

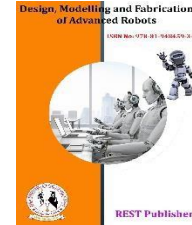


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Smart Emergency Shutdown System for Hazardous Gas Leak Prevention in Industrial Environments

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Abstract: Industrial factories handling combustible and toxic gases face persistent risks of gas leaks that can lead to hazardous conditions such as explosions, fires, and toxic exposure. This paper presents the design and development of a Smart Emergency Shutdown System (SESS) that continuously monitors hazardous gas levels and automatically initiates shutdown protocols to mitigate risks. The system integrates multi-gas sensors, microcontroller-based automation, and IoT-enabled communication for real-time detection and rapid intervention. Experimental results demonstrate reliable detection, fast response, and compatibility with industrial safety standards, enhancing factory safety and regulatory compliance.

Keywords: Hazardous gas detection, emergency shutdown, IoT monitoring, factory safety, industrial automation.

1. INTRODUCTION

Industrial environments dealing with combustible or toxic gases face a constant threat of leaks that can lead to explosions, fires, or health hazards. Conventional manual monitoring and delayed emergency responses often prove insufficient to prevent catastrophic incidents. The increasing adoption of smart and automated systems has paved the way for proactive safety mechanisms. This research introduces a Smart Emergency Shutdown System (SESS) designed to detect hazardous gases and initiate immediate safety actions through IoT-enabled automation and monitoring.

2. LITERATURE REVIEW

Modern industrial safety has evolved with the integration of intelligent sensors and automation systems. Researchers have explored gas sensing technologies using semiconductor, electrochemical, and photoionization principles for precise detection. IoT frameworks enable data transmission, remote monitoring, and predictive maintenance, significantly improving hazard response. However, challenges such as sensor drift, false alarms, and communication latency remain key research areas. Recent works emphasize combining sensor fusion and edge computing to improve accuracy and reliability in industrial safety systems.

3. SYSTEM DESIGN

The proposed SESS comprises multiple gas sensors strategically deployed near potential leak points in factories. Sensor data is continuously monitored by an ESP32 microcontroller, which processes readings and activates safety mechanisms when gas concentrations exceed defined thresholds. Upon detection, the system initiates equipment shutdown, activates alarms, and sends real-time notifications through IoT platforms. Wireless connectivity ensures data visibility on both control room dashboards and mobile devices.

4. COMPONENTS

- Gas Sensors (MQ-series): Detects methane, carbon monoxide, and VOCs. • Microcontroller (ESP32): Central control and processing unit with Wi-Fi connectivity.
- Communication Modules (Wi-Fi/LoRa): Enables long-range and reliable data transmission. • Relays and Actuators: Disconnects power to hazardous equipment during shutdown.
- Alarm Units: Buzzers and LEDs provide immediate local alerts.
- Power Supply: Regulated DC supply with UPS or battery backup for continuous operation.

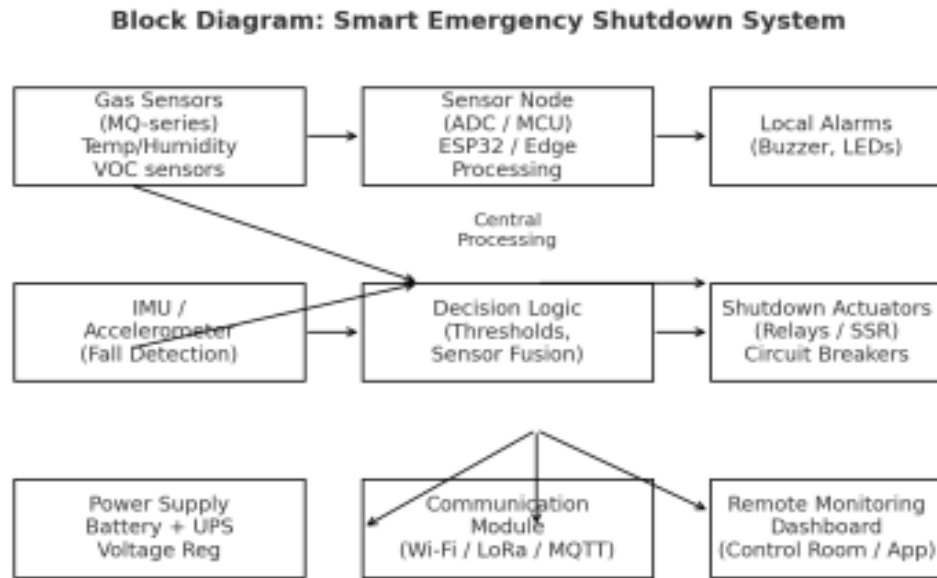


FIGURE 1.

5. CONCLUSION

The Smart Emergency Shutdown System effectively automates hazardous gas detection and mitigates risks in industrial environments. It ensures immediate action through automated shutdown, audible and visual alerts, and remote notifications. The system enhances plant safety, supports compliance with safety standards, and exemplifies the application of IoT in industrial hazard prevention. Future work will focus on expanding sensor networks, integrating AI-based predictive maintenance, and optimizing communication for large-scale factory applications.

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