

IoT-BASED LIQUEFIED PETROLEUM GAS LEAKAGE DETECTION AND ALERT SYSTEM

Obasi, C.* and Daniel, A.

Department of Computer Engineering, Edo State University, Uzairue, Edo State, Nigeria

*Corresponding email: Chukwuemeka.obasi@edouniversity.edu.ng

ABSTRACT

Liquefied petroleum gas (LPG) is commonly used for cooking in homes and businesses; however, any leakage from it poses severe fire, explosion, and health hazards. Early detection together with instant local and remote notification can help decrease the time between leakage occurrence and user's reaction. This paper aims to design and implement an IoT-based LPG leakage detection system that triggers both remote and local notification alert. The system was developed using an MQ-6 gas sensor and a WeMos D1 Mini based on the ESP8266EX Wi-Fi SoC. The gas sensor gives analogue output corresponding to the gas concentration, and the microcontroller controls the gas sensor and transfers monitoring data to the Blynk IoT cloud. Local notification is given by an OLED screen with a size of 0.96 inches, and audible notification is provided through the buzzer driven by the transistor. The prototype was tested at distances of 0, 1.5, and 3.0 meters from the gas source in the indoor environment. The observed concentrations were 1544 ppm at 0 meters, 674–743 ppm at 1.5 meters, and 528–602 ppm at 3.0 meters respectively. Leakage was detected instantly at 0 meters, within 3–5 minutes at 1.5 meters, and within 5–8 minutes at 3.0 meters. The results is an indication that low-cost materials can be used to achieve reasonable fire or explosion control by giving early warning alert in a local embedded system as well as provide useful remote dashboard engagement of relevant agencies for quick intervention and timely hazard control.

Keywords: Internet of Things, LPG leakage detection, MQ-6, ESP8266, WeMos D1 Mini, Blynk, OLED, gas monitoring

1 INTRODUCTION

LPG is commonly used as a fuel for cooking and heating purposes due to its relatively higher calorific value and ease of use. However, an accidental leak of such gas may lead to an accumulation of flammable gas, and hence a setup that could produce fire and other such hazards. Therefore, detection of LPG leaks early is a necessary factor that is vital for kitchen use in homes, businesses, and portable kitchens among other places where the use of LPG cylinders is prevalent. The existing methodologies for gas leakage detection rely on humans, smell, and alarms in general. Such methods limit the capacity to supervise the condition remotely especially when the persons are not at the place under supervision. The emergence of the Internet of Things (IoT) technology has led to the development of cheap sensor nodes that sense environmental data and communicate them wirelessly to the cloud-connected applications. In this case, people are able to remotely monitor and be warned of dangerous situations while being away from the site of sensing [1, 2, 3, 4]. MQ-series sensors have become prevalent in prototype gas sensing systems owing to their affordability, ease of electrically interfacing, and ability to detect combustible gases. MQ-6 is specifically made for detection of LPG and methane gases and has a detection range of about 300–10,000 ppm for methane and propane under the manufacturer's test conditions [5]. However, contemporary literature reviews have outlined significant drawbacks in terms of limitations associated with MQ-series sensors, such as environmental sensitivity, baseline drifting, cross sensitivity, need for calibration, and heater consumption [6]. Wi-Fi

enabled microcontrollers have been increasingly employed with MQ-series sensors in IoT-based LPG detection systems. An IoT-based LPG monitoring system utilizing MQ-6 and NodeMCU with Blynk notifications capability was developed by Mustofa and Fadlil [3]. Later, an IEEE study used MQ-6 and Blynk application for LPG detection and compared the prototype with a commercially available gas sensor [7]. More recently, a similar concept of kitchen safety system that uses MQ-6 for detection and an emergency shutoff mechanism was proposed [8]. In another study conducted in 2025, MQ-6-based LPG leakage system with Blynk notifications was introduced [9]. These studies demonstrate the continuing relevance of low-cost IoT architectures for gas-safety applications. The current study explores the development and testing of a prototype for portable LPG leakage detection and alarm using the MQ-6 sensor, WeMos D1 Mini/ESP8266EX controller, OLED screen, audio buzzer, and Blynk IoT platform. In contrast to those systems where a gas valve is automatically shut down or ventilated, this system has its emphasis on detection, local alarms, and remote monitoring. Testing of the prototype was performed for three different gas source distances in order to understand the behaviour of the system. The major achievements of the current work include the incorporation of a cheap MQ-6 sensing component into the IoT system with ESP8266, realization of both local and remote alarms, and experimental testing of the prototype behaviour at different gas source distances.

2 RELATED WORK

2.1 LPG Gas Detection Using Semiconductor Sensors

Metal oxide semiconductor gas sensors find wide application in inexpensive gas detection owing to their change in electrical resistance depending on the presence of certain gases. For example, MQ-6 gas sensor contains a tin dioxide as sensing material and can be applied for LPG and combustible gases. According to the manufacturer's data, the typical range of measurement for methane and propane gases is about 300–10,000 ppm [5]. The application of MQ-series sensors within IoT gas safety systems has already been demonstrated in several works. Mustofa and Fadlil designed the LPG detector based on MQ-6 and NodeMCU; Blynk was used for remote notification [3]. As a result, the experimental research revealed that the system can detect LPG and inform remotely about its presence via smartphone. Garcia et al. have designed the similar LPG monitoring system based on the MQ-6 and Blynk; in addition, they compared their prototype with commercial gas sensor [7]. But MQ-type gas sensors are not necessarily considered lab-standard analysers of gases. They depend on the surrounding and operating conditions. A review of LPG detection systems based on Arduino and IoT highlighted the following reliability factors: temperature and humidity influence, cross-sensitivity, aging of the sensor, baseline drift, calibration constraints, and power consumption [6]. Consequently, one should take into account the influence of these factors on concentration levels in prototype devices. ESP8266EX offers a Wi-Fi-enabled chip that is suitable for sensor networks and IoT devices. It uses wireless connection protocol IEEE 802.11 b/g/n and offers interfaces such as ADC, GPIO, UART, SPI, I2C, and PWM [10]. The embedded Wi-Fi capability of the chip is useful for sending sensor data to Internet-based monitoring services [11,12]. Existing literature shows an increasing trend toward the use of IoT systems for gas security. Ayeni and Akinola implemented an IoT-based gas and smoke detection mechanism, based on the ESP8266 and Blynk technology [2]. Similar implementation of IoT gas detection with MQ-6, NodeMCU, and Blynk, and local alarm system was made by Yusuf and Wahyu [1]. Ekah et al. have proposed an IoT-based kitchen LPG safety system using MQ-6 sensor and STM32 microcontroller, having remote notification and automatic gas supply cutoff [8]. The authors in [9] presented an IoT LPG leak detection and control system using MQ-6 and Blynk. These studies confirm the possibility of gas detection and remote notification using IoT connectivity [13]. In the current paper, a similar approach is used; however, the system includes a portable gas sensing, local OLED display, audible warning, and Blynk-based remote monitoring system.

3 SYSTEM DESIGN AND METHODOLOGY

3.1 System Architecture

The designed system incorporates the following five main functional modules: LPG sensing, embedded processing, local visual indication, local audible indication, and cloud-based monitoring. An MQ-6 sensor detects the presence of LPG and delivers the gas-sensing analog signal to the WeMos D1 Mini, which processes the analog signal and controls local visual and audible modules as well as

transmits monitoring information using the Wi-Fi module to the Blynk IoT platform. The architecture of the designed system is illustrated in Figure 1.

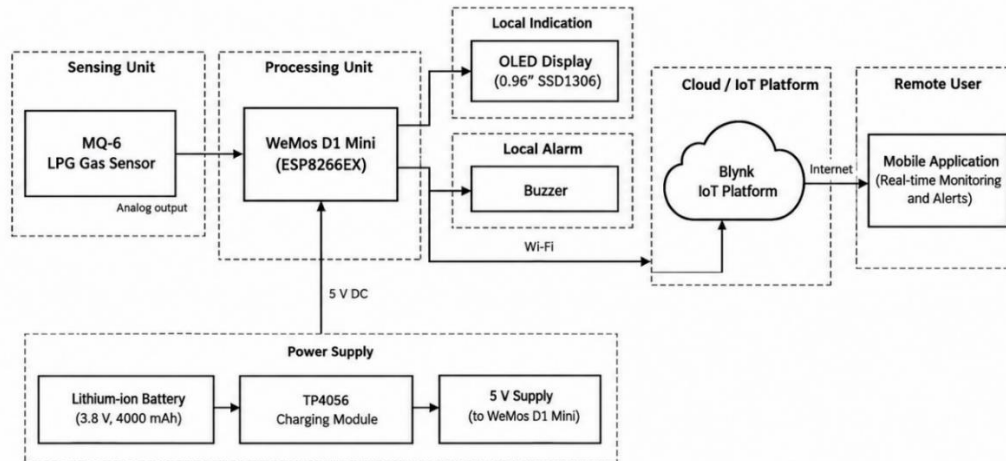


Figure 1. Block diagram of the IoT-based LPG leakage detection and alert system

The MQ-6 sensor makes up the sensing module and generates an analog signal depending on the amount of LPG detected. The WeMos D1 Mini, incorporating the ESP8266EX microcontroller, is responsible for the processing and communication modules. The processed gas-level information is visualized locally on the OLED module, whereas the buzzer provides an audible alarm once the pre-programmed threshold value is exceeded. The data on gas levels are communicated using the ESP8266 Wi-Fi interface to the Blynk IoT platform.

3.2 Hardware Components

The major hardware components used and their relevant specifications are presented in Table 1. The MQ-6 was selected because it is specifically intended for LPG and other combustible gases [5]. The ESP8266EX was selected because its integrated Wi-Fi functionality supports direct IoT communication [10].

Table 1. Components used in the Prototype Development

S/N	Component	Specification/Description	Function in the System
1	WeMos D1 Mini	ESP8266EX-based Wi-Fi development board	Processes the sensor signal and provides wireless communication with the Blynk IoT platform
2	MQ-6 gas sensor	Semiconductor LPG/combustible-gas sensor; nominal detection range of approximately 300–10,000 ppm	Detects LPG and produces an analogue signal corresponding to the gas concentration
3	OLED display	0.96-inch SSD1306, 128 × 64 pixels	Provides local visual indication of gas concentration and system status
4	Audible buzzer	Electronic buzzer	Provides local audible warning when the programmed gas-level condition is reached
5	BC547 transistor	NPN transistor switching stage	Drives the buzzer from the microcontroller output
6	Resistor	4.7 kΩ	Provides signal/current conditioning in the sensor and switching circuitry
7	Lithium-ion battery	3.8 V, 4000 mAh	Provides portable power for the prototype
8	TP4056 charging module	Lithium-ion battery charging/protection module	Provides battery charging and associated power-management functions
9	Connecting wires and accessories	Interconnection and supporting electronic components	Provide electrical connections between the sensing, processing, display, alarm, and power sections

3.3 Signal Processing for the Sensor

The MQ-6 provides an analogue output whose amplitude depends on the gas concentration and the operating parameters of the sensor. The ESP8266 collects data from the analogue sensor, and the analogue-to-digital converter (ADC) converts the analogue value into a software-based gas concentration estimate (digital equivalent) using equation (1), where C_{est} is the estimated LPG concentration in ppm and ADC is the 10-bit analogue-to-digital converter reading.

$$C_{\text{est}} = \frac{ADC}{1023} \times 10,000 \quad (1)$$

The prototype software relied on the ADC values within 0-1023 and mapped them to an approximate range of 0-10,000 ppm. The software uses the decision threshold function in equation (2) to determine the states of the system, where C represents the estimated LPG concentration.

$$S(C) = \begin{pmatrix} \text{SAFE,} & C < 600 \\ \text{WARNING,} & 600 \leq C < 1000 \\ \text{DANGER,} & 1000 \leq C < 2000 \\ \text{HIGH DANGER,} & C \geq 2000 \end{pmatrix} \quad (2)$$

3.4 IoT Integration with Blynk

ESP8266 sends sensor data to the Blynk IoT via Wi-Fi using HTTP protocol. The virtual pin concept of the Blynk allows the transfer of data from the embedded device to the application interface. Blynk interface enables remote monitoring of gas level information and system status. Hence, the user is able to monitor the status of the monitored location remotely with his/her mobile phone.

3.5 Experimental Procedure

The tests were carried out indoors under different distances from the gas source to the detection mechanism at 0 m, 1.5 m, and 3.0 m. The test condition was carried out without any ventilation processes with closed doors and windows. At each distance, the LPG behaviour of the device was examined in relation to the LPG concentration displayed by the OLED screen, the local reaction to the concentration and the remote reaction to the concentration via Blynk Internet of Things. In order to measure the attenuation caused by distance on the concentration of LPG observed, the percentage reduction of concentration in relation to the concentration measured at 0 m was calculated equation (3).

$$A(d) = \frac{C_0 - C_d}{C_0} \times 100\% \quad (3)$$

where C_0 is the LPG concentration measured at the reference distance of 0 m, C_d is the LPG concentration measured at distance d , and $A(d)$ is the percentage attenuation of the LPG concentration at that distance. When the system generated varying concentration values throughout the test, the middle point of the range of concentrations was computed in equation (4), while the corresponding half-range was calculated in equation (5). The resulting value was represented as $C_{\text{mid}} \pm \Delta C$.

$$C_{\text{mid}} = \frac{C_{\text{min}} + C_{\text{max}}}{2} \quad (4)$$

$$\Delta C = \frac{C_{\text{max}} - C_{\text{min}}}{2} \quad (5)$$

The complete circuit diagram that was used to implement this system is presented in Figure 2.

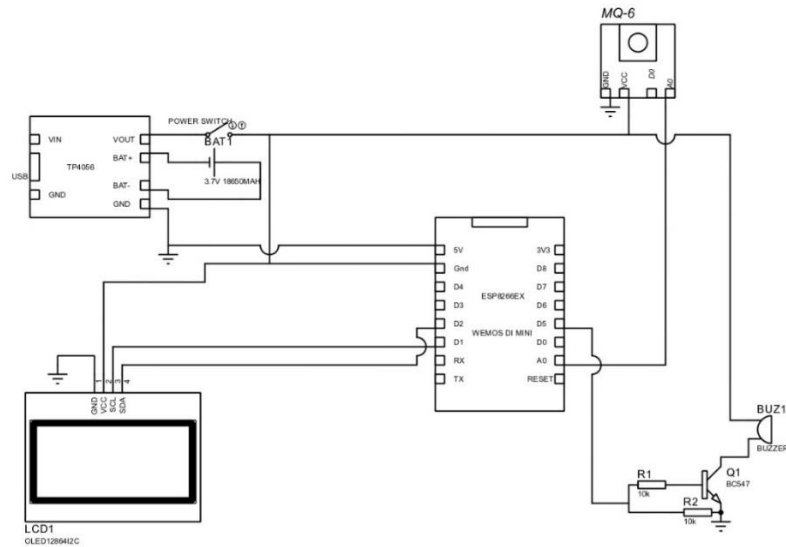


Figure 2. Complete Circuit Diagram

4 RESULTS AND DISCUSSION

4.1 Experimental Results

The principal experimental observations are summarized in Table 1.

Table 2. Observed LPG Detection Response at Different Distances

Test	Distance	Observed Concentration	Detection Time	System Response
1	0 m	Approximately 1544 ppm	Instantaneous	Buzzer activated; OLED warning; Blynk notification
2	1.5 m	674–743 ppm	3–5 min	Local warning and Blynk notification
3	3.0 m	528–602 ppm	5–8 min	Fluctuating indication; delayed Blynk notification

The results show the decrease in the observed concentration of the gas with the increase in the distance between the gas source and sensor. At 0 m, the prototype detected about 1544 ppm almost immediately. At 1.5 m, the observed range decreased to about 674-743 ppm and detection occurred within 3-5 min. At 3.0 m, the observed range further decreased to about 528-602 ppm and detection required about 5-8 min. This result is in line with the experimental results mentioned in the original project report. The experimental data collected from the three source-to-sensor separations are presented in Table 3. The midpoints and half-ranges of the measured data given in the ranges have been computed using the method described in Section III and taken as the representative data.

Table 3. Summary of Observed and Computed LPG Concentration Values

Distance	Observed range	C_{mid}	ΔC	Final reported result
0 m	1544 ppm	—	—	1544 ppm
1.5 m	674–743 ppm	708.5 ppm	34.5 ppm	708.5 ± 34.5 ppm
3.0 m	528–602 ppm	565 ppm	37 ppm	565 ± 37 ppm

4.2 Response at 0 m

At 0 m, the proximity of the sensor to the gas source resulted in the recording of a concentration of about 1544 ppm of LPG as shown in Table 3. There was an immediate response from the system as the buzzer turned on and OLED showed the hazardous situation while the Blynk notification was also received. The 0 m concentration was the reference concentration to analyse the impact of the distance increase between the gas source and the sensor.

4.3 Response at 1.5 m

At 1.5 m, the LPG concentration measured was within the range of 674 to 743 ppm with the midpoint concentration being 708.5 ppm and half-range 34.5 ppm. The value was therefore shown as

708.5 $\pm$ 34.5 ppm in Table 3. The response from the system took about 3-5 min after which the local alarm rang and the Blynk notification was received. It can be noticed that compared to the response at 0 m, there was a delay in the detection since there was a lower concentration of the gas.

4.4 Effect of Distance

At 3.0 m distance, the detected LPG concentration level in Table 3 was 528 to 602 ppm, which means that the midpoint concentration was 565 ppm with half-range of 37 ppm. Therefore, the data obtained was presented as 565 $\pm$ 37 ppm. The system reacted within 5-8 minutes. In addition, there was higher fluctuation of the gas, and the Blynk alert was received later than those responses detected at the short distances. Thus, one can state that increase in distance led to decrease in the detected LPG concentration and the time needed for its detection as shown in Figure 3.

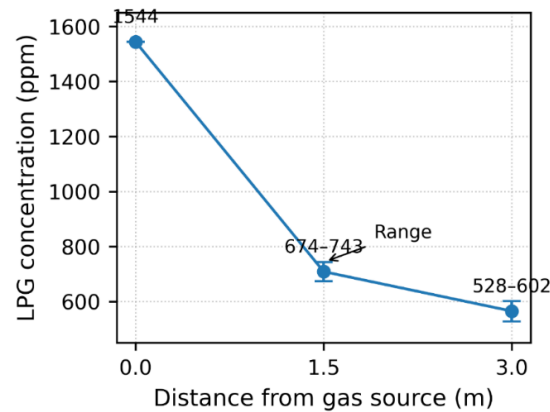


Figure 3. LPG concentration vs distance

4.6 Effect of Environmental Factors

These tests were carried out indoors with windows closed and with no ventilation. In such an environment, the gas will stay in the testing environment longer than it would in a naturally or artificially ventilated environment. Thus, the environmental factor constitutes only one of the many scenarios in which the device can operate. The MQ series of sensors is sensitive to environmental factors and to operating conditions of the sensor itself. New publications highlight the fact that temperature, humidity, drift of the zero point, cross-sensitivity, and calibration may have an effect on gas-sensor performance [6]. Thus, the concentrations obtained with this device cannot be regarded as universally applicable. Figure 4 shows the detection time vs distance.

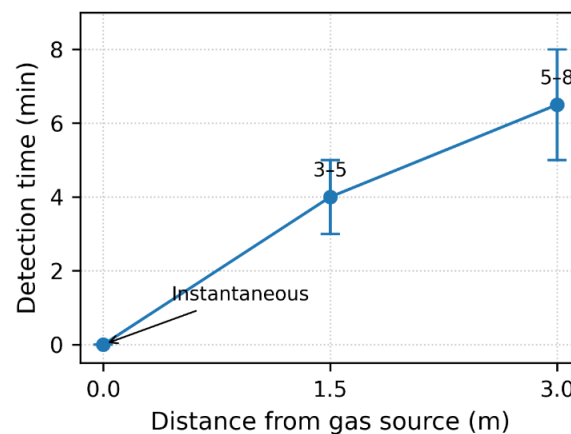


Figure 4. Detection time vs distance

4.7 Local and Remote Warning Systems

One of the key characteristics of the created prototype is the use of both local and remote warnings. On the one hand, feedback is achieved by using the OLED and buzzer, on the other – through

the use of Blynk for remote monitoring of the system status. The proposed solution resembles recent IoT-based systems of safety monitoring which use cloud or mobile platforms for increasing the range of action of traditional gas alarms [2, 7, 9]. Nevertheless, such remote warning systems require reliable connection via the Internet network. Therefore, the local buzzer is still an essential part of the system, and Blynk is not viewed as the only warning tool.

4.8 Comparison with Previous Work

Previous studies have shown several methodologies for LPG detection in the framework of IoT technology. García et al. employed the MQ-6 sensor along with microcontroller and the Blynk application and performed a comparative study using a commercial gas detector [7]. Ekah et al. introduced the idea using automatic gas shut-off and remote communications in the case of a Nigerian kitchen [9]. Novitaningrum et al. used the MQ-6 sensor and Blynk to implement the LPG leakage management system and detected LPG gas leakage at shorter source-to-sensor distances [10]. An analysis conducted in 2026 concerning the LPG detection systems within IoT showed that MQ-series sensors were commonly used in affordable devices but underlined their practical reliability drawbacks [6]. Compared with the use of automatic valves, ventilation or fire extinguishment, the current prototype involves a simpler scope of actions. The key advantage of the current prototype is a combination of affordable LPG gas detection with local signalling and remote monitoring by means of the Blynk app.

5 CONCLUSIONS

An IoT-based LPG leakage detection and notification system was designed and experimentally evaluated using an MQ-6 gas sensor, WeMos D1 Mini with ESP8266EX, SSD1306 OLED display, audible buzzer, and Blynk IoT platform. The prototype successfully provided both local and remote alerts when LPG was detected. Tests conducted at 0, 1.5, and 3.0 m showed that gas response decreased as the distance between the source and sensor increased. The system responded immediately at 0 m, within 3–5 min at 1.5 m, and approximately 5–8 min at 3.0 m, where readings were more volatile and remote notification was delayed. These results demonstrate the feasibility of a low-cost IoT architecture for LPG safety monitoring. However, the study represents a preliminary prototype evaluation. Only three distances were investigated under indoor conditions without active ventilation, and the reported concentration values were software-estimated rather than obtained through laboratory calibration. Therefore, conclusions regarding sensor accuracy, sensitivity, specificity, and reliability cannot be established. Future work should incorporate certified gas calibration, repeated experiments under controlled environmental conditions, and compensation for temperature, humidity, airflow, sensor ageing, and baseline drift. Further development could integrate data logging, fault detection, automatic ventilation, and solenoid-based gas shutoff to transform the prototype into a more comprehensive LPG safety system.

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