *Loss(%)*	Index
Very good	0%	4
Good	3%	3
Currently	15%	2
Bad	25%	1

2. Delay
   Delay is not only the time it takes for a data packet to be sent from the start of the queuing process to the destination point, but also the time it takes for data to go from source to destination. The type of transmission media used, distance, and processing time required at each intermediate point in the network are some of the factors that influence delay [13]. Delay categories can be seen in Table II.

TABLE II. DELAY

Category Delay	Delay(*ms*)	Index
Very good	<150	4
Good	150 s/d 300	3
Currently	300 s/d 450	2
Bad	>450	1

3. Throughput
   Throughput, calculated in bits per second (bps), is the number of packets that successfully arrive at the destination during a certain period, divided by the duration of that time interval[12]. Throughput categories can be seen in Table III.

TABLE III. THROUGHPUT

Category Troughput	Troughput	Index
Very good	100	4
Good	75	3
Currently	50	2
Bad	<25	1

4. Jitter
   Jitter can occur due to delays caused by routers or switches in a computer network[12]. Jitter categories can be seen in Table IV.

TABLE IV. JITTER

Category Jitter	Peak Jitter(ms)	Index
Very good	0	4
Good	0 s/d 75	3
Currently	75 s/d 125	2
Bad	125 s/d 225	1

III. RESULTS AND DISCUSSION

A. MQ-2 Calibration

The MQ-2 smoke gas sensor is used to detect smoke and LPG leaks in homes and businesses. This type of sensor measures the concentration of combustible gases and smoke in the air and outputs readings as analog voltage. It can be used to prevent fires by detecting smoke and LPG gas leaks[7][14]. One of the main features of the MQ-2 sensor is its high sensitivity and fast response time, which allows measurements to be made as quickly as possible. It has the ability to measure natural gas concentrations between 200 and 5000 *ppm*[9]. Due to its high sensitivity to various types of airborne particles, the MQ-2 sensor needs to be properly calibrated before use to ensure the accuracy and consistency of its data. This includes gases such as LPG, butane, hydrogen, smoke, and methane. The sensitivity of the sensor to different gas concentrations is changed by calibration. For a variety of applications, including gas leak detection, air quality monitoring, and security systems, this results in more accurate and reliable findings.

Calibration is considered to be a crucial step because it ensures that the sensor provides accurate and reliable readings. Without proper calibration, the sensor may give false readings or fail to detect dangerous gas concentrations, leading to potential safety hazards. If the calibration process is not done, the sensor might either overestimate or underestimate the gas concentration levels. Overestimation can cause unnecessary alarms and disruptions, while underestimation can prevent the detection of dangerous gas leaks, resulting in a failure to provide timely alerts and potentially causing catastrophic accidents, such as fires or explosions. Therefore, calibration is essential to maintain the effectiveness and reliability of the sensor in detecting gas leaks and ensuring safety.

The following list of steps outlines how to calibrate the MQ-2 sensor to detect LPG (Liquid Petroleum Gas) gas.

1. Before commencing the calibration of the MQ-2 gas sensor, it is essential to preheat the sensor to ensure accuracy in its measurements. The recommended preheating procedure involves applying a voltage of 5*V* to the sensor for approximately one hour. This process ensures the sensor is in optimal condition for accurate gas detection.

   To achieve the best operational state, the MQ-2 gas sensor utilizes a heating coil. The preheating technique consists of an initial heating phase where the sensor is heated for 60 *seconds* at 5*V*, followed by a secondary heating phase at 1.4*V* for 90 *seconds*. This dual-phase heating process enhances the sensor's readiness for precise gas measurement. The wiring of the voltage divider on the MQ-2 can be seen in Fig. 3.

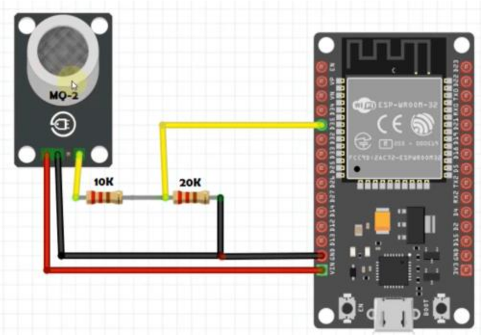

Fig. 4. The voltage divider for the MQ-2 voltage is 5V

2. Find the R_o value in the room that will be detected by the MQ-2 using the program below.

```
Mencari_RO
#define RL 10
float Analog_value = 0;
float VRL = 0;
float Rs = 0;
float Ro = 0;

void setup() {
  pinMode(35, INPUT);
  Serial.begin(115200);
}

void loop() {
  Analog_value = analogRead(35);
  VRL = Analog_value * (3.3 / 4095.0);
  Rs = ((3.3 / VRL) - 1) * RL;
  Ro = Rs / 9.6;
  Serial.print("RO di udara bersih = ");
  Serial.println(Ro);
  delay(1000);
}
```

Fig. 5. Look for the RO value

The R_L value is obtained from the resistance on the MQ-2 sensor. In the calculation of $R_o = R_s / 9.6$, the value 9.6 is obtained from the MQ-2 sensor datasheet (Fig.5) based on measurements in clean air conditions. The value 3.3 is the analog voltage produced by the ESP32 and the value 4095 is because the ESP32 ADC uses 12 bits.

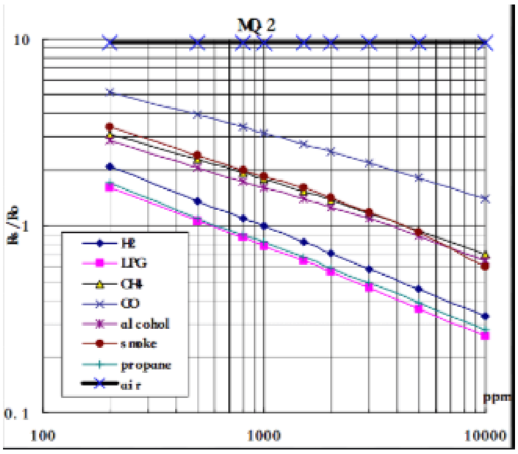

Fig. 6. MQ-2 datasheet graph

3. After completing the upload program, we can see the R_o value on the serial monitor. Make sure the R_o value seen on the serial monitor is stable before recording it.

4. Next, look for the values x_1, x_2, y_1, and y_2 using an additional website, namely webplotdigitizer.com using the datasheet from MQ-2. The result of this can be seen in Fig.7.

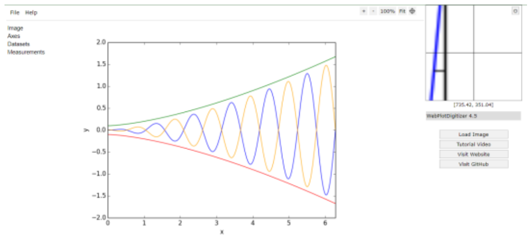

Fig. 7. Webplotdigitizer display

5. Select load image, then insert the image from the MQ-2 datasheet graph.

6. Next select 2D (X-Y) Plot, then click Align Axes, then click proceed continue like Fig.8.

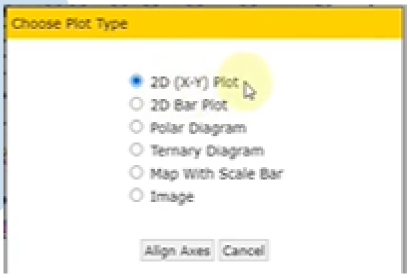

Fig. 8. Add images

7. The webplotdigitizer display will look like Fig.9.

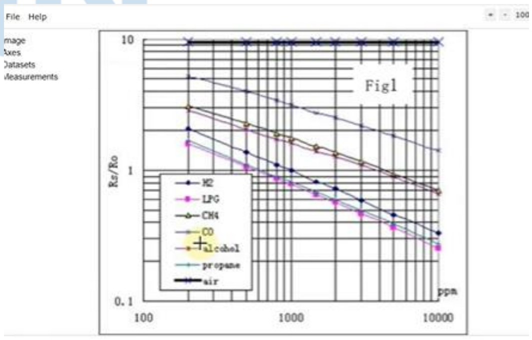

Fig. 9. Added images to Webplotdigitizer

8. To determine x_1, x_2, y_1, and y_2, click sequentially as in the Fig.10.

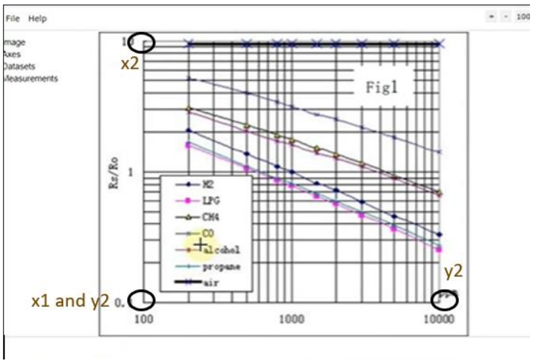

Fig. 10. Determine points x_1, x_2, y_1, and y_2

9. After that, click Completed and adjust the settings as shown in the Fig.11 then click OK.

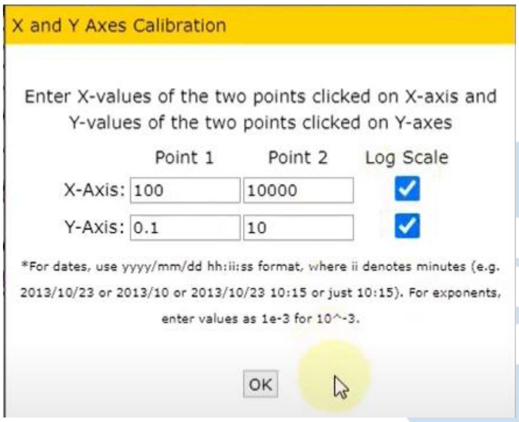

Fig. 11. Setting points x_1, x_2, y_1, and y_2

10. Determine points x_1 and x_2 for the LPG graph shown in Fig.12. Do this sequentially then click view data.

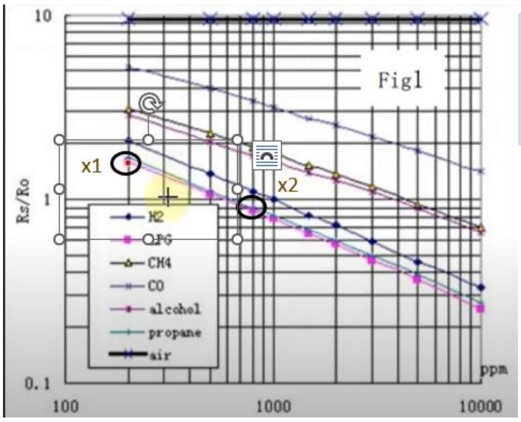

Fig. 12. Determine points x_1 and x_2 for LPG

11. Note the values that appear in the data view. The result of data shown in Fig.13.

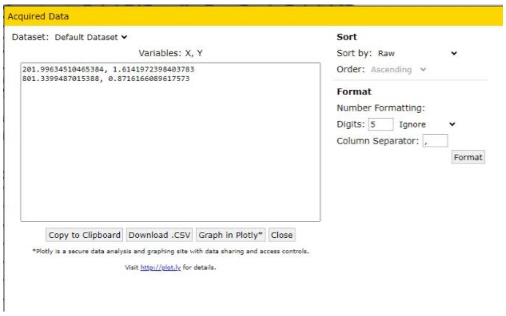

Fig. 13. Values x_1, x_2, y_1, and y_2

Results obtained :

$$x_1 = 201.99634510465384$$
$$x_2 = 801.3399487015388$$
$$y_1 = 1.6141972398403783$$
$$y_2 = 0.8716166089617573$$

12. Find the values of m and b with the following equation (1)

$$m = \frac{[\log(y_2) - \log(y_1)]}{[\log(x_2) - \log(x_1)]} \quad (1)$$

Results obtained:

$$m = -0.44719$$

13. After getting the value of m, we can find the value of b by creating an intersection point as shown in the Fig.14.

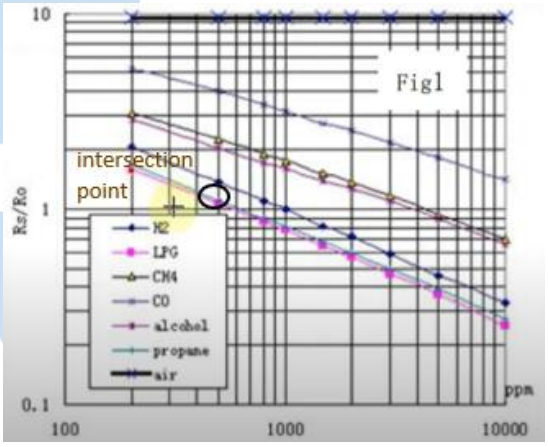

Fig. 14. Find the x and y values

14. Note the values that appear in the data view shown in the Fig. 15.

Fig. 15. x and y values

Results obtained:

$$X = 500.30707131293366$$
$$Y = 1.05562212823438789$$

15. Calculate the value of b using the following equation (2).

$$b = log(y) - (m)\,\mathrm{LOG}(x) \qquad (2)$$

Results obtained:

$$b = 1.23057$$

16. After getting the m and b values, we can calculate the LPG PPM value using the MQ-2 sensor using the following syntax shown in Fig.16.

```
Mencari_PPM §
#include <ESP32Servo.h>
#define RL 10
#define m -0.43779
#define b 1.19613
#define Ro 3.20
#define MQ_sensor 35
float VRL;
float Rs;
float ratio;
float ppm;

void setup() {
  Serial.begin(115200);
}

void loop() {
  VRL = analogRead(MQ_sensor) * (3.3 / 4095);
  Rs = ((3.3 * RL) / VRL) - RL;
  ratio = (Rs / Ro);
  ppm = pow(10, ((log10(ratio) - b) / m));

  Serial.print("LPG (ppm) = ");
  Serial.println(ppm);
  delay(500);
}
```

Fig. 16. Find the PPM value for LPG

The following are the reading results of the MQ-2 sensor before and after calibration under normal conditions without LPG gas contamination.

TABLE V. MQ-2 TESTING

No	Before calibrating	After calibrating
1	213.00	6.16
2	223.00	5.83
3	222.00	6.08
4	214.00	6.00
5	214.00	5.91
6	211.00	6.00
7	209.00	6.25
9	214.00	5.67
10	211.00	6.08
11	208.00	6.42
12	208.00	6.00
13	214.00	5.67
14	208.00	5.67
15	209.00	6.00
16	206.00	6.00
17	209.00	5.83
18	204.00	5.59
19	204.00	5.67
20	208.00	6.00
21	215.00	6.08
22	215.00	6.00
23	212.00	6.25
24	208.00	6.00
25	209.00	6.00
26	213.00	5.51
27	208.00	6.08
28	208.00	5.67
29	203.00	5.35
30	219.00	5.91
31	205.00	5.67
32	203.00	5.83
33	202.00	5.75
34	220.00	5.91
35	198.00	6.00
36	208.00	5.91
36	206.00	6.00
37	204.00	5.83
38	192.00	6.16
39	201.00	6.16
40	195.00	6.34
41	213.00	6.16

Based on Table V, it can be seen the difference in the reading values of the MQ-2 sensor before and after calibration. The MQ-2 sensor readings before calibration showed an average reading of 208.825 with a reading value of 195.00 – 223.00 under normal conditions without exposure to LPG gas. In contrast to the reading results of the MQ-2 sensor after calibration, the average value was 5.9515 with the reading value being 5.51 – 6.83 under normal conditions without exposure to LPG gas.

B. *Sensor and Buzzer Testing*

In testing the MQ2 sensor and buzzer, A buzzer is an electronic part that uses electric current to convert electrical energy into sound. Moving the coil forward or backward makes the air vibrate, which produces sound [10]. This system was designed to detect the presence of gas. When the sensor measures a value below twenty, the buzzer remains in silence, indicating that the environment is safe from harmful gases. However, once the sensor value exceeds the threshold of twenty, the buzzer immediately sounds loudly as a warning of the presence of gas that exceeds the safe limit. In this way, users can quickly and effectively recognize the presence of potentially threatening gas hazards, thereby enabling timely safety precautions.

Based on the Table VI, it can be concluded that the bell is functioning well. This was proven when the author carried out tests with a threshold limit of 20 PPM for LPG. If the MQ-2 sensor detects LPG above 20 PPM then the buzzer will turn on, whereas if the MQ-2 sensor detects LPG below 20 PPM then the buzzer will sound.

C. *Motor Servo Testing*

This system is designed to detect surrounding gas when testing the MQ2 sensor and buzzer. If the sensor value is below 20, the buzzer will be silent, indicating that the environment is safe; if the sensor value exceeds 20, the buzzer will sound, indicating the presence of dangerous gas. In addition, when the sensor value exceeds 20, the servo motor will rotate, indicating a potential danger, and when the sensor value is below 20, the servo motor will stop rotating. As a result, users can easily identify dangerous gases and take necessary precautions to maintain safety.

From the test results Table VII, it can be concluded that the servo is running well. This is proven by the servo not moving when the LPG gas condition is below 20. Meanwhile, when the LPG gas condition is above 20 the servo moves to open the regulator.

TABLE VI. SENSOR AND BUZZER TESTING

No	Gas Value	Identification	Buzzer
1	5.83	Gas not detected	Off
2	6.16	Gas not detected	Off
3	22.42	Gas detected	On
4	20.78	Gas detected	On
5	5.91	Gas not detected	Off
6	22.05	Gas detected	On
7	16.92	Gas not detected	Off
9	15.85	Gas not detected	Off
10	22.05	Gas detected	On
11	14.38	Gas not detected	Off
12	22.61	Gas detected	On
13	22.42	Gas detected	On
14	6.00	Gas not detected	Off
15	6.08	Gas not detected	Off
16	20.60	Gas detected	On
17	5.91	Gas not detected	Off
18	20.96	Gas detected	On
19	6.16	Gas not detected	Off
20	22.80	Gas detected	On
21	22.61	Gas detected	On
22	12.22	Gas not detected	Off
23	6.08	Gas not detected	Off
24	22.42	Gas detected	On
25	14.24	Gas not detected	Off
26	22.99	Gas detected	On
27	23.37	Gas detected	On
28	22.99	Gas detected	On
29	21.32	Gas detected	On
30	5.91	Gas not detected	Off
31	13.54	Gas not detected	Off
32	22.80	Gas detected	On
33	22.61	Gas detected	On
34	5.91	Gas not detected	Off
35	10.85	Gas not detected	Off
36	5.51	Gas not detected	Off
36	22.42	Gas detected	On
37	6.78	Gas not detected	Off
38	4.89	Gas not detected	Off
39	4.97	Gas not detected	Off
40	11.34	Gas not detected	Off

TABLE VII. MOTOR SERVO TESTING

No	Gas Value	Identification	Motor Servo
1	5.83	Gas not detected	Off
2	6.16	Gas not detected	Off
3	22.42	Gas detected	On
4	20.78	Gas detected	On
5	5.91	Gas not detected	Off
6	22.05	Gas detected	On
7	16.92	Gas not detected	Off
9	15.85	Gas not detected	Off
10	22.05	Gas detected	On
11	14.38	Gas not detected	Off
12	22.61	Gas detected	On
13	22.42	Gas detected	On
14	6.00	Gas not detected	Off
15	6.08	Gas not detected	Off
16	20.60	Gas detected	On

17	5.91	Gas not detected	Off
18	20.96	Gas detected	On
19	6.16	Gas not detected	Off
20	22.80	Gas detected	On
21	22.61	Gas detected	On
22	12.22	Gas not detected	Off
23	6.08	Gas not detected	Off
24	22.42	Gas detected	On
25	14.24	Gas not detected	Off
26	22.99	Gas detected	On
27	23.37	Gas detected	On
28	22.99	Gas detected	On
29	21.32	Gas detected	On
30	5.91	Gas not detected	Off
31	13.54	Gas not detected	Off
32	22.80	Gas detected	On
33	22.61	Gas detected	On
34	5.91	Gas not detected	Off
35	10.85	Gas not detected	Off
36	5.51	Gas not detected	Off
36	22.42	Gas detected	On
37	6.78	Gas not detected	Off
38	4.89	Gas not detected	Off
39	4.97	Gas not detected	Off
40	11.34	Gas not detected	Off

D. *Modular Testing*

This modular testing aims to evaluate whether the application is running well or not and to determine the QoS status of the application. The following is a display of the application shown in Fig.16 and Fig. 17.

Fig. 17. Application display when LPG leak is not detected

Fig. 18. Application display when an LPG leak is detected QoS

Fig. 17 shown when the *ppm* of LGP gas detected is still within safe limits. When the sensor detects the ppm of LPG gas above the safe limit (Fig. 18), the application will change the text "KONDISI AMAN" to "KONDISI TIDAK AMAN".

E. *QoS Testing*

QoS testing is carried out to manage or ensure data in the delivery process. Testing was carried out with the help of Wireshark software by sending 1512 data packets from ESP32 to Firebase to determine throughput, packet loss, delay and jitter values. Following are the test results at Fig.19.

Statistics

Measurement	Captured
Packets	1512
Time span, s	1928.882
Average pps	0.8
Average packet size, B	276
Bytes	417937
Average bytes/s	216
Average bits/s	1733

Fig. 19. Throughput testing

1924,898072	1924,897901	0,000171
1928,044875	1924,898072	3,146803
	Total Delay	1928,88197
	Average Delay	1,277405278

Fig. 20. Delay testing

-0,000171	0,000171	0,000342
-3,146632	3,146803	6,293435
	Total Jitter	1924,093161
	Average Jitter	1,274233881

Fig. 21. Jitter testing

TABLE VIII. PACKET LOSS TESTING

No	Time	Source	Destination
110	215.378333 9	54.169.4.174	192.168.62.216
121	253.370689	54.169.4.174	192.168.62.216
452	799.389220 0	204.79.197.2013	192.168.62.216

It can be seen in Fig. 19, the resulting throughput is 216.67 *bytes* or 1733 *bits/s*. In this test, the resulting throughput is included in the Very Good category. Fig.19 *records* the average delay of 1.28 *seconds* or 1277.41 *milliseconds* in the tests that have been carried out. Based on the results Fig. 20, the delay parameters on this system are included in the Very Bad latency category. Fig. 21 records that the average jitter produced was 1.28 *seconds* or 1274.23 *milliseconds*, which is also included in the Very Bad category. These Very Poor ratings for delay and jitter may be caused by network congestion, inefficient algorithms, or inadequate hardware. High delays and jitter impact the system by causing late or inconsistent warnings, which can reduce the effectiveness of the LPG leak detection system. This can potentially lead to dangerous situations due to delayed or unreliable notifications. To improve system performance, optimizing network infrastructure, improving data processing algorithms, and ensuring sufficient hardware capacity is essential. Table VIII, there are 3 data packets that were not sent out of the 1512 data sent. So the Loss Package value is obtained as equation (3).

(Package sent - Package received)/Package sent × 100 (3)

Results obtained:

$$Package\ Loss = \frac{(1512 - 1509)}{1512 \times 100} = 0.19\%$$

A packet loss rate of 0.19% indicates that a small fraction of data packets sent over the network were not successfully received. While this value is relatively low and generally acceptable in many network applications, it can still impact the system's performance. In the context of the LPG gas leak detection system, even a small packet loss can lead to delays or loss of critical data. This might result in missed or delayed alerts, reducing the reliability and effectiveness of the system in providing timely warnings about gas leaks. Therefore, minimizing packet loss is crucial to ensure that the system can consistently deliver accurate and prompt notifications to enhance user safety.

IV. CONCLUSION

This study builds a prototype LPG leak detection device using an MG996r servo motor, an ESP32 microprocessor, and a MQ-2 gas sensor. The MQ-2 sensor can identify several types of airborne particles. For this reason, accurate information needs to be obtained through a calibration process. The IoT system that detects this LPG gas uses firebase http communication. The throughput and packet loss figures for IoT connectivity fall into the very good category, according to the test results, with a throughput of 1733 *bits/s* and a packet loss percentage of 0.19%. Nevertheless, this IoT communication falls into the extremely poor category with a latency value of 1277.41 milliseconds and a jitter value of 1274.23 milliseconds.

The research results show that, although there is a slight delay and significant jitter, the IoT process can run well. Since the system does not require highly accurate real-time labor, this difference is not very significant. It is hoped that it will be used as an easy and cost-effective security tool. However, the weakness of this study is that it only uses one gas sensor and one actuator, and detection occurs only at one point without knowing exactly how close the sensor and gas sump are. Experimental results show that the MQ-2 sensor and buzzer are very effective in detecting gas leaks; if the sensor value falls below 20, the buzzer will sound, and the motor will rotate.

For future research, it is recommended to use multiple gas sensors and actuators to improve the system's detection accuracy and coverage. Additionally, the distance between the sensor and the gas sump should be considered, and real-time monitoring could be enhanced with more precise data analysis tools.

REFERENCES

[1] R. Fuadi Hasani, B. Nixon, A. Humairah, and A. Yasmin, "Rancang Bangun Alat Pendeteksi Uap Vaping dan Asap Rokok Berbasis Internet of Things Terintegerasi Aplikasi Android," Spektral, vol. 4, no. 1, pp. 151–158, 2023, doi: 10.32722/spektral.v4i1.5629.

[2] I. Jay Saldo et al., "Development and Comparison of Arduino Based MQ-2 and MQ-6 LPG Leak Sensors," Am. J. Sens. Technol., vol. 7, no. 1, pp. 1–9, 2023, doi: 10.12691/ajst-7-1-1.

[3] A. A. Laghari, K. Wu, R. Ali, L. Mureed, A. Abdullah, and A. Khan, "A Review and State of Art of Internet of Things (IoT) A Review and State of Art of Internet of Things (IoT)," Arch. Comput. Methods Eng., no. July, 2021, doi: 10.1007/s11831-021-09622-6.

[4] R. Singh, A. Tiwari, R. Singh, and S. Suman, "GAS LEAK DETECTION AND SMART ALERTING USING IoT," vol. 10, no. 3, pp. 1–1, 2021, doi: 10.1109/respect51740.2021.9620604.

[5] A. Manhas, N. Chambyal, M. Raina, S. Dutta, and E. P. Singh, "LPG Gas Leakage Detection Using IOT," vol. 3307, pp. 520–526.

[6] Z. A. Rashid and A. F. M. S. Yeong, "Microcontroller Based Monitoring and Controlling of LPG Leaks Using Internet of Things Microcontroller Based Monitoring and Controlling of LPG Leaks Using Internet of Things", doi: 10.1088/1757-899X/981/3/032021.

[7] E. Lety, I. Puspita, and I. K. A. Enriko, "Design Gas LPG Leak Detection System Based on Internet of Things," vol. 8, no. 3, pp. 1053–1060, 2023.

[8] R. S. H. Sirait, K. Erwansyah, and R. I. Ginting, "IMPLEMENTASI METODE FUZZY LOGIC PADA SISTEM MONITORING MIKROKONTROLER," (Jurnal Teknol. Komput. dan Sist. Informasi), vol. 2, no. 2, pp. 34–41, 2022.

[9] M. I. Azman, W. Nur, and H. Wan, "IoT-Based Early Warning Detection System for LPG Leakage Using

Raspberry Pi," vol. 3, no. 2, pp. 467–473, 2022.

[10] N. K. Jumaa, Y. M. Abdulkhaleq, M. A. Nadhim, and T. A. Abbas, "IoT Based Gas Leakage Detection and Alarming System using Blynk platforms," no. February, pp. 64–70, 2022, doi: 10.37917/ijeee.18.1.8.

[11] S. Wibawa, I. Made, A. Agung, N. Gunawan, P. I. Ketut, and S. I. Ketut, "Design and Manufacture of LPG Gas Leak Detection Based on Arduino Uno Using MQ-2 Sensor," vol. 8, no. 1, pp. 27–32, 2024, doi: 10.9734/AJR2P/2024/v8i1155.

[12] Guntoro, M. Sadar, and W. Syafitri, "Evaluasi Performance Jaringan Internet Kampus Menggunakan Quality of Service (Qos)," Pros. SEMASTER Semin. Nas. Teknol. Inf. Ilmu Komput., vol. 1, no. 1, pp. 280–290, 2020.

[13] R. S. Randi Sukri, "Analisis Qos Pada Jaringan Telepon Voip Dengan Menggunakan Perbandingan Metode Differentiated Service Dan Metode Integrated Service Di Hotel Safirna," J. Tek. Inform., vol. 5, no. 2, pp. 16–20, 2022, doi: 10.52046/j-tifa.v5i2.1422.

[14] M. Ainun Najib, S. Sulartopo, D. Sasmoko, D. Danang, and I. Saufik Suasana, "Sistem Pendeteksi Bencana Kebakaran Menggunakan ESP32 Dan Arduino Berbasis WEB," Neptunus J. Ilmu Komput. Dan Teknol. Informas, vol. 2, no. 1, pp. 15–24, 2024, [Online]. Available: https://doi.org/10.61132/neptunus.v2i1.62.