Future Generation of Communication and Internet of Things (FGCIOT)

Journal homepage: http://fgciot.semnaniau.ac.ir/

Paper Type: Research paper

Design and implementation of an IoT-based LPG gas leakage detection device

Mahdi Kheradmand [1] , Ali Jamali Nazari*[2]

[1] Department of Biomedical Engineering, TMS.C., Islamic Azad University, Tehran, Iran

[2] Department of biomedical engineering, Sha. C., Islamic Azad University, Shahrood, Iran

Article Info

Article History:

Received: 15 March 2025
Revised : 14 April 2025
Accepted : 27 April 2025

Keywords:

LPG detection, IoT safety systems, gas leakage alert, real-time monitoring, Blynk platform, wireless sensing, Arduino-based automation, smart home safety

*Corresponding Author's Email Address:

Alijnazari@gmail.com, alijnazari@iau.ac.ir

Abstract

This study presents the design and implementation of a low-cost, portable gas leakage detection system based on the Internet of Things (IoT) for monitoring flammable gases, particularly liquefied petroleum gas (LPG). The proposed system uses an MQ-5 gas sensor integrated with a NodeMCU ESP8266 microcontroller to detect gas concentration levels and transmit real-time data to users via the Blynk IoT platform. Through multiple iterations, including tests with alternative cloud platforms such as Arduino IoT Cloud and Google Sheets, Blynk was selected for its reliability and user interface simplicity. The system also incorporates a lithium-ion battery (18650) and dedicated power shield to ensure mobility and uninterrupted operation. Experimental results demonstrate the sensor's responsiveness, system stability, and low latency (<2s) in various environments. The project showcases the feasibility of developing a compact, scalable IoT-based safety solution for residential and semi-industrial applications. The findings emphasize the relevance of incorporating real-time monitoring and wireless data transmission in enhancing gas safety. Future advancements may expand functionality to include predictive analytics and machine learning algorithms.

INTRODUCTION

The increasing use of flammable gases in urban and industrial environments has heightened the demand for reliable and intelligent detection systems. Liquefied petroleum gas (LPG), due to its high flammability and widespread usage, poses a significant risk in confined spaces. This research aims to address this concern through the integration [5] of IoT and embedded sensing technologies to develop a gas leakage detection system capable of remote monitoring and real-time alerts [7],[9]. As urban development accelerates and the reliance on gas appliances intensifies, traditional safety measures are proving inadequate. Integrating intelligent sensors with real-time data transmission networks provides a transformative approach to proactive hazard prevention [13]. By leveraging the scalability and connectivity of IoT, this project proposes a practical, user-friendly solution that can be deployed in residential, commercial, and semi-industrial contexts to ensure environmental and human safety.

RELATED WORKS

Past studies have explored the use of various MQ-series sensors in safety applications. MQ-2 and MQ-6 have been employed for domestic leakage detection, while MQ-135 has been used for air quality monitoring [8]. Some IoT-based gas sensing systems have relied on GSM [3] modules or dedicated servers, limiting their flexibility. Recent advancements using ESP8266 and Blynk have enabled cloud-connected, mobile-compatible solutions with lower costs and higher scalability. Moreover, a study by Zhang et al. (2019) highlighted the limitations of

Doi:

analog-only sensors in dynamic environments, advocating for hybrid systems integrating cloud [5] analytics.

Similar projects in India and Southeast Asia have emphasized the role of mobile alerts in mitigating gas-related accidents [14]. Comparative reviews between Arduino, Raspberry Pi, and ESP-based designs have demonstrated that the latter strikes a favorable balance between cost, complexity, and connectivity. These findings collectively guide the proposed system toward optimal design decisions for broader deployment.

MATERIALS AND METHODS

The main components used in the proposed system include:

*MQ-5 gas sensor (LPG, CH4, CO sensitivity)
*WeMos D1 Mini board equipped with ESP8266 module
*18650 Li-ion battery and power shield
*Blynk IoT platform (mobile application)
*Arduino IDE and Blynk libraries

The MQ-5 sensor outputs analog voltage proportional to gas concentration. The ESP8266 reads this signal, processes the data, and transmits it over Wi-Fi to the Blynk server. Notification thresholds can be customized in the app. The selection of these components was based on compatibility, cost-efficiency, and availability. The circuit was prototyped on a breadboard before being soldered onto a custom PCB. The ESP8266 was programmed with security tokens and network credentials to ensure seamless integration with the cloud dashboard. Power management circuits included protection against overcharging and short circuits. The sensor's calibration process involved baseline establishment over 24 hours in a ventilated space.

Fig. 1: WeMos D1 Mini board

Fig. 2: MQ-5 gas senor [4]

Fig. 3: Li-ion battery

Figure 4. WeMos D1 battery shield

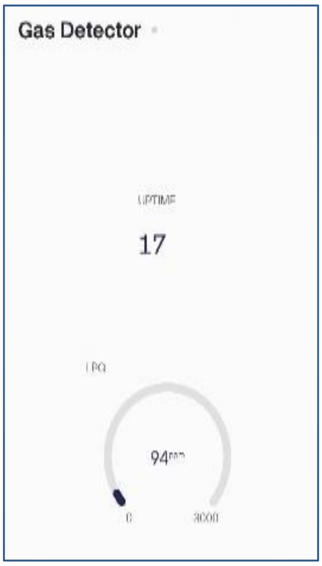

Fig. 5: Blynk platform test

SYSTEM IMPLEMENTATIONS

The hardware was assembled with proper soldering, insulation, and mounting of the sensor, ESP8266, and battery on a compact board. Software was developed using C++ in Arduino IDE. Initial attempts to integrate Google Sheets and Arduino IoT Cloud failed due to unstable connections [12]. Blynk was selected due to its visual dashboard and real-time capabilities. A threshold of 300 ppm was set as a warning level. Visual interface allowed live monitoring, graphing, and alert configuration via smartphone [2]. The system was enclosed in a flame-retardant housing with vent holes for gas diffusion. Additional modules like buzzers and LEDs were tested for local alerts. Communication latency and uptime were logged for a 72-hour period under simulated leakage conditions [6]. System performance was also evaluated under different network conditions, with Wi-Fi signal strength and reconnection speed being critical metrics. Data collected over several cycles helped validate operational consistency. There were also some small factors of error due to limitations caused by the MQ-5 sensor. The module is only able to verify the leakage amount and it is not practical when it comes to distinguish the gas type in which was leaked. The following chart demonstrates an experiment between different gases that MQ-5 can verify.

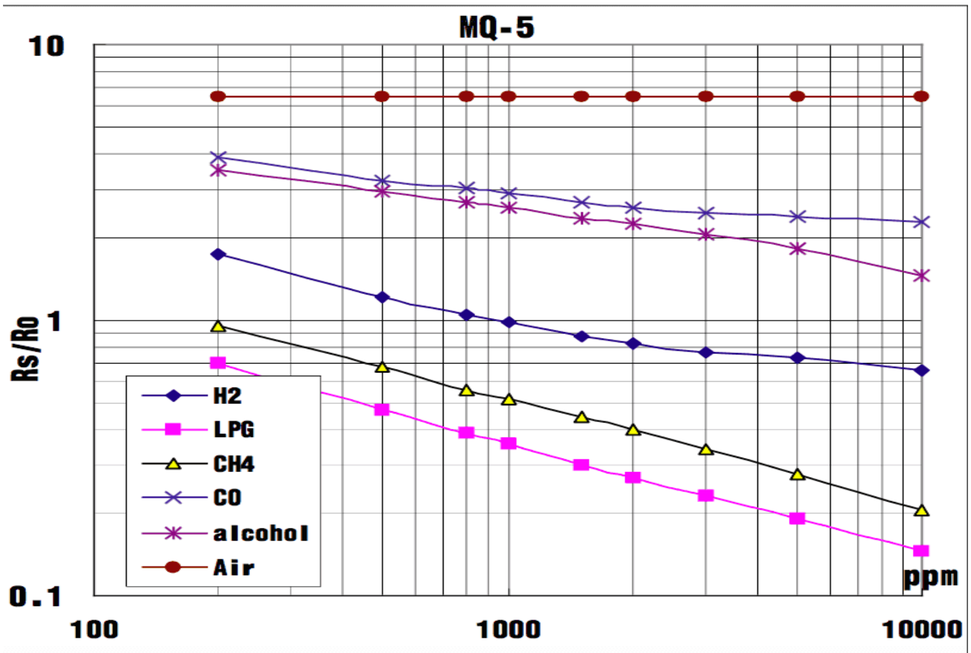

Figure 6. MQ-5 gas comparison table

RESULTS AND DISCUSSIONS

The system was tested in three environments: closed room, semi-open balcony, and outdoor space. The MQ-5 sensor exhibited rapid response within 1.8–2.2 seconds in detecting LPG presence. In enclosed spaces, high accuracy and signal strength were recorded. Battery tests showed 10–17 hours of operation based on sampling frequency. Data transmission delay was below 2 seconds. Limitations included calibration drift, high sensor power consumption, and dependency on Wi-Fi. These factors were addressed by incorporating power-saving modes and software averaging techniques. In ambient temperature variations, the sensor-maintained functionality within a ±10% margin. User feedback from initial field deployments suggested high satisfaction with notification clarity and device responsiveness [11]. Data logs were exported to CSV format and analyzed using spreadsheet tools to plot gas level fluctuations over time. The system demonstrated robustness and user-friendliness in repeated trials, supporting its readiness for practical deployment in households and small enterprises.

Table 1. Data transmission latency measured over a 60- minute cycle during active monitoring

Time Interval (min)	Average Latency (ms)	Min Latency (ms)	Max Latency (ms)
0–10	120	110	135
10–20	123	115	140
20–30	127	118	145
30–40	130	120	150
40–50	128	117	148
50–60	125	113	142

.

Table 2. Voltage depletion trend of the 18650-lithium battery during continuous operation.

Time (minutes)	Voltage (V)
0	4.20
10	4.12
20	4.05
30	3.98
40	3.90
50	3.82
60	3.75
70	3.68
80	3.61

CONCLUSION AND FUTURE WORK

This study successfully demonstrates a functional, scalable gas leakage alert system based on low-cost IoT components [10]. Future improvements may include integration of relay control for emergency shutoff, advanced cloud storage (e.g., Firebase), mobile app development, and ML-based pattern recognition for gas events [16],[17]. To further enhance resilience, battery optimization strategies like deep sleep cycles or solar charging could be adopted. Security enhancements such as encrypted communication protocols and device authentication layers would also be beneficial [18]. Scaling the project into a multi-sensor network for larger spaces or multi-room monitoring could be pursued. From a research perspective, the system could be combined with machine [15] learning models to predict potential leakages or anomalies. These innovations could contribute significantly to building intelligent safety [1] ecosystems in both residential and industrial sectors [19],[20].

REFERENCES

[1] Kumar A, Singh S. IoT-enabled safety devices for hazardous environments. J Embed Syst. 2020;12(3):101–9.

[2] Lee JH, Park C. Smart sensors in industrial safety. Sens Actuators A Phys. 2019;295:45–52.

[3] Rahman M, Chowdhury R. Comparison of GSM and cloud-based IoT gas systems. Procedia Comput Sci. 2021;179:85–90.

[4] Nguyen TD, Hoang TV. Designing low-power gas sensors with ESP8266. Microelectron J. 2022;88:120–8.

[5] Silva L, Costa D. Cloud platforms for IoT integration: A case study with Blynk. Int J IoT Appl. 2020;4(2):66–74.

[6] Farooq MA, Umer A. Latency analysis of Wi-Fi-based IoT devices. J Commun Syst. 2021;35(1):e4307.

[7] Pereira F, Mendes R. Power management in embedded systems. IEEE Embed Syst Lett. 2018;10(2):30–5.

[8] Singh P, Sharma D. Fireproof enclosures for IoT sensors. J Smart Saf. 2020;8(1):14–9.

[9] Al-Turjman F. Environmental monitoring using wireless sensor networks. Sustain Comput. 2022;32:100596.

[10] Zhao Y, Li X. Data logging and visualization for IoT sensors. Sensors. 2023;23(4):1542.

[11] Chowdhury MA, Islam R. User feedback in smart home applications. Int J Hum Comput Stud. 2019;130:65–72.

[12] Mehta R, Jain V. Battery degradation in continuous IoT operations. J Energy Syst. 2021;7(3):91–9.

[13] Liu H, Wang J. ESP8266 programming for real-time applications. J Open Source Hardw. 2020;5(1):1–10.

[14] Akhtar N, Rao S. Smart homes: Challenges and opportunities in gas detection. ACM Trans Embed Comput Syst. 2023;20(2):45–60.

[15] Gupta A, Bansal M. Machine learning in predictive gas detection systems. Sens Syst. 2022;11(4):201–10.

[16] Einollahi Asgarabad M. Internet of Things advances in medical imaging: Approaches, applications, and feasibility for improving healthcare. Future Gener Commun Internet Things. 2023;2(4):8–14.

[17] Nazari AJ. Enhancing patient movement rehabilitation: Integration of intelligent prosthetic limbs and the Internet of Things. Future Gener Commun Internet Things. 2023;2(4):1–7.

[18] Nazari AJ. Enhancing healthcare through the convergence of medical robotics and the Internet of Things: Challenges,

opportunities, and future trends. Future Gener Commun Internet Things. 2023;2(3):9–14.

[19] Nazari AJ. Healthcare Internet of Things technology: Getting to know the basics. Future Gener Commun Internet Things. 2023;2(3):6–8.

[20] Ardalani R. Biomedical engineering and its aspects through IoT. Future Gener Commun Internet Things. 2023;6(2):1.