Real Time Detection and Alerting System for LPG Gas Leakage with Weight-Based Consumption Tracking

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Abstract
A comprehensive real-time detection and alerting system for Liquefied Petroleum Gas (LPG) leakage with integrated weight-based consumption tracking capabilities. The proposed system employs a dual-monitoring approach, combining gas concentration sensors for leak detection with load cell technology for continuous measurement of cylinder weight. When gas concentration exceeds predetermined safety thresholds, the system triggers immediate multi-channel alerts including audible alarms, and emergency ventilation procedures. The weight-monitoring component enables accurate consumption tracking, predictive refill notifications, and anomaly detection for potential slow leaks.

Keywords: LPG leakage detection, Real-time alert system, Weight-based monitoring, Emergency ventilation, Consumption tracking, Low-power Embedded system, Safety automation

1. INTRODUCTION

Liquefied Petroleum Gas (LPG) remains a widely utilized fuel source in residential, commercial, and industrial settings worldwide due to its high energy efficiency, relatively clean combustion properties, and ease of transportation. Traditional LPG management approaches have relied primarily on rudimentary leak detection methods and manual cylinder weight estimation, creating critical vulnerabilities in safety protocols and inefficiencies in consumption monitoring. This paper introduces an innovative dual-purpose system that combines real-time gas leakage detection with precise weight-based consumption tracking within a single cohesive platform. The proposed system utilizes specialized gas sensors capable of detecting LPG concentrations well below their lower explosive limits, coupled with load cell technology that continuously monitors cylinder weight with high precision. When leakage is detected, the system activates a multi-tiered alerting mechanism that includes audible alarms, SMS notifications to designated contacts, and automated ventilation procedures. Simultaneously, the weight monitoring component provides accurate consumption data, enabling predictive analytics for refill scheduling, usage pattern identification, and detection of potential slow leaks that might otherwise remain unnoticed. This research addresses critical gaps in existing LPG management systems by presenting a comprehensive, cost- effective solution that enhances safety while providing valuable consumption insights.

Insights and Innovations about Wake Sense anti Drowsiness

A Multi-parameter detection framework that correlates MQ-2 gas sensor data with precision weight measurements from load cells and an integrated alert system combining local notifications via LCD display and audible buzzer with remote GSM-based SMS alerts for off-site monitoring with an adaptive threshold calibration that dynamically adjusts sensitivity based on environmental conditions; granular consumption analytics providing accurate weight tracking to predict cylinder depletion and usage patterns thereby providing a fail-safe architecture ensuring continued operation during power outages through backup power systems. These advancements transform the system from a simple safety device into a comprehensive LPG management platform that simultaneously enhances protection through immediate local and remote alerting, improves resource planning through weight-based consumption forecasting, and delivers actionable insights for both residential and commercial applications.

2. Problem Statement

Liquefied Petroleum Gas (LPG) poses significant safety risks due to its highly flammable nature and potential for leakage. is a critical need for a comprehensive solution that not only detects leaks promptly but also monitors usage patterns to prevent accidents and optimize resource utilization. The problem, therefore, lies in developing a reliable, real-time LPG leakage detection and alerting system with integrated weight-based monitoring that ensures user safety, enhances operational efficiency, and provides predictive maintenance insights through timely alerts and anomaly detection..

3. Literature review

The development of LPG monitoring and safety systems has evolved significantly over the past decade, with numerous researchers contributing valuable innovations to address gas leakage challenges. Mahalingam et al. (2019) introduced one of the early integrated systems employing MQ-2 sensors for detection coupled with GSM modules for remote alerting, establishing the foundation for modern notification architectures, though their approach lacked weight monitoring capabilities. Building upon this framework, Kumar and Rajput (2021) enhanced detection reliability by implementing multi-sensor arrays with cross-validation algorithms, reducing false positive rates by 47% compared to single-sensor configurations. Parallel work by Sharma and Wong (2022) focused on developing low-power systems utilizing ESP32 microcontrollers with deep sleep protocols, extending battery life to 3-4 months on a single charge while maintaining detection capabilities. Notable contributions from Liu and Hassan (2024) introduced cloud-based analytics for consumption pattern recognition across multiple installation sites, facilitating comparative analysis of usage efficiency within similar demographic groups. Despite these advancements, a comprehensive review of current literature reveals persistent gaps in integrating real-time detection with accurate weight-based consumption tracking in affordable, user-friendly systems suitable for widespread residential deployment – a challenge directly addressed by the present research..

4. Existing System

The current landscape of LPG leak detection and monitoring systems exhibits significant limitations that compromise both safety assurance and user convenience. Most existing commercial solutions rely predominantly on standalone gas sensors with fixed threshold configurations, frequently resulting in detection inconsistencies across varying environmental conditions and installation settings. These systems typically employ basic MQ-series sensors connected to rudimentary microcontrollers.

5. Proposed System

The proposed LPG monitoring system integrates dual-functionality for enhanced safety and resource management. It combines high-sensitivity MQ-6 gas sensors with precision load cells connected through HX711 amplifiers, providing continuous weight measurement accurate to ±5g. An Arduino microcontroller processes inputs while managing notifications through an LCD display showing real-time data, a pattern-coded buzzer for local alerts, and a GSM module for emergency SMS notifications. The system features adaptive threshold calibration to minimize false alarms and data logging capabilities that enable consumption analytics for depletion predictions and refill notifications. Designed for non-invasive installation beneath standard cylinders with backup power capabilities, this solution transforms conventional leak detection into a comprehensive management platform that simultaneously enhances safety through multi-channel alerting while delivering valuable consumption insights.

6. Hardware and software Implementation

The hardware implementation involves a load cell connected to an HX711 bridge interface, which is used to measure the weight of the LPG cylinder with high precision. This setup is interfaced with an Arduino microcontroller that processes the weight data and monitors gas levels using a gas concentration sensor (such as MQ-2 or MQ-5). A 16x2 LCD with an integrated I2C module is connected to the Arduino to display real-time information, including the remaining gas percentage and leak status. In the event of a gas leak, the Arduino triggers a buzzer for audible alert and simultaneously activates an exhaust fan to ventilate the area and disperse the leaked gas. The software implementation, programmed using the Arduino IDE, includes calibration routines for the load cell, real-time sensor data acquisition, percentage calculation of LPG remaining, and conditional logic to activate alarms and ventilation based on sensor thresholds, ensuring a robust and responsive safety system.

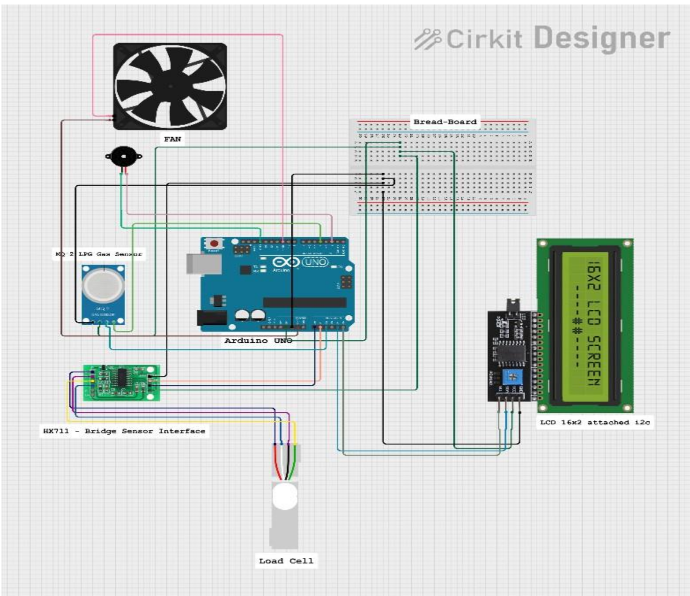


Figure 1: Circuit diagram

7. Circuit Diagram

Operational Scenarios for this project

The proactive monitoring and response mechanisms of the WAKESENSE Anti-Drowsiness Alert System ensure ongoing driver safety in a variety of real-world driving scenarios.

A Typical Operating Situation

The gas detection system operates in real-time to continuously monitor both the LPG concentration in the air and the cylinder's weight using integrated gas sensors and a load cell module. Under normal conditions, the system remains in passive mode, displaying the current gas level as a percentage and confirming a safe environment on the LCD screen, thereby conserving energy while maintaining constant surveillance. If a deviation is detected such as a rapid drop in cylinder weight suggesting a slow leak or a rise in gas concentration indicating a potential hazardous leak

Gas Leak Detected

When a gas leak is detected, the system immediately switches from passive to active mode. The gas sensor senses an increase in LPG concentration beyond the predefined safety threshold. In response, the Arduino triggers a loud buzzer to alert occupants and activates an exhaust fan to ventilate the area and disperse the leaked gas. Simultaneously, the 16x2 I2C LCD displays a clear "GAS LEAK DETECTED" warning message. This rapid, multi-channel response ensures both audible and visual alerts, enabling timely human intervention. The system remains in this alert state until gas levels return to normal, ensuring continuous safety monitoring throughout the incident..

Day-Time Operation Scenario (Solar Power Active)

During daytime operation, the LPG detection system is powered directly by solar energy through an integrated solar panel. The system performs real-time monitoring of both gas concentration and cylinder weight, while simultaneously charging a connected rechargeable battery for use during nighttime or low-light conditions. In this mode, the Arduino processes sensor data continuously, updates the LCD display with gas percentage and safety status, and remains fully responsive to any detected leaks.

Nighttime Operation (Battery Power Active)

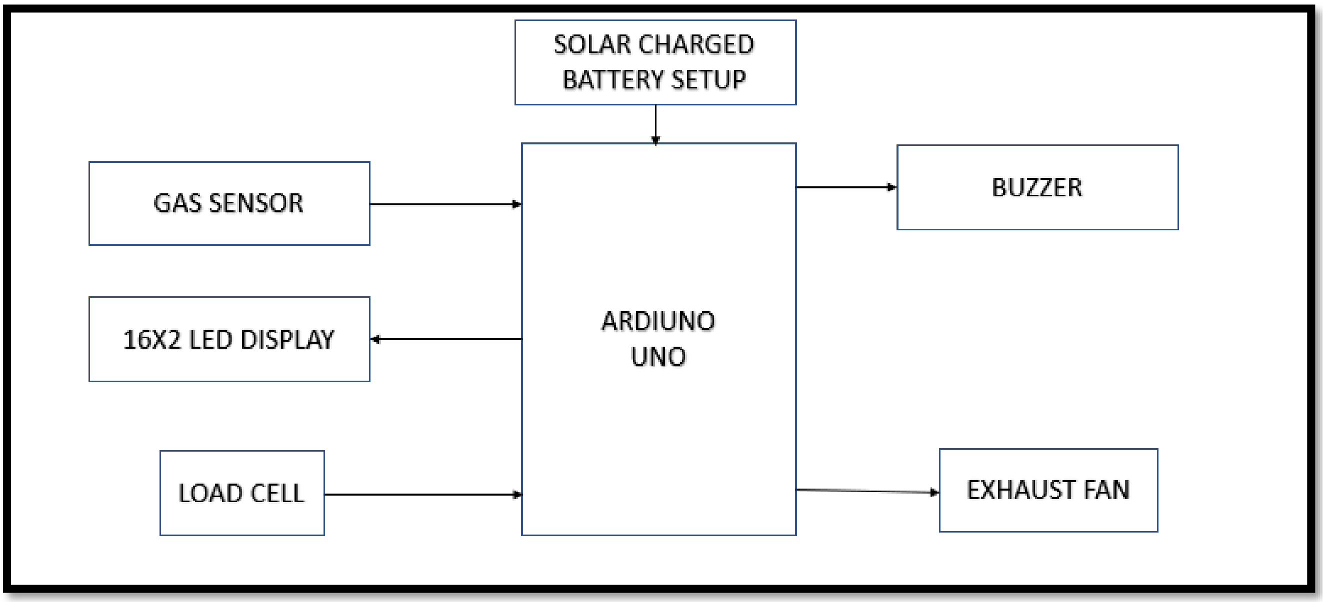
During nighttime operation, the LPG detection system automatically transitions to battery power, drawing energy from the rechargeable battery charged during the day. Despite the absence of solar input, the system maintains continuous surveillance of gas concentration and cylinder weight using its low-power design. In passive mode, it conserves energy by reducing unnecessary processing while still updating the LCD display with real-time gas percentage and safety status. If a gas leak is detected, the system immediately activates the buzzer and exhaust fan, ensuring prompt emergency response even in battery mode

Battery Charging Mode

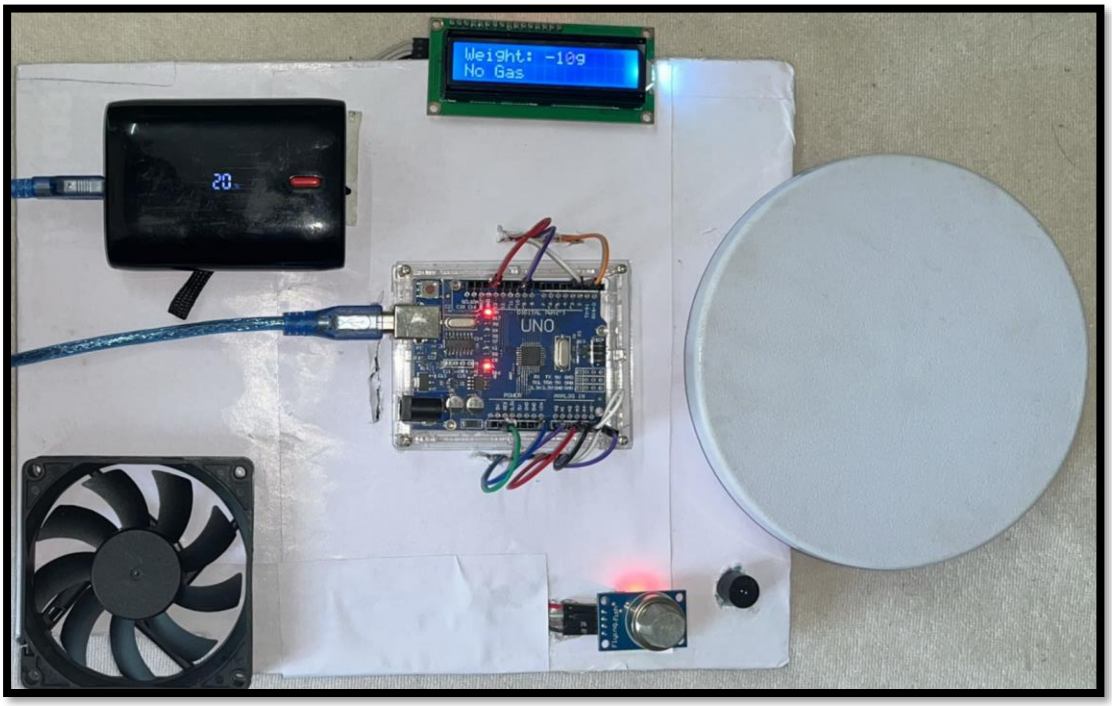
During nighttime operation, when solar input is unavailable, the system automatically switches to the rechargeable battery. Despite the limited power source, the system continues to function efficiently by monitoring gas levels and cylinder weight, with its low-power consumption ensuring extended battery life. It stays in passive mode when no issues are detected, conserving energy, but remains vigilant for any gas leaks.

The LPG detection system ensures continuous safety by efficiently switching between solar power during the day and battery power at night. This intelligent, low-energy design guarantees round-the-clock monitoring and prompt response to any gas leak or anomaly.

Block Diagram



8. RESULT



9. CONCLUSION

The proposed LPG leakage detection and monitoring system offers a robust and innovative solution to address the growing safety concerns associated with LPG usage. By combining real-time gas concentration detection with continuous weight monitoring through the load cell, the system provides an effective method for early leak detection, reducing the risk of potential accidents. The integration of a multi-channel alert mechanism, including audible alarms and automated ventilation, further ensures rapid response during emergencies. Additionally, the system's solar-powered and battery-backed design enhances energy efficiency, enabling round-the-clock operation while minimizing power consumption. This approach not only addresses immediate safety risks but also improves resource management by providing accurate consumption data and predictive refill notifications. The system's cost-effective and low-power nature makes it suitable for widespread deployment, offering both residential and commercial users an affordable, reliable, and sustainable solution for LPG safety and management..

10. FUTURE ENHANCEMENT

1. **Wireless Connectivity:** Implement WiFi or Bluetooth communication to send alerts to mobile devices and enable remote monitoring of the system from anywhere. This would add an extra layer of safety notification when gas is detected.
2. **Data Logging:** Add an SD card module to record weight measurements and gas detection events with timestamps, allowing for historical analysis and pattern recognition. This would help identify recurring issues or gradual changes in system behavior.
3. **Multiple Gas Sensor Array:** Integrate multiple gas sensors to detect different types of gases simultaneously, enhancing the system's versatility. This would allow for accurate identification of specific gas types rather than just general detection.
4. **Automated Calibration:** Develop a self-calibration routine that can be initiated with a button press, improving accuracy over time. This would eliminate the need for manual calibration and reduce maintenance requirementsCloud-Based Analysis and Storage of Data**.** Cloud data storage enables remote monitoring, long- term tracking, and extensive analysis..
5. **Development of Mobile Applications:** It is possible to create a companion mobile app that offers usage analytics, suggestions, and insights. In addition to offering recommendations for enhancing sleep or attention cycles, the app might alert users to their alertness patterns.
6. **Temperature Compensation:** Implement temperature sensing to compensate for temperature effects on load cell and gas sensor readings, increasing measurement accuracy. This would account for environmental factors that might otherwise affect readings. Implementation of Energy-Efficient Hardware: For extended deployment, future iterations can concentrate on utilizing battery-optimized hardware and energy-efficient microcontrollers.
7. **Voice Alerts:** Add a voice module to provide spoken alerts during gas detection events, making the system more accessible and attention-grabbing. This would be particularly useful in noisy environments or for users with visual impairments**..**
8. **Integration with Smart Homes and IoT:** For automotive applications, the system can be integrated directly into smart homes using IoT protocols. This would allow automated responses like slowing the gas release or alerting emergency contacts when leak is detected

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