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IoT based LPG Gas Cylinder Trolley to Prevent Hazards with Voice Controlled Features

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Abstract: *The LPG gas cylinder trolley system integrates advanced safety features to detect and mitigate potential hazards like gas leaks and fire risks, ensuring a secure environment for users. At its core, the system utilizes a PIC18F4520 microcontroller that processes inputs from various sensors, including an LPG gas sensor, fire sensor, and load cell, to monitor gas leaks, fire conditions, and the weight of the gas cylinder. When a hazardous situation is detected, the microcontroller triggers safety measures, such as activating an exhaust fan to disperse gas and shutting off the cylinder valve to prevent further leakage. Real-time status updates are displayed on an LCD screen, while a buzzer provides an audible alarm for immediate attention. Additionally, the system features Bluetooth and GSM modules for remote control and alerts, enabling users to monitor and manage the system from a distance via voice commands or SMS notifications. The system is powered by a stable 12V battery, with a 7805 voltage regulator ensuring consistent 5V supply to critical components. The overall design incorporates essential protection features, including diodes, transistors, and capacitors, to safeguard the circuit from overcurrent and voltage fluctuations. The modularity of the system allows for future upgrades, such as adding more sensors, to enhance its capabilities further. This comprehensive safety mechanism not only prevents accidents but also offers a user-friendly interface for easy interaction and control.*

Keywords: LPG gas cylinder, microcontroller, safety system, Bluetooth module, fire sensor

I. INTRODUCTION

LPG (Liquefied Petroleum Gas) is widely used for cooking, heating, and industrial applications, making it a crucial resource in households and businesses. However, the use of LPG carries inherent risks, primarily due to the potential for gas leaks, which can lead to dangerous explosions or fires. Despite its widespread use, many homes and industries still rely on manual checks and rudimentary safety measures to detect and respond to such hazards. This gap in safety protocols underscores the need for an automated, real-time monitoring and control system for LPG cylinders, designed to protect both individuals and properties from gas-related accidents.

The increasing awareness of safety in gas cylinder management has sparked the development of intelligent systems that incorporate sensors, microcontrollers, and communication modules. These systems can detect gas leaks, fires, and other potentially hazardous conditions and respond immediately to mitigate risks. Modern advancements in embedded systems and wireless communication technologies offer an opportunity to build more sophisticated, responsive, and user-friendly solutions. This project aims to design and implement an LPG gas cylinder trolley that incorporates real-time hazard detection and automated safety features.

A core component of this system is the microcontroller, which acts as the central control unit. It processes inputs from multiple sensors, such as the LPG gas sensor, fire sensor, and load cell, and controls outputs like alarms, relays, and exhaust fans. The use of the PIC18F4520 microcontroller allows for seamless integration of these sensors and actuators, ensuring that the system can respond to hazardous conditions with high precision and reliability. Additionally, the system integrates wireless communication features, such as Bluetooth and GSM modules, enabling remote monitoring and control. This means users can receive alerts or even issue commands, such as turning off the gas valve, from their mobile devices.

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In the context of safety, real-time feedback is essential for timely intervention. The LPG gas cylinder trolley utilizes visual and auditory indicators, including LEDs and buzzers, to provide immediate feedback when a gas leak or fire is detected. The system also incorporates an emergency shutdown mechanism, where the microcontroller triggers actions like closing the gas valve and activating the exhaust fan to vent harmful gases from the environment. This integrated response mechanism significantly reduces the likelihood of a catastrophic event, ensuring a safer environment for users.

One of the key features of this system is its user- friendliness, achieved through the inclusion of voice control. The Bluetooth module enables the system to interpret voice commands, making it more accessible, especially during emergencies when manual operation may not be possible. Moreover, the GSM module allows for remote notifications via SMS, ensuring that users can stay informed even when they are away from the system. These advancements in user interaction further enhance the overall safety and convenience provided by the system.

The integration of modularity in the design ensures that additional sensors or functionalities can be incorporated into the system with ease. For example, sensors for temperature, smoke, or even vibration can be added to create a more comprehensive monitoring system. The system is also designed to be scalable, meaning it can be adapted for use in various settings, such as residential homes, industrial facilities, or commercial kitchens.

This project reflects the convergence of several cutting- edge technologies, such as embedded systems, wireless communication, and automation, in the field of safety and hazard prevention. By integrating these technologies, the LPG gas cylinder trolley offers an innovative solution to address the longstanding safety concerns associated with LPG use. This design not only aims to improve the safety of households and industries but also contributes to a broader movement towards smarter, more secure living environments.

In conclusion, the LPG gas cylinder trolley project seeks to provide a highly effective, automated safety system that can detect hazards, alert users, and take preventive actions. The design combines the power of real-time sensor data processing, remote communication, and intuitive user control, offering a comprehensive solution to mitigate the risks associated with LPG usage. As safety continues to be a top priority in both residential and industrial environments, the development of such intelligent safety systems is crucial in creating safer, smarter living spaces.

II. PROBLEM STATEMENT

LPG gas leaks pose significant safety risks, including fires, explosions, and health hazards, especially in households and industrial settings where traditional safety measures may be insufficient. The lack of real-time monitoring and automated responses to such dangers leaves users vulnerable to these risks. This project aims to address these challenges by developing an intelligent LPG gas cylinder trolley that integrates real-time hazard detection, automatic shutoff mechanisms, and remote monitoring, ensuring a safer environment through advanced technology.

III. OBJECTIVE

- To design an LPG gas cylinder trolley with integrated gas leak and fire detection systems.
- To implement an automatic shutoff mechanism for the gas cylinder in case of detected hazards.
- To enable remote monitoring and control of the system via Bluetooth and GSM modules.
- To enhance user safety by incorporating voice control for system interaction.
- To provide real-time hazard alerts through visual indicators and audible alarms.

IV. LITERATURE SURVEY

1. Title: Design and Implementation of LPG Gas Leak Detection and Automatic Shutoff System
- Authors: P. S. K. Kumar, K. S. Sridhar, et al.
- Published in: International Journal of Advanced Research in Electrical, Electronics, and Instrumentation Engineering, 2015.
- Summary: This paper discusses the development of a gas leakage detection system, which integrates a gas sensor with an automatic shutoff valve. The system is designed to monitor gas levels and automatically close the valve in case of detected leaks. The system uses a microcontroller for processing sensor inputs and controlling the valve, thereby improving safety in household and industrial environments.

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2. Title: IoT-Based LPG Gas Leakage Detection and Prevention System
• Authors: A. S. Dinesh, N. G. Kumar, et al.
• Published in: IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology, 2017.
• Summary: This paper presents an IoT-based solution for detecting LPG gas leaks and automatically sending alerts via SMS and email to the concerned authorities. The system leverages GSM and Wi-Fi modules to send real-time notifications. It also integrates a relay to control the gas valve, ensuring safety by preventing leaks and enhancing user awareness.

3. Title: Smart LPG Gas Monitoring System Using GSM and Bluetooth
• Authors: R. R. Raut, S. S. Meena, et al.
• Published in: Journal of Electrical Engineering & Technology, 2018.
• Summary: The authors propose a smart LPG gas monitoring system incorporating both GSM and Bluetooth modules. The system provides remote control of the gas cylinder and sends notifications to users about gas leakage and cylinder status. The system includes sensors for leakage detection and a voice control module for user interaction, ensuring an enhanced safety experience.

4. Title: Automated Fire and Gas Detection System for Industrial Safety
• Authors: H. M. R. Manogaran, S. K. S. Rajendran, et al.
• Published in: International Journal of Industrial Electronics and Control, 2019.
• Summary: The paper focuses on industrial safety, where an automated fire and gas detection system is implemented using sensors and microcontrollers. The system automatically activates fire suppression systems and shuts off hazardous gas supplies. It provides insights into sensor integration for real- time hazard detection in industrial settings and addresses the importance of immediate action to prevent accidents.

5. Title: Development of a Voice-Controlled LPG Gas Leak Detection and Alert System
• Authors: A. P. Joshi, M. R. Mahajan, et al.
• Published in: IEEE International Conference on Intelligent Computing and Communication, 2020.
• Summary: This paper explores a voice-controlled LPG gas leak detection and alert system, enabling users to interact with the system using voice commands. It uses GSM modules for communication and microcontrollers for processing inputs. The system also incorporates an exhaust fan and automatic valve shutoff mechanism, ensuring quick responses to gas leakage scenarios and offering improved user engagement.

V. WORKING OF PROPOSED SYSTEM

The proposed LPG gas cylinder trolley system is designed to provide enhanced safety by detecting hazardous conditions such as gas leaks and fires, while also monitoring the weight of the gas cylinder. The core of the system is a microcontroller (PIC18F4520) that interfaces with multiple sensors, actuators, and wireless communication modules to manage the entire process of hazard detection and response. The system is powered by a 12V battery, which is regulated down to 5V using a voltage regulator to supply the necessary power to the microcontroller and sensors. Capacitors and diodes are included in the circuit for noise filtering and to protect the system from voltage fluctuations, ensuring a stable power supply to all components.

The microcontroller plays a central role in the system by receiving input data from the various sensors. The LPG gas sensor detects any gas leakage by monitoring the concentration of LPG in the environment. Once the concentration exceeds a certain threshold, the sensor sends a signal to the microcontroller. The microcontroller then activates an alarm and sends a signal to the actuator to close the gas valve, preventing further leakage. Simultaneously, the system turns on the exhaust fan, which is controlled by the microcontroller, to ventilate the area and disperse any accumulated gas, reducing the risk of fire or explosion.

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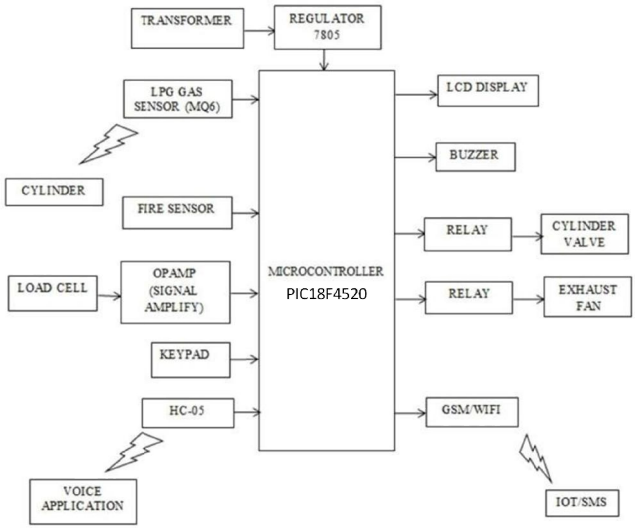

Fig.1 System Architecture

In addition to the LPG gas sensor, the system also includes a fire sensor, which continuously monitors the environment for the presence of fire. If the fire sensor detects any flame or heat, it signals the microcontroller to trigger an alarm, activate the exhaust fan, and shut off the gas valve, ensuring that no further fuel is available to the fire. Another important sensor in the system is the load cell, which monitors the weight of the gas cylinder. If the weight of the cylinder falls below a predefined threshold, indicating that the gas is running low, the system sends an alert to notify the user to replace the cylinder.

The system's actuators, such as the gas valve control and the exhaust fan, are powered by transistors (BC547) that act as switches. When the microcontroller processes a sensor's input and determines that a hazardous situation exists, it sends a signal to the corresponding transistor. The transistor then controls the higher power devices, such as the gas valve and exhaust fan, by allowing the current to flow through them. This automatic response system ensures that the hazards are addressed swiftly, minimizing the potential risks of gas leaks and fires.

The proposed system also includes wireless communication modules for remote control and monitoring. The Bluetooth module (HC05) enables the user to interact with the system through voice commands, allowing for actions like shutting off the gas valve or turning on the exhaust fan from a distance. The GSM module adds another layer of functionality by sending SMS alerts to the user or emergency services in case of an emergency, ensuring that the system can be monitored and controlled even if the user is not physically present.

In addition to the primary safety features, the system provides visual and audible indicators to inform the user about the current status. LEDs are used to display different statuses, such as whether the gas leak detection system is active, if the exhaust fan is running, or if the system is powered on. The buzzer provides an audible warning in the event of a gas leak or fire, ensuring that the user is alerted immediately. The combination of these indicators ensures that the user is well-informed about the system's operation and any potential dangers.

Overall, the working of the proposed system combines real-time monitoring, automatic response mechanisms, and remote communication capabilities to provide a comprehensive and effective safety solution for LPG gas cylinders. By integrating multiple sensors, actuators, and communication modules, the system not only detects and responds to gas leaks and fire hazards but also ensures that users are informed and can take action in case of an emergency, significantly reducing the risk of accidents and improving overall safety.

VI. DISCUSSION AND SUMMARY

The working of the proposed LPG Gas Cylinder Trolley system is designed to enhance safety by detecting gas leaks, fires, and monitoring the cylinder's weight while providing real-time alerts and responses. The system integrates multiple sensors, a microcontroller, and wireless

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communication modules to create a comprehensive safety mechanism. The key components and their functionalities are outlined below:

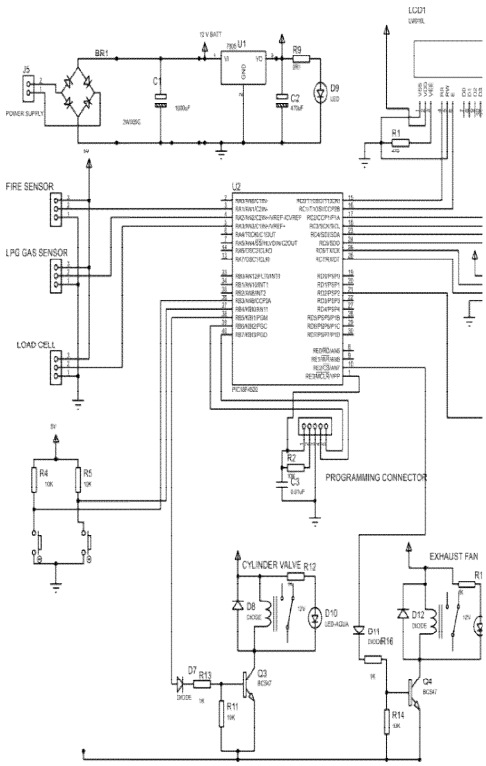

Fig.2 Circuit Diagram

Power Supply: The system operates on a 12V battery, which powers all components. The power is regulated by a voltage regulator (7805), which steps down the voltage to 5V to safely power the microcontroller, sensors, and communication modules. Capacitors and diodes are used for noise filtering and protection against voltage spikes, ensuring stable operation.

Microcontroller (PIC18F4520): The microcontroller serves as the brain of the system. It is responsible for processing data from the sensors and controlling the actuators and communication modules. It receives inputs from the LPG gas sensor, fire sensor, and load cell. Based on the sensor readings, the microcontroller takes necessary actions such as activating alarms, turning off the gas valve, or triggering the exhaust fan.

Sensors:

LPG Gas Sensor: This sensor detects any leakage of LPG gas. When the gas concentration exceeds a certain threshold, it sends a signal to the microcontroller, which triggers an alarm and closes the gas valve to prevent further leakage.

Fire Sensor: The fire sensor detects the presence of fire or flame in the vicinity. If a fire is detected, the microcontroller activates the alarm system and triggers the appropriate safety measures, such as closing the gas valve and turning on the exhaust fan.

Load Cell: The load cell continuously measures the weight of the gas cylinder, allowing the system to monitor the amount of gas remaining. When the weight drops below a predefined threshold, the system alerts the user that the gas is running low.

Actuators:

Gas Valve Control: The system uses a 12V actuator, which is controlled by the microcontroller via a transistor (BC547). In case of gas leakage or fire detection, the microcontroller sends a signal to the transistor, which then controls the actuator to close the gas valve, stopping the flow of gas.

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Exhaust Fan Control: To ventilate any leaked gas, the microcontroller triggers a 12V exhaust fan (via another transistor), which helps dissipate the gas and reduces the chances of an explosion or fire. The exhaust fan is activated when a gas leak is detected.

Indicating Devices:

LEDs: The system uses various LEDs to display the current status of the system. These include indicators for gas leakage detection, fire detection, and the operation of the exhaust fan. The LEDs provide visual feedback to the user about the status of the system.

Buzzer: In addition to LEDs, a buzzer is employed to sound an audible alarm in the event of a gas leak or fire, alerting the users to take immediate action.

Wireless Communication Modules:

Bluetooth Module (HC05): The system is equipped with a Bluetooth module that allows users to control and monitor the system remotely via voice commands. Users can issue commands to shut off the gas valve or activate the exhaust fan through a smartphone or a Bluetooth- enabled device.

GSM Module: The GSM module sends SMS alerts to users or emergency responders if a gas leak or fire is detected. This feature ensures that even when the user is not present in the vicinity, they will be notified in case of an emergency.

Signal Conditioning and Protection: Capacitors and diodes are strategically placed to filter out noise from the power supply and to protect the system from voltage spikes or reverse polarity issues. Diodes are also used to ensure proper current flow direction and to safeguard sensitive components from overcurrent conditions

User Interface and Control:

The system offers a user-friendly interface that integrates both visual and audible indicators, ensuring that the user can quickly assess the system's status.

Voice control through the Bluetooth module adds an extra layer of convenience, allowing users to interact with the system without the need for physical interaction.

Emergency Shutdown Mechanism: If a gas leak or fire is detected, the system automatically shuts off the gas valve and activates the exhaust fan. This emergency shutdown feature prevents the accumulation of hazardous gases and minimizes the risk of explosion or fire, enhancing overall safety.

Real-Time Monitoring: The microcontroller continuously monitors the sensor data to detect any dangerous conditions in real time. Upon detecting a gas leak or fire, the system responds immediately, providing both local (alarm, LED indicators) and remote (SMS alert) notifications, ensuring timely action.

In summary, the proposed LPG gas cylinder trolley system integrates sensors, actuators, a microcontroller, and wireless communication to provide a highly responsive and reliable safety mechanism. This system ensures the detection of gas leaks and fires, automatic valve shutoff, ventilation, and real-time alerts, making it a comprehensive solution for LPG cylinder safety

VII. RESULT

Fig.3 Hardware Interface

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The LPG gas cylinder trolley system successfully integrates multiple safety features, ensuring both proactive and reactive measures to prevent accidents involving gas leaks, fire, and low gas levels. The system's real-time response to hazardous conditions, such as gas leakage or fire detection, is highly efficient. Once a hazard is detected, the system automatically triggers the exhaust fan to ventilate the area and closes the gas cylinder valve to stop the gas flow, minimizing the risk of explosions or fire escalation. Additionally, the remote monitoring and control via Bluetooth and GSM modules enhance the system's usability, allowing users to interact with and monitor the system from a distance. Alerts are promptly sent through SMS or voice notifications, ensuring timely response from the user or emergency services.

Fig.4 Software Interface

Key results observed in the system's performance:

- **Real-time Detection and Response**: The gas and fire sensors accurately detect hazardous conditions and initiate immediate actions such as activating the exhaust fan and closing the gas valve.
- **User Interface**: Bluetooth and GSM modules enable remote control and monitoring, allowing users to send commands or receive alerts even from a distance.
- **Effective Safety Measures**: The system's automatic shutdown feature (in case of gas leaks or fire) helps prevent potentially dangerous situations.
- **Visual and Audible Indicators**: LEDs and buzzers effectively communicate system status and alerts, providing clear feedback for the user.
- **Modularity and Expandability**: The system can be enhanced by integrating additional sensors or communication modules, improving its adaptability to different environments.

Overall, the system provides a comprehensive, reliable, and user-friendly safety solution for managing LPG gas cylinders.

VIII. FUTURE SCOPE

The system can be enhanced by integrating advanced sensors such as smoke and temperature detectors for better hazard detection. Additionally, incorporating machine learning algorithms for predictive maintenance and gas usage analysis could further optimize safety and efficiency.

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IX. CONCLUSION

In conclusion, the LPG gas cylinder trolley with integrated safety features provides an effective solution to detect and prevent hazardous situations such as gas leaks and fire incidents. The system, powered by a microcontroller, leverages sensors, wireless communication modules, and actuators to ensure real-time monitoring and response. With the addition of voice control and emergency shutdown mechanisms, it offers enhanced safety, making it an essential tool for both household and industrial environments. The system's modular design also allows for future enhancements, ensuring long-term usability and reliability.

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