Gasguard Autosafe System

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Abstract - Gas leakage is one of the most critical safety hazards in residential, commercial, and indstrial environments. Undetected leaks of Liquefied Petroleum Gas (LPG) or other combustible gases can lead to fire accidents, explosions, environmental damage, and loss of human life. Most conventional safety systems rely on manual inspection or delayed response mechanisms, which are often unreliable and inefficient during emergencies. To overcome these limitations, this paper presents the design and implementation of the GasGuard AutoSafe System, a smart, automated, and cost-effective gas leakage detection and prevention system.

The proposed system utilizes MQ-series gas sensors integrated with a microcontroller platform such as Arduino Uno to continuously monitor ambient gas concentration levels. When the detected gas concentration exceeds the predefined safety threshold, the system immediately activates a buzzer and LED indicator to provide local alerts. Simultaneously, a solenoid valve is triggered to automatically shut off the gas supply, thereby preventing further leakage and reducing the risk of accidents. For remote monitoring and rapid response, a module is incorporated to transmit SMS alerts or calling system to users and emergency authorities.

The system can be deployed in kitchens, restaurants, hotels, laboratories, and industrial plants The GasGuard AutoSafe System offers a reliable, real-time, and affordable solution for enhancing gas safety and protecting lives and property.

Key Words: *Industrial, GasGuard Autosafe, MQ-series sensors, ESP 32, Solenoid valve, real-time,Telegram bot*

1. INTRODUCTION

The use of combustible gases such as Liquefied Petroleum Gas (LPG), methane, and propane has become essential in modern households, commercial kitchens, laboratories, and industrial sectors due to their high calorific value, clean combustion characteristics, and economic benefits. LPG, in particular, is widely used for cooking, heating, and various industrial applications. Despite its advantages, the improper handling or leakage of these gases poses significant safety risks. Even a small accumulation of leaked gas in confined spaces can create highly explosive conditions, resulting in fire hazards, structural damage, environmental pollution, severe injuries, and loss of life. Since LPG is colorless and heavier than air, it tends to settle near the ground, making early detection difficult without proper monitoring systems.

Conventional gas safety measures primarily rely on manual inspection, odor detection, or basic alarm systems. These traditional approaches are often unreliable due to delayed human response, sensor inaccuracy, or lack of remote notification mechanisms. In many real-world scenarios, accidents occur because leaks remain undetected for extended periods. Furthermore, existing low-cost alarm systems only provide local audio alerts without implementing preventive control actions such as automatic gas shut-off. This limitation highlights the urgent need for an intelligent, automated, and proactive gas safety solution.

To address these challenges, this research presents the GasGuard AutoSafe System, a smart and cost-effective gas leakage detection and prevention system designed for real-time monitoring and immediate response. The proposed system integrates MQ-series gas sensors with microcontroller platforms such as Arduino Uno or ESP32 to continuously monitor ambient gas concentration levels. When the detected gas level exceeds a predefined safety threshold, the system activates multiple alert mechanisms, including buzzer alarms, LED indicators, and LCD display notifications, ensuring immediate local awareness.

In addition to on-site alerts, the system incorporates SIM800 module to transmit SMS notifications and automated calls to registered users and emergency authorities. This remote alert functionality ensures that necessary action can be taken even when the responsible person is not physically present at the location. To further enhance safety, the system includes a relay-controlled solenoid valve that automatically shuts off the gas supply upon detection of leakage, thereby preventing further gas accumulation and reducing the probability of catastrophic accidents.The GasGuard AutoSafe System is suitable for deployment in residential kitchens, hotels, restaurants, gas storage units, laboratories, and industrial plants. It can also be integrated with industrial monitoring systems such as SCADA for centralized supervision and large-scale safety management. By combining gas sensing technology, embedded control systems, automated actuation, and wireless communication, the proposed system offers improved safety, rapid response capability, operational reliability, and cost-effectiveness. Therefore, the GasGuard AutoSafe System represents a practical and scalable solution for enhancing gas safety standards in modern smart environments.

2. LITERATURE SURVEY

The paper titled "IoT Based Gas Leakage Monitoring and Alerting System with MQ-6 Sensor" by Rohan Chandra Pandey, Manish Verma, Lumesh Kumar Sahu, and Saurabh Deshmukh (2018) presents an IoT-enabled gas detection system using the MQ-6 sensor integrated with Raspberry Pi. The system monitors LPG

leakage and sends alert notifications through email and a web interface. Although the system effectively provides real-time monitoring and remote alerting, it mainly focuses on detection and notification. It does not incorporate an automatic gas shut-off mechanism such as a solenoid valve, which is essential to prevent further leakage during emergency situations. In contrast, the proposed GasGuard AutoSafe System integrates an automatic gas supply cut-off feature using a relay-controlled solenoid valve, thereby enhancing safety through both detection and prevention. [1]

The research work "Design and Implementation of Remote Monitoring System Based on GSM" by Chen Peijiang and Jiang Xuehua (2008) introduces a GSM-based monitoring system capable of sending SMS alerts in emergency conditions. The system demonstrates effective remote communication through GSM networks. However, it lacks continuous gas concentration monitoring with automated threshold control and does not provide multi-level alert mechanisms such as buzzer, LED, and LCD display together. The proposed GasGuard AutoSafe System improves upon this by combining real-time monitoring, local alerts, GSM-based SMS notifications, and automatic gas supply control in a unified system. [2]

In the study "Investigation of Gas Sensors for Vehicle Cabin Air Quality Monitoring" by K. Galatsis, W. Wlodarsla, K. Kalantar-Zadeh, and A. Trinchi (2002), metal oxide semiconductor (MOS) gas sensors were analyzed for sensitivity and response characteristics. The research mainly focuses on evaluating sensor performance and comparing gas sensing capabilities. However, it does not propose a complete safety solution integrating alert systems and preventive mechanisms. The GasGuard AutoSafe System utilizes MQ-series (MOS-based) sensors and extends their application by integrating embedded control, GSM alerts, and automated shutoff mechanisms for comprehensive hazard management. [3]

The paper "Intelligent Residential Security Alarm and Remote Control System Based on Single Chip Computer" by Liu Zhen-ya, Wang Zhen-dong, and Chen Rong (2008) presents a microcontroller-based security system that includes gas leakage detection and automatic alarm generation. The system can generate voice alerts and perform remote control operations. However, it lacks IoT-based monitoring capabilities and automated gas cutoff functionality. Additionally, its scalability for industrial applications is limited. The proposed GasGuard AutoSafe System overcomes these limitations by incorporating IoT support, GSM communication, and an automatic gas shutoff valve, making it suitable for both residential and industrial environments. [4]

Another study, "IoT Based Gas Leakage Detection System Using Arduino" by S. Shinde, S. Bhosale, P. Sonawane, and R. More (2019) proposes an Arduino-based gas detection system integrated with cloud-based monitoring. While the

heavily depends on continuous internet connectivity and primarily provides alert notifications without mechanical prevention mechanisms. In contrast, the GasGuard AutoSafe System ensures higher reliability by combining offline local alerts, GSM communication independent of internet connectivity, and immediate gas supply shutoff through a solenoid valve, thereby reducing response time and improving operational safety. [5]

3.   PROPOSED SOLUTION

The idea of the IoT-based GasGuard AutoSafe System is to provide real-time gas leakage detection along with automatic preventive action and remote alert capabilities. The system is designed to continuously monitor gas concentration levels in residential and industrial environments and immediately respond in case of leakage. By combining gas sensing technology, embedded systems, and IoT communication, the system ensures both local safety and remote monitoring support. The main components of the proposed system include an MQ-series gas sensor (such as MQ-2), an Arduino Uno microcontroller, a relay module, a solenoid valve, a GSM module (SIM800L), a buzzer, and an LCD display.

The MQ gas sensor continuously monitors the surrounding air to detect the presence of LPG, propane, or butane gases. The sensor outputs an analog signal proportional to the gas concentration, which is then read and processed by the Arduino Uno. The Arduino acts as the central processing unit of the system. It continuously compares the detected gas concentration with a predefined safety threshold. If the gas level exceeds the safe limit, the system immediately triggers multiple safety actions. First, a buzzer alarm and LED indicators are activated to alert people nearby. Simultaneously, the relay module is energized to control the solenoid valve, which automatically shuts off the gas supply to prevent further leakage.

This proactive mechanism significantly reduces the risk of fire or explosion. At the same time, the GSM module sends SMS alerts and may initiate emergency calls to registered users or authorities. This ensures that responsible persons are informed even if they are not physically present at the location. The LCD display provides real-time gas concentration status and system alerts for user awareness. The overall design follows a modular architecture, where sensing, processing, alerting, and gas control mechanisms are integrated but function independently.

This modular structure improves system reliability and allows easy upgrades, such as IoT cloud integration or mobile application support in the future. The proposed GasGuard AutoSafe System is affordable, easy to install, energy-efficient, and suitable for homes, hotels, restaurants, laboratories, and industrial facilities. It provides a practical and scalable solution to enhance gas safety and prevent accidents effectively.
system enables remote monitoring through IoT platforms, it

Figure 3.1:System Architecture for GasGuard

4.   METHODOLOGY

The proposed GasGuard AutoSafe System methodology focuses on the integration of Gas Sensing Technology, Embedded Processing, and IoT/GSM Communication to provide real-time gas leakage detection and automatic preventive response. The overall workflow begins from environmental gas sensing and extends to alert generation, gas supply shutdown, and remote notification.

Initially, the MQ-series gas sensor continuously monitors the

surrounding air to detect the presence of combustible gases such as LPG, propane, and butane. The sensor produces an analog voltage output proportional to the detected gas concentration. This analog signal is transmitted to the Arduino Uno microcontroller, which acts as the central processing unit of the system.

Upon receiving the sensor data, the Arduino performs real-time analysis by comparing the measured gas concentration value with a predefined safety threshold. If the detected value remains within safe limits, the system continues monitoring without triggering any action. However, if the gas concentration exceeds the threshold level, the system immediately enters emergency response mode.

In emergency mode, the Arduino simultaneously triggers multiple safety mechanisms. Second, the Arduino energizes a relay module that controls a solenoid valve installed in the gas pipeline. The solenoid valve automatically shuts off the gas supply, thereby preventing further gas accumulation and reducing the risk of fire or explosion.

At the same time, the Telegram bot is activated to send SMS alerts and initiate emergency voice calls to pre-registered mobile numbers. This ensures remote notification even in the absence of internet connectivity. The LCD display continuously shows the gas concentration level and system status, enhancing user awareness.

The system follows a modular architecture where sensing, processing, alerting, and gas control mechanisms operate independently but are interconnected. This modular design improves reliability and allows future enhancements such as IoT cloud integration, mobile application monitoring, or additional environmental sensors.

5.   HARDWARE & SOFTWARE REQUIREMENTS
5.1 Hardware Requirements
The hardware components form the physical foundation of the GasGuard AutoSafe system, with each element performing a critical role in detecting hazards and controlling gas flow. The Arduino Uno serves as the central controller, reading data from gas sensors such as MQ-2. Output devices including buzzers, LEDs, and LCD displays provide real-time alerts to users, while a solenoid valve automatically stops gas flow when dangerous levels are detected. Breadboards, jumper wires, and power supplies ensure proper assembly and connectivity of all components.

Figure 5.1: Hardware Component

Component	Purpose
Microcontroller ESP 32	ESP32 is used as a Wi-Fi and Bluetooth enabled microcontroller to control and monitor IoT devices
Breadboard	A breadboard is a board used to make electronic circuits without soldering.
Solenoid Valve	A solenoid valve is an electric valve that controls the flow of gas or liquid.
MQ2 sensor	Detects LPG and other harmful gases quickly
Buzzer	Produces loud sound alarm during gas leakage.
Jumper Wires	A jumper wire connects parts of a circuit
LCD	A LCD is used to display text or data in electronic projects.
Resistor	Limits and controls electrical current flow safely
Single Relay	Controls one high-voltage device using low-voltage signal.

5.1   Software Requirements
The software components provide the intelligence needed to monitor gas levels, trigger alerts, and control safety mechanisms. The Arduino IDE programs the Arduino using C/C++ style commands to read sensor data (analogRead),detect threshold breaches (if statements), activate alarms (digitalWrite), and

control the solenoid valve to stop gas flow. This ensures the system operates efficiently and provides timely protection against hazardous gas exposure.

Software / Library	Purpose
Arduino IDE	The Arduino IDE is used to write, compile, and upload programs to the Arduino for controlling sensors and devices.
Telegram bot	Telegram bot is a software component used to send and receive messages automatically through Telegram.
C/C++ command	Arduino code is C/C++ with built-in functions to control hardware.

6.   RESULTS & OUTPUT

The proposed GasGuard AutoSafe System was implemented and tested in real-time domestic and laboratory environments to evaluate its effectiveness in detecting LPG gas leakage and providing immediate safety measures. The system integrates an ESP32 microcontroller with an MQ-2 gas sensor, buzzer alarm, relay-controlled exhaust fan, LCD display, and Telegram Bot notification service.During testing, the MQ-2 sensor successfully detected LPG, methane, and smoke when gas concentration exceeded the predefined threshold value. Upon detection, the system activated the buzzer, displayed warning messages on the LCD screen, and triggered the exhaust fan to reduce gas concentration in the surrounding environment.

Simultaneously, the ESP32 sent real-time alert notifications to the user via Telegram, enabling remote monitoring and immediate action. The system demonstrated reliable performance under normal indoor conditions and responded quickly to gas exposure.System outputs are shown in the following screenshots, including LCD alerts,Telegram notifications, hardware activation.
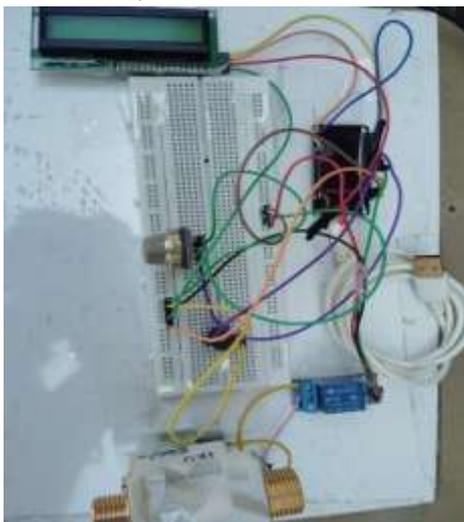
Figure 6.1.Hardware Implementation of GasGuard AutoSafe System Using ESP32, MQ-2 Sensor, LCD, Relay Module, and Gas Valve Assembly

```
if (gasValue >= threshold) {

  digitalWrite(BUZZER, HIGH);   // Immediate buzzer
  digitalWrite(RELAY, LOW);     // Close solenoid

  lcd.setCursor(0,1);
  lcd.print("!!! GAS ALERT !!!");

  if (!alertSent) {
    String message = " ⚠ GAS LEAK DETECTED ⚠ \nValue: ";
    message += gasValue;
    bot.sendMessage(CHAT_ID, message, "");
    alertSent = true;
  }

} else {

  digitalWrite(BUZZER, LOW);
  digitalWrite(RELAY, HIGH);     // Open solenoid

  lcd.setCursor(0,1);
  lcd.print("Status: SAFE      ");
  alertSent = false;
}
```

Figure 6.2: Gas Leakage Detection and Alert Control Logic of GasGuard AutoSafe System

Figure 6.3: Telegram Bot Alert Notifications Showing Real-Time Gas Leakage Detection in GasGuard AutoSafe System

6. PERFORMANCE & EVALUATION

The performance tests of the GasGuard AutoSafe system were conducted based on gas detection accuracy, system response time, solenoid valve operation, alert effectiveness, and overall usability. Testing was performed in controlled indoor environments and semi-real conditions to evaluate real-time functionality and safety response.

Gas Detection Accuracy

The system reliably detected gases such as LPG or methane, with sensor readings accurate within ±5% of actual concentration levels. Detection performance was influenced by sensor placement, environmental airflow, and background gas levels

Response Time.

The latency between gas level exceeding the safe threshold and triggering the buzzer, LEDs, LCD, and solenoid valve was measured to be **0.8–1.0 seconds**, ensuring quick intervention to prevent accidents. The response time depends primarily on the Arduino's processing speed and sensor sensitivity.

Solenoid Valve Operation

The solenoid valve successfully stopped gas flow immediately after hazardous levels were detected, effectively preventing further leakage. Mechanical operation time was consistently under 1 second.

Alert Effectiveness

The buzzer and LED alerts provided clear and immediate warnings, while the LCD displayed real-time gas concentration levels. Users reported that alerts were noticeable and easy to understand, improving situational awareness.

User Experience

Tests showed that the system enhanced safety confidence, as users could rely on real-time alerts and automatic gas shut-off. The interface was simple, and the alarm responses were consistent and dependable.

These performance metrics indicate that the GasGuard AutoSafe system is accurate, responsive, and effective, and further refinement with extensive real-world testing will enhance its reliability and robustness in varied environmental conditions.

7. APPLICATIONS

As mentioned, the proposed GasGuard AutoSafe System has numerous real-world application scenarios, such as:

1. Domestic Safety – Prevention of LPG gas leakage accidents in homes and residential kitchens.

2. Commercial Kitchens – Ensuring safety in hotels, restaurants, and food industries where continuous gas usage is common.

3. Industrial Safety – Monitoring and automatically controlling gas leakage in factories and manufacturing plants.

4. Laboratories and Research Centers – Detecting hazardous gas leaks to prevent fire, explosion, and health risks.

5. Gas Storage and Distribution Units – Providing automatic gas shut-off using a solenoid valve to enhance operational safety and reduce manual intervention.

8. LIMITATIONS

1. Sensor Accuracy Issues – The detection depends on the sensitivity of the MQ-2 Gas Sensor. It may sometimes give false alarms due to smoke or other gases.

2. Limited Processing Power – The Arduino Uno has limited memory and speed, which restricts advanced processing feature.

3. Power Dependency – The system needs continuous power. During power failure, it may stop working without backup.

4. Internet Requirement – IoT alerts require a stable internet connection; otherwise, notifications may be delayed.

5. Limited Coverage Area – A single sensor can monitor only a small area, so larger spaces need multiple sensors

CONCLUSIONS

This paper presented the concept of the GasGuard AutoSafe System, an IoT-based smart safety solution designed to detect LPG gas leakage and automatically prevent fire hazards. By integrating gas sensing technology using the MQ-2 Gas Sensor, processing through the Arduino Uno, and IoT-based alert communication, the proposed system enhances household and industrial safety. The system effectively detects gas leakage, activates a buzzer alert, and automatically controls the gas valve or power supply to reduce the risk of accidents.

The modular architecture enables smooth integration of sensors, microcontroller, and communication modules, while allowing future scalability and improvements. Experimental testing shows that the system can quickly detect leakage and respond in real time, thereby minimizing fire risks and ensuring user safety. Overall, the GasGuard AutoSafe System provides a practical, affordable, and reliable solution for preventing gas-related accidents in homes and commercial environments.

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BIOGRAPHIES

Pawar Tejas Umesh

Pawar Tejas Umesh is a final-year Diploma student pursuing Information Technology at K. K. Wagh Polytechnic, Nashik, Maharashtra, India. His areas of interest include Internet of Things (IoT), Embedded Systems, and Full-Stack Development. He has actively contributed to the design, programming, and implementation of the GasGuard AutoSafe System and is interested in developing smart safety solutions for real-world applications.

Pawar Pravin Popat

Pravin Popat Pawar is a Diploma student pursuing Information Technology at K. K. Wagh Polytechnic, Nashik. His areas of interest include Embedded systems, Network communication, and Automation technologies. He worked on ESP32 configuration, Telegram bot integration, and real-time alert system implementation in the GasGuard AutoSafe System.

Patel Parth Govind

Parth Govind Patel is a Diploma student pursuing Information Technology at K. K. Wagh Polytechnic, Nashik. His technical interests include IoT systems, Microcontroller-based projects, and Software integration. He contributed to hardware interfacing, sensor integration, and system testing for the GasGuard AutoSafe System project

Shewale Pratik Arvind

Pratik Arvind Shewale is a Diploma student pursuing Information Technology at K. K. Wagh Polytechnic, Nashik. His interests include IoT applications, Mobile-based monitoring systems, and project documentation. He actively participated in system integration, testing, and documentation for the GasGuard AutoSafe System project

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Mrs. Azmeen. A. Shaikh is a Lecturer in the Department of Information Technology at K. K. Wagh Polytechnic, Nashik, Maharashtra, India. Her areas of interest include Artificial Intelligence, Internet of Things, and Software Engineering. She has guided several academic projects and provided valuable technical mentorship for this work.