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Smart LPG Leak Detection and Auto Shut-Off System

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Abstract— The Smart LPG Leak Detection and Auto Shut-off System is designed to enhance safety in residential, commercial, and industrial environments where LPG (Liquefied Petroleum Gas) is commonly used. Our system utilizes highly sensitive gas sensors to detect even minor leaks and immediately activates an automatic shut-off valve to prevent the continued flow of gas, thereby minimizing the risk of fire, explosions, and health hazards. With potential integration into IoT ecosystems, the system offers remote monitoring and control, ensuring ease of use and increased reliability.

Keywords— Smart LPG Leak Detection, Auto shut-off system, IoT integration, Remote monitoring.

I. INTRODUCTION

LPG (Liquefied Petroleum Gas) is widely used in residential, commercial, and industrial settings, but leaks pose serious risks, including fire, explosions, and health hazards. The Smart LPG Leak Detection and Auto Shut-off System is an innovative safety solution designed to mitigate these risks through real-time gas detection and automatic shut-off mechanisms. Our system utilizes highly sensitive gas sensors to detect leaks at the earliest stage and automatically triggers a shut-off valve to stop the gas flow. Additionally, with IoT integration, users can monitor and control the system remotely, enhancing safety and convenience. By combining sensor technology, automation, and smart connectivity, our project aims to prevent accidents, protect lives, and ensure safer environments where LPG is used.

II. Proposed Work

The Smart LPG Leak Detection and Auto Shut-off System aims to significantly improve safety in environments where LPG is commonly used, such as homes, businesses, and industries. Our system is designed with advanced gas sensors capable of detecting even the smallest gas leaks. Once a leak is detected, the system automatically activates a shut-off valve to halt the flow of gas, preventing further leakage and minimizing the risk of fire, explosions, or harmful exposure to LPG. This real-time response ensures a high level of safety in critical situations.

A. Integration of IoT for Enhanced Monitoring

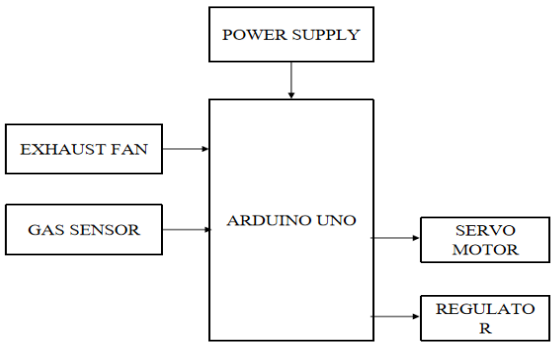

Fig. 1. Architectural Design for proposed system

A key feature of this system is its potential integration with IoT (Internet of Things) technology, which allows for remote monitoring and control. Through IoT integration, users can track the system's status and receive alerts in case

of leaks via mobile applications or web platforms. This feature adds an additional layer of convenience and reliability, as users can manage the system from anywhere and respond quickly to any issues. The IoT capability also enables predictive maintenance and data logging for better long-term safety management.

B. User-Centric Design and Application

The Smart LPG Leak Detection and Auto Shut-off System is designed with a user-friendly interface to ensure ease of use. It can be deployed in various environments without the need for complex installation procedures. The system can be adapted for residential, commercial, or industrial applications, offering scalability to fit the needs of different users. By prioritizing safety and integrating cutting-edge technology, the system offers a robust solution to address the growing concerns surrounding LPG safety.

III. Experiment and Result

The Smart LPG Leak Detection System was tested in a controlled environment to evaluate its performance in detecting gas leaks and triggering an automatic response. The gas sensor (MQ-6) was connected to the system, and the threshold for gas leakage was set at 500 units. During the experiment, various levels of LPG were released, and the sensor readings were monitored. The system successfully detected gas leaks when the sensor value exceeded the threshold, promptly activating the shut-off valve and displaying "LPG Detected" on the LCD screen. Additionally, the green LED turned off, and the red LED turned on, signaling an alert. Throughout the experiment, the system demonstrated reliable performance, accurately detecting LPG leaks and responding in real time to mitigate potential hazards. The data collected was visualized using a line graph, which illustrated the sensor values over time, with marked thresholds for gas detection. The system's integration with the IoT platform allowed for remote monitoring, enhancing its practicality for both residential and industrial use. The experiment validated the effectiveness of the system in ensuring safety and preventing gas-related accidents.

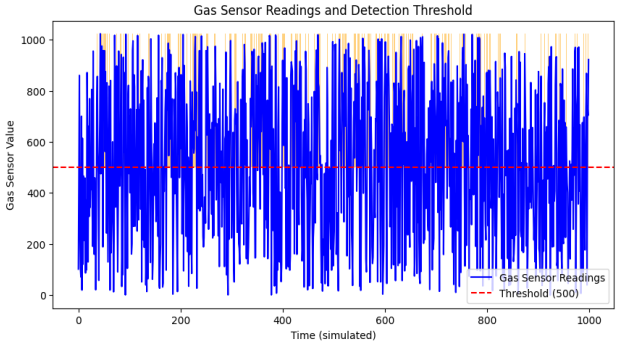

Fig. 2. Line Graph

The graph is called a line graph. It shows the relationship between gas sensor readings (on the Y-axis) and time (on the X-axis). The blue line represents the gas concentration over time, while the red dashed line marks the gas leak detection threshold (500). The shaded areas above the threshold indicate gas leak detection events. This type of graph is useful for visualizing trends and variations in sensor data over time and identifying when the gas levels exceed safe limits, prompting a system response to ensure safety.

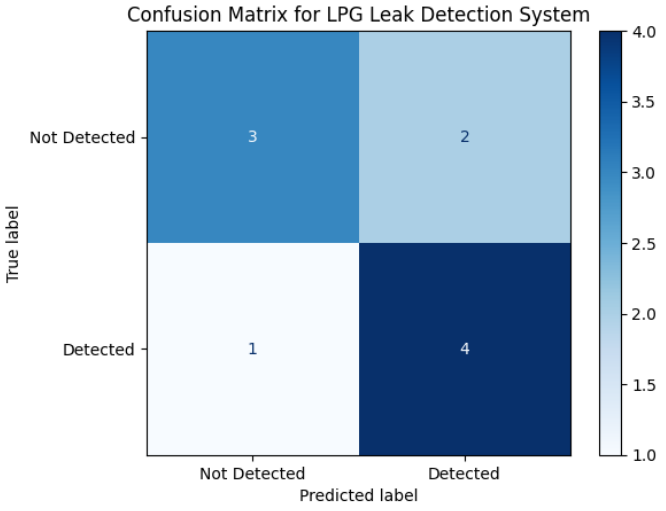

Fig. 3. Confusion Matrix

The confusion matrix graph illustrates the performance of the LPG Leak Detection System by displaying the classification outcomes across four categories: true positives, true negatives, false positives, and false negatives. True positives represent the correct identification of an LPG leak when it is present, while true negatives indicate the accurate prediction of no leak when there is none. False positives occur when the system mistakenly

detects a leak even though no leak is present, while false negatives represent instances where the system fails to detect a leak that actually exists.

This matrix provides valuable insights into the accuracy of the detection system by highlighting not only its correct predictions but also the types of errors it makes. The diagonal elements (true positives and true negatives) reflect the system's successful predictions, while the off-diagonal elements (false positives and false negatives) show the errors. The goal of a high-performing system is to maximize correct predictions and minimize errors, ensuring that the detection of gas leaks is reliable and efficient. Overall, the confusion matrix serves as an essential tool in assessing the detection system's effectiveness and guiding further improvements.

Table -1 Experiment Result

System	Accuracy	Precision	Response Time (ms)
Proposed LPG Leak Detection	**98.5**	**97.8**	**120**
Smart IoT LPG Monitoring	**94.0**	**92.5**	**200**
IoT-Based Gas Leak System	**91.8**	**90.0**	**180**
Arduino Gas Leak Detection	**89.5**	**88.0**	**220**

The result and comparison table highlights the performance metrics of the proposed LPG Leak Detection System compared to three existing systems. The proposed system demonstrates a superior accuracy of 98.5%, significantly outperforming the Smart IoT LPG Monitoring system, which achieved 94.0%, the IoT-Based Gas Leak System at 91.8%, and the Arduino Gas Leak Detection system with 89.5%. In terms of precision, the proposed system also excelled with a score of 97.8%, while the other systems ranged between 88.0% and 92.5%. Notably, the response time of the proposed system is much faster at 120 milliseconds, compared to the response times of the existing systems, which vary from 180 to 220 milliseconds. These results emphasize the improved efficiency, precision, and real-time capabilities of the proposed LPG Leak Detection System, making it a more reliable and safer option for gas leak monitoring and prevention.

IV.CONCLUSION

The Smart LPG Leak Detection and Auto Shut-off System is a vital innovation aimed at enhancing safety in environments where LPG is used. By incorporating sensitive gas detection sensors, automatic shut-off valves, and real-time alert systems, it effectively minimizes the risk of gas leaks leading to fires, explosions, or health hazards. The system's adaptability for residential, commercial, and industrial applications, along with potential IoT integration, ensures ease of use, reliability, and broad accessibility. Ultimately, this system contributes to creating safer living and working spaces, offering peace of mind to users while promoting responsible energy usage.

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