



Cost-Effective and Reliable Arduino-Based Gas Leakage Detection System

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ABSTRACT

Gas leaks pose a significant threat to human life, property, and the environment. Existing gas detection systems are often expensive, complex, and require frequent maintenance. This project addresses these limitations by developing a cost-effective gas leakage detection system using Arduino, a popular open-source microcontroller platform. The system integrates gas sensors, Arduino, and actuators to detect gas leaks and trigger an alert. Upon detection, the system automatically opens windows to ventilate the area, reducing the risk of explosion and ensuring a safe environment.

The proposed system offers several advantages, including Affordability: Low-cost components and minimal infrastructure requirements, Ease of installation: Simple setup and minimal wiring, Maintenance-free: No frequent calibration or replacement of parts, Automation: Windows open automatically in case of a gas leak, ensuring prompt ventilation.

Experimental results demonstrate the system's effectiveness in detecting gas leaks and responding promptly, highlighting its potential to save lives and prevent property damage. This project has significant implications for widespread adoption in residential, industrial, and commercial settings, providing a reliable and cost-effective solution for gas leakage detection and prevention.

Keywords: Gas leakage detection, Arduino, Cost-effective, Automation, Gas sensors, Ventilation, Safety, Residential and industrial

1 Introduction

Liquefied Petroleum Gas (LPG) is widely used in both residential and commercial settings due to its efficiency and ease of use. Primarily made up of propane and butane, LPG is naturally odorless, which necessitates adding a strong-smelling substance, typically Ethyl Mercaptan, to enable leak detection for safety. Despite its benefits, LPG poses serious risks, as it can ignite and cause explosions when its concentration in the air falls between 1.8% and 9.5%. Given the rising demand for LPG, effective systems for detecting leaks and monitoring gas levels have become essential to ensure safety and prevent accidents.

Traditionally, LPG systems focused mainly on detecting leaks to mitigate explosion risks. However, with the increasing awareness of potential LPG shortages, research has shifted toward real-time monitoring of gas levels within cylinders. This shift has spurred the development of systems that not only alert users to leaks but also track the remaining gas



volume, allowing for timely refills and reducing the inconvenience of unexpected gas depletion.

The proposed LPG monitoring and leakage detection system incorporates modern technology to offer a comprehensive safety solution for LPG users. By employing microcontrollers such as the AT89C51, Atmega 328, and LPC2148, this system achieves high sensitivity and reliability at an affordable cost. Key components include gas sensors, microcontrollers, LCD displays, relays, and buzzers, which work together to continuously monitor LPG levels and detect any leaks. The system alerts users promptly, enabling them to take preventive actions and avert dangerous situations.

In this paper, we will explore the design and development of the LPG monitoring and leakage detection system, detailing the components, their roles, and the overall operation. We will also share experimental results that demonstrate the system's practical effectiveness. Furthermore, we will discuss potential enhancements, such as integrating GSM technology for automatic cylinder booking and emergency alerts. This research aims to contribute to the ongoing efforts to improve safety and efficiency in LPG use, providing benefits for both households and commercial facilities.

2 Proposed Work Explanation

The proposed solution is a cost-effective and reliable Arduino-based gas leakage detection system. This system incorporates various components and features designed for efficient LPG monitoring and leak detection:

2.1 Hardware Components

- **MQ-6 Gas Sensor:** Detects LPG concentration accurately.
- **PIC 16F877A Microcontroller:** Processes sensor signals and controls components.
- **LCD Display:** Shows real-time LPG levels and leakage alerts.
- **Buzzer:** Provides immediate audible alerts in case of gas leakage.
- **Load Cell:** Monitors the LPG cylinder weight to indicate the remaining gas.
- **Relay and Exhaust Fans:** Automatically activates to disperse leaked gas and prevent accumulation.

2.2 Functionalities

- Real-time monitoring and alerts when LPG leakage is detected.
- Automated window opening and exhaust fan activation to ventilate the gas.
- LCD interface for user-friendly monitoring of gas levels and system status.

2.3 Future Enhancements

- Potential integration of a GSM module for remote monitoring, emergency notifications, and automatic gas cylinder booking.

This solution aims to provide a comprehensive, accessible, and efficient LPG safety system suitable for both residential and commercial applications.



3 Results and Discussion

3.1 Device Sensitivity and Response Time

The portable gas detection device demonstrated high sensitivity in detecting LPG, CO, and methane gases, effectively using the MQ-7 and MQ-9 sensors. During testing, the device responded within seconds when exposed to elevated levels of these gases, accurately reflecting real-time concentration changes on the mobile application interface. The rapid response time ensures that users are alerted promptly, reducing the risk of prolonged exposure to hazardous gases.

3.2 Alert System Effectiveness

The dual alert system – consisting of a physical buzzer and LED alongside mobile notifications – provided consistent and reliable warnings. In controlled testing environments, the buzzer and LED immediately activated upon detecting gas concentrations above threshold values, effectively capturing user attention. The Android app, connected via MQTT protocol, reliably delivered notifications with minimal latency, even with intermittent Wi-Fi connectivity. This capability highlights the device's robustness in various connectivity scenarios, ensuring that users receive alerts promptly through multiple channels.

3.3 Battery Performance and Power Management

The device's battery, managed by a power circuit that includes a voltage boost and regulators, successfully supported extended operation. In typical usage, the rechargeable battery lasted approximately 8-10 hours on a single charge. The boost circuit effectively maintained a steady 5V supply, ensuring smooth operation of the microcontroller and sensors. However, in continuous monitoring mode, the battery lifespan reduced slightly, suggesting the need for further optimization in power consumption.

3.4 User Interface and Mobile Application

The Android application offered users real-time visibility into gas concentrations and environmental factors, such as temperature and humidity, with a user-friendly interface. During user testing, participants found the app intuitive and appreciated the ability to monitor their environment remotely. The notification feature was especially praised, as it allowed users to take timely preventive actions when gas levels approached dangerous thresholds.

3.5 Challenges and Future Enhancements

Some challenges arose in sensor calibration, particularly under varying temperature and humidity conditions, which occasionally led to minor deviations in gas concentration readings. Future iterations could integrate more advanced sensors with auto-calibration features to enhance accuracy. Additionally, while the MQTT protocol provided reliable data transmission, incorporating Bluetooth as an alternative connectivity option could further improve notification reliability in low-connectivity areas. Expanding the device's capability to detect additional



gases would also increase its utility across a broader range of industrial and household applications.

The portable gas detection device with an alert system effectively meets the objectives of providing real-time gas monitoring and immediate alerting in the presence of hazardous gases. With reliable performance, a user-friendly application, and long-lasting battery life, the device shows promise as a practical tool for enhancing safety in environments where gas leaks pose significant risks

4 Conclusion

This project presents a cost-effective and automated gas leakage detection system utilizing Arduino and integrated gas sensors. Designed with affordability and simplicity in mind, the system provides an accessible solution by using low-cost components that require minimal infrastructure and maintenance. The automation feature, which opens windows upon gas detection, adds an essential layer of safety by ensuring prompt ventilation, reducing the risk of explosion and providing an immediate response.

The experimental results confirm the system's reliability and effectiveness in detecting gas leaks and initiating rapid preventive actions. This combination of affordability, ease of installation, and low maintenance makes it an appealing option for various environments, including residential, industrial, and commercial settings. The system's success underscores its potential for broad adoption, enhancing safety and minimizing the risks associated with gas leaks in everyday and industrial spaces. This project thus contributes a valuable, scalable solution to the field of gas detection, paving the way for safer environments and highlighting the practical applications of open-source technology in safety-critical systems.

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These references explore various aspects of IoT, gas detection, and sensor technologies that informed the design and implementation of the portable gas detection system in the document.