International Journal of Engineering & Extended Technologies Research (IJEETR)

|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802212

Intelligent IoT Enabled Gas Leakage Detection and Alert System with GSM-GPS Integration

Annapoorna M[1], Barath S[2], Guna S[3], Aravinthar K R[4], Kesavan M[5]

Assistant Professor[1], Department of Electronics and Communication Engineering, AVS Engineering College (Autonomous), Salem, Tamil Nadu, India[1]

Department Electronics and Communication of Engineering, AVS Engineering College (Autonomous), Salem, Tamil Nadu, India[2-5]

Publication History: Received: 25.02.2026; Revised: 20.03.2026; Accepted: 25.03. 2026; Published: 28.03.2026.

ABSTRACT: Gas leakage in domestic, commercial, and industrial environments poses serious risks to human life and property. Early detection and rapid alert mechanisms are essential to prevent accidents such as fire explosions and asphyxiation.

This paper presents the design and implementation of an intelligent IoT-enabled gas leakage detection and alert system with GSM-GPS integration for real-time monitoring and emergency notification. The proposed system utilizes a gas sensor to continuously monitor the presence of hazardous gases and a flow sensor to detect abnormal gas flow conditions.

Sensor data is processed by a microcontroller unit, which compares the measured values with predefined safety thresholds. Upon detecting a gas leak, the system activates an audible buzzer alarm for immediate local warning and displays real-time status information on an LCD module. To ensure remote alerting, a GSM module is integrated to transmit instant warning messages to authorized users. The inclusion of a GPS module enables accurate location tracking of the leakage source, which is highly beneficial during emergency response and rescue operations.

A regulated power supply with a voltage regulator ensures stable and reliable system operation. The proposed system offers a cost-effective, reliable, and scalable solution for continuous gas monitoring and emergency alerting. It is suitable for applications in smart homes, industries, gas pipelines, and public safety systems. The modular design allows easy expansion to include cloud analytics and intelligent decision-making in future developments.

KEYWORDS: IoT, Gas Leakage Detection, GSM Module, GPS Tracking, Gas Sensor, Real-Time Monitoring, Emergency Alert System

I. INTRODUCTION

The increasing use of combustible and toxic gases in domestic, commercial, and industrial environments has significantly raised concerns regarding safety and accident prevention. Gas leakage incidents can lead to severe consequences such as fires, explosions, health hazards, and loss of life. Conventional gas detection systems often rely on manual inspection or localized alarms, which may not provide timely alerts or remote notification during emergency situations. Hence, there is a critical need for intelligent, automated, and remotely accessible gas leakage detection systems.

Recent advancements in the Internet of Things (IoT) and wireless communication technologies have enabled the development of smart monitoring systems capable of real-time data acquisition and alerting. IoT-based gas detection systems allow continuous monitoring of gas concentration levels and instant communication of critical information to users and emergency responders. However, many existing systems lack precise location tracking and integrated flow analysis, limiting their effectiveness in large-scale or distributed environments.

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The proposed Intelligent IoT-Enabled Gas Leakage Detection and Alert System with GSM-GPS Integration addresses these limitations by combining gas sensing, flow monitoring, and wireless alert mechanisms into a unified platform. A gas sensor continuously monitors the presence of hazardous gases, while a flow sensor detects abnormal gas flow conditions that may indicate leakage. A microcontroller unit processes sensor data and triggers immediate alerts when predefined safety thresholds are exceeded.

For effective emergency response, a GSM module is used to transmit real-time alert messages to authorized personnel, while a GPS module provides accurate location information of the leakage site. Local alerts are generated using a buzzer, and real-time system status is displayed on an LCD. A regulated power supply ensures stable operation of all system components.

The proposed system offers a reliable, cost-effective, and scalable solution for gas leakage detection and alerting. It is suitable for applications in smart homes, industries, gas pipelines, and public infrastructure, significantly enhancing safety through early detection, rapid response, and remote monitoring.

II. LITERATURE REVIEW

Recent studies highlight that IoT-based gas leakage detection systems provide continuous monitoring and real-time alerts, improving safety in both domestic and industrial environments. These systems typically use gas sensors, microcontrollers, and communication modules such as GSM and Wi-Fi to detect abnormal gas concentrations and trigger alarms. The integration of multiple components enables faster response and reduces the risk of accidents. Researchers emphasize that such systems are cost-effective and scalable for practical deployment.

Several researchers have focused on LPG leakage detection using microcontroller-based architectures combined with GSM modules. In these systems, gas sensors identify leakage levels and automatically activate alarms, exhaust fans, and message alerts to users. The use of GSM communication ensures immediate notification even in remote areas. These designs improve response time and enhance safety through automated actions. However, improvements are still needed in sensor accuracy and reliability.

Recent advancements include IoT-enabled systems that not only detect gas leakage but also monitor gas cylinder levels and usage patterns. These systems integrate cloud platforms to provide remote monitoring and predictive analysis. By using sensors like MQ-series and load cells, they can alert users about both leakage and gas depletion. Such multifunctional systems enhance convenience and safety simultaneously. They also support data-driven decision-making for better resource management.

A number of review studies have analyzed existing IoT-based gas detection techniques and identified key challenges. These include limitations in sensor precision, system scalability, and real-time responsiveness. Researchers suggest that future systems must focus on improving detection accuracy, reducing false alarms, and enhancing communication efficiency. The integration of cloud computing and advanced analytics is also recommended. Overall, there is a growing need for more reliable and efficient smart detection systems.

Modern IoT-based gas detection systems incorporate real-time monitoring, cloud storage, and mobile notification features. These systems allow users to remotely track gas levels and receive instant alerts during leakage events. The use of communication technologies like GSM and mobile applications ensures rapid response and improved safety management. Additionally, these systems are designed to be flexible and easily integrated into existing infrastructure. This makes them suitable for smart homes and industrial applications.

Recent developments also include intelligent systems capable of automatically controlling gas supply during leakage. These systems use sensors and control mechanisms to shut off valves and prevent further gas flow. Some designs incorporate dual sensors for detecting multiple gases and GPS modules for location tracking. This enhances emergency response by providing accurate location information. Such intelligent systems significantly reduce the risk of fire accidents and environmental hazards.

III. RESEARCH METHODOLOGY

The proposed system is designed using an IoT-based approach to continuously monitor gas leakage in real time. A gas sensor is used to detect the presence of harmful gases, and its output is processed by a microcontroller. The system is programmed to identify abnormal gas concentration levels and trigger alerts accordingly. This ensures early detection and minimizes potential hazards.

The hardware implementation includes components such as a gas sensor (MQ series), microcontroller (Arduino/ESP8266), GSM module, GPS module, and buzzer. The sensor collects environmental data, which is analyzed by the controller to determine leakage conditions. When a threshold is exceeded, the system activates an alarm and sends notifications. The integration of GSM and GPS enables communication and location tracking.

On the software side, embedded programming is used to control sensor readings, data processing, and communication functions. The algorithm compares real-time sensor values with predefined safety limits to detect leaks. Upon detection, the system sends SMS alerts and location details to the user. This automation reduces the need for manual monitoring and increases system reliability.

The overall methodology also includes testing and validation of the system under different gas exposure conditions. Performance is evaluated based on response time, accuracy, and alert efficiency. Multiple test scenarios are conducted to ensure consistent operation and minimal false alarms. This structured approach helps in developing a dependable and efficient gas leakage detection system.

IV. RESULTS AND DISCUSSION

The developed system successfully detected gas leakage under different test conditions and responded within a short time frame. The MQ-series sensor showed reliable sensitivity to LPG and similar gases. Once the threshold level was exceeded, the system immediately activated the buzzer and sent alert messages. This confirms the effectiveness of the real-time monitoring approach.

The integration of GSM and GPS modules provided efficient communication and location tracking during leakage events. SMS alerts were delivered promptly to the registered user with accurate location details. This feature is especially useful in emergency situations where quick action is required. The system demonstrated consistent performance during repeated trials.

The response time of the system was observed to be quick and suitable for practical applications. The delay between detection and alert transmission was minimal. This ensures that users can take immediate preventive measures.

Sensor accuracy was satisfactory under controlled conditions, though minor variations were noticed due to environmental factors. Proper calibration helped in reducing false readings. Overall, the system maintained dependable detection capability.

The system also showed good stability during continuous operation over extended periods. There were no major interruptions in data processing or communication. This indicates its suitability for long-term deployment.

However, the system can be further improved by enhancing sensor precision and integrating advanced data analysis techniques. Future improvements may include cloud connectivity and mobile app support. These additions can increase usability and system intelligence.

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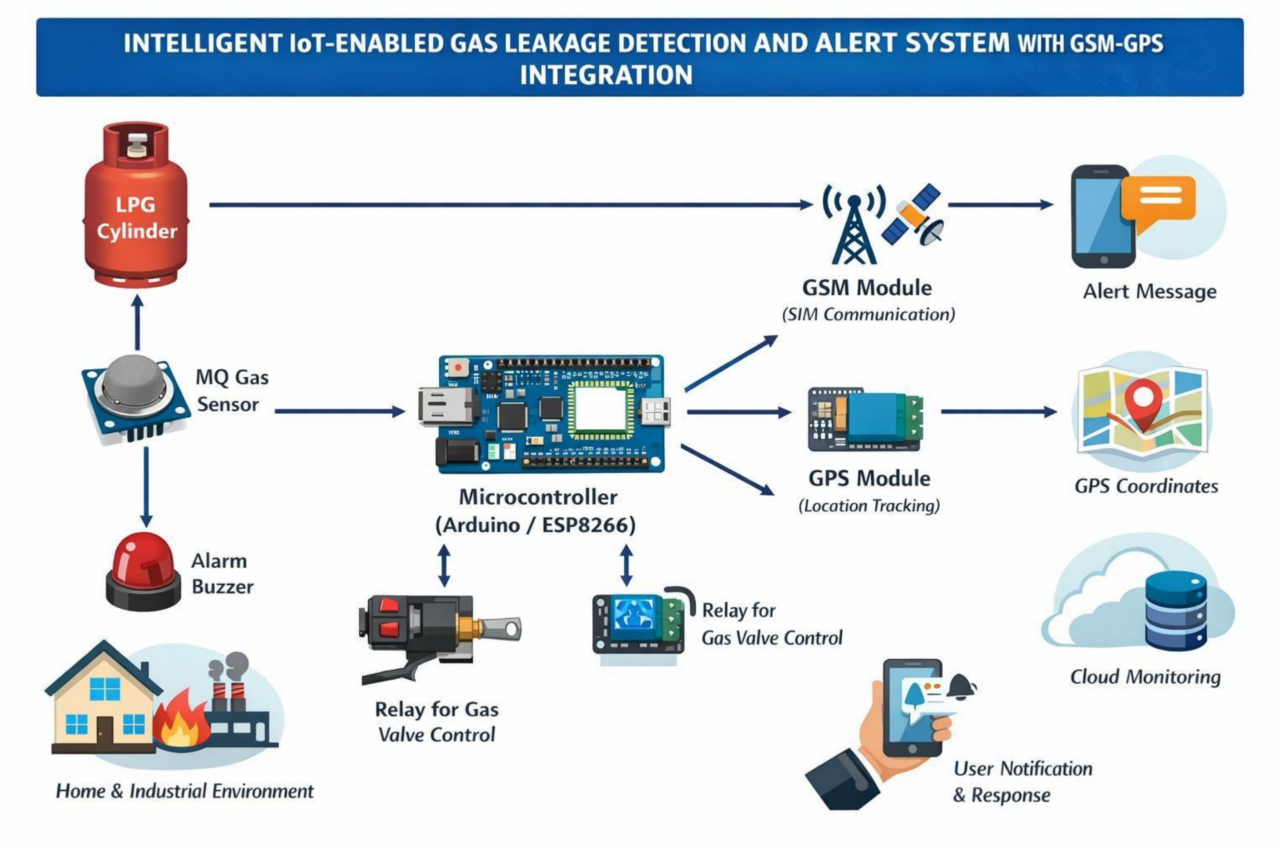

FIG: 1

V. CONCLUSION

Enhanced Safety: The sensor-based alarm system significantly improves safety by providing early detection of potential hazards such as gas leaks, fires, and mechanical failures, allowing for quick responses to mitigate risks.

Real-Time Monitoring: Continuous, real-time monitoring of critical parameters (gas levels, pressure, temperature, vibration) ensures immediate alerts when predefined thresholds are exceeded, enabling timely intervention.

Integration with Existing Systems: The proposed system can seamlessly integrate with existing safety infrastructure (SCADA, SIS) to create a comprehensive safety solution across operations.

Automated Responses: The system can trigger automated shutdown procedures and activate safety measures (e.g., fire suppression or valve closures), reducing human error and preventing catastrophic events.

Predictive Maintenance: By analyzing sensor data, the system can predict equipment failures before they occur, optimizing maintenance schedules and reducing downtime and operational costs.

VI. FUTURE WORK

Predictive Analytics: AI and ML algorithms will enable the system to not only detect threats but also predict future risks based on historical data and sensor inputs. For instance, predicting equipment failure patterns or potential gas leaks before they occur will allow for proactive maintenance and risk management.

Edge Computing: The deployment of edge computing, where data processing occurs closer to the source (i.e., on-site or at the sensor level), will enable faster decision-making by reducing the delay from transmitting data to a central server or cloud platform. This can ensure immediate action when safety threats are detected.

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Improved Latency: Real-time data processing at the edge will enable immediate triggering of alarms and automatic shutdowns, minimizing the risk of accidents that require human intervention.

Anomaly Detection: AI can be used to analyze sensor data in real-time to identify patterns and anomalies that could signify a threat, enable faster response times and reducing the likelihood of false alarms.

Multi-Modal Sensors: The future will see the development of more advanced multi-modal sensors that can monitor various environmental and operational parameters simultaneously, reducing the need for multiple, specialized devices. For example, multi-gas sensors that can detect several hazardous gases at once with higher sensitivity and specificity.

Wireless and Flexible Sensors: As sensor technology advances, more sophisticated wireless sensors will be developed, providing even more flexible and cost-effective installation in challenging environments.

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