

# **GAS LEAKAGE DETECTION SYSTEM USING IoT**

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**Abstract:** Gas leakage incidents pose significant risks to human safety, property, and industrial environments due to the possibility of explosions, toxic exposure, and fire hazards. Traditional gas detection methods rely on manual monitoring and standalone alarms, which lack remote alerting capabilities and real-time environmental monitoring. With the advancement of Internet of Things (IoT) technologies, intelligent gas detection systems can be developed to provide continuous monitoring, automated alerts, and remote supervision.

This paper proposes a Gas Leakage Detection System using IoT, an intelligent embedded monitoring solution designed to detect hazardous gas concentrations and environmental variations while providing instant user notifications. The system integrates ESP32 as the core IoT controller, MQ-2 and MQ-135 gas sensors for detecting combustible and harmful gases, a DHT11 sensor for temperature and humidity monitoring, and SIM800L GSM module for SMS-based alert communication. Power management is handled using dual 3.7 V batteries and LM2596 voltage regulator to ensure stable system operation.

The proposed system continuously monitors gas concentration levels and environmental parameters. When abnormal conditions are detected, the ESP32 triggers local alerts and transmits SMS notifications to predefined users, enabling rapid response. Experimental implementation demonstrates improved safety monitoring, real-time alerting capability, energy-efficient operation, and cost-effective deployment. The proposed IoT-based Gas Leakage Detection System provides a reliable and scalable solution suitable for residential, industrial, and commercial safety applications.

**Keywords:** Gas Leakage Detection, IoT Safety System, ESP32, MQ-2 Sensor, MQ-135 Sensor, DHT11, SIM800L GSM, Embedded Monitoring, Hazard Detection, Smart Safety System.

## **I. INTRODUCTION**

Gas leakage represents a critical safety concern in residential homes, commercial buildings, and industrial facilities where combustible or toxic gases are stored and utilized. Undetected gas leaks can result in severe accidents including fire outbreaks, explosions, and harmful inhalation, leading to loss of life and property damage. Conventional gas detection systems typically operate as standalone alarm units without remote notification or environmental monitoring features.

Recent developments in IoT and embedded systems enable the design of intelligent monitoring solutions capable of real-time sensing, automated decision-making, and remote alert communication. Microcontroller platforms such as ESP32 provide integrated Wi-Fi capability, low power consumption, and sufficient processing capacity for multi-sensor integration. Gas sensors like MQ-2 and MQ-135 allow detection of combustible gases, smoke, and harmful air pollutants, while environmental sensors such as DHT11 contribute contextual information about ambient conditions.

To address the limitations of traditional detection systems, this research proposes a Gas Leakage Detection System using IoT that integrates multi-sensor monitoring, GSM-based alerting, and embedded decision logic. The system continuously evaluates gas concentration levels and triggers alerts when thresholds are exceeded, thereby improving safety awareness and enabling rapid intervention.

## **II. LITERATURE SURVEY**

### **2.1 Conventional Gas Detection Systems**

Traditional gas detection systems primarily consist of gas sensors connected to local alarms. While effective for immediate awareness, these systems lack remote monitoring capability, environmental context analysis, and intelligent notification mechanisms.

2.2 IoT-Based Safety Monitoring Systems

IoT-enabled monitoring systems incorporate network connectivity and embedded processing to provide real-time data collection and remote alerting. Studies indicate that IoT safety systems improve situational awareness and response efficiency compared to isolated detection devices.

2.3 Multi-Sensor Environmental Monitoring

Research highlights the effectiveness of integrating multiple sensors for comprehensive hazard detection. Combining gas sensors with environmental sensors enhances reliability and reduces false alarms by providing contextual environmental data.

2.4 Research Gap and Motivation

Existing gas detection solutions either focus on single-sensor detection or lack remote communication capability. Few systems integrate multi-gas detection, environmental monitoring, GSM alerting, and portable power management into a unified embedded platform. This motivates the development of the proposed IoT-based Gas Leakage Detection System.

III SYSTEM ARCHITECTURE

The system architecture follows an embedded IoT monitoring model comprising sensing, processing, communication, and alert layers. Gas and environmental sensors provide real-time data to the ESP32 controller, which performs threshold evaluation and triggers local alerts and SMS notifications via SIM800L module.

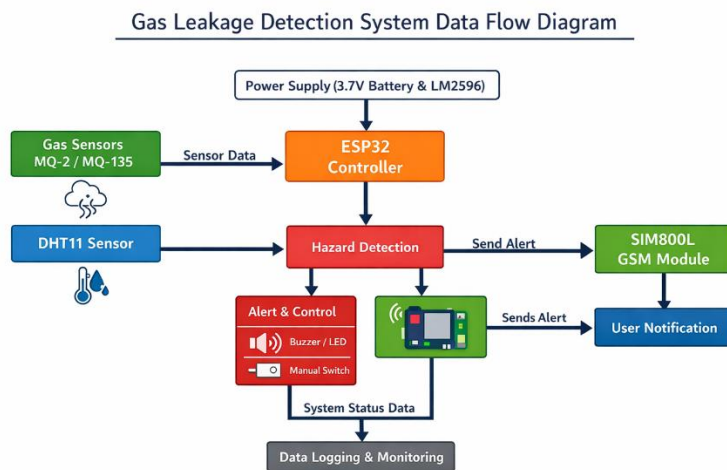


Fig 3.1 System Architecture

3.2 Modules of the Proposed System

| Module               | Technologies Used   | Description  |
|----------------------|---------------------|--|
| Sensing Module       | MQ-2, MQ-135, DHT11 | Detects gas concentration and environmental parameters |
| Processing Module    | ESP32               | Performs data processing and decision making           |
| Communication Module | SIM800L GSM         | Sends SMS alerts to users                              |
| Power Module         | Battery + LM2596    | Provides regulated power supply                        |
| Alert Module         | Buzzer/LED          | Local warning indication                               |
| Control Module       | Switch              | Enables manual system control                          |

Table 3.2.1 Module

### 3.3 Key Features

| Feature                  | Technology Used  | Description                           |
|--------------------------|------------------|---------------------------------------|
| Multi-Gas Detection      | MQ-2, MQ-135     | Detects combustible and harmful gases |
| Environmental Monitoring | DHT11            | Measures temperature and humidity     |
| Real-time Alert          | SIM800L          | Sends SMS notifications               |
| Embedded Processing      | ESP32            | Intelligent threshold evaluation      |
| Portable Power           | Li-ion Batteries | Mobile deployment capability          |
| Stable Voltage           | LM2596           | Ensures safe module operation         |

Table 3.3.1 Key Features

### 3.4 Workflow

The system continuously reads sensor data through ESP32. When gas levels exceed predefined thresholds, the controller activates local alerts and sends SMS notifications. Environmental parameters are simultaneously monitored to support contextual analysis.

Workflow Diagram – Gas Leakage Detection System using IoT

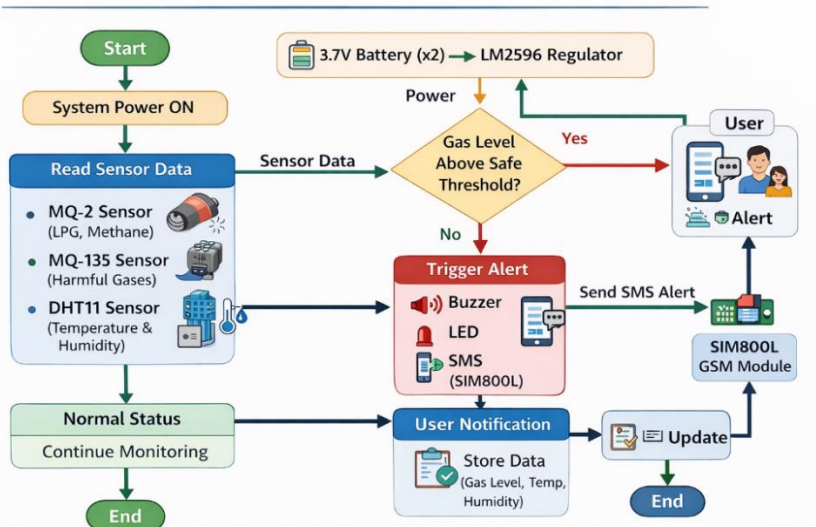


Fig 3.4.1 Workflow

| Process Stage        | Description                        |
|----------------------|------------------------------------|
| System Power ON      | Battery and regulator supply power |
| Sensor Monitoring    | ESP32 reads sensor values          |
| Threshold Evaluation | Gas levels compared with limits    |
| Alert Trigger        | Local buzzer/LED activated         |
| SMS Notification     | User receives warning message      |

Table 3.4.2 Workflow Stages

IV. DATA FLOW DIAGRAM

The data flow begins with sensor data acquisition followed by processing in ESP32. Decision logic determines hazard conditions and triggers alert and communication modules while maintaining system monitoring continuity.

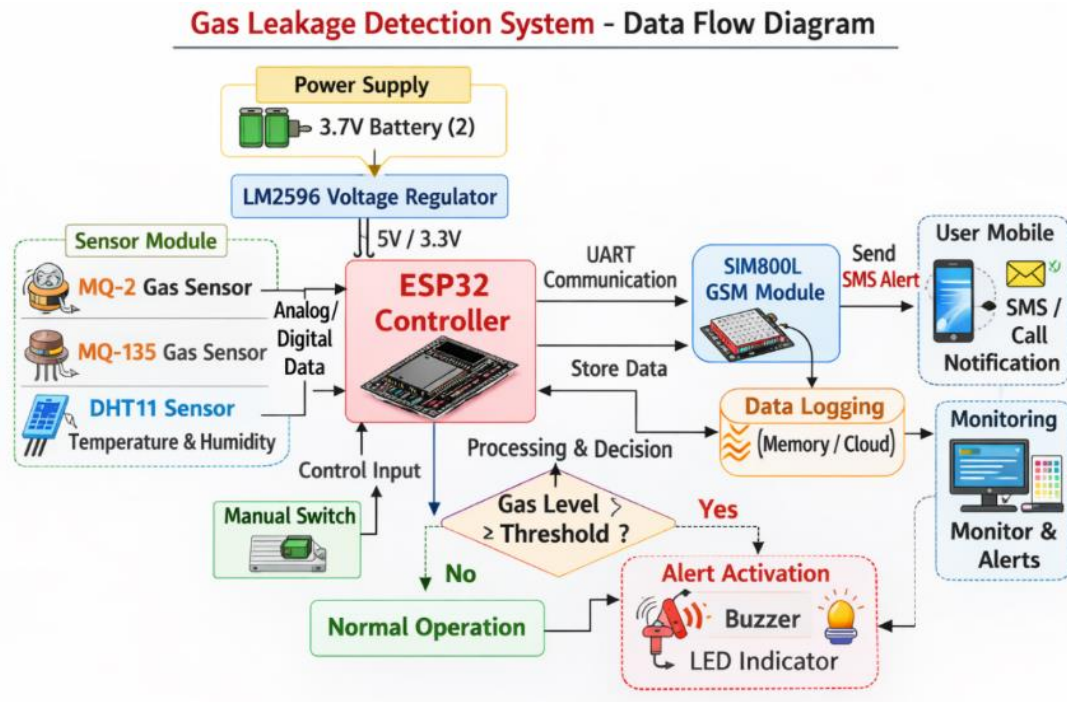


Fig 4.1 Data Flow Diagram

V. METHODOLOGY

The proposed Gas Leakage Detection System using IoT follows an embedded layered methodology integrating multi-sensor monitoring, real-time data processing, hazard evaluation, local alert generation, and GSM-based remote notification mechanisms. The methodology ensures continuous environmental surveillance, reliable gas leak detection, rapid user alerting, and efficient system operation through coordinated interaction between sensing, processing, communication, and power management modules.

**Step 1: Power Initialization through Battery and Regulator**

The system begins operation by receiving power from dual 3.7 V lithium-ion batteries. The LM2596 voltage regulator stabilizes and converts the battery voltage into suitable operating levels required by ESP32, sensors, and communication modules. This regulated power supply ensures reliable system performance and protects components from voltage fluctuations.

**Step 2: Continuous Sensor Data Acquisition**

Gas sensors MQ-2 and MQ-135 continuously monitor the surrounding environment for combustible and harmful gas concentrations, while the DHT11 sensor measures ambient temperature and humidity. The ESP32 microcontroller periodically collects analog and digital sensor readings, enabling real-time environmental awareness and data processing.

**Step 3: Embedded Threshold-Based Hazard Evaluation**

The ESP32 controller performs embedded decision-making by comparing acquired sensor readings with predefined safety thresholds. This threshold-based evaluation mechanism allows the system to determine whether gas concentration levels represent normal environmental conditions or potential hazard situations requiring intervention.

**Step 4: Local Alert Activation upon Detection**

When sensor readings exceed safe limits, the ESP32 immediately activates local alert mechanisms such as buzzer and

LED indicators. These alerts provide instant on-site notification, enabling occupants or personnel to recognize hazardous conditions and initiate safety measures without delay.

**Step 5: GSM-Based Remote Notification**

Simultaneously, the SIM800L GSM module is triggered to transmit SMS notifications to predefined mobile numbers. This remote alert capability ensures that users receive real-time hazard information even when away from the monitored environment, thereby enhancing safety responsiveness and situational awareness.

| Module        | Technology          | Function           |
|---------------|---------------------|--------------------|
| Sensing       | MQ-2, MQ-135, DHT11 | Data acquisition   |
| Processing    | ESP32               | Decision logic     |
| Communication | SIM800L             | Alert transmission |
| Power         | Battery + LM2596    | System powering    |
| Alert         | Buzzer/LED          | Local warning      |

**Table 5.1 Module Description**

**VI. IMPLEMENTATION**

The system is implemented using ESP32 as the central controller interfacing with gas sensors, environmental sensors, and GSM module. Analog sensor signals are processed through ESP32 ADC channels, while digital communication with SIM800L enables SMS transmission. Voltage regulation using LM2596 ensures stable module operation, and dual batteries support portable deployment. The prototype demonstrates reliable gas detection and prompt alert generation.

| Module        | Technology Used     | Purpose         |
|---------------|---------------------|-----------------|
| Controller    | ESP32               | Data processing |
| Sensors       | MQ-2, MQ-135, DHT11 | Monitoring      |
| Communication | SIM800L             | SMS alert       |
| Power         | Battery + LM2596    | Regulation      |

**Table 6.1 Implementation**

**VII. BENEFITS AND CHALLENGES**

**7.1 Benefits**

The proposed Gas Leakage Detection System using IoT significantly enhances environmental safety and hazard awareness by integrating multi-gas sensing, embedded processing, real-time alert mechanisms, and GSM-based remote notification capabilities. The system ensures continuous monitoring of hazardous gases, enables rapid response through local and remote alerts, and improves overall safety management in residential and industrial environments. The integration of portable power supply and voltage regulation further supports reliable and flexible deployment. Additionally, automated detection and notification reduce dependence on manual supervision while improving situational awareness and accident prevention.

| <b>Benefit</b>             | <b>Description</b>   |
|----------------------------|--|
| Early Hazard Detection     | Multi-gas sensors enable timely identification of leakage conditions |
| Real-Time Alerting         | Immediate buzzer and LED activation provides local awareness         |
| Remote Notification        | GSM module sends SMS alerts for off-site monitoring                  |
| Multi-Parameter Monitoring | Simultaneous gas, temperature, and humidity sensing                  |
| Improved Safety            | Reduces risk of fire, explosion, and toxic exposure                  |
| Portable Deployment        | Battery-powered design supports mobile installation                  |
| Stable Operation           | LM2596 regulator ensures consistent voltage supply                   |
| Cost-Effective Solution    | Uses affordable embedded and sensing components                      |
| Reduced Human Intervention | Automated detection minimizes manual monitoring                      |
| Scalability                | System architecture allows integration of additional sensors         |

**Table 7.1.1 Benefits of the Proposed System**

**7.2 Challenges**

Despite its advantages, the proposed Gas Leakage Detection System encounters certain challenges related to sensor accuracy, communication reliability, power management, and environmental variability. Ensuring proper calibration of gas sensors and maintaining reliable GSM connectivity are important for accurate detection and timely notification. Battery life optimization and protection against false alarms caused by environmental fluctuations are additional considerations that influence system performance and operational reliability.

| <b>Challenge</b>          | <b>Description</b>                                    |
|---------------------------|---|
| Sensor Calibration        | Gas sensors require periodic calibration for accuracy |
| False Alarms              | Environmental factors may influence sensor readings   |
| GSM Signal Dependency     | SMS alerts depend on network availability             |
| Power Management          | Battery life optimization is required                 |
| Environmental Variability | Temperature and humidity affect sensor behavior       |
| Hardware Maintenance      | Sensors and modules require periodic servicing        |
| Installation Constraints  | Proper placement is necessary for effective detection |
| System Reliability        | Component failure may impact monitoring continuity    |
| Response Delay            | GSM transmission may introduce notification delay     |
| Scalability Complexity    | Adding sensors increases system integration effort    |

**Table 7.2.1 Challenges of the Proposed System**

**VIII. DISCUSSION AND FUTURE WORK****Discussion:**

The proposed Gas Leakage Detection System using IoT effectively integrates multi-sensor environmental monitoring, embedded processing, and GSM-based communication to address critical safety challenges associated with gas leakage incidents. By employing MQ-2 and MQ-135 gas sensors alongside DHT11 environmental sensing, the system enables comprehensive monitoring of hazardous conditions while providing contextual environmental awareness. The ESP32 microcontroller serves as an efficient processing unit, facilitating real-time data acquisition, threshold-based hazard evaluation, and coordinated activation of alert mechanisms.

The implementation of local alert components such as buzzer and LED indicators ensures immediate on-site awareness, allowing occupants to respond promptly to potential hazards. Simultaneously, the incorporation of SIM800L GSM communication enhances system reliability by enabling remote notification through SMS alerts, thereby improving situational awareness even when users are away from the monitored environment. The battery-powered architecture supported by LM2596 voltage regulation contributes to system portability and operational stability, making the solution suitable for residential, commercial, and small-scale industrial deployments.

Experimental observations indicate that the proposed system provides timely gas leak detection, reliable alert delivery, and cost-effective implementation compared to conventional standalone detection systems. However, factors such as sensor calibration requirements, GSM network dependency, and environmental variability may influence detection accuracy and notification latency. Despite these limitations, the overall system demonstrates strong potential as a practical IoT-based safety monitoring solution capable of enhancing accident prevention and environmental awareness.

**Future Work:**

Future enhancements of the proposed Gas Leakage Detection System aim to improve system intelligence, connectivity, and scalability. Integration of cloud-based IoT platforms can enable real-time data visualization, historical analysis, and remote monitoring through web dashboards and mobile applications. The incorporation of Wi-Fi-based communication alongside GSM functionality may provide redundant communication pathways and improve notification reliability.

Advanced machine learning techniques can be explored to implement anomaly detection models capable of distinguishing between normal environmental variations and hazardous gas leakage patterns, thereby reducing false alarms. Additional sensor integration, including flame sensors, carbon monoxide detectors, and air quality sensors, can further extend system capability for comprehensive safety monitoring in industrial environments. Energy-efficient power management strategies and solar charging mechanisms may also be investigated to support long-term autonomous deployment.

Furthermore, development of multilingual user interfaces, smart home automation integration, and predictive maintenance analytics can enhance usability and system adoption. These future directions position the proposed system as a scalable foundation for next-generation intelligent environmental safety monitoring solutions.

**IX. CONCLUSION**

The IoT-based Gas Leakage Detection System provides an effective and reliable solution for real-time hazard monitoring and alerting. The integration of ESP32, multi-gas sensors, GSM communication, and portable power management ensures improved safety awareness and rapid response capability. The system demonstrates strong potential for practical deployment across residential and industrial safety scenarios.

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