International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

IoT-Enabled Gas Leakage Detection and Auto Shut-Off System

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Abstract: ***Gas leakage is one of the most critical safety hazards in residential, commercial, and industrial environments. Liquefied Petroleum Gas (LPG), widely used for cooking and heating, is highly flammable and can lead to severe fire accidents and explosions if leakage occurs. Despite the presence of odorants in LPG for manual detection, relying solely on human senses is unreliable, especially during sleep hours, absence of occupants, or in poorly ventilated areas. This paper presents an IoT-enabled gas leakage detection and automatic shut-off system with call alert, designed to provide intelligent, real-time monitoring and enhanced safety. The system continuously monitors gas concentration levels in parts per million (PPM) using an MQ series gas sensor. The sensor data is processed by an ESP8266 microcontroller, which compares the values with predefined safety thresholds. Upon detection of gas leakage, the system performs multiple automated safety actions simultaneously. A buzzer is activated for immediate local alert, a relay module cuts off electrical power supply to prevent spark hazards, and a solenoid valve shuts off the gas supply to stop further leakage. Additionally, a GSM module sends SMS notifications and initiates call alerts to registered users, ensuring remote notification even without internet connectivity. The system also incorporates IoT functionality by transmitting real-time sensor data to the ThingSpeak cloud platform, enabling continuous monitoring, data visualization, and analysis. A mobile application developed using MIT App Inventor allows users to remotely monitor gas levels, receive alerts, and control system devices. The proposed system is cost-effective, scalable, and suitable for both residential and small industrial applications. By integrating early detection, automatic control, real-time monitoring, and multi-level alert mechanisms, the system significantly enhances safety and reduces the risk of fire and explosion hazards.***

Keywords: IoT, Gas Leakage Detection, ESP8266, MQ-2 Sensor, Real-Time Monitoring, GSM Alerts, Solenoid Valve, Relay Module, ThingSpeak, Mobile Application

1. Introduction

Gas leakage is one of the most critical safety hazards in residential, commercial, and industrial environments. Liquefied Petroleum Gas (LPG), widely used for cooking, heating, and industrial applications, is highly flammable and can lead to severe fire accidents and explosions if leakage occurs. Electrical sparks during leakage further increase the risk of hazardous incidents, resulting in property damage and potential loss of human life.

Gas leakage can occur due to several reasons such as damaged pipelines, loose regulators, improper installation, aging rubber tubes, or accidental mishandling. In most conventional systems, leakage detection relies on human sense of smell, as LPG is mixed with odorants. However, this approach is unreliable, particularly during sleep hours, absence of occupants, or in poorly ventilated environments. Hence, there is a strong need for an automated and intelligent system that can detect leakage and respond immediately.

Traditional gas detection systems provide only basic alert mechanisms and lack automatic safety actions such as power cut-off and gas supply control. These limitations increase the response time and risk associated with gas leakage incidents. Therefore, an advanced system that integrates detection, control, and communication is essential to improve safety standards.

With the advancement of Internet of Things (IoT) technology, it has become possible to develop smart monitoring systems capable of real-time data acquisition, processing, and remote communication. IoT enables devices to continuously monitor environmental parameters, transmit data to cloud platforms, and provide remote access to users through mobile applications.

The proposed system, titled "IoT-Enabled Gas Leakage Detection and Auto Shut-Off System with Call Alert," is designed to provide a comprehensive safety solution. The system uses an MQ-2 gas sensor to continuously monitor gas concentration levels in parts per million (PPM). The sensor data is processed by an ESP8266 microcontroller, which compares the readings with predefined safety thresholds.

When gas leakage is detected, the system performs multiple automated safety actions simultaneously. A buzzer is activated to provide an immediate local alert. A relay module cuts off the electrical power supply to prevent spark-related hazards. A solenoid valve is used to automatically shut off the gas supply, thereby preventing further leakage. In addition, a GSM module sends SMS notifications and initiates call alerts to the registered mobile number, ensuring user awareness even without internet connectivity.

Furthermore, the system integrates IoT functionality by uploading real-time sensor data to the ThingSpeak cloud platform. This enables continuous monitoring, data visualization, and remote access. A mobile application developed using MIT App Inventor allows users to monitor gas levels, receive alerts, and control system devices from any location.

Thus, the proposed system provides a reliable, cost-effective,

and efficient solution by combining early detection, automatic control, real-time monitoring, and multi-level alert mechanisms to significantly enhance safety and reduce the risks associated with gas leakage.

2. Objectives

The primary objective of this project is to design and implement an intelligent gas leakage detection system integrated with IoT technology and automatic control mechanisms to enhance safety standards.

The specific objectives of the proposed system are as follows:

- To continuously monitor LPG gas concentration using an MQ-2 gas sensor.
- To detect abnormal gas levels in real time based on predefined threshold values.
- To activate an audible buzzer alert during gas leakage conditions.
- To automatically shut off the gas supply using a solenoid valve.
- To disconnect electrical appliances through a relay module to prevent spark ignition.
- To send SMS notifications to the registered mobile number using a GSM module.
- To initiate automatic call alerts during emergency situations.
- To upload real-time gas concentration data to a cloud platform (ThingSpeak).
- To enable remote monitoring through a web interface or mobile application.
- To design a low-cost, reliable, and efficient safety system suitable for residential applications.

The project aims to integrate detection, prevention, and communication into a single unified framework to significantly improve safety and reduce risks associated with gas leakage.

3. Existing System

Existing gas leakage detection systems are generally standalone devices equipped with a gas sensor and a buzzer. When the gas concentration exceeds a predefined threshold level, the system triggers an audible alarm to alert nearby users. Although this provides immediate local notification, such systems suffer from several limitations.

Most traditional gas detection systems do not include automatic safety mechanisms. They are unable to shut off the gas supply or disconnect electrical circuits, which increases the risk of fire hazards due to potential spark ignition. In addition, these systems do not provide remote notification facilities and depend entirely on human presence and response for corrective action.

Furthermore, conventional systems lack real-time monitoring capabilities and do not support cloud-based data storage or analysis. As a result, users cannot monitor gas levels remotely or receive timely alerts when they are away from the location.

Some advanced systems incorporate SMS alert functionality using GSM modules. However, these systems often lack comprehensive features such as automatic gas shut-off, electrical power cut-off, and call alert mechanisms. Industrial-grade gas detection systems offer higher reliability and advanced features, but they are expensive and not suitable for small-scale or residential applications.

These limitations highlight the need for an integrated, automated, and IoT-enabled gas leakage detection system that ensures real-time monitoring, remote alerting, and immediate safety actions.

4. Proposed System

The proposed system is designed to overcome the limitations of existing gas leakage detection systems by integrating sensing, automation, communication, and real-time monitoring into a single unified platform. The system provides both immediate local response and remote user notification, thereby significantly enhancing safety and reliability.

The system consists of several key components, including an MQ-2 gas sensor for LPG detection, an ESP8266 microcontroller for data processing and IoT connectivity, a GSM module for SMS and call alerts, a solenoid valve for automatic gas shut-off, a relay module for electrical disconnection, and a buzzer for audible alerts. Additionally, a cloud platform is used for real-time data monitoring and visualization.

The MQ-2 sensor continuously monitors the gas concentration in the environment and sends analog signals to the ESP8266 microcontroller. The microcontroller processes the sensor data and compares it with predefined safety threshold values. When the gas concentration exceeds the threshold level, the system immediately initiates a series of automated safety actions.

An audible buzzer alert is activated to warn nearby individuals. Simultaneously, the solenoid valve automatically shuts off the gas supply to prevent further leakage. The relay module disconnects electrical appliances to eliminate the risk of spark ignition. In addition, the GSM module sends an SMS notification and initiates a call alert to the registered mobile number, ensuring that the user is informed even in the absence of internet connectivity.

Furthermore, the system uploads real-time gas concentration data to a cloud platform such as ThingSpeak, enabling continuous monitoring and data visualization. Users can remotely access the system through a web interface or mobile application to monitor gas levels and system status.

This integrated approach ensures rapid detection, immediate preventive action, and effective communication, thereby reducing the risk of accidents and improving overall safety in residential and small industrial environments.

5. Methodology

The proposed system follows a continuous monitoring and event-driven response methodology to ensure timely

detection and prevention of gas leakage hazards. The system operates by continuously sensing environmental gas concentration and initiating automated safety actions when abnormal conditions are detected.

The MQ-2 gas sensor continuously monitors the surrounding air and generates an analog voltage corresponding to the gas concentration level. This analog signal is read at regular intervals by the ESP8266 microcontroller. The microcontroller processes the sensor data by converting it into meaningful values and comparing it with predefined safety threshold levels.

Under normal conditions, when the gas concentration remains below the threshold value, the system continues its monitoring process without triggering any safety mechanisms. During this phase, the sensor data is periodically transmitted to the ThingSpeak cloud platform via Wi-Fi for real-time visualization and remote monitoring.

When the gas concentration exceeds the predefined safe limit, the system immediately initiates a series of emergency response actions. An audible buzzer is activated to provide immediate local alert to occupants. Simultaneously, the relay module disconnects electrical appliances to eliminate the risk of spark ignition. The solenoid valve is triggered to automatically shut off the gas supply, thereby preventing further leakage.

In addition to local safety actions, the GSM module sends an SMS alert and initiates a call notification to the registered mobile number, ensuring remote awareness even in the absence of internet connectivity. At the same time, the updated gas concentration data is uploaded to the ThingSpeak cloud platform, and the mobile application developed using MIT App Inventor displays the alert status to the user.

This layered methodology ensures early detection, rapid response, automatic prevention, reliable communication, and continuous remote monitoring, thereby significantly enhancing the overall safety and effectiveness of the system.

6. Block Diagram

The block diagram illustrates the overall architecture of the proposed system. The MQ-2 gas sensor continuously monitors the gas concentration in the environment and sends the data to the ESP8266 microcontroller. The microcontroller processes the sensor readings and compares them with predefined threshold values.

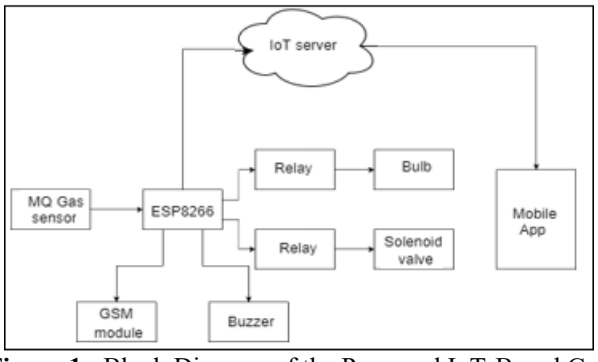


Figure 1: Block Diagram of the Proposed IoT-Based Gas Leakage Detection System

When gas leakage is detected, the ESP8266 activates the buzzer to provide an immediate local alert. At the same time, it triggers the relay module to disconnect electrical appliances and activates the solenoid valve to shut off the gas supply.

Additionally, the GSM module is used to send SMS alerts and initiate call notifications to the user. The system also uploads real-time gas concentration data to the ThingSpeak cloud platform using Wi-Fi. A mobile application developed using MIT App Inventor allows users to monitor the system remotely and receive alerts.

7. Circuit Diagram

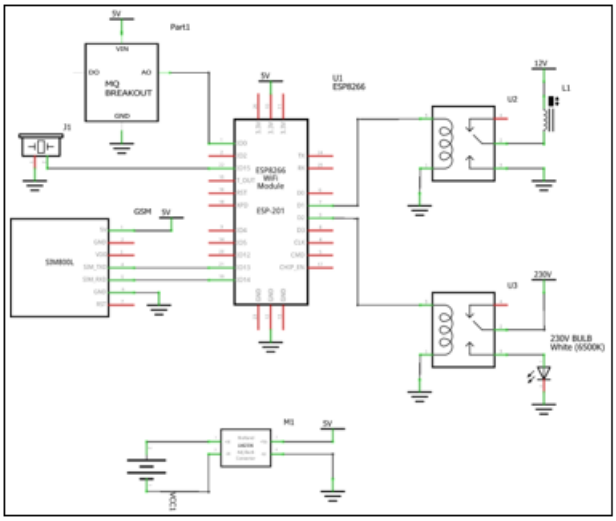


Figure 2: Circuit Diagram of the Proposed IoT-Based Gas Leakage Detection System

The circuit diagram illustrates the detailed hardware connections of the proposed gas leakage detection and prevention system. The MQ-2 gas sensor is used to continuously monitor the concentration of LPG in the surrounding environment. The analog output of the sensor is connected to the ESP8266 microcontroller, which processes the sensor readings and determines whether the gas level exceeds the predefined safety threshold.

The ESP8266 acts as the central control unit of the system. It interfaces with multiple components to perform automated safety actions. A relay module is connected to the microcontroller to control electrical appliances. When gas leakage is detected, the relay disconnects the power supply to prevent spark generation and reduce fire hazards.

A solenoid valve is integrated into the system to automatically shut off the gas supply during leakage conditions. The valve is controlled through the relay module or a driver circuit, ensuring immediate response to prevent further gas leakage.

The GSM module is connected to the ESP8266 using serial communication (UART). It is responsible for sending SMS

alerts and initiating call notifications to the registered mobile number during emergency situations. This ensures that the user is notified even in the absence of internet connectivity.

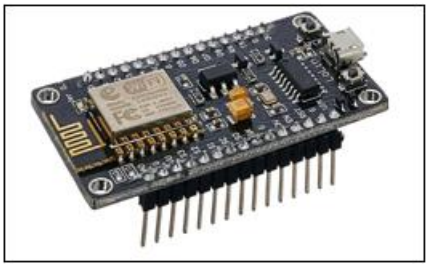
Additionally, a buzzer is connected to the microcontroller to provide an audible alert for nearby occupants. The ESP8266 also utilizes its built-in Wi-Fi capability to transmit real-time gas concentration data to the ThingSpeak cloud platform. This enables remote monitoring and visualization of sensor data through a web interface or a mobile application developed using MIT App Inventor.

The entire system is powered using a regulated power supply to ensure stable and reliable operation of all components.

8. Hardware Components

The major hardware components used in the proposed IoT-based gas leakage detection system are described below. Each component plays a critical role in sensing, processing, control, communication, and safety automation.

ESP8266 Microcontroller



The ESP8266 microcontroller acts as the brain of the entire system and is responsible for processing, control, and communication.

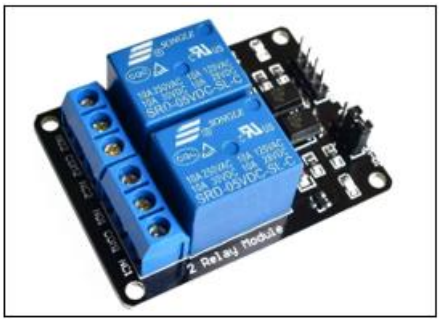
- Serves as the central processing unit (CPU) of the system.
- Reads analog data from the MQ-2 gas sensor through ADC.
- Compares gas concentration with predefined safety threshold values.
- Controls output devices such as relay, buzzer, and solenoid valve.
- Interfaces with GSM module for SMS and call alert functionality.
- Provides built-in Wi-Fi capability for IoT communication.
- Uploads real-time gas concentration data to ThingSpeak cloud platform.
- Enables remote monitoring and control through mobile application.
- Supports low power consumption and compact design.

MQ-2 Gas Sensor

The MQ-2 gas sensor is used for detecting the presence of LPG and other combustible gases in the environment.

- Detects LPG, methane, propane, hydrogen, and smoke.
- Provides analog output proportional to gas concentration (PPM).
- High sensitivity and fast response time.
- Capable of continuous environmental monitoring.
- Operates using SnO2 (tin dioxide) sensing material.
- Suitable for both domestic and industrial safety applications.
- Enables early detection of gas leakage before reaching dangerous levels.

Relay Module



The relay module is used to control high-voltage electrical appliances safely.

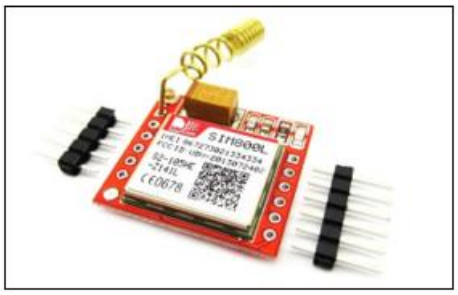
- Acts as an electrically operated switch.
- Allows low-voltage ESP8266 to control high-voltage circuits.
- Disconnects electrical appliances during gas leakage.
- Prevents spark generation, reducing fire hazards.
- Provides electrical isolation between control and load circuits.
- Can control devices such as bulbs, fans, and other appliances.

Solenoid Valve

The solenoid valve is responsible for automatic gas supply control.

- Automatically shuts off gas supply during leakage conditions.
- Operates using an electromagnetic coil mechanism.
- Provides rapid response to prevent further gas escape.
- Ensures safety by isolating gas source immediately.
- Can be integrated directly into LPG pipeline systems.
- Reduces risk of explosion and fire accidents.

GSM Module

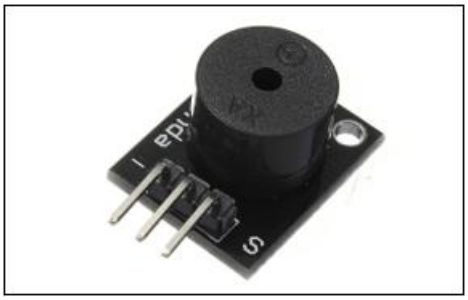


The GSM module enables remote communication and alert generation.

Sends SMS alerts to registered mobile numbers.

- Initiates automatic voice call alerts during emergency.
- Operates using cellular network (SIM-based communication).
- Works even without internet connectivity.
- Uses UART communication with ESP8266.
- Ensures reliable long-distance communication.

Buzzer



The buzzer provides immediate local alert during gas leakage.

- Generates audible alarm signal.
- Alerts nearby occupants instantly.
- Helps in quick evacuation and emergency response.
- Simple and low power device.
- Activated immediately when threshold is exceeded.

LM2596 Buck Converter

The LM2596 buck converter is used for voltage regulation.

- Steps down voltage from 12V to 5V/3.3V.
- Provides stable and regulated power supply.
- High efficiency switching regulator.
- Protects sensitive components from voltage fluctuations.
- Supports adjustable output voltage.

12V Li-ion Battery

The battery acts as a backup power source for uninterrupted system operation.

- Provides power during mains supply failure.
- Ensures continuous monitoring and safety operation.
- Rechargeable and portable energy source.
- Improves system reliability and availability.
- Suitable for long-duration operation.

9. Software Tools and Technologies

The proposed system utilizes various software tools for programming, cloud integration, and remote monitoring.

- **Arduino IDE:** Used for writing, compiling, and uploading programs to the ESP8266 microcontroller. It supports required libraries for sensor interfacing and Wi-Fi communication.
- **Embedded C:** Used to implement system logic including gas detection, threshold comparison, and control of relay, buzzer, and solenoid valve.
- **ThingSpeak Cloud Platform:** Used for real-time monitoring and visualization of gas concentration data. Sensor values are displayed in graphical format.
- **MIT App Inventor:** Used to develop a mobile application for remote monitoring. It allows users to view gas levels and receive alerts.

10. Results and Discussion

The proposed IoT-based gas leakage detection system was tested under different environmental conditions to evaluate its performance and reliability. The MQ-2 gas sensor successfully detected LPG gas concentration levels and transmitted real-time data to the ESP8266 microcontroller.

During testing, when gas concentration exceeded the predefined threshold value, the system responded immediately. The buzzer was activated to provide an audible alert, and the relay module disconnected electrical appliances to prevent spark hazards. Simultaneously, the solenoid valve automatically shut off the gas supply, effectively preventing further leakage.

The GSM module functioned reliably by sending SMS alerts and initiating call notifications to the registered mobile number without delay. In addition, real-time gas concentration data was uploaded to the ThingSpeak cloud platform, allowing continuous monitoring and visualization.

The system demonstrated fast response time, accurate detection, and proper coordination between hardware and

software components. The results confirm that the proposed system is efficient, cost-effective, and suitable for real-time gas leakage detection and safety applications in residential and small-scale environments.

11. Conclusion

The IoT-Enabled Gas Leakage Detection and Auto Shut-Off System with Call Alert has been successfully developed, implemented, and evaluated. The system demonstrated reliable performance in detecting LPG leakage using the MQ series gas sensor, and the ESP8266 microcontroller provided real-time monitoring and rapid decision-making. The automatic shut-off mechanism using a solenoid valve and relay not only triggers audible alerts but also physically cuts off the gas supply and disconnects electrical appliances, effectively reducing the risk of fire or explosion. The inclusion of GSM-based SMS and automated voice call alerts ensures timely emergency communication even when internet connectivity is unavailable.

Integration with the ThingSpeak cloud platform enables real-time data visualization and remote monitoring, and the mobile application provides a user-friendly interface for system status viewing and alert reception. Continuous testing showed stable interaction between hardware and software components, confirming system reliability and practical usability. Overall, the proposed system represents a cost-effective, efficient, and intelligent safety solution suitable for residential kitchens, small commercial environments, and other LPG-using spaces. Future work may include advanced analytics, edge-AI integration, and interoperability with broader smart home systems.

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