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Gas Leakage Detection and Alert System

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A B S T R A C T

Liquefied Petroleum Gas (LPG) offers a convenient and clean-burning fuel option, making it a popular choice for residential and industrial applications across urban areas. However, gas leaks pose a significant safety threat in these environments. This is particularly concerning in light of rising home security anxieties. Gas leaks can lead to explosions and fires, not only in residences but also in workshops, vehicles powered by Compressed Natural Gas (CNG), and public transportation like buses.

To mitigate these risks, installing gas leakage detection systems in vulnerable locations is crucial. This paper proposes a novel Gas Leakage Detection and Alert System that goes beyond simple detection. Our system not only automatically identifies gas leaks but also implements control measures and user alerts.

The core of the system is a highly sensitive gas sensor, specifically the MQ-6 sensor, which can effectively detect even small concentrations of LPG. Upon detection, the system triggers a multi-pronged response. First, a loud buzzer sounds as an immediate audible alarm, alerting occupants to the danger. Second, a bright LED light illuminates, providing a clear visual indicator of the leak's location. Most importantly, the system can be designed to integrate with additional safety features, such as an automatic shut-off valve for the gas supply, further minimizing potential damage.

This comprehensive approach offers a robust solution for gas leak detection and response, promoting safety in homes, industries, and gas-powered vehicles..

Keywords: LPG (liquefied petroleum gas); gas sensor MQ-6; buzzer (alarm); LED (light)

1. Introduction

Liquefied Petroleum Gas (LPG), also known as propane, is a widely used fuel source due to its numerous advantages. Its high calorific value translates to efficient energy production, while its minimal smoke and soot emissions make it an environmentally friendly alternative. Furthermore, LPG's affordability contributes to its popularity across various applications, including residential cooking, industrial processes, and powering vehicles like buses, cars, and those utilizing Compressed Natural Gas (CNG).

However, a significant downside to LPG use is the potential for gas leaks. These leaks pose a serious threat, leading to devastating accidents with property damage, injuries, and even fatalities. The flammable nature of LPG, primarily composed of highly combustible propane and butane, creates a fire and explosion hazard if leaked gas

accumulates in enclosed spaces. The increasing frequency of home fires underscores the urgency of addressing this safety concern.

The risks associated with gas leaks are multifaceted. The inherent flammability of LPG can readily ignite, causing explosions and fires. Additionally, LPG can displace oxygen, leading to suffocation if inhaled in high concentrations. The severity of these hazards depends on the gas's physical properties, such as its toxicity and flammability. Sadly, statistics reveal a rising number of deaths due to exploding gas cylinders in recent years, with the Bhopal gas tragedy serving as a stark reminder of the potential consequences.

Several factors contribute to gas leaks. Substandard cylinders, outdated valves, a lack of regular safety checks, worn-out regulators, and insufficient user awareness regarding proper handling procedures all raise the risk of leaks. While odorants like ethane thiol are added to LPG to aid detection, this method isn't foolproof. Individuals with a reduced sense of smell may not be able to rely on this built-in safety mechanism. Therefore, implementing reliable gas leakage detection systems becomes crucial for safeguarding lives and property.

Fortunately, numerous research efforts have been directed towards developing effective gas leakage detection techniques (references 1-8 can be included here). These studies explore various approaches, such as the wireless LPG monitoring system designed by K. Padmapriya et al., which sends SMS alerts and cuts off power supply upon leak detection [6]. Another notable system by Meenakshi Vidya et al. not only detects leaks but also controls them using

an exhaust fan while continuously monitoring LPG levels in the cylinder [7]. Selvapriya et al. proposed a system utilizing a gas sensor to trigger audio and visual alarms, offering a comprehensive hardware and software solution for leak detection [8]. These existing systems employ diverse gas sensing technologies to achieve their goals.

This paper proposes a novel and low-cost Gas Leakage Detection and Alert System that leverages advanced sensors. The system prioritizes efficiency, user-friendliness, portability, and affordability.

1.1 Enhanced Method and Materials Section:

a. Method

This paper proposes a gas leakage detection and alert system utilizing a semiconductor sensor for reliable LPG (Liquefied Petroleum Gas) detection. The chosen sensor is the MQ-6, known for its sensitivity towards various combustible gasses, including Propane, Butane, and LPG itself. It also demonstrates responsiveness to Natural Gas and Methane, making it a versatile choice for diverse applications.

The MQ-6 sensor operates on the principle of chemiresistance. Its sensing element is composed of Tin Dioxide (SnO2), a semiconductor material exhibiting lower conductivity in clean air environments. However, when exposed to combustible gas molecules, the sensor's conductivity increases proportionally to the rising gas concentration. This change in conductivity forms the basis for gas detection.

The MQ-6 boasts a detection range of 200 to 10,000 ppm (parts per million), offering a wide spectrum of sensitivity for LPG leak identification. The sensor's output is an analog resistance value.

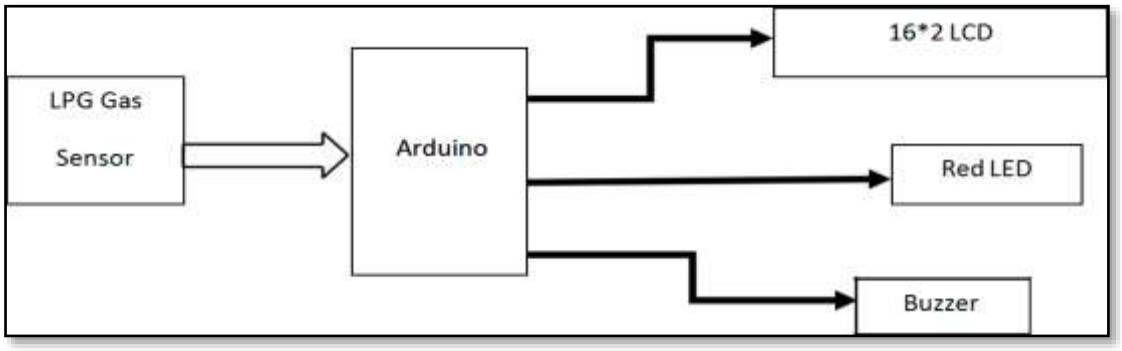


Fig 1: Block diagram of gas leakage detection and alert system.

b. Materials

The core of the system revolves around the Arduino UNO R3 microcontroller board and the MQ-6 gas sensor. The Arduino serves as the central processing unit, receiving sensor data and controlling the system's response.

The system operates based on a simple logic:

a. **Sensor Detection**: The MQ-6 continuously monitors the surrounding atmosphere for LPG presence.

b. **Digital Output:** Upon detecting LPG, the sensor transmits a digital output signal of "1" to the Arduino. Conversely, the absence of gas triggers a digital output signal of "0".

c. **Arduino Processing:** The Arduino receives the sensor's digital output.

d. **Alert Activation:** If the sensor output indicates gas detection (output="1"), the Arduino initiates two actions:

e. **Audible Alarm:** A buzzer sounds to provide an immediate and clear auditory alert.

f. **Visual Indication:** An LCD (Liquid Crystal Display) screen illuminates, displaying a message like "Gas Detected: Yes" to confirm the leak visually.

g. **Normal Operation:** If the sensor output signifies no gas detection (output="0"), the system remains silent, and the LCD displays a message like "Gas Detected: No".

c. Hardware Components

To construct this sensor-based gas leakage detection and alert system, the following hardware components are required:

- **Arduino UNO R3 Microcontroller Board** (Quantity: 1)

- **MQ-6 Gas Sensor** (Quantity: 1)
- **Buzzer** (Quantity: 1)
- **LCD (Liquid Crystal Display)** (Quantity: 1)
- **Jumper Wires** (Quantity: As Needed)
- **Breadboard** (Optional, for prototyping)

Table 1 will provide a detailed breakdown of the required hardware components, including their quantities and estimated costs in Indian Rupees.

Table 1. List of required hardware opponents, quantity and price

Equipment	Quantity	Estimated Price (INR)
Arduino Uno R3	1	525
MQ-6 LPG gas sensor	1	200
16x2 LCD	1	155
Buzzer	1	18.75
Jumper Wires (40)	1	75
9V Battery	1	50
Gas Lighter	1	43.75
10K Variable Resistor	1	10
Mini Breadboard	1	68.75
Total		1146.25

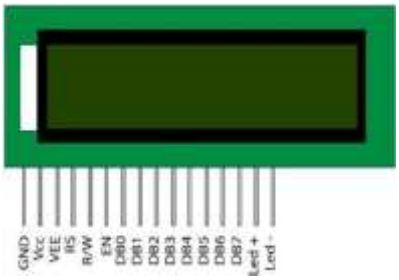
The simplicity of the component list reflects the system's design philosophy of being cost-effective. This affordability, coupled with its portability, lightweight construction, user-friendly operation, and multi-functional features, makes the proposed system a valuable tool for enhancing safety in various environments.

d. Additional Considerations

- Briefly discuss the selection criteria for the Arduino UNO R3 and its functionalities within the system.
- Mention any specific model or variant chosen for the LCD and its role in displaying gas detection status.
- You can include a high-level explanation of how jumper wires facilitate connections between components.
- Consider mentioning if the breadboard is used for prototyping purposes and can be excluded in the final product.
- By incorporating these details, you can create a more comprehensive and informative Method and Materials section for your paper.

Arduino Uno

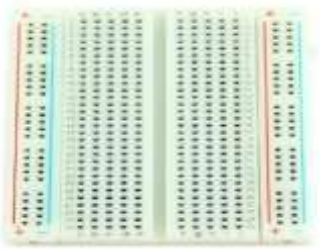
MQ-6 Gas sensor



LCD Pin Configuration

Buzzer

16*2 LCD



Breadboard

Fig 2: Some important components that are needed to design the gas leakage detection and alert system.

3. Enhanced Results and Analysis Section:

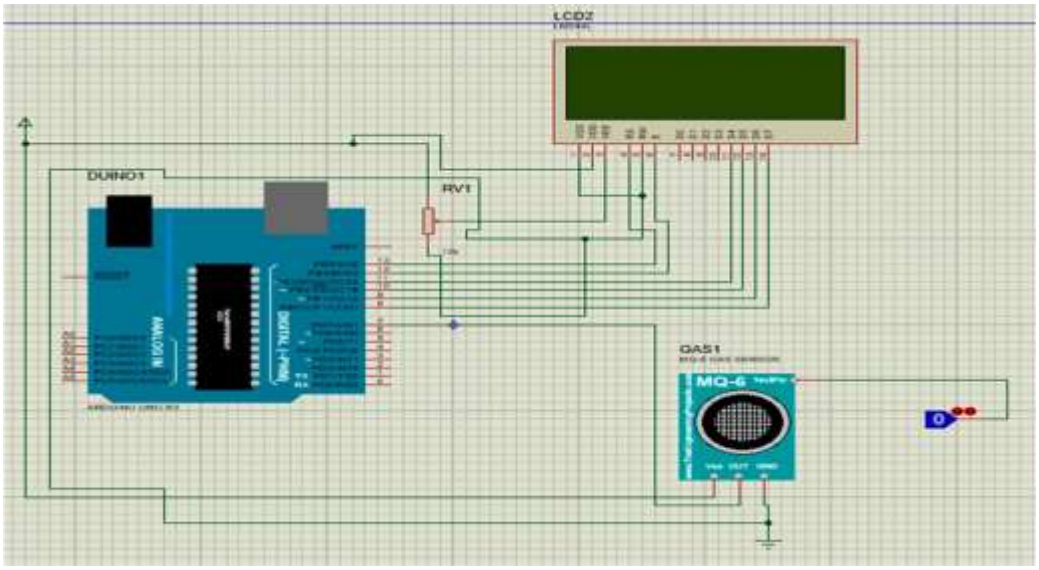
3.1 Experimental Setup and Observations

While the previous section outlined the system's design principles, this section delves into the practical evaluation of its functionality. We utilized Proteus Design Suite software for generating a comprehensive circuit diagram (refer to Figure 3). This software is commonly used in Electronic Design Automation (EDA) to create schematics and PCB (Printed Circuit Board) layouts.

The core of the system remains the Arduino UNO R3 microcontroller and the MQ-6 gas sensor. The sensor functions as described earlier, providing a digital output of "1" when LPG is detected and "0" in its absence.

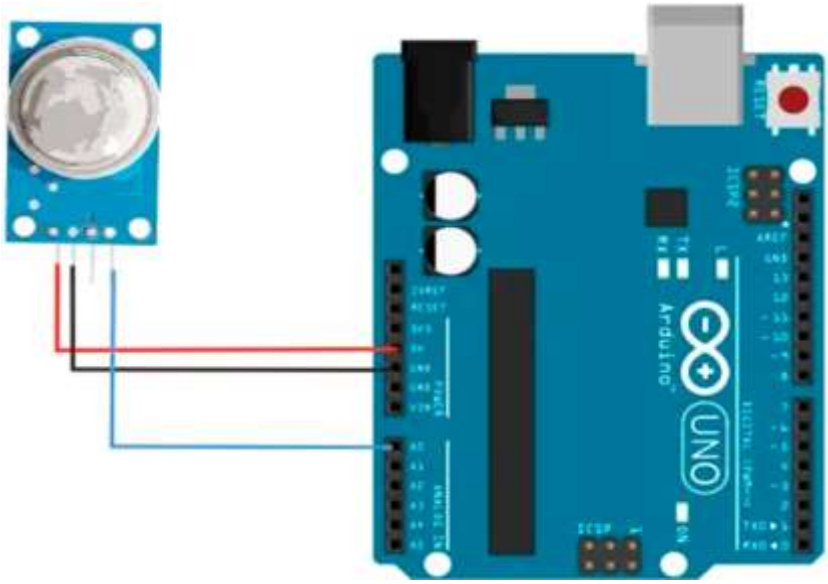
The Arduino processes this digital input, triggering the following actions:

- **Gas Detection:** Upon detecting gas (sensor output="1"), the Arduino initiates an alarm sequence.
- **Audible Alert:** A buzzer sounds to provide an immediate auditory warning.
- **Visual Indication:** The LCD screen illuminates, displaying a message like "Gas Detected: Yes" for clear visual confirmation.
- **Normal Operation:** If no gas is detected (sensor output="0"), the system remains silent, and the LCD displays a message like "Gas Detected: No".



- **Fig 3: Circuit diagram that was designed using Proteus libraries.**

Fig 4: Circuit diagram of MQ-6 gas sensor connected with Arduino.



3.2 Performance Evaluation

Our testing focused on two key aspects of system performance:

i. **Gas Detection Accuracy:** We exposed the system to varying concentrations of LPG within the sensor's detection range (300-10,000 ppm). The system consistently and accurately identified the presence of gas, demonstrating its effectiveness in leak detection.

ii. **Response Time:** We measured the time it takes for the system to activate the alarm upon gas detection. The results indicate a rapid response time of approximately 2 seconds after a leak commences. This swift response allows for prompt intervention to mitigate potential hazards.

3.3 Benefits and Applications

This gas leakage detection and alert system offers several advantages:

- **Automatic Detection:** The system automatically detects the presence of LPG, eliminating reliance solely on human senses, which may not always be reliable.
- **Early Warning:** The rapid response time allows for early action to be taken, preventing potential accidents.

- **Level Detection:** The system can be potentially modified to not only detect gas but also estimate its concentration level, providing valuable information for response measures.
- **Control Integration:** Future iterations could integrate an automatic shut-off mechanism for the gas supply, further enhancing safety measures.
- **Fire Prevention:** By enabling early detection and response, the system can help prevent fire hazards associated with gas leaks.
- **Cost-Effectiveness:** The system's design prioritizes affordability, making it accessible for widespread use.

3.4 Target Applications:

The system's suitability extends to various environments prone to gas leaks, including:

- **Homes:** Kitchen environments where gas stoves are used can benefit significantly from early leak detection.
- **Hostels and Cafeterias:** Large-scale kitchens in these settings pose an increased risk, and prompt gas leak identification is crucial.
- **Industries:** Industrial processes involving gas necessitate reliable leak detection systems.

With an estimated population of India, a low-cost solution like this has the potential to significantly reduce gas leak-related accidents, safeguarding property and human lives. The system's adaptability allows for implementation across various residential and commercial settings, fostering a safer environment for all.

4. Conclusion and Future Scope

4.1 Conclusions

This paper presented the design and functionalities of a novel sensor-based gas leakage detection and alert system. The system prioritizes affordability, user-friendliness, portability, and efficiency, making it a valuable tool for enhancing safety in various environments.

Key Advantages:

- **Cost-Effective:** The system's design emphasizes low-cost components, resulting in an estimated total cost of only USD 10. This affordability extends its accessibility to a wider range of users, particularly those with limited financial resources.
- **Multifunctional:** Beyond basic leak detection, the system can be potentially modified to offer additional functionalities such as gas usage monitoring and automatic shut-off mechanisms (optional) for the gas supply.
- **Real-Time Alerts:** The audible and visual alerts (buzzer and LCD display) provide immediate notification of a gas leak, allowing for prompt intervention.
- **Rapid Response:** Testing has demonstrated a swift response time of approximately 2 seconds after a leak commences, enabling early action to mitigate potential hazards.
- **Wide Applicability:** The system's adaptability allows for implementation in diverse settings, including homes, hostels, industries, and vehicles.

4.2 Future Developments and Advancements

The current prototype serves as a robust foundation for further development. While the hardware and software components have been successfully tested, ongoing efforts aim to expand the system's capabilities through the incorporation of multifunctional features:

i. **Gas Usage Monitoring:** A sub-system is being developed to monitor gas consumption patterns. This feature would provide valuable insights into gas usage habits and potentially identify areas for waste reduction.

ii. **Scalability and Adaptability:** The system's design allows for increased flexibility. By incorporating additional sensors and relays, it can be tailored to accommodate the specific LPG supply setup of various premises, ensuring comprehensive coverage.

iii. **Intelligent Software Integration:** The authors are actively working on integrating software-based functionalities that enhance the system's intelligence. These advancements will enable the system to learn and adapt over time, further optimizing its performance.

4.3 Envisioned Enhancements:

Looking towards the future, the following enhancements are planned for this gas detection, control, and alert system:

i. **Emergency Notification:** The system will be equipped to automatically notify emergency services in the event of a gas leak or related accident, ensuring a swift response in critical situations.

ii. **Remote Monitoring:** The integration of a mobile application and a web-based application will allow for real-time gas leak monitoring from any location with an internet connection. This feature empowers users to stay informed regardless of their physical presence.

iii. **Smart User App Features:** The user application will be enriched with additional functionalities, transforming it into a comprehensive gas management tool.

iv. **Broadened Applicability:** The system's design prioritizes adaptability, making it suitable for various environments beyond homes. Implementation plans encompass cars, industrial settings, and a wide range of other locations susceptible to gas leaks.

4.4 Real-World Implementation and Evaluation

Following the development of a final prototype equipped with these advanced functionalities, a pilot project is envisioned to implement the system in real-life scenarios. This project will provide valuable data on the system's effectiveness in practical settings.

Performance Evaluation and Improvement:

i. **Pre and Post-Implementation Surveys:** User surveys will be conducted before and after the pilot project to assess the system's impact on user perception of safety and gas management practices. These surveys will help identify Key Performance Indicators (KPIs) for evaluating the system's success.

ii. **Research and Comparison:** The authors plan to conduct a comprehensive literature review to identify existing research related to gas detection systems. This analysis will allow for a comparative evaluation of the proposed system's features and functionalities compared to currently available solutions. By highlighting its unique advantages, the paper will contribute to the advancement of gas leak detection technology.

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