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Smart IoT Based Gas Leakage Detection and Auto Shut-Off System

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Abstract

Gas leakage poses a significant threat in residential and industrial environments, often leading to hazardous situations like fires and explosions. This paper presents a Smart IoT-based Gas Leakage Detection and Auto Shut-off System that enhances safety by integrating real-time monitoring with an automated response mechanism. The system detects gas leaks using an MQ-6 sensor and promptly shuts off the gas supply through a servo motor-based valve control. Additionally, an alert notification is sent to users via an LCD display and buzzer to ensure immediate awareness. This paper discusses the half-implemented version of the system, focusing on gas detection and auto shut-off functionalities. The proposed system improves upon existing gas detection techniques by offering a cost-effective, highly responsive, and automated approach to preventing gas-related accidents.

INTRODUCTION

With the increased reliance on liquefied petroleum gas (LPG) in households and industries, gas leakage incidents have become a major safety concern. Gas is widely used for cooking, heating, and industrial processes, making it an essential energy source. However, gas leaks can lead to hazardous situations, including explosions, fires, and toxic inhalation, which pose serious risks to life and property. Traditional safety mechanisms depend heavily on manual intervention, which is prone to human errors and delays. The absence of an automated response system increases the likelihood of accidents due to unaddressed leaks. Many existing gas detection systems are limited to alerting users through an alarm or indicator without taking any corrective action. While these systems provide awareness, they do not prevent further leakage, making them insufficient in critical situations. Moreover, some advanced gas leak detectors rely on internet-based notifications, which may not be accessible in areas with poor connectivity. As a result, an intelligent gas leak detection and shut-off system is required to ensure comprehensive safety.

This project introduces a smart IoT-enabled system that detects gas leakage and immediately shuts off the gas supply to prevent potential hazards. The system consists of an MQ-6 gas sensor, an Arduino Uno microcontroller, and a servo motor that operates a shut-off valve. When the sensor detects an abnormal concentration of gas, the microcontroller processes the data and activates the servo motor to close the gas supply. Additionally, a buzzer and an LCD display provide real-time alerts, ensuring that users are immediately notified of the situation. Unlike

conventional systems, this solution not only detects gas leaks but also takes preventive measures, making it more effective in ensuring safety.

One of the key advantages of this system is its standalone capability. It does not require an internet connection to function, making it suitable for a wide range of applications, including households, restaurants, and industrial settings. The system can also be expanded in the future to include GSM-based alerts, enabling remote notifications via SMS or mobile applications. This half-implemented version focuses on the core functionalities of gas detection, alert generation, and automatic shut-off, laying the foundation for future enhancements.

By implementing this smart safety solution, gas-related accidents can be significantly reduced, and users can have peace of mind knowing that an automated system is in place to prevent potential disasters. This paper discusses the development, methodology, and expected outcomes of the system, highlighting its role in improving gas safety measures.

LITERATURE SURVEY

Arun Kumar et al. (2024) [1] introduce a gas leakage detection system designed to enhance safety in various environments through real-time notifications and automatic response mechanisms. The system employs a gas detector coupled with a GSM module to alert users via SMS in the event of a gas leak. A key feature is the continuous operation of a buzzer, which sounds until the gas concentration returns to a safe level, thereby preventing potential explosions or fires. This approach emphasizes the importance of timely detection and immediate alerting to mitigate risks associated with gas leaks. The study highlights the system's suitability for residential and commercial settings, focusing on its ability to provide proactive safety measures. The integration of SMS alerts and audible notifications ensures that users are promptly informed of any hazardous conditions, thus contributing to overall safety and preventing gas-related incidents.

Mahabooba et al. (2024) [2] introduce an advanced LPG gas leakage detection and cut-off system that integrates IoT technology for enhanced safety in both household and industrial settings. The system employs MQ-6 gas sensors to detect the presence of flammable gases with high accuracy. Upon detecting a gas leak, the system activates a servo motor to cut off the gas supply, thereby preventing further leakage. The integration of a web application allows for real-time monitoring and remote control, providing users with timely alerts and the ability to manage the system from connected mobile devices. This proactive approach not only mitigates the risk of gas-related accidents but also ensures regulatory compliance and user convenience. The study underscores the significance of combining IoT with traditional safety measures, marking a significant advancement in gas safety technology. This system offers a comprehensive solution for both immediate response to gas leaks and long-term safety management, setting a new standard for gas leak detection and emergency response systems.

Chaudhary and Mishra (2019) [3] present a gas leakage detection system using Arduino technology, designed to enhance safety in residential and commercial environments. The system utilizes an MQ-6 gas sensor to detect LPG leaks and integrates a GSM module to send SMS alerts to users in case of detection. The design incorporates an audible alarm system to alert occupants of gas leaks, and the system also features a visual indication through LEDs to denote the presence of gas. This approach provides a straightforward and cost-effective solution for early gas leak detection and emergency response. The system's ability to alert users remotely via SMS adds an extra layer of safety, especially in scenarios where no one is present at the location. The study highlights the system's effectiveness in detecting varying levels of gas leakage and its suitability for various applications, including homes, hotels, and industrial settings. This model offers a practical and efficient solution to mitigate the risks associated with gas leaks and enhance overall safety.

Chafekar et al. (2018) [4] present a comprehensive system for automatic gas accident prevention using Arduino and GSM technology. The study focuses on the development of a gas leakage detection system equipped with an MQ-5 gas sensor, known for its high sensitivity to LPG and natural gases. This system aims to enhance safety by automatically detecting gas leaks and initiating multiple precautionary measures. Upon detection, the system shuts off the gas supply valve and activates an exhaust fan to disperse leaked gas. Additionally, it turns off the main power supply to prevent potential fire hazards. An SMS alert is sent to the user via a GSM module to provide timely notifications. The system's effectiveness lies in its ability to integrate these safety features, offering a robust solution to prevent gas-related accidents. This approach not only detects leaks but also proactively mitigates risks associated with gas leakage, demonstrating a practical and effective

safety enhancement for both residential and industrial applications.

Loshali et al. (2017) describe the design and implementation of an LPG gas detector system that integrates both hardware and software components to address gas leakage issues. The system utilizes an MQ-5 gas sensor to detect LPG and includes a solenoid valve to shut off the gas supply in case of a leak. It also features a visual display and an audible alarm to alert users of gas presence. The system is designed to deactivate the alarm once the gas concentration drops below a specified threshold, reducing false alarms and ensuring user comfort. This approach underscores the practical application of gas detection technology in household settings, with potential for industrial use as well. The study demonstrates the effectiveness of combining sensor technology with responsive safety measures to prevent gas-related accidents, highlighting the system's adaptability.

Figure: Literature Survey Table

Author	Title	Year	Key Focus	Methodology	Results/Findings
Arun Kumar et al.	Gas Leakage Detection System with Real-Time Alerts and Automated Response Mechanisms	2024	Implementation of a gas leakage detection system with r eal-time alerts and automatic response mechanisms.	Incorporates a gas detector and GSM module to send SMS alerts. A buzzer continuously sounds until gas concentration reaches a safe level, preventing potential fires or explosions.	Ensures timely detection and immediate user notification, enhancing safety in residential and commercial settings by preventing gas-related incidents.
Mahabooba et al.	IoT-Integrated LPG Gas Leakage Detection and Cut-Off System	2024	Advanced IoT-based LPG gas leakage detection and cut-off system for household and industrial safety.	Uses MQ-6 gas sensors for accurate detection, activates a servo motor to stop gas flow, and integrates a web application for real-time monitoring and remote control.	Enhances gas safety by providing real-time alerts, remote accessibility, and regulatory compliance, making it a significant advancement in gas leakage prevention systems.
Chaudhary and Mishra	Arduino-Based Gas Leakage Detection System with SMS Alerts	2019	Development of an Arduino-based gas leakage detection system for residential and commercial safety.	Utilizes an MQ-6 gas sensor for LPG leak detection, a GSM module for SMS alerts, an audible alarm for occupant warning, and LED indicators for visual notification.	Provides a cost-effective and efficient solution for early leak detection, offering remote alerts and increasing safety in various applications, including homes, hotels, and industrial sites.
Chafekar et	Automatic	2018	Development of	Utilizes an	The system

al.	Gas Accident Prevention System Using Arduino and GSM Technology		an automatic gas leakage detection and accident prevention system integrating Arduino and GSM technology.	MQ-5 gas sensor for LPG and natural gas detection. Upon detecting a leak, the system shuts off the gas supply, activates an exhaust fan to disperse gas, turns off the main power supply, and sends SMS alerts.	effectively detects gas leaks and initiates multiple safety measures, reducing fire hazards and ensuring rapid emergency response for residential and industrial applications.
Loshali et al. 2017	LPG Gas Detection System Using Sensor Technology and Safety Mechanisms	2017	Design and implementation of an LPG gas detector system integrating hardware and software components for enhanced safety.	Uses an MQ-5 gas sensor to detect LPG leaks, a solenoid valve to shut off gas supply, a visual display, and an audible alarm to alert users. The system deactivates alarms once gas concentration is reduced to avoid false alerts.	Demonstrates a practical and efficient safety system suitable for both residential and industrial applications by reducing risks associated with gas leaks.

COMPARATIVE ANALYSIS

Feature	**Existing System**	**Proposed Architecture**
Functionality	Manual gas knob monitoring	Automated gas knob detection with IoT integration
Efficiency	Prone to human error and negligence	Real-time monitoring with alerts
Technology Used	No smart technology	IoT-based sensors and AI for detection
Safety Measures	Limited safety, risk of gas leaks	Immediate alerts and shutdown mechanisms
User Convenience	Requires physical checks	Remote access and monitoring through mobile apps

OBJECTIVE

The primary objective of this project is to design and develop a smart gas leakage detection system with an automatic shut-off mechanism. Specific objectives include:

- **Real-time monitoring of gas concentration using the MQ-6 sensor:** The system continuously monitors the surrounding environment for gas leaks using an MQ-6 gas sensor. The sensor detects even minor leaks, ensuring early detection before the situation escalates. The real-time data is processed by the microcontroller to determine if gas levels exceed a predefined threshold.
- **Automatic shut-off of the gas supply when a leak is detected:** If the sensor detects a gas concentration above the safe limit, the microcontroller immediately

activates a servo motor. The servo motor turns the gas valve off, stopping further leakage and preventing hazardous incidents such as explosions or fires. This automatic intervention eliminates the need for manual action, reducing the risk of human error.

- **Providing immediate local alerts via a buzzer and LCD display:** When a leak is detected, the system activates an alarm using a buzzer to alert nearby individuals. An LCD display provides real-time updates about the gas concentration and system status, ensuring users are informed. This feature is particularly useful in households, kitchens, and industrial environments where quick response is necessary.
- **Enhancing safety by reducing human intervention in emergency situations:** Traditional gas safety measures often rely on human intervention, which may be delayed or ineffective in emergencies. The proposed system automatically detects and mitigates leaks, ensuring a proactive approach to gas safety. By minimizing the need for manual responses, the system increases efficiency and reliability in handling gas-related hazards.
- **Developing a scalable system that can be expanded with GSM and IoT features in future iterations:** The current implementation is a standalone system but is designed with scalability in mind. Future enhancements may include GSM-based alerts, where users can receive SMS notifications regarding gas leaks. IoT integration can further enable remote monitoring via mobile applications or cloud-based systems, improving accessibility and control.

PROPOSED WORK

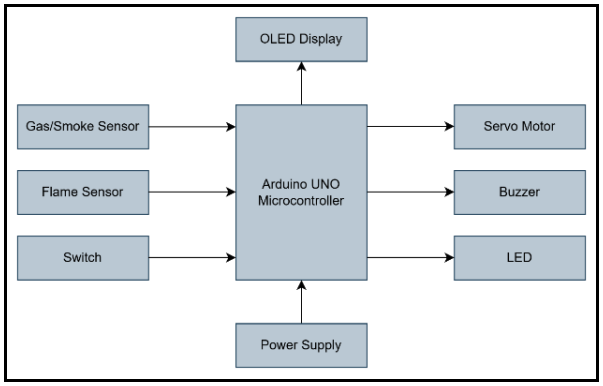

Figure: Block Diagram

This proposed system can be categorized into several key components:

1. **Hazard Detection:** The system employs multiple sensors to continuously monitor the surroundings of the gas burner. A gas sensor is responsible for detecting any leakage in the air, ensuring early identification of potential hazards. The flame sensor checks whether the burner's flame is burning correctly, confirming that the burner is functioning as intended. Additionally, a smoke sensor tracks the presence of smoke, which may result from incomplete combustion or system malfunctions. If any of these risks are detected, the sensors instantly transmit a signal to the Arduino Uno microcontroller, which then analyzes the data to identify the potential hazard.
2. **Automated Response:** Upon detecting a hazard, the Arduino Uno microcontroller promptly processes the incoming data and initiates appropriate countermeasures. The system is designed to shut off the gas supply by activating a servo motor that rotates the gas knob to the "OFF" position. This immediate action prevents the further release of gas, reducing the likelihood of explosions, fire hazards, or exposure to toxic gases. This rapid response mechanism ensures that emergency measures are implemented without requiring human intervention, thereby enhancing safety and reliability.
3. **Timer Functionality:** To prevent accidental prolonged usage, the system features a built-in timer that allows users to set a predefined operational duration for the gas burner. Once the designated time limit is reached, the Arduino microcontroller signals the servo motor to turn off the gas knob, automatically halting burner operation. This functionality is particularly beneficial in preventing unintentional gas wastage and potential fire hazards due to unattended burners. By enforcing controlled usage, the system significantly improves safety while optimizing energy consumption.
4. **User Notifications:** To keep users informed about the system's actions and any detected hazards, the system integrates multiple notification mechanisms. A buzzer emits an audible alarm whenever a risk is identified, ensuring immediate attention. LED indicators visually display the system's operational status, alerting users to any ongoing issues. Additionally, an OLED display provides detailed real-time updates, displaying alerts such as "Gas Leak Detected," "Flame Extinguished," or "Burner Off." These notifications offer essential insights into the system’s operation, keeping users well-informed about

potential dangers and necessary precautions.

5. **Integration and Reliability:** At the core of this system lies the Arduino Uno microcontroller, which seamlessly integrates all sensors and actuators. It processes real-time data efficiently, executes necessary control commands, and maintains a high level of operational stability. Engineered for robust and continuous functionality, the system is suitable for both residential and industrial applications. Its dependable hazard detection and swift response mechanisms make it a crucial safety tool for any environment utilizing gas burners, ensuring consistent and proactive risk management.

METHODOLOGY

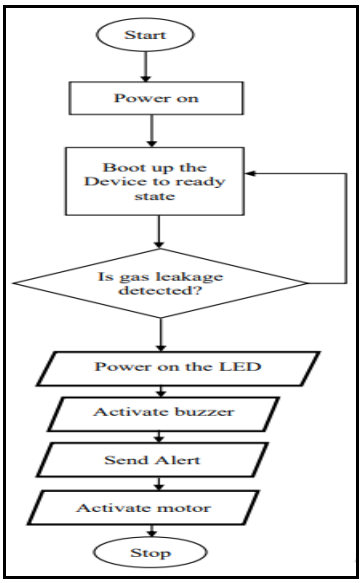

Figure: Flowchart

- The gas leakage detection system operates by continuously monitoring the environment for any gas leaks and taking immediate safety actions if leakage is detected. The process starts with powering on the device, which then undergoes a boot-up phase to ensure all sensors and components are functional.
- Once the system is in a ready state, it continuously checks for gas leakage. If no leakage is detected, it remains in monitoring mode. However, if gas leakage is identified, the system activates a series of safety measures.
- First, an LED light is turned on to provide a visual warning. Simultaneously, a buzzer is triggered to alert nearby individuals about the danger. Additionally, the system sends an emergency notification through SMS or app alerts to inform authorities or users.
- To prevent further hazards, a motor, such as an exhaust fan, is activated to ventilate the area and disperse the gas. These automated actions help in mitigating the risks of fire, explosions, and health hazards.
- Finally, after executing all necessary safety measures, the system completes the process. This gas leakage detection system is crucial for ensuring safety in homes, industries, and workplaces by enabling early detection and quick response to potential gas leaks.

RESULT

The gas leakage detection system ensures **early detection and quick response** to gas leaks, significantly reducing risks associated with hazardous gases. The expected results include:

- **Timely Detection of Gas Leakage** – The system continuously monitors the environment and detects gas leaks as soon as they occur.
- **Immediate Alert Mechanism** – Once leakage is detected, the system triggers an LED indicator, buzzer, and alert notifications (such as SMS or app alerts) to inform users or authorities.
- **Prevention of Accidents** – By activating an exhaust fan or motor, the system helps disperse leaked gas, reducing the chances of fire, explosions, or health hazards.
- **Enhanced Safety Measures** – People in the vicinity are warned promptly, allowing them to take necessary precautions, such as turning off gas supply or evacuating the area.
- **Automation and Efficiency** – The system operates automatically, requiring minimal human intervention, making it ideal for households, industries, and workplaces.

CONCLUSION

The gas leakage detection system plays a crucial role in ensuring safety by automatically detecting gas leaks and triggering immediate safety actions. It continuously monitors the environment and, upon detecting leakage, activates an LED indicator, a buzzer, sends alerts, and operates an exhaust fan to minimize risks. This automated approach reduces the chances of fire, explosions, and health hazards, making it highly effective in both residential and industrial settings. By providing real-time alerts and quick responses, the system helps prevent accidents and ensures the well-being of individuals. Its automation, reliability, and efficiency make it an essential safety solution in places where gas usage is common.

Implementing such systems can significantly enhance safety standards, protect lives, and prevent property damage.

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