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Smart LPG Cylinder Monitoring and Explosion Management System

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ABSTRACT: In the present day, real-time resident security is very important for every location. Whether it is used to protect various events. When serious events occur it can be alert, collecting various incidents and analysis of potential issues to use security planning and to protect future incidents. Therefore, the Internet of Things (IoT) can be used as a security system to solve issues with inspection of various incidents as a preliminary notification before serious incidents occur such as ventilation issues, fire, or pollution that affect people living inside the building. Our design makes a smart smoke and fire detector more efficient by using smoke and heat sensors from ESP32 for monitoring notifications, storing data, and displaying to prevent incidents in the future and will be able to use the collected data to analyze and plan for future issues. This research aims to design a better detector of fire and pollution for residents or any building by using NODEMCU, and Sensors.

KEYWORDS: LPG Cylinder, Leakage Detection, Internet of Things (IoT), Explosion Management.

I. INTRODUCTION

Gas leakage represents a significant safety risk in both residential and industrial settings, necessitating the implementation of robust detection and alert systems. Utilizing readily available components such as Node MCU, gas sensors, LCD display, servo motors, buzzers, and the Telegram API, a comprehensive gas leakage detection and alert system can be developed. This system serves to promptly identify gas leaks, activate necessary safety measures such as shutting off the gas supply or ventilating the area, and crucially, alert users remotely via the Telegram application. By integrating these components, users can receive timely notifications and take appropriate action to mitigate the potential hazards posed by gas leaks, enhancing overall safety and peace of mind.

II. LITERATURE REVIEW

S. Vijayalakshmi and P. Vijayakumar published in the International Journal of Advanced Research in Electrical, Electronics, and Instrumentation Engineering in 2015, delves into the development and implementation of an LPG Gas Leakage Monitoring and Alert System. This paper underscores the importance of detecting gas leaks, issuing timely alerts, and implementing measures to shut off gas supplies, thereby mitigating potential accidents. Furthermore, it provides valuable insights into the essential hardware and software components essential for effectively monitoring LPG cylinders and managing gas leaks.

P. Suresh Kumar, S. A. B. Rizvi, S. Sharma, and R. Kumar, and presented at the 2017 International Conference on Internet of Things and Renewable Energy (ICITRE), introduced an IoT-Based LPG Gas Cylinder Monitoring and Leakage Detection System. This paper proposes a sophisticated architecture comprising a wireless sensor network and a cloud-based platform. These elements facilitate real-time monitoring, data analysis, and the establishment of standards and protocols to ensure seamless integration with existing systems and devices.

Additionally, several critical aspects must be considered in the development and implementation of the gas leakage detection and alert system. Privacy concerns demand strict adherence to data protection regulations, empowering users with control over their personal data and privacy preferences. Furthermore, the system's maintainability is crucial, necessitating well-documented, modular code for efficient troubleshooting, bug fixing, and future enhancements. Compliance with industry standards and safety guidelines is non-negotiable, ensuring the system's alignment with both local and international regulations. Finally, robust backup and disaster recovery mechanisms are essential to guarantee the system's resilience and availability in the face of unforeseen events or disasters.

Authored by S. J. Patel, A. D. Shah, and M. C. Pandya, this study, published in the International Journal of Engineering Research and Applications in 2014, introduces a sophisticated gas cylinder monitoring system leveraging wireless

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sensor networks (WSNs). The research discusses the strategic placement of sensor nodes on LPG cylinders to monitor crucial parameters such as gas levels, temperature, and pressure. Furthermore, it investigates the utilization of WSNs for seamless data transmission, aggregation, and remote monitoring. Through the integration of sensors, WSNs, and software components, the study emphasizes the system's efficiency in monitoring and managing LPG cylinders.

In the 2018 4th International Conference on Computing Communication Control and Automation (ICCUBEA), A. R. Joshi and R. A. Dube present their research on wireless sensor networks for LPG leakage detection and prevention. Their paper outlines the design and implementation of a system based on wireless sensor networks, which integrates gas sensors, microcontrollers, and a central monitoring unit. The study underscores the critical importance of real-time monitoring, early detection of gas leaks, and the implementation of automated response mechanisms to effectively mitigate risks associated with LPG usage.

III. PROPOSED METHOD

The usage of Liquefied Petroleum Gas (LPG) cylinders in households and commercial establishments poses significant safety risks due to potential gas leaks and the risk of explosions. Traditional methods of monitoring LPG cylinders are often inadequate and rely heavily on manual intervention, which can lead to delayed detection of leaks or improper management of potential explosions. Therefore, there is a critical need for a comprehensive Smart LPG Cylinder Monitoring and Explosion Management to address the following issues:

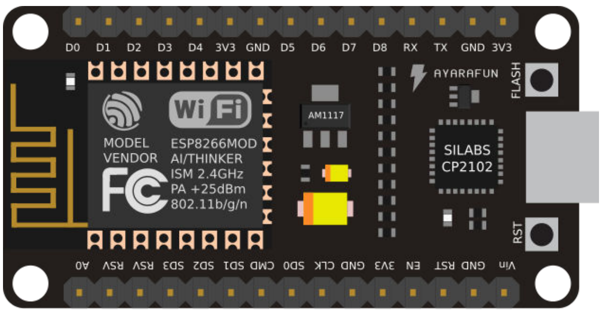
1. Inefficient Monitoring - Existing monitoring mechanisms for LPG cylinders lack real-time data collection and tracking capabilities. This hampers the ability to promptly identify issues such as gas leaks, low cylinder levels, or abnormal pressure and temperature readings.
2. Delayed Leaked Detection - Gas leaks can lead to hazardous situations, including fire and explosions. Current methods rely on visual inspection or manual detection, resulting in delayed identification of leaks, putting lives and properties at risk.
3. Lack of Automated Response In the event of a potential gas leak or explosion, there is a lack of automated systems that can swiftly respond and take necessary preventive measures. This often leads to further escalation of the situation before appropriate actions can be taken.
4. Compatibility Challenges - The integration of smart technologies with existing LPG cylinder infrastructure and appliances can be challenging due to compatibility issues. Ensuring seamless interoperability between different components is crucial for the successful implementation of a comprehensive monitoring and management system.

System Design and Architecture: The methodology commences with the design and architecture of the IoT-based LPG Monitoring and Explosion Management System. This involves conceptualizing the system components, defining communication protocols, and establishing data flow mechanisms. The architecture is designed to accommodate Safety mechanisms, Automated response, and interoperability with other management systems components.

Selection of IoT Devices and Sensors: Following system design, suitable IoT devices and sensors are meticulously chosen based on the specific requirements of LPG monitoring and Explosion Management systems. These devices may include gas sensors, Node MCU, Step down transformer, Servo motor, Carbon monoxide Sensor (mq-7), Buzzer, and Liquid Crystal Display. The selection process emphasizes compatibility, reliability, and accuracy to ensure robust data collection.

NODEMCU:

Node MCU is an open-source IOT platform. It includes firmware that runs on the ESP8266 Wi-Fi soc from Espressif Systems, and hardware that is based on the ESP-12 module. The term "Node MCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the elua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open-source projects, such as lua-cjson, and spiffs.



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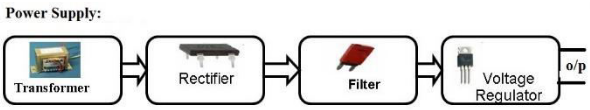
REGULATOR POWER SUPPLY:

A **regulated power supply** is an embedded circuit; it converts unregulated AC into a constant DC. With the help of a rectifier it converts AC supply into DC. Its function is to supply a stable voltage (or less often current), to a circuit or device that must be operated within certain power supply limits. The output from the regulated power supply may be alternating or unidirectional but is nearly always DC.

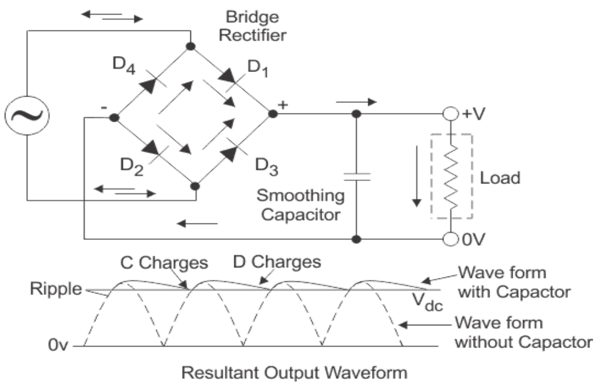


Step Down Transformer:

A step-down will step down the voltage from the AC mains to the required voltage level. The turn ratio of the transformer is so adjusted such as to obtain the required voltage value. The output of the transformer is given as an input to the rectifier circuit.

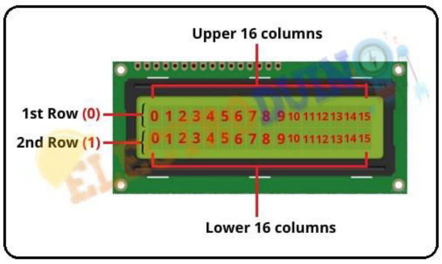
DC Filtration:

The rectified voltage from the rectifier is a pulsating DC voltage having a very high ripple content. But this is not what we want, we want a pure ripple-free DC waveform. Hence a filter is used. Different types of filters are used such as capacitor filter, LC filter, Choke input filter, π type filter. The figure below shows a capacitor filter connected along the output of the rectifier and the resultant output waveform.



LIQUID CRYSTAL DISPLAY:

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.



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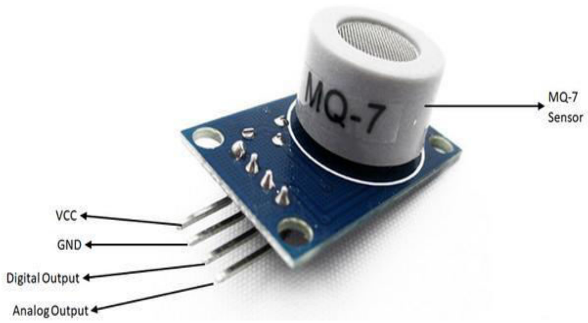
SERVO MOTOR:

A **servo motor** is an electrical device that can push or rotate an object with great precision. If you want to rotate and object at some specific angles or distance, then you use servo motor. It is just made up of simple motor which run through **servo mechanism**. If motor is used is DC powered then it is called DC servo motor, and if it is AC powered motor then it is called AC servo motor. We can get a very high torque servo motor in a small and light weight packages. Doe to these features they are being used in many applications like toy car, RC helicopters and planes, Robotics, Machine etc.

CARBON MONOXIDE SENSOR (MQ-7):

MQ-7 is a Carbon Monoxide (CO) sensor, suitable for sensing Carbon Monoxide concentrations (PPM) in the air. The MQ-7 sensor can measure CO concentrations ranging from 20 to 2000ppm.This sensor has a high sensitivity and fast response time. The sensor's output is an analog resistance. The drive circuit is very simple , just a voltage divider; all you need to do is power the heater coil with 5V DC or AC , add a load resistance, and connect the output to an ADC or a simple OPAMP comparator.



BUZZER:

The **piezo buzzer** produces sound based on the reverse of the piezoelectric effect. The generation of pressure variation or strain by the application of electric potential across a piezoelectric material is the underlying principle. These buzzers can be used to alert a user of an event corresponding to a switching action, counter signal, or sensor input. They are also used in alarm circuits. The buzzer produces the same noisy sound irrespective of the voltage variation applied to it. It consists of piezo crystals between two conductors. When a potential is applied across these crystals, they push on one conductor and pull on the other. This push-and-pull action, results in a sound wave. Most buzzers produce sound in the range of 2 to 4 kHz.

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Deployment of IoT Devices: Once selected, the IoT devices are strategically deployed within solar installations, considering factors such as panel orientation, shading, and accessibility. Installation locations are chosen to maximize data collection coverage while minimizing interference and obstructions. Proper installation procedures are followed to ensure device stability and longevity in varying environmental conditions.

Data Acquisition and Transmission: With the IoT devices deployed, data acquisition begins, capturing real-time information on energy production, environmental parameters, and system performance metrics. The collected data is transmitted securely to the central monitoring system through wired or wireless communication channels, adhering to industry standards and encryption protocols to safeguard data integrity and privacy.

Data Processing and Analysis: Upon receiving the data, the central monitoring system processes and analyzes it using advanced analytics algorithms. Data preprocessing techniques are employed to clean, aggregate, and normalize the data for analysis. Advanced analytics methods, such as statistical modeling, machine learning, and anomaly detection, are applied to extract actionable insights and identify performance trends.

Integration with Telegram: To enhance interoperability and functionality, the LPG Monitoring and Explosion Management System may be integrated with Telegram, so that it can notify us through the notification which is automated response initiated by micro controller.

Testing and Validation: Finally, the developed LPG Monitoring and Explosion Management undergoes comprehensive testing and validation to ensure accuracy, reliability, and compliance with user requirements. Test scenarios simulate various operating conditions and validate system performance and resilience under diverse scenarios.

IV. PROPOSED METHOD

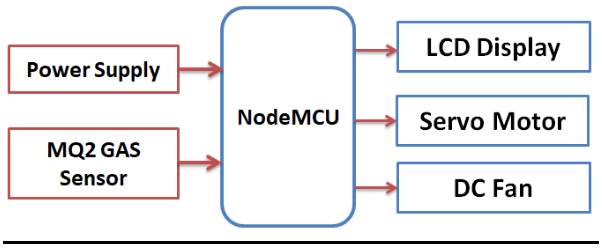

Fig 4.1 proposed method

Power integration: The system incorporates step down transformer to convert AC to DC electrical energy, which is then used to power the IoT devices and sensors

Monitoring system: The IoT-based LPG monitoring system is designed to control and monitor the gas leakage, including gas sensors, buzzer, and micro-controller.

Gas Leakage and Explosion Monitoring: The system monitors the gas accumulated near the device to optimize their output and ensure effective leakage detection and explosion management.

Real-time Detection and Notifing : The IoT-based monitoring system offers real-time detection of gas leakage around the device and instant notification through Telegram, which improves the efficiency of gas detection and provides the opportunity to take quick action.

Telegram integration: The system uses a messenger platform which is Telegram, By using Telegram Bot to notify the gas leakage status based on the data from the sensors and connected IoT devices, enabling remote monitoring and analysis.

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Automated Response: The IoT-based monitoring system allows for taking automated actions such as, alerting the gas leakage early on using a buzzer and taking corrective measures like turning the gas regulator and turning the exhaust fan to disperse the gas leaked that can prevent accidents that may occur.

V. EXPERIMENT RESULTS

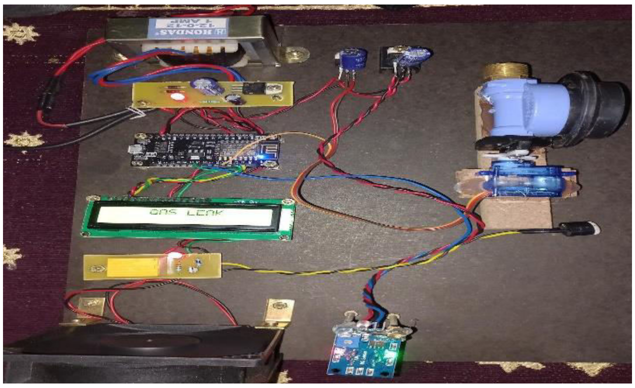

Figure 1: Device

Experiment-1: When the device turned on the gas sensor starts detecting the gases around the device for detecting the gas leakage. As there was no gas leakage it shows no gas leakage text on the LCD.

Figure 2: NO gas Leakage

Experiment 2: When as gas source such as a lighter brought near the device it senses the gas and displays the Gas Leak on the LCD

Figure 3: Gas Leak

When the gas leakage detected we are alerted through a buzzer and by Node MCU takes multiple actions like using Telegram Bot is notifies us of the gas leak detected. Simultaneously turn-off the gas regulator with the help of servo motor, relay switches and turn-ons the exhaust fan so that the accumulated gas can be dispersed it automatically turn-offs when the gas is fully dispersed such that it doesn't cause a false detection.

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Figure 4: Notification

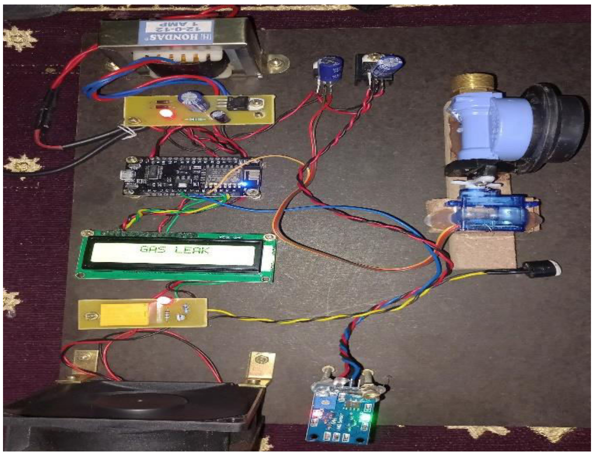

Figure 5: Regulator on

When the servo motor rotates it turn-offs the regulator

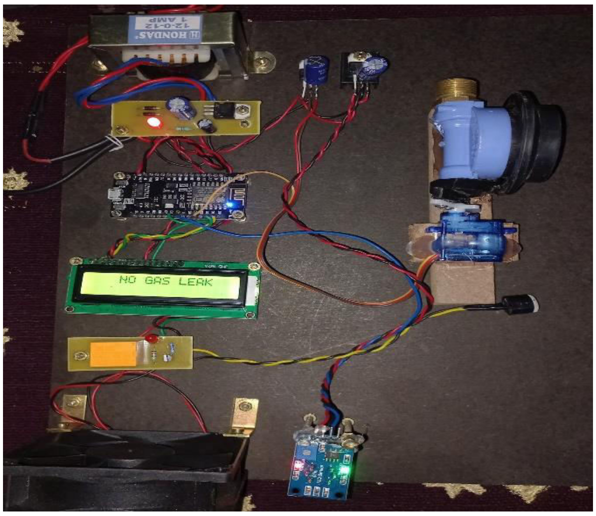

Figure 6: Regulator off

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Improved efficiency and performance:
By monitoring the gas around the device, it increases the accuracy of the gas leakage detection.
Early detection of issues like gas leakage or explosive sources such as fuels allows for preventive actions, reducing reaction time which improves the performance.

Remote monitoring:
Users can access real-time status about the device and gas leakage from anywhere through a Telegram Bot, enabling informed decision-making.
This data provides information such as there is a leakage or explosive source near the LPG cylinder so they can take action according to it and can avoid any accidents in the future with same cause.

VI. RESULTS AND DISCUSSION

The proposed system is deployed for motoring and Explosion management. The LPG device is placed on to the LPG Cylinder such as the Servo Motor is positioned in a way that it can rotate clockwise and counterclockwise. The MQ-7 gas sensor is placed in the open environment near the cooking stove and LPG Cylinder to monitor the PPM in the air molecules. The results are observed as follows.

S.no	Sensor readings	Servo motor rotation	regulator	action
1	Greater than 800 ppm	clockwise	off	LCD text, buzzer, notification, Exhaust fan
2	Less than 500 ppm after leakage	Anti-clockwise	on	

The above table shows the readings of the gas sensor and the actions responses accordingly. When the reading is less than 800 ppm it does not considers it as the gas leakage, but when it exceeds the 800 ppm then by considering it as leakage it turn-ons the relay switch 1 which makes the servo motor to rotate clockwise so that the regulator turn-offs. Simultaneously it shows the Gas leakage notification on LCD also sends notification through the Telegram Bot then turn-ons the Exhaust fan to disperse the gas and buzzer to notify leakage.

After the leakage is detected and taken care the actions takes place till the readings reach less than 500 ppm, when the reading is less than 500 ppm the relay switch 2 is turned on to rotate the Servo Motor anti-clockwise to turn on the regulator also changes the Text shown on LCD and turn-offs the buzzer and Exhaust fan.

VII. CONCLUSION

In conclusion, the Smart LPG Cylinder Monitoring and Explosion Management System represents a paradigm shift in ensuring the safety and reliability of LPG cylinder installations. Through the integration of cutting-edge sensors capable of real-time monitoring of gas leakage, the system offers early detection of potential hazards, such as leaks or

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abnormal pressure fluctuations, facilitating prompt intervention and accident prevention. Furthermore, its automated data collection and analysis, leveraging IoT (Internet of Things) technology, reduces dependence on manual monitoring, thereby enhancing operational efficiency and minimizing the risk of human error.

By automatically triggering the buzzer and activating advanced safety mechanisms, such as turning off the regulator automatically and turning on the Exhaust fan to disperse the gas, the system enables proactive risk management by addressing potential issues before they escalate into emergencies. Leveraging advanced sensor technology and machine learning algorithms ensures precise monitoring, minimizing false alarms and enhancing overall reliability. Additionally, further elevating safety and reliability standards.

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