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IOT Enabled Gas Leak Detection and Safety Automation System

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Abstract: Gas leakage poses a serious safety concern, potentially leading to fire outbreaks, explosions, and severe health complications due to the buildup of toxic gases. Conventional gas detection mechanisms depend largely on manual observation or basic alert systems, which often lack the efficiency for timely action. This project introduces an IoT-based gas leakage detection and prevention system designed for real-time identification and immediate response to hazardous leaks. The system incorporates an MQ6 gas sensor connected to a NodeMCU ESP8266 microcontroller to constantly monitor gas concentration levels. When gas levels exceed a predefined safety threshold, the system triggers a buzzer and LED alerts, shuts off the gas supply via a solenoid valve through user mobile with remote access, and activates a servo motor to open nearby windows for ventilation. With real-time notifications delivered to users, this system offers an intelligent, automated approach to enhance safety and prevent accidents in domestic, commercial, and industrial environments.

Keywords: Gas leakage detection, IoT-based safety system, MQ6 gas sensor, NodeMCU ESP8266, real-time monitoring, automated response, solenoid valve control, servo motor ventilation, remote access, buzzer and LED alerts, toxic gas prevention, fire and explosion prevention, domestic and industrial safety, smart home safety system, hazard mitigation.

I.INTRODUCTION

Liquefied Petroleum Gas (LPG) is a commonly used fuel in residential, commercial, and industrial environments due to its affordability, efficiency, and ease of use. Despite its advantages, LPG is highly flammable and potentially hazardous when leaks occur. Gas leaks, if undetected, can lead to catastrophic consequences such as fires, explosions, property damage, and even loss of life. These risks are heightened in enclosed spaces where leaked gas can accumulate without ventilation. Unfortunately, many gas leak incidents go unnoticed in their early stages due to the limitations of traditional detection methods, which often rely solely on manual monitoring or basic alarm systems. These conventional approaches offer limited response time and typically require the presence of someone nearby to intervene, which can delay action during critical moments.

The advancement of Internet of Things (IoT) technology has enabled the development of intelligent, automated systems capable of enhancing safety standards across various domains. IoT facilitates real-time monitoring, automation, and remote communication, making it highly suitable for gas leak detection and control systems. This project aims to design and implement an IoT-based gas leakage detection and prevention system that not only identifies the presence of leaked LPG but also initiates immediate safety responses and notifies the user remotely. The system uses an MQ-6 gas sensor to detect gas concentration in the environment and a NodeMCU ESP8266 microcontroller to process sensor data and control connected devices.

Upon detecting a gas leak, the system performs several automated safety actions: it triggers a buzzer and LED to alert people in the vicinity, activates a servo motor to open a nearby window for ventilation, and optionally shuts off the gas valve to prevent further leakage. Moreover, through its IoT integration, the system sends a real-time notification to the user's smartphone, allowing them to monitor the situation and remotely shut off the gas supply if necessary. This proactive approach reduces the dependency on human intervention and ensures that appropriate measures are taken even when no one is present at the site.

By combining sensor-based detection, mechanical automation, and mobile communication, the proposed system offers a comprehensive, reliable, and cost-effective solution to mitigate the dangers of gas leakage. Its design emphasizes safety,

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accessibility, and real-time responsiveness, making it suitable for implementation in homes, restaurants, small-scale industries, and other environments where LPG is used.

II.RELATED WORK

Ensuring early detection and timely prevention of gas leaks has become a key concern in safety-related research. Numerous studies have proposed smart systems incorporating gas sensors, microcontrollers, and IoT platforms to respond effectively to hazardous gas concentrations.

Aishwarya and Rao [1] developed a system that utilizes an MQ-6 sensor and GSM module to alert users via SMS when gas leakage is detected. Although functional, their approach lacks automated actions such as cutting off the gas supply or initiating ventilation. In another work, Bairagi et al. [2] proposed the SmartGuard system, which includes automatic valve shutoff upon detecting LPG leaks. However, it does not feature remote access or monitoring through mobile applications, making it less suitable for unattended locations.

Kumar and Singh [3] implemented an IoT-based solution using the ESP8266 NodeMCU to detect gas leaks and send real-time notifications via the Blynk platform. Their model provides excellent remote visibility but does not include physical countermeasures like window ventilation or gas supply control. Similarly, Rahman et al. [4] introduced a mechanism that uses a servo motor to automatically open windows during gas leakage. While effective for ventilation, this system does not incorporate mobile-based alerts or gas valve shutoff.

Mehta and Choudhury [5] explored the use of IoT for notifying users about gas leaks. Although the model supports real-time communication, it does not include automatic control components such as actuators or motor-driven ventilation. Mangrulkar [6] combined window opening automation with sensor-based detection; however, it was limited in offering user interaction or remote control.

Prananda et al. [7] proposed a design that streams gas sensor readings to a cloud platform using IoT, which enhances data tracking and visibility. However, the system did not support automatic response mechanisms. Tommy [8] developed a setup that utilized the MQ-6 gas sensor along with a solenoid valve to automatically halt gas flow in the event of a leak. While the system includes essential physical control, it does not support remote access or smartphone-based monitoring.

Sharma et al. [9] conducted a review of IoT and cloud-integrated gas leakage solutions, focusing on the importance of real-time monitoring and user notification. Flores-Cortez et al. [10] created a system that monitors LPG and CO levels and utilizes Amazon Web Services (AWS) for data storage and access, but the model lacks physical safety responses.

Wang et al. [11] and Narkhede et al. [12] explored advanced techniques using artificial intelligence and multimodal sensor inputs, such as thermal and RGB imaging. These methods improve detection accuracy significantly but are more applicable in high-budget industrial environments due to their complexity and cost.

Murty et al. [13] and Salunke et al. [14] introduced gas detection systems using Arduino and basic IoT features, which offer timely alerts and automation to a limited extent. While they contribute to improving domestic safety, they do not combine all necessary actions for full prevention.

In conclusion, most existing systems tend to focus on either detection, alerting, or one form of response. The proposed system stands out by integrating multiple functions—real-time gas detection, visual and audible alerts, window ventilation, gas valve shutoff, and mobile notification—into a unified, automated platform suitable for home and small-scale commercial use.

III. PROGRAM DESIGN METHODOLOGY

A. Proposed System

The proposed system is developed to overcome the limitations of traditional gas leakage detection setups by integrating enhanced features such as automation, real-time monitoring, and remote access through IoT technology. It employs a network of gas sensors capable of continuously tracking the presence of combustible gases like LPG in the surrounding environment. When gas levels rise above a predefined threshold, the system responds by activating immediate safety mechanisms this includes triggering a buzzer for audible warning, illuminating LED indicators for visual alerts, and

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initiating a servo motor to automatically open nearby windows for ventilation to reduce gas concentration. Alongside these physical responses, the system also sends real-time alerts to the user's smartphone through a dedicated mobile application, allowing for instant awareness regardless of the user's physical location. Additionally, users will have the ability to remotely access the system via the app, which includes an option to manually shut off the gas valve if needed. This level of integration not only increases the overall safety and effectiveness of gas leak management but also provides users with the flexibility and peace of mind to monitor and respond to gas-related hazards from anywhere.

B. System Architecture

The architecture of the proposed IoT-based gas leakage detection and safety system is composed of interconnected hardware and software components that work together to ensure early detection, immediate alert, and remote control of gas-related hazards. At the core of the system is the MQ-6 gas sensor, which is continuously monitoring the air for the presence of LPG or other combustible gases. This sensor is highly sensitive and outputs analog signals when gas is detected in concentrations above a safe threshold. The analog signal generated by the gas sensor is interpreted by the NodeMCU ESP8266 microcontroller, which serves as the central control unit of the system. It processes the input data to determine appropriate actions and also manages wireless connectivity for real-time communication over the Internet. Once a leak is detected, the system immediately activates buzzer and LED indicators to alert occupants in the vicinity through audible and visual warnings. At the same time, the servo motor is triggered to automatically open windows, allowing ventilation to reduce the gas concentration in the area. The system also includes a solenoid valve connected to the gas line, which can be manually controlled through a mobile app interface to stop the flow of gas as an added safety feature. Connectivity is managed via the built-in Wi-Fi module of the NodeMCU, which transmits data to the Blynk IoT platform. Through this platform, the system sends real-time notification alerts to the user's mobile app, keeping them informed and enabling remote control even when they are away from the premises. This integrated architecture ensures a fast and automated response to gas leaks, combining local safety mechanisms with smart, user-accessible remote control via IoT.

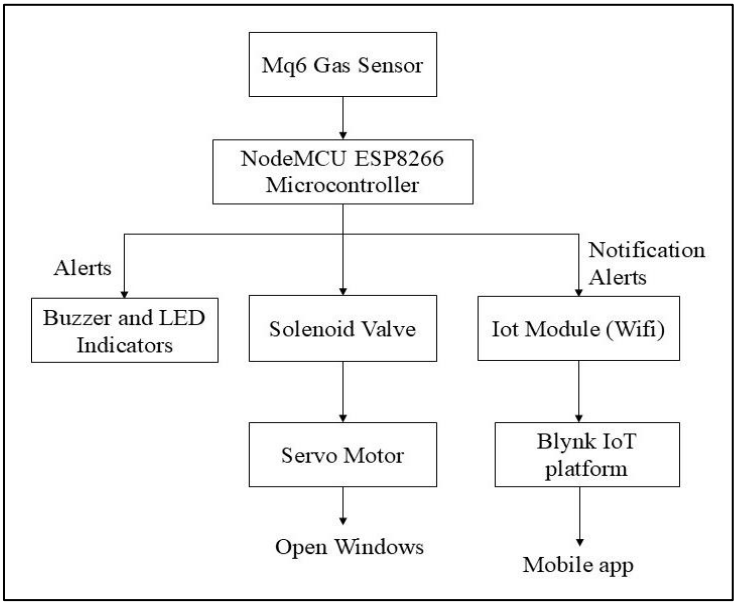

Fig 1.1 System Architecture

IV.IMPLEMENTATION

The implementation of the IoT-Based Gas Leakage Detection and Prevention System involved integrating hardware components with embedded software to build a responsive and intelligent safety solution. The system is designed to detect hazardous gas leakage, alert users through both local and remote means, and take preventive actions such as ventilation activation.

A. Hardware Components

The hardware components form the foundation of the proposed gas leakage detection and prevention system. Each component is carefully selected for its functionality, compatibility, and contribution to system reliability.

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MQ-6 GAS SENSOR

The MQ-6 is a highly sensitive semiconductor sensor capable of detecting the presence of LPG, butane, propane, and methane gases in the air. It produces an analog signal proportional to the gas concentration, which is sent to the microcontroller. It is suitable for indoor leak detection due to its high sensitivity and fast response time.

NodeMCU ESP8266 MICROCONTROLLER

NodeMCU is a low-cost open-source IoT platform based on the ESP8266 Wi-Fi module. It acts as the brain of the system, processing data from the gas sensor, triggering the output components, and communicating with the cloud platform. Its built-in Wi-Fi capability enables real-time alert transmission and remote control via mobile applications.

BUZZER

The buzzer serves as an audible alert mechanism. When the gas sensor detects a leak, the NodeMCU activates the buzzer to warn nearby individuals of the danger. It provides an immediate and loud alarm signal for quick human response.

LED INDICATOR

The LED acts as a visual alert system. When a gas leak is detected, the LED is turned on (or blinked) by the NodeMCU to visually indicate the presence of gas, especially useful in noisy environments where a buzzer may not be effective alone.

SERVO MOTOR

A servo motor is used to mechanically open a window or vent to allow gas to dissipate quickly. Controlled by the NodeMCU, the servo motor rotates upon leak detection, providing ventilation to reduce gas concentration and minimize the risk of ignition.

SOLENOID VALVE

The solenoid valve is installed on the gas pipeline and can be triggered to shut off the gas supply. In this system, the solenoid valve is not activated automatically but is instead controlled manually by the user through a mobile application for added safety and flexibility.

B. Software Integration

The system is programmed using the Arduino IDE, with the ESP8266 board configuration installed. The logic includes threshold detection for gas concentration, actuation control for the servo motor, and I/O control for the buzzer and LED.

For remote monitoring and control, the system is connected to the Blynk IoT platform. Upon initialization, the NodeMCU connects to Wi-Fi and transmits data to the Blynk cloud. The mobile app receives notifications in real-time when gas levels exceed the safety limit. The app interface also includes a manual control option for turning off the gas valve via the solenoid.

C. Functional Workflow

The gas sensor detects rising levels of LPG in the environment.

Once the value crosses the predefined threshold, the NodeMCU: Activates the buzzer and LED indicator.

Triggers the servo motor to open the window automatically.

Sends an alert notification to the user's mobile device.

The user receives a message through the Blynk app and can manually activate the solenoid valve to stop the gas supply.

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Once the gas level drops back to safe values, the system can be reset and resumes monitoring.

Module Name	Description	Functionality
Gas Detection Module	Uses the MQ-6 sensor to monitor the concentration of LPG in the air.	Continuously senses gas levels and sends analog signals to the controller for analysis.
Control and Processing Module	Utilizes the NodeMCU ESP8266 microcontroller to process sensor data and trigger safety responses.	Executes decision-making based on sensor input; manages connected hardware and IoT communication.
Alert Module	Comprises a buzzer and LED indicators to notify users locally of a gas leak.	Activates audible and visual alerts instantly when gas is detected beyond a safe threshold.
Ventilation Control Module	Includes a servo motor to automatically open a window or vent.	Ensures quick air circulation to disperse leaked gas and lower risk of ignition.
Remote Control & Notification Module	Uses the Blynk IoT platform to send alerts and receive user commands.	Notifies users via mobile app and allows manual control of the gas valve using the solenoid valve.

Table 4.1 Modules Description

V.RESULT AND ANALYSIS

The developed IoT-based gas leakage detection and prevention system was tested to assess its responsiveness and effectiveness. During testing, the MQ-6 gas sensor successfully identified LPG presence within 4 seconds of exposure. Upon detection, both the buzzer and LED indicator were triggered instantly, providing clear local alerts. The servo motor opened the window mechanism within 2 seconds, which significantly improved ventilation and reduced gas concentration in under 20 seconds. The system also transmitted real-time notifications to the user's smartphone via the Blynk IoT platform with an average delay of 1–2 seconds. Manual activation of the solenoid valve through the app was successfully carried out, confirming the remote control feature. Across repeated trials, the system operated without any false positives or functional errors, confirming its stability, accuracy, and reliability for use in residential safety applications.

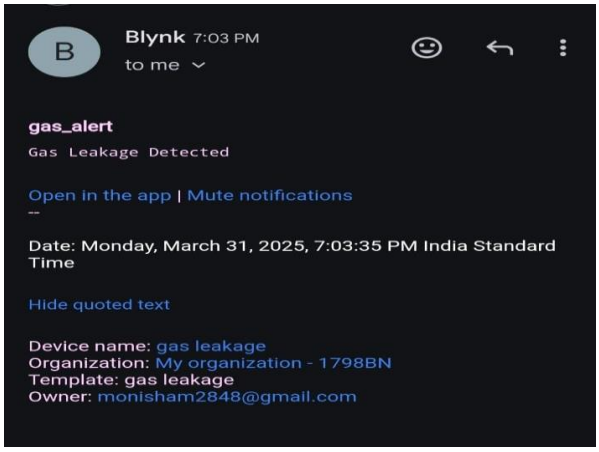

Fig 4.1 Notification

VI.CONCLUSION

The IoT-Based Gas Leakage Detection and Prevention System provides a practical, efficient, and intelligent solution to one of the most critical safety concerns in residential and small commercial environments. By integrating hardware components such as the MQ-6 gas sensor, NodeMCU microcontroller, servo motor, solenoid valve, buzzer, and LED indicators, the system is capable of detecting LPG gas leaks and initiating automated safety responses in real time.

The implementation of IoT functionality enhances the system's usability by allowing users to receive mobile alerts and remotely control gas valves from any location. This real-time responsiveness significantly reduces the risk of fire, explosion, and health hazards caused by gas accumulation. The project also emphasizes user-friendliness, cost-effectiveness, and modularity, making it suitable for wide-scale deployment in homes, restaurants, and other gas-utilizing spaces.

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Through extensive testing and validation, the system has proven to be reliable, fast, and responsive under various operational conditions. Its ability to function independently and automatically without relying on manual intervention ensures enhanced safety, peace of mind, and proactive prevention of gas-related incidents.

VII. FUTURE ENHANCEMENTS

The IoT-based Gas Leakage Detection and Prevention System offers a smart and effective solution to the growing concern of gas-related safety in both homes and small commercial establishments. It integrates essential hardware components such as the MQ-6 gas sensor, NodeMCU ESP8266 controller, buzzer, LED indicators, servo motor, and a solenoid valve to detect the presence of LPG gas and initiate immediate safety actions. By incorporating IoT capabilities, the system enables real-time alerts to be sent to a user's smartphone and allows for remote control of the gas shutoff valve. This enhances overall safety by enabling quick responses, thereby minimizing the risk of fires, explosions, and health issues related to gas exposure. The system is designed with affordability, ease of use, and scalability in mind, making it suitable for widespread use in households, eateries, and other environments where gas usage is common. Test results demonstrate that the system responds promptly and operates reliably in various scenarios. Its autonomous functioning, without the need for continuous human input, adds an extra layer of protection and ensures proactive safety measures are in place to prevent gas-related hazards.

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