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IoT-Based LPG Gas Leak Detection System Using an MQ-2 Sensor and ESP32

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ABSTRACT *– Liquefied Petroleum Gas (LPG) is widely used in household and industrial sectors because it is efficient and relatively affordable. However, LPG use poses fire risks, one of which is caused by gas leaks that go unnoticed by users. This study aims to develop an Internet of Things (IoT) system for detecting LPG gas leaks using an MQ-2 sensor and an ESP32 microcontroller. The system is equipped with LED indicators, a buzzer, an LCD, and a notification feature through a Telegram bot to provide warnings to users. The research methods include system design, circuit block analysis, workflow diagram development, testing using the Wokwi simulator, and Telegram message delivery testing. The results show that the MQ-2 sensor can detect three levels of gas concentration: safe (<200 ppm), caution (200–1000 ppm), and dangerous (>1000 ppm). The system can automatically activate the LED indicators, display gas concentration and category on the LCD, and send immediate alerts to users through the Telegram bot. Therefore, the developed system can be used as a monitoring and early warning device for LPG gas leaks.*

Keywords *– LPG Gass, Internet of Things, Sensor MQ-2, ESP32, Bot Telegram*

Sistem Pendeteksi Kebocoran Gas LPG Berbasis Iot Dengan Sensor MQ-2 Dan ESP32

ABSTRAK *– Liquefied Petroleum Gas (LPG) banyak digunakan pada sektor rumah tangga maupun industri karena efisien dan relatif terjangkau. Namun, penggunaan LPG memiliki risiko kebakaran yang salah satunya disebabkan oleh kebocoran gas yang tidak disadari pengguna. Penelitian ini bertujuan mengembangkan sistem Internet of Things (IoT) untuk mendeteksi kebocoran gas LPG menggunakan sensor MQ-2 dan mikrokontroler ESP32. Sistem dilengkapi LED, buzzer, LCD, serta fitur notifikasi melalui bot Telegram untuk memberikan peringatan kepada pengguna. Metode penelitian meliputi perancangan sistem, analisis blok rangkaian, pembuatan diagram alur kerja, serta pengujian menggunakan simulator Wokwi dan pengujian pengiriman pesan melalui Telegram. Hasil pengujian menunjukkan bahwa sensor MQ-2 mampu mendeteksi tiga tingkat konsentrasi gas, yaitu aman (<200 ppm), waspada (200–1000 ppm), dan berbahaya (>1000 ppm). Sistem mampu mengaktifkan indikator LED secara otomatis, menampilkan kadar dan kategori gas pada LCD, serta mengirimkan peringatan secara langsung kepada pengguna melalui bot Telegram. Dengan demikian, sistem yang dikembangkan dapat digunakan sebagai perangkat pemantauan dan peringatan dini terhadap kebocoran gas LPG..*

Kata Kunci *– LPG Gas, Internet of Things, MQ-2 Sensor, ESP32, Telegram Bot.*

1. INTRODUCTION

Liquefied Petroleum Gas (LPG) is widely used in both household and industrial sectors because of its high efficiency and relatively affordable price [1]. LPG offers several benefits, including improving the efficiency of cleaner heat production and reducing air pollution. However, LPG is highly flammable and can pose a risk of fire and explosion if a gas leak goes undetected [2][3].

Fire incidents caused by LPG gas leaks remain a significant problem to date [4]. LPG has a distinctive odor that allows leaks to be detected naturally. However, when leaked gas seeps into drainage systems, electrical installations, or becomes trapped beneath carpets, it can be difficult to detect using the sense of smell alone. Therefore, a gas leak detection system that is fast, accurate, and capable of providing early warnings is needed to improve user safety [5].

Several previous studies have developed gas leak detection systems using microcontrollers and gas sensors. Study [6] developed a gas detection system equipped with an automatic protection mechanism. When a potential fire was detected, a water pump was automatically activated to spray water as an initial mitigation measure. Meanwhile, Prasetyo and Paramytha [7] developed an LPG gas leak detection system utilizing Internet of Things (IoT) technology and an MQ-5 sensor connected to the Blynk application for real-time monitoring. The system was also equipped with a buzzer, motor pump, and relay as automatic protection mechanisms when a gas leak or fire was detected.

Based on these problems, a gas leak detection system is needed that can not only provide local early warnings but also send remote notifications to users. This study develops an LPG gas leak detection system using an ESP32 microcontroller and an MQ-2 gas sensor. The system is equipped with a buzzer, indicator light, and LCD display to provide real-time information on gas concentration and its corresponding category. In addition, the system utilizes a Telegram bot to automatically send notifications to users when a gas leak is detected. Therefore, the developed system is expected to serve as a monitoring and early warning solution for LPG gas leaks.

2. LITERATURE RIVIEW

Several previous studies [8]–[10] have developed gas leak detection prototypes by combining gas sensors, microcontrollers, local indicators, and remote communication capabilities. Wirdatiningsih, Hamdan, and Hendro [8] designed an LPG detector based on an MQ-2 sensor integrated with an ATmega328P microcontroller. The study focused on determining the optimal sensor installation position. The results showed that placing the sensor parallel to the gas source outlet at a horizontal distance of 20 cm provided the fastest detection response. The system was equipped with LED and buzzer indicators as early warning mechanisms when the gas concentration exceeded the specified threshold.

Dicky Dermawan and Rino [9] developed a gas leak detection device using an Arduino Uno (ATmega328P) and an MQ-2 sensor, equipped with a buzzer, 16×2 LCD, LED indicator, and SI900A GSM module for sending SMS notifications. The test results showed that the system responded effectively by detecting gas leaks, activating the alarm, displaying the system status on the LCD, and automatically sending warnings via SMS. This remote communication feature enabled users who were not at the location to receive gas leak notifications.

Ikrar Nur Maulana, Dewi Leyla Rahmah, and Arie Prabowo [4] integrated an MQ-2 sensor with a NodeMCU (ESP32) to develop an IoT-based system. Sensor readings were processed using the Naive Bayes method to classify conditions as safe or dangerous. In their study, the threshold was set at 250 ppm. When the threshold was exceeded, the red LED and buzzer were activated, and an automatic notification was sent through a Telegram bot. The results indicated that combining classification processing with IoT connectivity could improve the speed and accuracy of early warnings. The use of Telegram was also considered more efficient than SMS because it only required an internet connection to automatically deliver warning messages.

Liquefied Petroleum Gas (LPG) is a processed product of natural gas consisting of various hydrocarbon compounds, primarily propane (C_3H_8) and butane (C_4H_{10}) [11]. LPG used in the industrial sector generally consists of propane, whereas household LPG commonly consists of a mixture of propane and butane. Mixed LPG typically contains approximately 30% propane and 70% butane [11].

The use of LPG poses potential risks, one of which is leakage from gas cylinders or distribution systems, which can trigger a fire when the leaked gas comes into contact with an ignition source. Naturally, LPG is odorless, making leaks difficult to detect without additional substances. To address this issue, Pertamina adds ethyl mercaptan, which has a strong and distinctive odor, so that gas leaks can be detected more easily [5].

The MQ-2 sensor is a gas sensor with high sensitivity for detecting various gases, including LPG, smoke, alcohol, propane, hydrogen, methane, and carbon monoxide in the air. The sensor operates based on changes in electrical resistance that occur when gas interacts with the sensor surface, making it suitable for indoor air quality monitoring and early fire or gas leak detection systems [14].

The MQ-2 sensor provides a fast response and is commonly used in the development of microcontroller- and IoT-based gas leak detection prototypes [13]. Integrating the MQ-2 sensor with microcontrollers such as the ESP8266 or ESP32 enables sensor data to be transmitted in real time to monitoring applications, thereby improving the effectiveness of early warning systems.

The ESP32 is a microcontroller developed by

Espressif Systems as a successor to the ESP8266 [10]. It offers several advantages, including a dual-core 32-bit processor, larger memory capacity, and integrated Wi-Fi and Bluetooth Low Energy (BLE) connectivity. The microcontroller is widely used in Internet of Things (IoT) applications because of its efficient power consumption and support for various sensors and actuators. In addition, the ESP32 provides numerous input/output pins, allowing flexibility in the development of embedded systems and remote control applications using wireless networks.

The ESP32 is also effective for automation applications, such as hydroponic systems that require the monitoring and control of environmental parameters such as temperature, humidity, and pH. Its integrated Wi-Fi and Bluetooth connectivity supports remote control, facilitating real-time monitoring and management. The dual-core Xtensa LX6 CPU architecture, combined with its memory capacity and wireless communication capabilities, makes the ESP32 a suitable microcontroller for various IoT research and development applications [12].

3. RESEARCH METHODS

The design of the Internet of Things (IoT)-based LPG gas leak detection system using an MQ-2 sensor and an ESP32 microcontroller was carried out in two main stages: hardware development and software development. The system block diagram illustrates the overall design of the LPG gas leak detection prototype for indoor environments, including the input, processing, and output components. The system block diagram is presented in Figure 1.

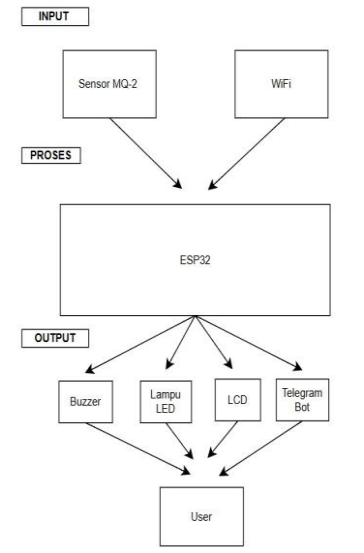
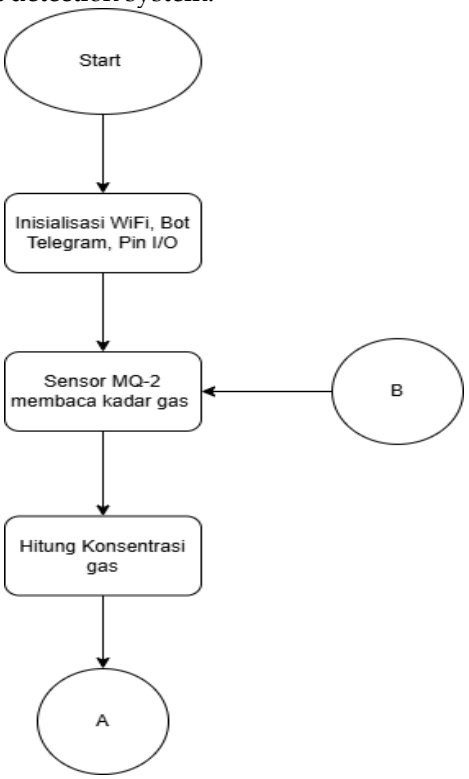


Figure 1. System Block Diagram

The system consists of three main sections, namely input, process, and output. The input section receives signals that are subsequently transmitted to the ESP32 for further processing. In this system, the input section uses the MQ-2 gas sensor to detect gas and the Wi-Fi module to transmit data over the internet.

The process section serves as the main stage for processing signals received from the input section. The ESP32 microcontroller is used to process the sensor data. The ESP32 reads information from the MQ-2 sensor and determines whether the LPG concentration remains within a safe level or indicates a dangerous condition. In addition, the ESP32 provides Wi-Fi connectivity, allowing the system to connect directly to the internet.

The LPG gas leak detection system uses the ESP32 to receive data from the MQ-2 sensor. The processed results are presented through three local output devices, namely a buzzer, LCD, and LED indicators, as well as a Telegram bot that sends notifications to the user. The buzzer provides an audible early warning when a gas leak is detected. The LCD displays the detected gas concentration. The LED indicators provide a visual representation of the room condition, with different colors representing different gas concentration levels. The green LED indicates a safe condition, the yellow LED indicates a warning condition, and the red LED indicates a dangerous condition. In addition, the Telegram bot serves as a remote notification medium through the smartphone. Through the Telegram bot, users can receive information directly on their smartphones even when they are away from the monitored location. Figure 2 presents the flowchart of the LPG gas leak detection system.



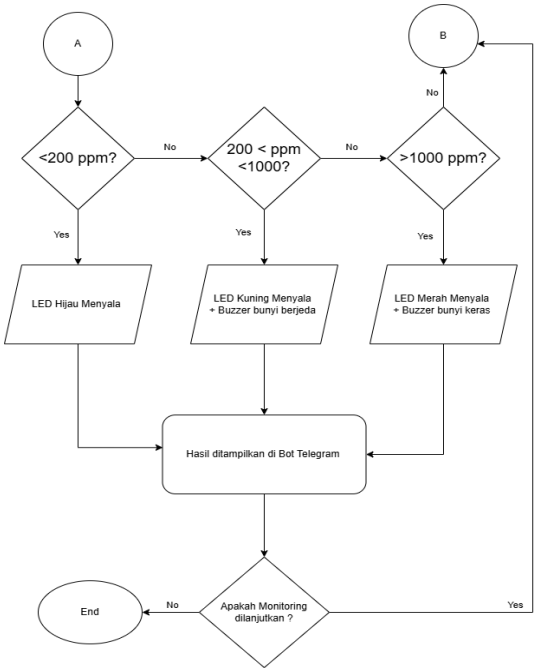


Figure 2. Flowchart of the LPG Gas Leak Detection System

The operation of the LPG gas leak detection system is illustrated in the flowchart in Figure 2. The process begins with the initialization of the Wi-Fi connection, the Telegram bot, and the input/output (I/O) pins on the ESP32 microcontroller. After initialization, the MQ-2 gas sensor reads the gas level in the monitored room. The sensor readings are then processed by the ESP32 to calculate the gas concentration in parts per million (ppm).

The calculated gas concentration is then compared against three threshold conditions. If the concentration is below 200 ppm, the system classifies the room as safe and turns on the green LED. If the concentration is between 200 and 1000 ppm, the system classifies the condition as a warning, turns on the yellow LED, and activates the buzzer with an intermittent sound. If the concentration exceeds 1000 ppm, the system classifies the condition as dangerous, turns on the red LED, and activates the buzzer with a loud, continuous sound as an emergency alarm.

Regardless of the condition detected, the monitoring results are displayed through the Telegram bot so that users can monitor the room condition remotely via their smartphones. After the results are sent, the system checks whether monitoring should be continued. If so, the process returns to the gas reading stage and repeats continuously. If not, the system ends the monitoring process.

4. RESULT AND DISCUSSION

This section presents the research results, focusing on the simulation of an Internet of Things-based gas leak detection system using an ESP32 microcontroller and an MQ-2 sensor. The system is designed to monitor gas concentration automatically and provide early warnings through LED indicators, an LCD screen, a buzzer, and notifications on the Telegram application. All tests were conducted using the Wokwi Simulator as a virtual testing medium, so the simulation results could be analyzed without direct use of physical hardware.

A wiring diagram is a schematic representation showing the connections between electronic components in a system, including pin connections, the direction of current flow, and the configuration of the components used. In this study, the wiring diagram is used to show the connections between the ESP32 microcontroller, the MQ-2 sensor, the LED indicators, the LCD, the buzzer, and the Wi-Fi network connection.

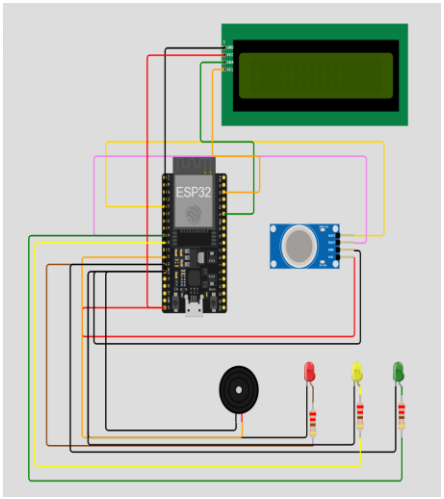


Figure 3. Wiring Diagram of the Gas Leak Detection System

Figure 3 shows that the MQ-2 sensor is connected to an analog pin of the ESP32 to read the gas concentration in parts per million (ppm). The gas concentration value is displayed on a 16x2 LCD connected through an I2C module, allowing users to monitor the gas level directly on the LCD screen. The LEDs then light up according to the gas concentration. The green LED indicates a safe gas level; the yellow LED and the active buzzer indicate an increase in gas level, raising the status to warning; and the red LED and a long buzzer sound indicate that a gas leak has been detected at a dangerous level. The ESP32 is also configured to connect to a Wi-Fi network so that the system can send warning notifications through a Telegram bot.

System testing was carried out to ensure that all components and functions work according to the design. Testing was conducted through simulation on the Wokwi Simulator by varying the output value of the MQ-2 sensor to represent different gas concentration conditions. The functional test aims to verify the system's main function of detecting gas

levels and responding according to the detected condition.

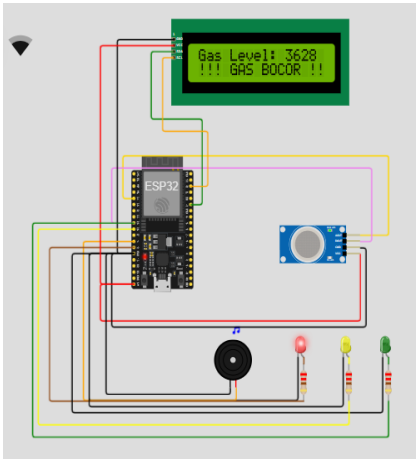


Figure 4. Gas Leak Detection System Circuit – Gas Leak Status

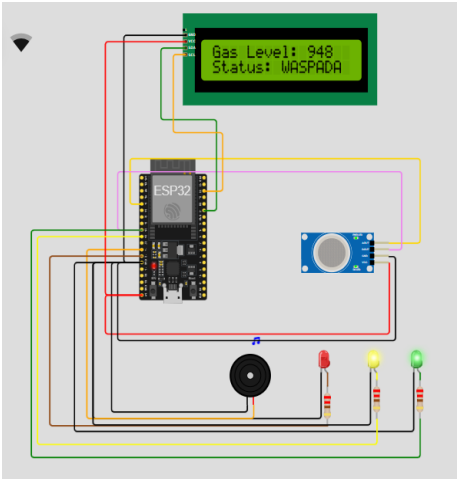


Figure 5. Gas Leak Detection System Circuit – Warning Status

Table 1. System Conditions Based on Gas Concentration Values

Sensor Value (ppm)	Gas Condition	Number of Interested	Active Led	Remarks
3628	Informatio n System	47	Active (continuous sound)	High gas concentration; the system detects a gas leak
2	Game	21	Active (short beeps)	Gas concentration is rising; the system gives an early warning

Based on the simulation results in Figure 4, Figure 5, and Table 1, the system successfully changes its status according to the gas concentration read by the sensor. At concentrations below 200 ppm, the system is in a safe condition with the green LED on and the buzzer off. However, in the Wokwi simulation the sensor readings only start from 843 ppm, so the safe condition cannot be displayed directly. When the concentration is in the range of 200–1000 ppm, the system enters the warning status, with the yellow LED on and the buzzer sounding short beeps as an early warning. When the sensor value exceeds 1000 ppm, the system detects a dangerous condition, with the red LED on and the buzzer active continuously, indicating a gas leak.

The IoT integration test was conducted to ensure that the ESP32 microcontroller, the Wi-Fi connection, and the Telegram Bot platform work properly together. In the simulation stage, several libraries had to be added to the Wokwi Simulator: WiFi.h and HTTPClient.h for internet connectivity and data communication with the Telegram API, and Wire.h and LiquidCrystal_I2C.h for displaying sensor data on the LCD. The ESP32 connects to the Wi-Fi network and then sends data through https://api.telegram.org/bot<BOT_TOKEN>/getUpdates. Figure 6 shows the Telegram API response when the ESP32 sends a message. When the sensor value exceeds a certain threshold, the system automatically sends a message containing the status and gas concentration value to the Telegram Bot.



Figure 6. Telegram API Response When the ESP32 Sends a Message



Figure 7. Gas Warning Notification (WARNING) on the Telegram Bot Application



Figure 8. Gas Warning Notification (DANGER) on the Telegram Bot Application

Figures 7 and 8 show the results of integration testing using the Telegram platform through a bot named Bocorbot. Both results show that the system can work in real time, sending messages according to the gas level between the ESP32 and the Telegram server. Thus, the integration of the Internet of Things (IoT) in the gas leak detection system can effectively provide remote warnings to users.

5. CONSLUSION

Based on the design and testing results, it can be concluded that the IoT-based LPG gas leak detection system using the MQ-2 sensor and the ESP32 microcontroller works well in detecting gas levels in real time. The MQ-2 sensor can identify changes in gas concentration and classify conditions into three levels: safe (<200 ppm), warning (200–1000 ppm), and danger (>1000 ppm). The system's response to changes in gas level also follows the design, as shown by the activation of the LED indicators, the gas level display on the LCD, and the buzzer sound that adjusts to the danger level. In addition, the integration of the system with the Telegram Bot platform works well, allowing users to receive automatic notifications quickly through the internet. The Wokwi simulation results show that all components operate stably and respond appropriately to gas leak conditions. Therefore, the integration of the MQ-2 sensor, the ESP32, and IoT services proves effective in providing early warning of potential LPG gas leaks, thereby improving safety and reducing the risk of fire or explosion in the user's environment.

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