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IoT-driven smart solutions for LPG leak detection and safety management

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Abstract

The increasing use of Liquefied Petroleum Gas (LPG) in India has raised safety and efficiency concerns, leading to the development of an IoT-enabled Automatic LPG Gas Leakage Detection and Regulator Control System. This system integrates a Node-MCU ESP8266 microcontroller with an MQ-6 gas sensor and a load cell for accurate monitoring and leak detection in both household and industrial settings. It features real-time data processing, immediate hazard response, and an automatic shut-off mechanism. With Blynk Edgent Cloud services, users can remotely monitor and control the system via a mobile app, ensuring continuous safety. The research shows high accuracy and cost-effectiveness, making it suitable for widespread deployment. The paper discusses testing results and socio-economic implications, emphasizing its potential to reduce accidents, save lives, and promote efficient energy use, aligning with smart city initiatives for urban safety and sustainable development.

Subject Classification: *68M11, 68U35, 94C12.*

Keywords: *Internet of things (IoT), Liquefied petroleum gas (LPG), Gas leakage detection, Smart safety systems, Cloud computing, Node-mcu esp8266, mq-6 gas sensor, Load cell technology, Blynk edgent.*

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1. Introduction

Liquefied Petroleum Gas (LPG) has emerged as a crucial clean fuel source in India, serving diverse applications across household and industrial sectors. Its widespread adoption, however, has brought to light significant challenges that users face daily. Chief among these is the difficulty in accurately determining the remaining gas level in cylinders, often resulting in unexpected depletion and subsequent inconvenience due to the inability to replace cylinders promptly.

The increasing demand for LPG in recent years has coincided with a troubling uptick in accidents associated with its use. These incidents, primarily attributed to cylinder explosions and undetected gas leaks, underscore the urgent need for enhanced safety measures and monitoring systems. The lack of real-time information on gas levels and potential leaks poses a substantial risk to users and their surroundings.

To address these critical issues, our research proposes an innovative solution that harnesses the power of Internet of Things (IoT) technology and cloud computing. By utilizing Blynk Edgent Cloud services, we have developed a sophisticated system capable of accurate gas level measurement and rapid leak detection.

Our project integrates advanced sensors with GSM connectivity, enabling real-time data transmission to a mobile app. Users can remotely monitor LPG usage, receive alerts, and take timely safety actions. At its core is an IoT-enabled Automatic LPG Gas Leakage Detection and Regulator Control System. Unlike traditional single-sensor setups, our

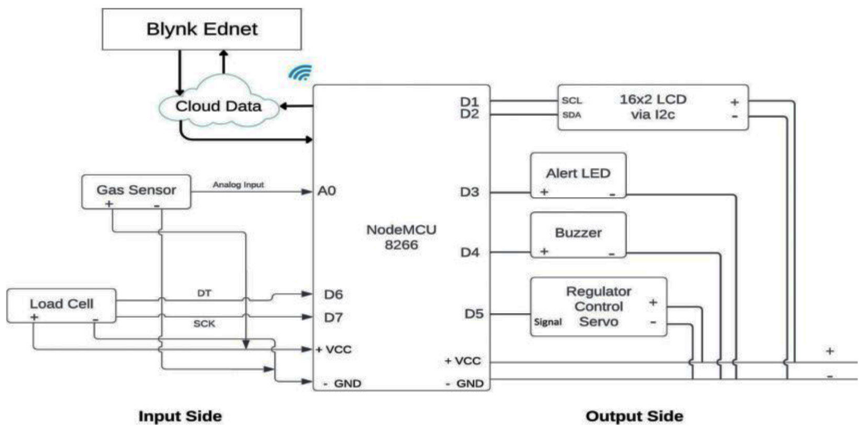

Figure 1

Block diagram

dual MQ-6 sensor design detects both minor and major leaks and identifies whether the source is the cylinder or the stove. The system includes an automatic shut-off mechanism to halt gas supply during hazardous leaks, preventing accidents.

With cloud-based alerts and user-friendly design, our solution redefines household LPG safety. It promotes efficient, secure gas usage and supports India's vision of smart, safe, and connected urban living. The overall architecture of the proposed system, including sensors, controller, and cloud connectivity, is illustrated in Figure 1.

2. Literature Review

Hasibuan, Syafriwel, and Idris [1] developed an intelligent LPG gas leak detection system that employed an MQ-series gas sensor and a GSM module to send SMS alerts to users when gas concentration exceeded the safe threshold. While this design proved effective for timely notification, it lacked automation in response—no hardware mechanism was included to stop the gas flow automatically. Keshamoni and Hemanth [2] advanced this concept by integrating an IoT-based gas monitoring and automatic booking system using Arduino and Wi-Fi connectivity. Their model allowed remote gas level monitoring and refill management through a mobile interface but still operated on a single-sensor threshold and offered no physical safety intervention in case of leakage.

Evalina and Azis [3] introduced a microcontroller-based gas leakage detection system using ATMega8, capable of detecting hazardous gases through voltage variation in the MQ sensor circuit. Although this system provided quick detection and local alarm generation, it lacked internet connectivity and cloud data logging, limiting its real-time usability. Malbog et al. [4] proposed a rule-based LPG leakage and flame detection system equipped with an SMS alert mechanism and a local siren. This dual-function setup improved early hazard detection but relied heavily on GSM communication and offered no cloud integration or automatic regulator shut-off.

Suryana et al. [5] explored a different dimension of household gas safety by employing pressure sensors along LPG distribution pipelines to detect the exact position of leaks using the continuity equation. Their work enhanced localization accuracy but introduced hardware complexity unsuitable for domestic use. Similarly, Tio and Santiputri [6] designed an IoT-based gas leakage detection device capable of transmitting leak information through cloud services. However, the study focused primarily on data transmission, neglecting mechanical response systems necessary to mitigate leakage incidents effectively.

Verma et al. [7] examined automation in the thermal power sector through IoT and sensor integration, while Gupta et al. [8] proposed an energy-efficient fog–cloud architecture for healthcare applications. Both studies demonstrated the reliability of IoT-cloud connectivity in managing real-time data for safety-critical systems, though their applications were outside the LPG domain. Together, these works establish a solid foundation for IoT-based monitoring but reveal consistent gaps such as the absence of dual-level sensing, automated cut-off control, and mobile-based real-time alerts.

To overcome these limitations, the proposed IoT-driven LPG leakage detection and safety management system employs dual MQ-6 sensors configured at 200 PPM and 950 PPM thresholds to distinguish between minor and major leaks. It integrates a servo motor for automatic gas shut-off and Blynk Edgent Cloud for remote monitoring and instant mobile alerts. This unified architecture transforms conventional leak detectors into a proactive safety solution that not only detects but also responds, ensuring enhanced security, affordability, and accessibility for domestic users.

3. Limitations of Existing Systems and Our Proposed Solution

Conventional gas detection systems often lack comprehensive safety features. Most depend on a single sensor with limited detection capacity and no intelligent response. They also provide minimal real-time alerts or remote monitoring, leaving users vulnerable. The comparative analysis of existing systems and the proposed model is summarized in Table 1.

- **Basic Detection Only**: Fixed-threshold sensors cannot distinguish between minor and major leaks, often resulting in delayed or false alarms.
- **No Automation or Remote Access**: Absence of automatic shut-off and cloud integration restricts timely responses and user control during emergencies.

Our system introduces a smart, responsive, and modular approach to LPG safety. It enhances accuracy, automates emergency response, and empowers users with real-time mobile alerts and monitoring—all while remaining affordable and adaptable [9].

- **Intelligent Dual-Sensor Detection**: Uses multiple MQ-6 sensors set at 200 and 950 PPM to detect and classify leaks accurately based on severity and location [10].
- **Cloud Integration with Auto Shut-off**: Blynk Edgent Cloud enables remote monitoring, while a servo mechanism cuts off gas supply automatically during major leaks.

Table 1

Existing Gas Leakage Detection Systems vs. Proposed System

Feature	Traditional Gas Detectors	IoT-Based Leak Detection (Existing)	Proposed System
Gas Sensors Used	General detection (no intensity differentiation)	Single threshold detection	Dual-threshold detection (200 PPM for minor, 950 PPM for major leaks)
Leak Detection Levels	No	No	Yes
Gas Level Monitoring	No	Yes, in some devices (mostly commercial)	Yes, real-time LPG weight tracking and alerts for <5% of 30kg
Source Identification	No	Limited (manual intervention required)	Yes (automatic shut-off on major leaks)
Real-Time Alerts	No	Yes	Yes (via mobile app, instant notifications)
Cloud Integration & User Customization	No	Yes	Yes

4. Module Description

The proposed Automatic LPG Gas Leakage Detection and Turn-off System integrates key modules for safety, gas level monitoring, and real-time data access. These modules work together to detect hazards, track consumption, and promptly alert users.

4.1 *Gas Leakage Detection Module:*

This module uses a NodeMCU ESP8266, MQ-6 gas sensor, and a buzzer to detect LPG leaks. The sensor alters its voltage output based on gas concentration, which the NodeMCU processes to trigger an alarm and automatically shut off the gas valve—minimizing fire or explosion risks[11]. The MQ-6 gas sensor used for leak detection and signal processing is shown in Figure 2.

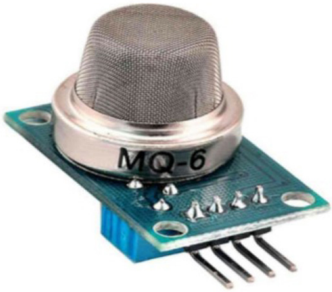

Figure 2

MQ-6 Gas Sensor

4.2 *Gas Level Monitoring Module*

This module uses a load cell with NodeMCU ESP8266 to monitor LPG cylinder weight in real time. When it falls below 5%, the system alerts the user via the mobile app. It auto-recalibrates upon placing a new cylinder for continued accurate tracking. The configuration of the load cell and the HX711 amplifier used for gas level measurement is illustrated in Figure 3.

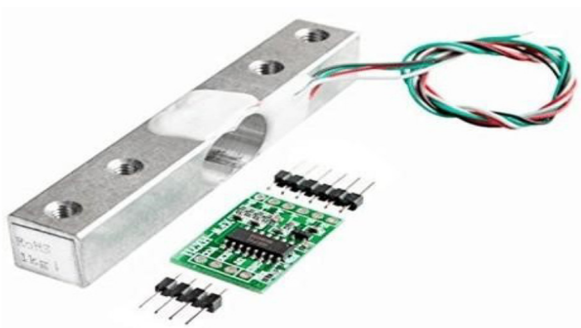

Figure 3

Load Cell and HX711 Amplifier

4.3 *Cloud Integration Module:*

This module uses Blynk Edgent Cloud to store real-time data from gas leakage and level sensors. The NodeMCU sends this data to the cloud, enabling remote monitoring and instant leak alerts via a mobile app for improved safety and convenience [12]. The connection and data flow between the IoT device and the Blynk Edgent Cloud are represented in Figure 4.

Figure 4

Blynk Edgent

5. Methodology

5.1 *System Flow*

The system combines NodeMCU ESP8266, MQ-6 gas sensor, load cell, and servo motor with Blynk Edgent Cloud for real-time data access

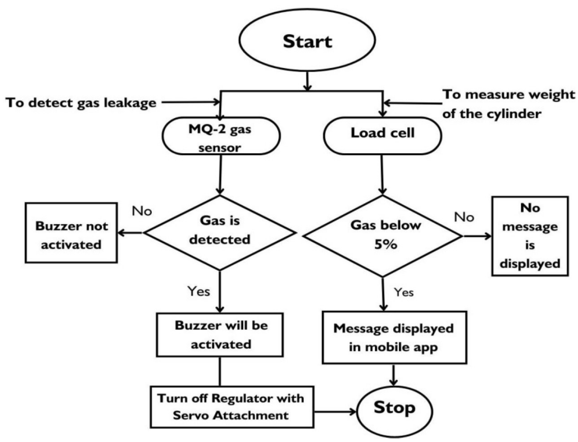

Figure 5

Flowchart

and remote alerts. The MQ-6 monitors gas leaks, while the load cell tracks cylinder weight. Each module works independently yet communicates effectively to detect hazards, shut off gas supply, and notify users via mobile, ensuring enhanced safety and convenience. The following steps detail its hardware, cloud integration, and decision-making process. The working principle and decision-making process of the proposed system are outlined in Figure 5.

The system performs two main functions: detecting gas leaks and monitoring LPG cylinder levels. Here's a concise overview of its operation:

1. **System Initialization**: On startup, the system begins monitoring for gas leaks and gas levels simultaneously.
2. **Gas Leakage Detection**: The MQ-6 sensors continuously scan for LPG leaks. If no leak is found, the system stays idle and silent. If a leak is detected:
   a) The buzzer sounds to alert nearby users.
   b) The servo motor shuts off the gas regulator to prevent accidents.

   Using multiple MQ-6 sensors calibrated at different PPM levels, the system detects both minor and major leaks—whether at the cylinder, nozzle, regulator, stove, or pipes. Sensor configurations are detailed in Table 2.

Table 2

Sensor Configuration for Leakage Detection

Sensor PPM Level	Detection Purpose	Common Use Cases
200 PPM	Minor Leakage Detection	Small leaks near the nozzle, regulator, or gas cylinder; Checking for leaks during delivery
950 PPM	Major Leakage Detection	Large leaks near the stove, gas pipes, or significant gas buildup in the kitchen

3. **Gas Level Monitoring:** The Load Cell continuously measures the weight of the LPG cylinder to determine its gas level. If the weight is above 5% of the cylinder's capacity, no message is sent to the user. If the weight of the cylinder falls below 5%, the system recognizes the need for refilling or replacing the cylinder. A message is displayed on the mobile app, notifying the user to take action.

4. The system concludes its operation after performing the necessary actions based on the sensor inputs:
   a) Either the gas leakage has been mitigated by turning off the regulator.
   b) Or the user has been notified to refill the gas cylinder.

Once the appropriate action is completed, the system stops or resets to continue monitoring.

5.2 *Prototype Implementation and Hardware Setup*

5.2.1 Full Prototype Setup Image:

To validate the proposed LPG leakage detection and shut-off system, a prototype was developed using MQ-6 gas sensors, a servo motor for automatic gas regulation, and a digital display for status updates. This setup enables real-time leak detection, LPG level monitoring, and immediate safety responses. The images below showcase the complete hardware prototype, including internal wiring, circuit connections, microcontroller integration, sensor placements, LCD display, automatic shut-off mechanism, and the weighing scale. The complete hardware prototype developed for experimental testing is displayed in Figure 6.

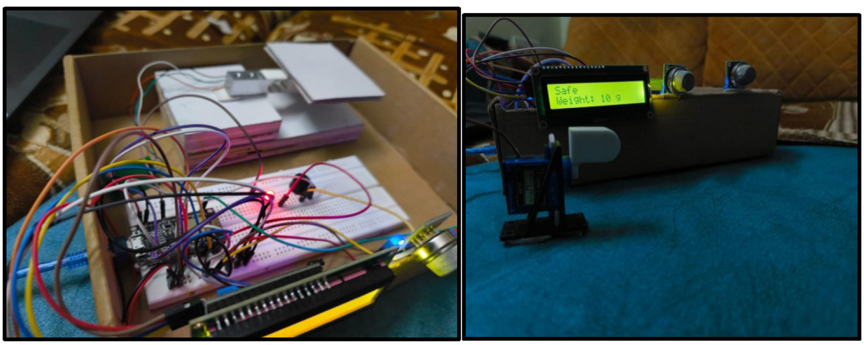

Figure 6

Prototype Image

5.2.2 MQ-6 Sensor Placement Illustration and Shut-Off Mechanism:

The system uses two MQ-6 sensors near the cylinder and stove to detect minor (200 PPM) and major (950 PPM) leaks. Data is sent to the IoT control unit, which triggers alerts and activates a servo motor with a

3D-printed knob to shut off the gas. This low-cost design is household-friendly and can be upgraded to electromechanical valves for better performance.

The sensor placement near the cylinder and stove, as well as the servo-based shut-off mechanism, are illustrated in Figure 7 and Figure 8, respectively.

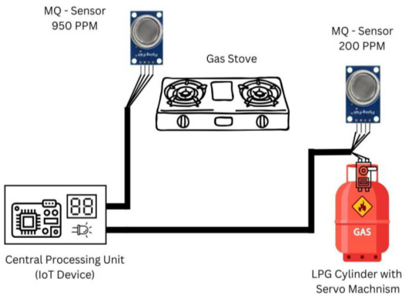

Figure 7

MQ - Sensors Placement Illustration

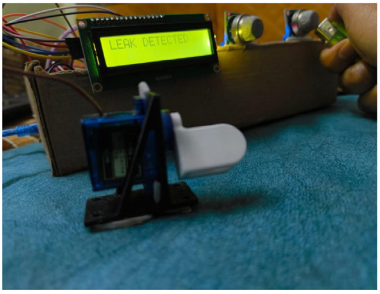

Figure 8

3D printed knob with servo motor

5.2.3 Blynk Edgent Cloud Monitoring:

The system integrates Blynk Edgent Cloud for real-time monitoring and remote control. This platform enables users to track gas leakage levels, receive instant alerts, and activate the shut-off mechanism from their smartphones. The cloud connectivity ensures that users remain informed

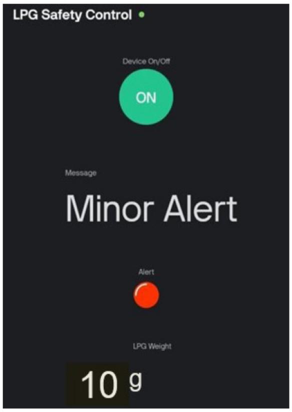

Figure 9

Blynk Edgent Android Interface

about potential hazards even when they are away from home. The user interface for mobile monitoring and alert control on the Blynk Edgent Android application is shown in Figure 9.

6. Results and Future Scope

6.1 *System Performance Analysis*

We tested the prototype under various simulated gas leak scenarios, monitoring the system's response to different PPM levels. The system successfully identified both minor and major leaks, activated the shut-off mechanism, and sent alerts via the mobile app. Results are summarized below in Table 3:

Table 3
Leakage Detection Trials

Trial No.	Simulated Leak Source	Detected PPM Level	Sensor Triggered	**Shut-Off Activated**	**Alert Sent to User**
1	Gas regulator nozzle	210	Minor Leak Sensor (200 PPM)	No	Yes
2	Gas cylinder valve	980	Major Leak Sensor (950 PPM)	Yes	Yes
3	Gas pipe joint	970	Major Leak Sensor (950 PPM)	Yes	Yes
4	Delivery inspection	190	No Detection	No	No
5	Stove connection pipe	960	Major Leak Sensor (950 PPM)	Yes	Yes
6	Slight leak near regulator	220	Minor Leak Sensor (200 PPM)	No	Yes
7	Kitchen air accumulation	1000	Major Leak Sensor (950 PPM)	Yes	Yes

6.2 *Future Scope*

To enhance system intelligence and expand its applications, the following improvements are envisioned:

- **Coriolis Flow Meter Integration**: Enables accurate real-time mass flow monitoring, especially for piped gas networks like MNGL. It helps detect abnormal usage, optimize consumption, and enhance safety.

- **AI-Powered Predictive Alerts**: Machine learning can analyze sensor trends and environmental data to predict potential leaks before they occur, triggering automated responses and improving reliability.
- **Gas Agency Notifications & Analytics**: A production-ready model can notify nearby gas agencies in case of major leaks and generate usage reports through a user-friendly dashboard for better management.

7. Advantages and Socio-Economic Impact

The IoT-enabled Automatic LPG Gas Leakage Detection and Regulator Control System not only enhances household safety but also contributes to broader socio-economic development. By integrating real-time monitoring, automatic shut-off features, and cloud connectivity, the system addresses critical safety concerns while remaining cost-effective and scalable. Its widespread adoption can lead to improved public safety infrastructure, economic opportunities, and increased accessibility for all.

- **Enhanced Safety**: Real-time gas leak detection, instant alerts, and automatic shut-off reduce the risk of fire or explosions.
- **Affordable Design**: Built using low-cost components to ensure accessibility across all income groups.
- **Community Collaboration and Job Creation**: Promotes partnerships with local authorities and service providers for installation, maintenance, and compliance, while also generating employment opportunities in manufacturing, implementation, and support services.

8. Conclusion

Gas safety continues to be a pressing concern, with conventional detection systems often falling short due to their reliance on single sensors, fixed thresholds, and the absence of automated safety responses. These limitations hinder their effectiveness in distinguishing between minor and major leaks and leave users vulnerable to delayed intervention and potential hazards.

Our proposed IoT-enabled LPG Gas Leakage Detection and Regulator Control System overcomes these gaps through a multi-sensor, dual-threshold approach. By deploying MQ-6 sensors at 200 PPM and 950 PPM, the system offers precise leak detection and source identification—distinguishing whether the leak originates from the cylinder or the stove. The inclusion of an automatic shut-off mechanism and cloud-based real-time alerts via Blynk Edgent ensures rapid, remote response, enhancing both user safety and convenience.

Validated through successful prototype trials, the system proved effective in detecting varying leak levels, initiating alerts, and executing shut-off actions promptly. With its scalable and adaptable design, it is suitable for homes, restaurants, and industrial kitchens. Future developments—such as AI-powered predictive analytics and Coriolis-based gas flow monitoring—promise to further improve its accuracy, intelligence, and applicability across broader safety-critical environments, advancing the vision of smarter and safer energy management.

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