A

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on

”Smart Gas Detector: IoT Based LPG Detection and Auto Shutdown”

Submitted in partial fulfillment of the requirements

for Third Year B.Tech. Semester II

in

Computer Science and Engineering

to

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

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CERTIFICATE

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" Smart Gas Detector: IoT Based LPG Detection and Auto Shutdown"

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ABSTRACT

The SmartGas Guardian project is an IoT-based safety solution designed to detect Liquefied Petroleum Gas (LPG) leaks and initiate automatic preventive actions to minimize risk. This intelligent system addresses the critical safety needs of households, commercial kitchens, and remote facilities where LPG is widely used for cooking, heating, and industrial applications. Given LPG's high flammability, even minor leaks can lead to life-threatening situations. The SmartGas Guardian enhances safety by continuously monitoring gas levels using the MQ-2 sensor and instantly alerting users via SMS using a GSM module when a leak is detected.

In addition to real-time alerts, the system automatically activates a solenoid valve to shut off the gas supply, thereby reducing the potential for fire or explosion. Unlike Wi-Fi-dependent systems, this solution uses GSM-based communication to operate independently of internet availability, making it ideal for remote and rural areas. The platform leverages embedded systems and IoT technologies to deliver a low-cost, reliable, and scalable safety mechanism that supports safe and smart living environments.

By automating the leak detection and response process, the SmartGas Guardian empowers users with a proactive safety tool, enhances emergency responsiveness, and prevents property damage and loss of life. This project contributes to the development of smart safety infrastructure and raises awareness about the need for intelligent gas monitoring solutions in modern households and industries.

Keywords: IoT, LPG Leak Detection, Gas Sensor, GSM Alerts, Embedded Systems, Auto Shutoff, Solenoid Valve, Fire Safety, Smart Home, Rural Safety Solutions, Real-Time Monitoring, MQ-2 Sensor.

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NOMENCLATURE

LPG – Liquefied Petroleum Gas

IoT – Internet of Things

GSM – Global System for Mobile Communications

SMS – Short Message Service

MQ-2 – Gas sensor module used for detecting LPG, smoke, and other gases

MCU – Microcontroller Unit (e.g., Arduino or ESP32)

Solenoid Valve – Electromechanical device for controlling gas flow

Leak Detection – Process of identifying the presence of gas leakage

Real-Time Monitoring – Continuous observation of gas concentration levels

Auto Shutdown – Automatic closure of gas valve upon leak detection

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Chapter 1

1 Introduction

1.1 Background:

Liquefied Petroleum Gas (LPG) has become an essential energy source for cooking, heating, and industrial applications due to its efficiency, affordability, and availability. Its use spans across residential households, commercial establishments, and remote areas where piped natural gas infrastructure is lacking. However, LPG is a highly flammable substance, and even a small leakage can lead to disastrous consequences including fires, explosions, and threats to human life and property. This makes early detection and response to gas leaks a critical safety concern.[2]

Traditional gas leak detection systems often rely on manual monitoring or basic alarm mechanisms that are limited in functionality and incapable of providing timely alerts or automated responses. With the advancement in embedded systems and the Internet of Things (IoT), there is a growing opportunity to create intelligent, connected safety solutions that can operate independently and offer real-time monitoring, alerting, and control.[4]

This project aims to design and implement a Smart Gas Detector system that not only detects the presence of LPG in the air but also takes immediate preventive actions to reduce the risk. The system employs an MQ-2 gas sensor for continuous gas concentration monitoring and integrates a SIM-based GSM module to send SMS alerts to users in the event of a leak. Additionally, the system includes an automated solenoid valve mechanism to shut off the gas supply upon detection of a leak, thereby minimizing potential hazards.

Unlike Wi-Fi-based systems that depend on internet connectivity, the use of a GSM module allows the system to function in areas where internet access may be unreliable or unavailable, making it a practical solution for both urban and remote settings. By combining sensor technology, GSM communication, and automated control, this project contributes to the development of low-cost, scalable safety systems suited for modern and smart living environments.[6]

1.2 Problem Statements

1. **Need for a IoT-Based LPG Detection and Auto Shutdown:**

   LPG is widely used as a domestic and industrial fuel due to its high efficiency and ease of use. However, accidental gas leaks caused by faulty cylinders, damaged pipes, or unattended appliances pose significant risks such as fire, explosions, and health hazards. Traditional LPG detection methods are limited to manual inspection or basic alarm systems, which lack the ability to notify users remotely or take preventive actions automatically.

   Moreover, many existing smart detection systems rely on internet connectivity, making them unsuitable for deployment in areas with limited or no access to Wi-Fi or broadband services. This creates a critical gap in safety infrastructure, particularly in rural and semi-urban areas where LPG usage is high but access to modern connectivity is limited.[6]

   Therefore, there is a need for a cost-effective, standalone, and automated system that can:

1.3 Objectives

The primary objective of this project is to design and implement a smart LPG gas leakage detection and safety system that ensures rapid response and remote alerting using GSM technology. The specific objectives are:

(a) **To design a reliable LPG leakage detection system**

– using the MQ-2 gas sensor that continuously monitors gas concentrations in the environment.

(b) **To implement automatic shutdown functionality**

– using a solenoid valve that cuts off the gas supply immediately upon detecting a leak, preventing fire hazards.

(c) **To integrate GSM-based communication**

– using a SIM module (e.g., SIM800) for sending real-time SMS alerts to the user, enabling remote awareness even in the absence of Wi-Fi or internet.

(d) **To develop a compact and cost-effective hardware setup**

– that is easy to install in domestic and commercial environments.

(e) **To ensure system reliability through proper calibration and testing**

– that false positives and system failures are minimized.[7]

1.4 Scope of the Project:

(a) **LPG Leak Detection**

i. Real-Time Monitoring: The system will continuously monitor LPG concentrations using the MQ-2 gas sensor, providing real-time detection of any gas leak.

ii. Threshold Configuration: The system will allow users to set customizable detection thresholds for better accuracy.

iii. Signal Processing: The analog signal from the gas sensor will be converted to a digital signal by the microcontroller for accurate leak detection.

(b) **Alert System**

i. GSM Communication: The system will send SMS alerts to users through a SIM-based GSM module (e.g., SIM800) when an LPG leak is detected.

ii. Immediate Notification: SMS alerts will be sent instantly to predefined contacts, ensuring quick response and intervention.

(c) **Auto Shutdown Mechanism**

i. Automatic Gas Shutoff: The system will trigger the automatic activation of a solenoid valve to shut off the gas supply upon detecting a leak.

ii. Safety Assurance: The system will stop the flow of gas, preventing further risks such as fire or explosion.

(d) **Alarm System**

i. Local Alarm Activation: The system will activate an audible buzzer indicator for immediate local alerts.

ii. Immediate Awareness: The buzzer indicator ensure that anyone nearby is immediately aware of a gas leak, even if SMS alerts are delayed.[4]

(e) **Hardware and Software Integration**

i. Microcontroller Integration: The system will integrate hardware components (sensor, GSM module, solenoid valve, buzzer) through a microcontroller unit (e.g., Arduino).

ii. Embedded Programming: The system will use embedded programming for controlling the sensor data, GSM communication, and activation of the solenoid valve and alarm system.

iii. Signal Processing: Proper signal conversion, threshold setting, and logic for actuation of the gas shutoff mechanism will be implemented.[6]

(f) **Prototype Development**

i. Prototype Assembly: A working prototype will be developed, integrating all hardware components on a breadboard.

ii. Testing: The system will be tested under various controlled leak scenarios to ensure proper operation.

Chapter 2

2 Literature Review

2.1 Literature Review

“IoT-Based Gas Leak Detection: An Overview” – Smith et al. (2018) Says that: This study provides an overview of IoT-based gas leak detection systems, examining various sensors, communication technologies, and alert mechanisms used in modern systems. It highlights how IoT devices are capable of detecting gas leaks in real-time and notifying users instantly, enhancing safety in residential and industrial areas. SmartGas Guardian can implement similar sensor technologies to provide reliable detection and alerting[7].

“Wireless Sensor Networks for LPG Gas Leak Detection” – Choi Lee (2020) Says that: The paper analyzes the role of wireless sensor networks (WSNs) in detecting LPG gas leaks and their ability to communicate effectively in critical situations. It underscores the importance of low-cost sensors that can transmit data in real-time to control units or mobile devices. SmartGas Guardian can leverage wireless networks to ensure fast response times and immediate intervention in case of a gas leak.

“Enhancing Safety with IoT in Smart Homes” – Jones et al. (2019) Says that: This research explores how IoT technologies are integrated into smart home systems, particularly for safety applications such as fire detection and gas leak prevention. It discusses how connected devices can work together to protect inhabitants by shutting off gas supplies and alerting emergency services. SmartGas Guardian could adopt similar integrations to enhance household safety and provide proactive responses to gas leaks and fire hazards.[9]

“Real-Time Gas Leak Monitoring Systems” – Kumar Sharma (2021) Says that: This study focuses on the design of real-time monitoring systems for gas leak detection, emphasizing the use of advanced sensors and data analytics to predict gas leakage patterns. The study shows that integrating AI into detection systems can provide predictive alerts based on environmental factors. SmartGas Guardian could use AI to predict gas leaks based on sensor data and send warnings to users in advance, thereby minimizing risks.

“Mobile Integration for Emergency Alerts in IoT Systems” – Patel Singh (2017) Says that: This paper highlights how mobile applications can enhance emergency response systems by delivering real-time alerts, location tracking, and instant communication with emergency services. SmartGas Guardian can integrate mobile functionality to notify users via SMS or app notifications about gas leaks, and even notify emergency responders if necessary.

“Consumer Trust and Adoption of IoT Safety Systems” – Fisher O’Connor (2015) Says that: This research explores consumer behavior in adopting IoT safety systems, such as gas leak detection and fire safety alarms. It suggests that consumers are more likely to adopt these systems when they have trust in the technology’s reliability and ease of use. SmartGas Guardian could focus on ensuring ease of installation, user-friendly interfaces, and transparent alerts to build consumer trust.

“Challenges in Deploying IoT Safety Systems” – Lopez Garcia (2020) Says that: The study identifies several challenges in the widespread deployment of IoT-based safety systems, including issues related to power consumption, connectivity in remote areas, and sensor calibration. It also discusses the importance of ensuring the accuracy and reliability of sensors. SmartGas Guardian could address these challenges by implementing energy-efficient designs and providing guidelines for sensor maintenance and calibration.[9]

“Mobile Payments and IoT Device Management” – Singh Verma (2018) Says that: This research focuses on integrating mobile payment systems with IoT applications to simplify device management and service subscriptions. The study suggests that mobile payment options can improve user experience by offering subscription-based services for monitoring and maintenance. SmartGas Guardian can integrate secure mobile payment systems to allow users to subscribe to ongoing service packages, including maintenance and remote monitoring.

“Sustainability in IoT-Enabled Safety Devices” – Harrison et al. (2019) Says that: This paper explores the role of sustainability in IoT devices, particularly in reducing the environmental impact of safety devices. It suggests that IoT manufacturers should focus on energy-efficient designs and minimize waste in the production of hardware components. SmartGas Guardian could adopt eco-friendly manufacturing practices and provide users with guidelines on how to dispose of or recycle outdated devices.

“Community-Based IoT Systems for Safety and Security” – Brown Black (2021) Says that: This research investigates the importance of community-building features in IoT-based safety systems. It emphasizes how community-driven platforms can allow users to share safety tips, review system performance, and engage with local emergency services. SmartGas Guardian could integrate community-based features, such as forums and user feedback systems, to enhance collaboration and collective safety efforts.[8]

[

“The Role of Blockchain in Smart Safety Systems” – Peterson Martin (2020) Says that: This study discusses the potential of blockchain technology in providing transparency and security in smart safety systems, such as gas leak detection and fire safety alarms. Blockchain can help ensure the integrity of sensor data and provide tamper-proof logs for auditing purposes. SmartGas Guardian could explore the integration of blockchain to enhance data security and provide users with transparent safety records.

“Social Media and Community Engagement for Safety Awareness” – Singh Verma (2019) Says that: This paper explores the role of social media platforms in raising awareness about safety technologies and encouraging user engagement. It shows that social media can be a powerful tool in educating consumers about the importance of safety systems. SmartGas Guardian could use social media integration to engage users, share educational content, and promote safety awareness.

“The Impact of Cloud Computing on IoT Safety Applications” – Zhang et al. (2021) Says that: This paper discusses the role of cloud computing in enhancing the scalability and reliability of IoT safety applications. It suggests that cloud platforms can provide real-time data processing and storage, enabling better decision-making and system management. SmartGas Guardian could use cloud computing to store sensor data and analyze patterns to predict gas leaks and fire risks.

“Cultural Impacts of Safety Technologies in Global Markets” – Williams Thomas (2018) Says that: This research explores how safety technologies, including gas leak detection and fire safety systems, are perceived and adopted across different cultures. It emphasizes the need for localizing safety systems to meet the specific needs and preferences of various communities. SmartGas Guardian could tailor its features and marketing strategies to different cultural contexts, ensuring global usability and acceptance.

Chapter 3

3 Project Design

3.1 Architecture:

1. **MQ-2 Gas Sensor (Input Module)**
   (a) Detects LPG concentration in the air.
   (b) Outputs analog voltage proportional to gas level.
   (c) Connected to the microcontroller's ADC pin.[7]

2. **Microcontroller (Processing Unit)**
   (a) Core of the system (e.g., Arduino UNO)
   (b) Continuously reads gas sensor data.
   (c) Makes decisions based on threshold gas concentration.
   (d) Controls output devices (buzzer, GSM, solenoid valve).[5]

3. **GSM Module (SIM800)**
   (a) Sends SMS alerts to preconfigured mobile numbers.
   (b) Communicates via UART with the microcontroller
   (c) Operates without internet; only requires a SIM card with network coverage.

4. **Buzzer(Alert Module)**
   (a) Provides local alert
   (b) Activated immediately on gas detection above threshold.

5. **Solenoid Valve (Auto Shutdown Mechanism)**
   (a) Connected via a relay.
   (b) Automatically cuts gas supply if leakage is detected.

6. **Power Supply**
   (a) Regulated power for microcontroller (e.g., 5V), GSM (usually 12V with 2A capacity), and solenoid valve.
   (b) Includes backup battery or adapter for continuous power.

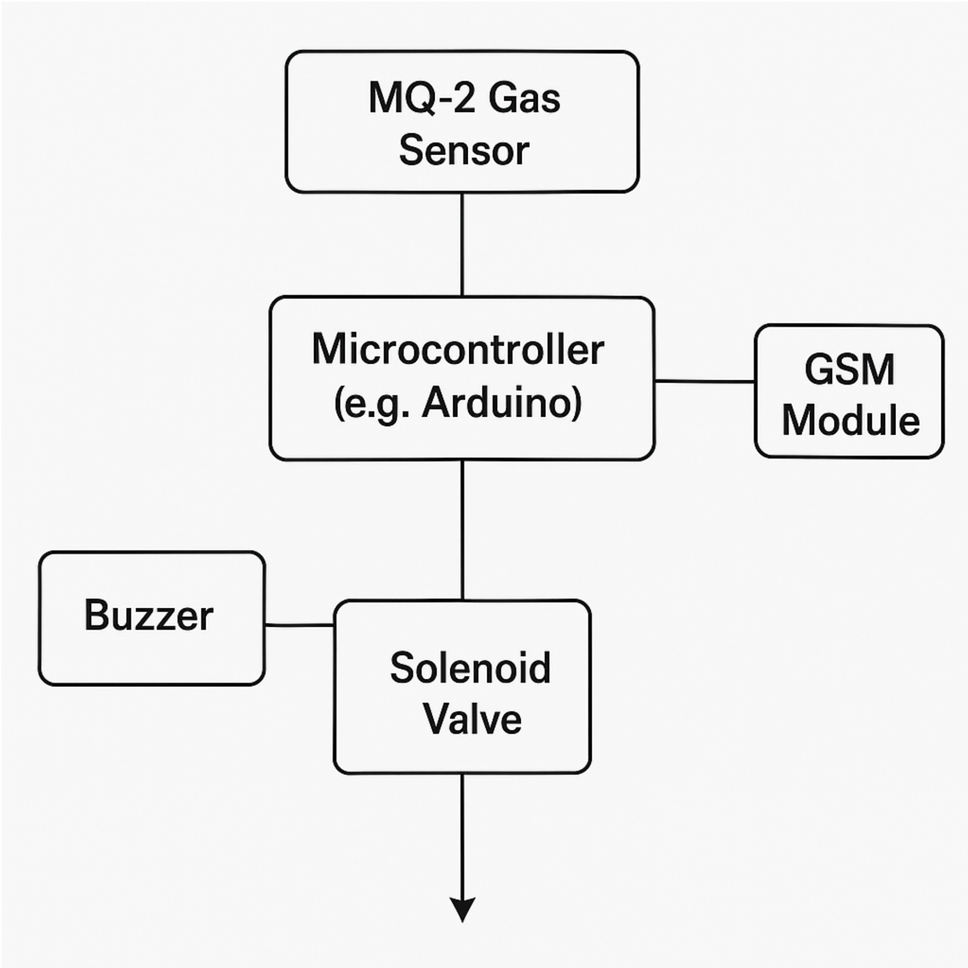

Figure 1: Architecture

3.2 Data Flow Diagrams (DFD) and ERD

0 Level DFD

1. **Entities:)**
   (a) **User**
   (b) **IoT Dashboard**
   (c) **Gas Utility Provider**
2. **Process:**
   (a) **Smart Gas Detector System**
3. **Data Stores:**
   (a) Sensor Data Log
4. **Data Flows:**
   (a) From User to System: Control Commands, System Configuration[4]
   (b) From System to User: Gas Alerts, System Status, Shutdown Notification
   (c) From Environment to System: Gas Concentration Data[9]
   (d) From System to Gas Utility Provider: Emergency Alert
   (e) From System to Dashboard: Sensor Data, Alert Messages

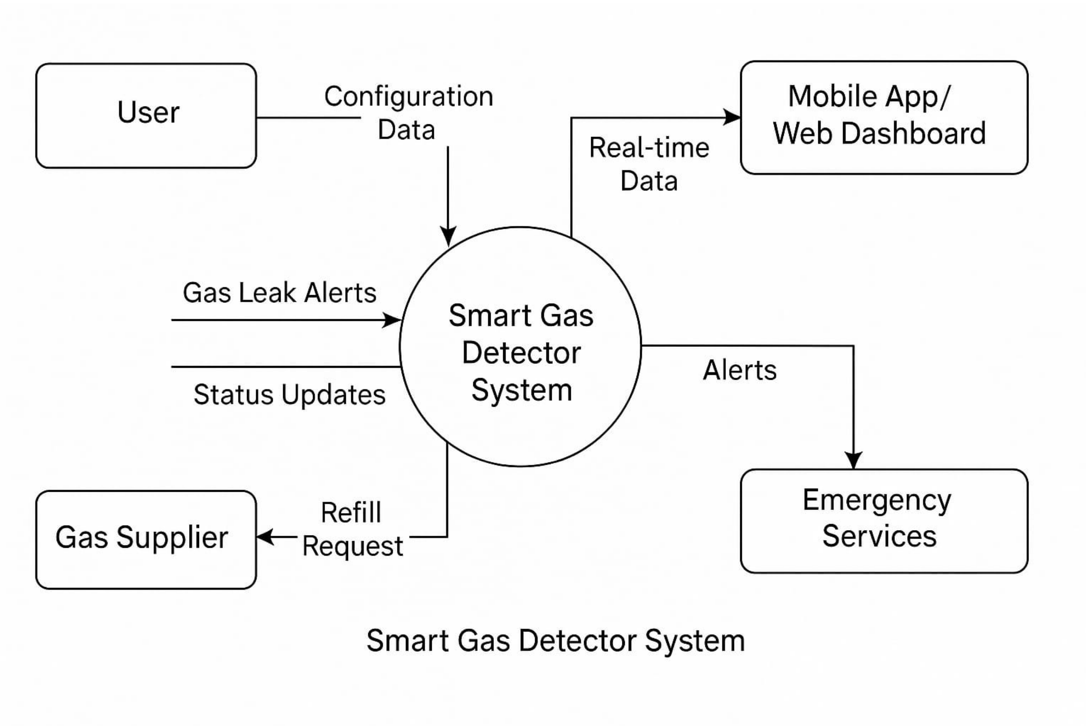

Figure 2: DFD level 0

Entity-Relationship Diagram (ERD):

1. **User**
   (a) **Attributes:Phone(Resident)**
2. **GasSensor**
   (a) Attributes: Sensor ID (PK), Location, Threshold Level, Status (Active/Inactive)
3. **GasReading**
   (a) Attributes: Gas Level, Temperature
4. **Alert**
   (a) Attributes: Alert ID, Reading ID, Alert Type (High/Normal), Alert Time, Resolved Status[10]
5. **Actuator (Auto Shutdown Unit)**
   (a) Attributes: Actuator name Status (On/Off)
6. **Dashboard**
   (a) Attributes:Notification Preference

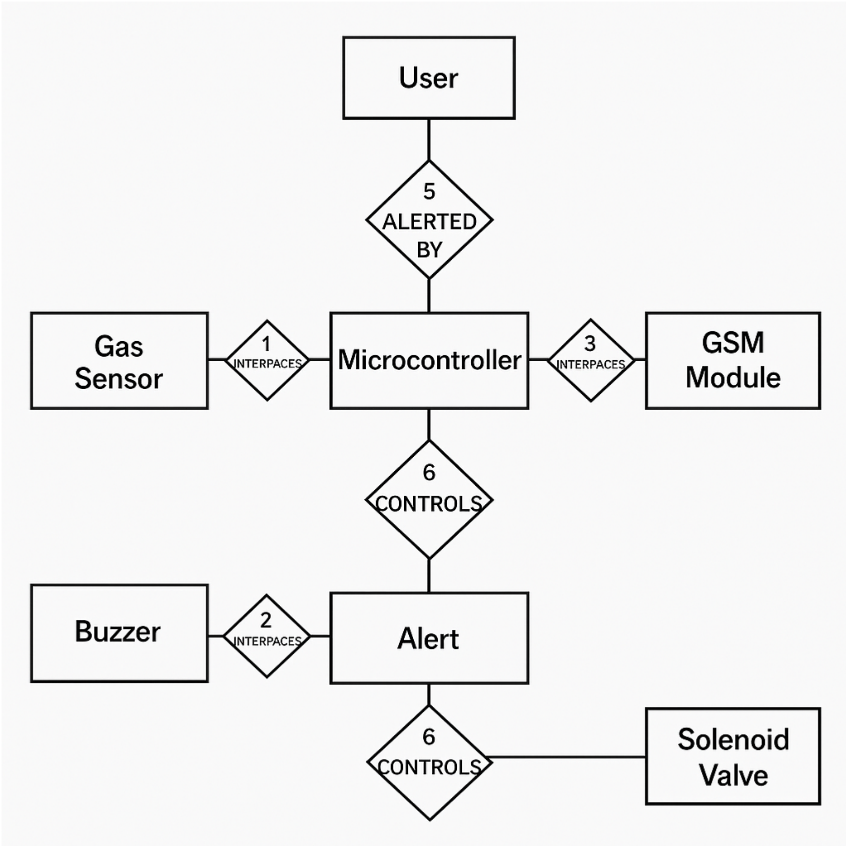

Figure 3: Entity-Relationship Diagram

3.3 Technologies Used::

In the ”Smart Gas Detector: IoT-Based LPG Detection and Auto Shutdown” project, several hardware and software technologies are integrated to build a functional, standalone safety system. Here’s an overview of the technologies used:

Hardware Technologies

1. **MQ-2 Gas Sensor:**
   - Used to detect LPG, methane, and smoke concentrations in the air.
2. **Microcontroller: (e.g., Arduino UNO)**
   - Acts as the brain of the system.
   - Reads data from the gas sensor and takes action (triggering alarms, sending SMS, etc.).
3. **GSM Module: (e.g., SIM800)**
   - Sends SMS alerts to users when a gas leak is detected.
   - Works on 2G cellular networks without internet.
4. **Solenoid Valve:**
   - Electrically controlled valve that shuts off the gas line automatically in case of a leak.
   - Controlled by the microcontroller through a driver circuit.
5. **Buzzer:**
   - Provides audible alarm as a local alert when gas leakage is detected.

Software Technologies

1. **Arduino IDE:**
   - Used to write, compile, and upload code to the Arduino microcontroller.
2. **Embedded Programming:**
   - Implements logic for sensor data acquisition, threshold comparison, GSM communication, and actuator control.

Communication Technology

1. **GSM Communication (SIM based)**
   - Enables wireless communication via SMS.
   - Operates independently of Wi-Fi or cloud.
   - Suitable for use in remote areas.

Chapter 4

4 Methodology

4.1 Project Planning

1. **Project Initialization:**
   (a) **Objective:** Define the problem and scope.
   (b) **Activities:**
   - Identify safety issues related to LPG leakage.
   - Determine system goals: leak detection, SMS alert, auto shutdown.
   - Select target users (households, small businesses).

   (c) **Deliverables:**
   - Problem statement
   - Project objectives
   - Initial system concept

2. **Research and Requirement Analysis:**
   (a) **Objective:**Analyze existing systems and technology options.
   (b) **Activities:**
   - Literature review of previous similar works.
   - Evaluation of sensors, GSM modules, and microcontrollers.
   - Select suitable components (MQ-2, SIM800L, Arduino UNO).

   (c) **Deliverables:**
   - System requirements document
   - Component selection report

3. **System Design**
   (a) **Objective:** Create a blueprint for implementation.
   (b) **Activities:**
   - Design block diagram and system architecture.
   - Draft circuit diagram for component interfacing.
   - Plan communication flow (sensor $\rightarrow$ microcontroller $\rightarrow$ GSM + valve).

   (c) **Deliverables:**
   - Architecture diagram
   - Circuit layout
   - Functional flow design

4. **Development:**
    (a) **Objective:** Build the physical and logical system.
    (b) **Activities:**
        - Assemble hardware on breadboard or PCB.
        - Develop embedded software in Arduino IDE.
        - Implement AT command handling for GSM alerts.
        - Integrate valve control, buzzer logic, and threshold detection.
    (c) **Deliverables:**
        - Working prototype
        - Source code
        - Functional test results
5. **Testing and Calibration:**
    (a) **Objective:** Verify functionality and reliability.
    (b) **Activities:**
        - Simulate gas leaks using a lighter (without flame).
        - Calibrate gas sensor for accurate detection levels.
        - Test SMS alerts and solenoid valve activation.
        - Analyze response time and false alarm rate.
    (c) **Deliverables:**
        - Test report
        - Adjusted threshold values
        - System performance analysis
6. **Documentation and Presentation:**
    (a) **Objective:**Finalize the project and prepare for evaluation.
    (b) **Activities:**
        - Compile report (abstract, intro, methodology, results, etc.)
        - Create presentation slides and visual aids.
        - Prepare demonstration of prototype functionality.
    (c) **Deliverables:**
        - Final project report
        - Demonstration-ready prototype
        - Presentation materials

4.2 Approaches

1. **Sensor-Based Detection Approach:**
   - Utilized the MQ-2 gas sensor for real-time detection of LPG.
   - Analog output from the sensor is monitored continuously.
   - A threshold-based comparison method is used to determine leakage.
2. **Threshold Triggering Approach:**
   - A predefined gas concentration threshold is set in the microcontroller code.
   - Once the sensor value crosses this threshold, the system:
     - Activates the buzzer (local alert).
     - Sends an SMS via GSM.
     - Triggers solenoid valve shutdown.
3. **GSM-Based Communication Approach:**
   - Chose SIM800/SIM900 GSM module over Wi-Fi to ensure usability in areas without internet.
   - Used AT Commands over serial UART to send real-time SMS alerts.
   - Designed to function entirely on mobile network connectivity.
4. **Automatic Shutdown Approach:**
   - Implemented a solenoid valve control circuit.
   - If a gas leak is detected, the valve is automatically deactivated, cutting the gas supply.
   - This safety mechanism works independently of human intervention.
5. **Embedded System Integration Approach:**
   - All components were interfaced with an Arduino UNO microcontroller.
   - Read sensor values
   - Compare data
   - Control output devices
   - Ensures real-time performance with minimal latency.
6. **Standalone System Design Approach:**
   - No dependency on cloud, Wi-Fi, or external servers.
   - Powered by a regulated supply, ensuring independence and reliability.
   - Ideal for rural or remote applications.

4.3 Tools and Environment:

Hardware Tools

(a) **MQ-2 Gas Sensor:**
- Used to detect LPG, methane, and smoke concentrations in the air.

(b) **Microcontroller: (e.g., Arduino UNO)**
- Acts as the brain of the system.
- Reads data from the gas sensor and takes action (triggering alarms, sending SMS, etc.).

(c) **GSM Module: (e.g., SIM800)**
- Sends SMS alerts to users when a gas leak is detected.
- Works on 2G cellular networks without internet.

(d) **Solenoid Valve:**
- Electrically controlled valve that shuts off the gas line automatically in case of a leak.
- Controlled by the microcontroller through a driver circuit.

(e) **Buzzer:**
- Provides audible alarm as a local alert when gas leakage is detected.

Software Tools

(a) **Arduino IDE:**
- Used to write, compile, and upload code to the Arduino microcontroller.

(b) **Embedded Programming:**
- Implements logic for sensor data acquisition, threshold comparison, GSM communication, and actuator control.

Communication Tools

(a) **GSM Communication (SIM based)**
- Enables wireless communication via SMS.
- Operates independently of Wi-Fi or cloud.
- Suitable for use in remote areas.

Development Environment:

The entire system was developed in a desktop environment running Windows 10, though it is also compatible with Linux and macOS platforms. All development was carried out using standard Arduino libraries, with no requirement for external or proprietary software dependencies.

The image displays a table titled ”Hardware Components and Descriptions” with two columns. It lists key components of an LPG leak detection system such as the MQ-2 Gas Sensor, Arduino Uno, SIM800L GSM Module, and others. Each row includes the component name, a representative image, and a brief description of its function. The table helps visualize the parts used and understand their roles in the project.

Hardware Components and Descriptions

Hardware Component	Description
IQ-2 Gas Sensor 	Detects LPG, methane, smoke, and other gases in the environment.
umper Wires 	Used to make electrical connections between components on a breadboard.
rduino Uno 	Microcontroller board used to control the entire system.
ervo Motor 	Controls the valve to shut off the gas supply automatically.
IM800L GSM Module 	Sends SMS alerts to users in case of gas leakage.
readboard 	Used to build the prototype circuit without soldering.
uzzer 	Provides an audible alert when gas leakage is detected

Table no 2:Hardware Component And Description

4.4 Testing Strategy

The testing strategy for the Smart Gas Detector project ensures that each component of the system sensor, microcontroller, GSM module, buzzer, and solenoid valve functions as expected under both normal and gas leak conditions. The strategy includes unit testing, integration testing, system testing, and real-world simulation testing.

(a) **Testing Methods**

i. **Unit Testing:**
- **Sensor Test:** Validate MQ-2 sensor's analog output under different gas concentrations (e.g., using a lighter without a flame).
- **GSM Module Test:** Test SMS sending using AT commands and verify delivery on recipient's phone.
- **Buzzer Test:** Confirm buzzer activates at programmed threshold.
- **Valve Test:**Check solenoid valve opens/closes as per control signal.

ii. **Integration Testing:**
- Test sensor, microcontroller, GSM, buzzer, and solenoid valve as a unified system.)
- Simulate gas leak to trigger the full response sequence (alert + shutdown + alarm).
- Check data flow from sensor → MCU → outputs.

iii. **System Testing:**
- Power up the entire system and simulate various gas levels.
- Verify that:
  - SMS is sent instantly on gas leak detection.
  - Valve closes automatically.
  - Buzzer sounds an alert.
- Test for stability under continuous operation (burn in testing).

iv. **Boundary/Threshold Testing:**
- Set multiple gas concentration thresholds and observe response:
  - Below threshold → No action
  - At threshold → System should activate
  - Above threshold → All safety mechanisms must trigger

v. **Real-World Simulation:**
- Conduct tests in a small room or enclosed space.
- Use actual LPG leakage (safely simulated) to ensure the system responds correctly.
- Test with power fluctuations and GSM signal drops to evaluate robustness.

Chapter 5

5 Implemention

(a) **Hardware Setup:**

i. **Component Integration:**

- The MQ-2 gas sensor was connected to an analog input pin of the Arduino UNO to continuously monitor gas concentration.
- The SIM800L GSM module was interfaced via UART (Tx/Rx pins) using the SoftwareSerial library.
- A buzzer was connected to a digital output pin to provide immediate audio alerts.
- A solenoid valve was connected via a relay or driver circuit to control the gas flow (auto shutdown mechanism).
- Power to the GSM and valve was regulated using a 12V power source, with a 5V supply provided to the Arduino and sensor.

ii. **Wiring and Circuit Design:**

- Components were first assembled on a breadboard for prototyping.
- All devices were grounded properly and tested using a multimeter to avoid short circuits or overvoltage.
- The final setup was transferred to a general-purpose board for a stable prototype.

(b) **Software Development**

i. **Platform:**

- Code was written in Embedded C/C++ using the Arduino IDE.

ii. **Functional Code Blocks:**

- Sensor Reading: Analog values from MQ-2 are read and mapped to ppm estimates.
- Threshold Logic: If the sensor value exceeds a defined threshold (e.g., 300 ppm), the following actions are triggered:
  - SMS Alert: An AT command is sent to the GSM module to notify the user.
  - Buzzer Activation: The buzzer is turned on for a fixed duration or until reset.
  - Valve Shutdown: The solenoid valve is de-energized to stop gas flow.

iii. **AT Commands Used:**

- AT+CMGF=1 – Set SMS text mode.
- AT+CMGS="PhoneNumber" – Send SMS with leak warning message.
- Delays were added between commands to ensure reliable GSM response.

iv. **Error Handling:**

- Checks were included to prevent multiple SMS spams using flags/timers.
- LED or Serial output indicated GSM signal errors or sensor faults.

(c) **Testing and Calibration:**

- The sensor was tested using a butane lighter (no flame) to simulate LPG presence.
- Multiple gas levels were used to calibrate the threshold value for real-world sensitivity.
- SMS delivery was confirmed across different mobile networks.
- The buzzer and solenoid were validated under triggered and reset conditions.

(d) **Power Supply and Enclosure**

- A 12V adapter was used to supply power to GSM and solenoid valve.
- The circuit was later enclosed in a protective plastic casing with holes near the sensor for gas entry.
- Proper insulation and heat resistance were ensured for safety.

(e) **Final Prototype Features:**

- Standalone system – does not rely on internet or external servers.
- Real-time leak detection and response.
- SMS alert and buzzer-based local notification.
- Automatic gas supply cut-off using the valve.
- Portable, low-cost, and scalable for household use

5.1 Modules:

(a) **Gas Sensing Module**

- Component: MQ-2 Gas Sensor
- Function: Continuously monitors the surrounding air for LPG (propane/butane)
- Output: Analog voltage proportional to gas concentration.
- Role: Detects gas levels and sends readings to the microcontroller.

Figure 4: MQ sensor

(b) **Processing Control Module**

- Component: Arduino UNO Microcontroller
- Function: Acts as the brain of the system. It:
  - Reads sensor data
  - Compares it with a set threshold
  - Triggers necessary actions
- Role: Decision-making based on input signals.

Figure 5: Arduino UNO

(c) **Alert/Notification Module**

- Component: SIM800L GSM Module
- Function: Sends an SMS alert to predefined mobile numbers when gas leakage is detected.
- Communication: Via AT Commands over UART.
- Role: Notifies users remotely of potential danger.

Figure 6: SIM800L GSM Module

(d) **Alarm Module**

- Component: Buzzer
- Function: Produces an immediate audio (and/or visual) alert to nearby individuals in the event of a leak.
- Role: Local warning mechanism.

Figure 7: Buzzer

(e) **Auto Shutdown Module**

- Component:Servo Motor
- Function: Cuts off gas flow by closing the valve upon leak detection.
- Control: Driven by microcontroller signal through a transistor/relay driver.
- Role: Prevents further leakage and fire hazards.

Figure 8: Servo Motor

5.2 Cost Estimation

(a) The project uses affordable and easily available hardware components.

(b) **Key components include:**

  i. **MQ-2 Gas Sensor** – for detecting LPG gas leaks.

  ii. **Arduino Uno** – serves as the central microcontroller.

  iii. **SIM800L GSM Module** – sends SMS alerts in case of a gas leak.

  iv. **Servo Motor** – automatically shuts off the gas supply.

  v. Jumper Wires, Breadboard, and Buzzer – used for circuit connections and alerts.

(c) All components are selected to ensure low-cost implementation and ease of integration.

(d) The estimated total cost of the hardware setup is approximately INR 1,410.

This makes the system highly suitable for home use, small businesses, and rural areas

Cost Estimation

Component	Estimated Cost (INR)
MQ-2 Gas Sensor	150
Jumper Wires	50
Arduino Uno	550
Servo Motor	180
SIM800L GSM Module	350
Breadboard	100
Buzzer	30
Total	1410

Table no 2:Cost Estimation

5.3 Challenges Faced:

1. **Product Authenticity Verification:** Ensuring that products listed by local artisans were genuine and handmade required a trust-based mechanism, which was challenging without a physical verification process.
2. **Real-Time Inventory Management:** Maintaining up-to-date inventory across multiple sellers in real-time using Firestore introduced complexities related to data consistency and synchronization.
3. **User Onboarding and Retention:** Educating small-scale artisans with limited digital exposure on how to register, list, and manage products online required simplified UI and multilingual support.
4. **Payment Gateway Integration:** Integrating a secure and easy-to-use payment system while handling multiple currencies for global transactions posed technical and regulatory challenges.
5. **Responsive and Accessible Design:**Designing a platform accessible on all screen sizes and for users with varying internet bandwidth demanded careful frontend optimization and testing.
6. **Offline Product Drafts:**mplementing a feature for sellers to save product details offline and sync them once connected to the internet added complexity to data storage and UI logic.
7. **Trust and Safety Between Buyers and Sellers:** Building mechanisms to prevent fraudulent activities and ensuring trust between international buyers and rural sellers required user reviews, verifications, and dispute handling systems.
8. **Data Privacy and Compliance:** Ensuring GDPR and data privacy compliance, especially when dealing with international customers and sellers, required thorough planning and secure Firebase rules.
9. **Scalable Backend Infrastructure:** Designing a Firebase Firestore-based system that scales efficiently with increasing product listings and user traffic during festivals or promotions posed architectural challenges.
10. **Standing Out in the E-Commerce Market:** Competing with major e-commerce platforms required unique value propositions, such as cultural storytelling, artisan profiles, and locally sourced product highlights to retain niche appeal.

Chapter 6

6 Result

6.1 Screenshots:

The image displays a practical implementation of an Arduino Uno-based IoT system for LPG gas leak and fire detection. The system includes a breadboard connected to gas sensors and a flame sensor, which are wired to the Arduino microcontroller. A GSM module is also integrated to send emergency alerts. The setup is connected to a laptop via USB, where the Arduino IDE is used to upload and monitor the code in real-time. The glowing LEDs indicate active sensor status and working system logic.

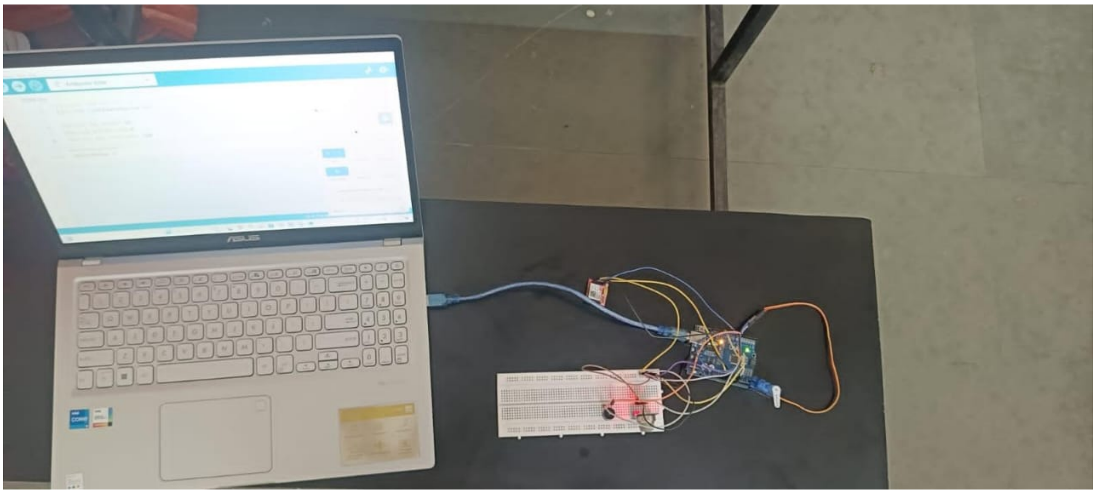

Figure 9: Result

The image shows the complete hardware connection of the gas and fire detection project interfaced with an Arduino Uno. Multiple jumper wires connect sensors like the MQ-series gas sensor and flame sensor to the Arduino's analog and digital pins. A GSM module is also connected via serial communication pins (TX, RX) for sending SMS alerts. The breadboard is used for power distribution and houses LEDs to indicate alert conditions. The system is powered and programmed through a USB cable connected to the laptop running the Arduino IDE. Proper color-coded wiring ensures clear separation of signal, power, and ground lines.

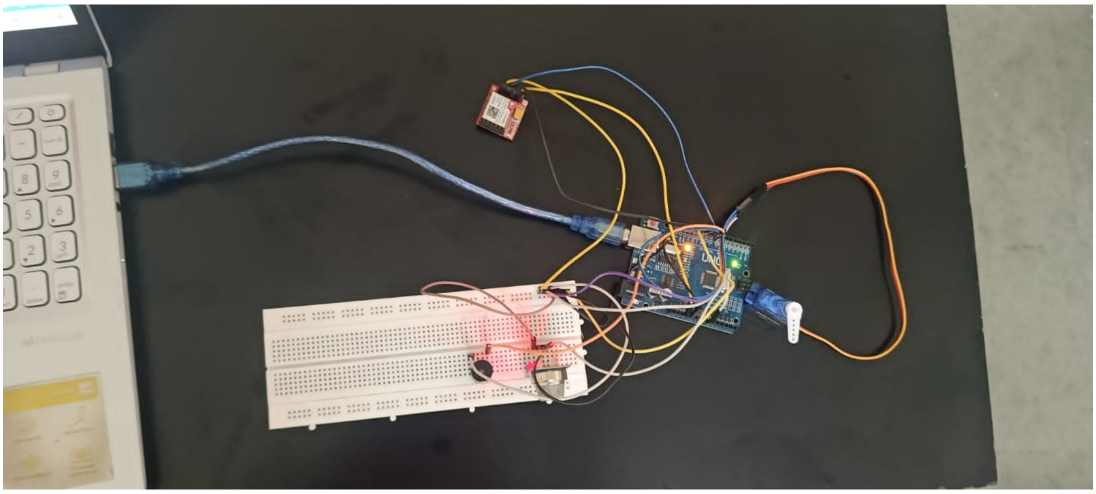

Figure 10: Connection

The Arduino sketch implements a gas leak detection system using an MQ2 sensor, a buzzer, and a servo motor. The gas sensor is connected to analog pin A0, and its readings are compared against a threshold. When gas levels exceed the set threshold, the buzzer sounds for 2 seconds, and the servo rotates to 90°, simulating a shutoff valve. After 5 seconds, the servo resets to its original position. The code also prints the gas sensor values on the serial monitor for debugging. This setup helps in detecting gas leaks and triggering mechanical and audible responses automatically.

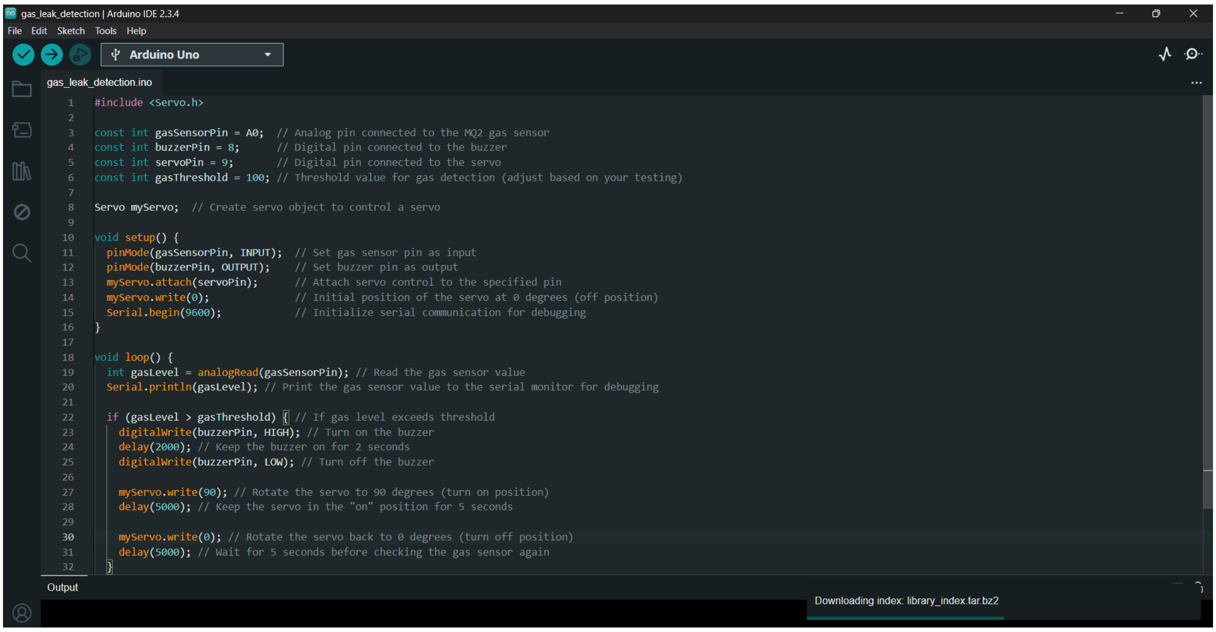

Figure 11: Code

6.2 Comparison with Existing Systems

Here’s a different format for the comparison, presented in a bullet point style with headings for clarity:

Smart LPG Leak Detection System

Functionality	Existing Systems
• Real-time LPG detection using MQ-2 sensor • Automated solenoid valve shutoff • SMS alert via GSM module	• Manual detection or basic alarms • No auto shutoff
• LED indicators and buzzer for leak alert • Simple and user-friendly setup	• No interface or minimal buzzer alerfтatı • Works without internet
Alert & Communication • GSM module sends SMS alerts instantly • Works without internet	• No SMS or mobile alerts • Internet-dependent in some cases
Safety Automation • Automatic gas valve control • Minimizes fire/expiosion risk	• Manual intervention required • Delayed response during emergency
Power & Connectivity • Can run on battery backup • GSM-based, no WI-Fi neeeded	• Often dependent on power or Wi-Fi • Not ideal for remote areas
Data Management • Can log events for further analysis (optional upgrade)	• No data storage or analysis capability
Scalability & Integration • Modular design • Can be extended for smart homes or industries	• Closed systems, hard to integrate or expand • May suffer from false positives
Cost Efficiency • Low-cost components (MQ–2, SIM800, Arduino)	• Often expensive commercial syste ms • Maintenance-heavy

Table no 3:Comparison with Existing Systems

Chapter 7

7 Conclusion and Future Work

Conclusion:

The SmartGas Guardian system effectively addresses the critical need for real-time LPG leakage detection and safety in both domestic and commercial environments. By leveraging the MQ-2 gas sensor and GSM-based alert mechanisms, the system ensures continuous monitoring and immediate response without relying on internet connectivity, making it especially valuable in rural or remote areas. The integration of a solenoid valve for auto shutoff further enhances safety by preventing gas-related accidents proactively.

This project demonstrates how IoT and embedded systems can be harnessed to build cost-effective, reliable, and scalable solutions that enhance everyday safety. Through rigorous testing and calibration, the SmartGas Guardian proves to be a dependable tool for preventing fire hazards and safeguarding human lives and property. Moving forward, the system can be expanded with additional features like mobile app integration, battery backup, and cloud data logging to support smarter and more connected living.

Limitions:

1. **Sensor Sensitivity and Calibration:** The MQ-2 sensor may require frequent calibration to ensure accurate gas concentration readings and can be affected by environmental conditions like humidity or dust.

2. **Power Dependency** The system relies on continuous power supply. In case of power outages without backup (e.g., battery/UPS), the system may not function during critical moments.

3. **Single Gas Detection** The current setup is optimized for LPG only. It does not detect other harmful gases like CO or methane unless additional sensors are integrated.

4. **No Mobile App or Cloud Dashboard** The system uses SMS-based alerts only and lacks an integrated mobile app or cloud interface for advanced monitoring, data logging, or historical analysis. must be continuously updated to prevent breaches.

5. **Limited Scalability for Industrial Us** While effective for domestic and small commercial setups, the current system might need hardware and software upgrades to scale up for industrial-level deployment.

6. **Component Availability and Cost Fluctuations** Dependence on specific modules like SIM800 and solenoid valves may face availability or price fluctuations affecting cost-effectiveness and repairs.

7. The system does not include GPS-based location tracking, which can be useful in emergency services during severe gas leak events.

8. **No Audible or Visual Local Alarms** The current system focuses on SMS alerts and may not include loud buzzers or flashing lights which are important in immediate local warning scenarios.

9. **Limited Multi-User Alert System** The SMS alert system currently supports limited recipients; expanding alert broadcasts to multiple family members or authorities would require additional logic.

Future Scope:

The SmartGas Guardian system presents a significant advancement in ensuring safety from LPG leaks and fire hazards through real-time detection and automated shutdown. Future developments can enhance its functionality, scalability, and usability across broader environments:

1. **Multi-Gas Detection Capability** Expand the system to detect other hazardous gases like methane (CH), carbon monoxide (CO), and butane to offer comprehensive gas safety coverage in both domestic and industrial environments.
2. **Mobile App Integration** Develop an Android/iOS app for real-time monitoring, alert logs, device status updates, and configuration options, enhancing user interaction beyond SMS alerts.
3. **Battery Backup System** Add a rechargeable battery module or solar power support to ensure uninterrupted operation during power outages, making it more reliable in rural or load-shedding-prone areas.
4. **GPS and Location-Based Alerts** Incorporate GPS modules to enable location-based alerts, which are useful in case of large-scale industrial leaks or for informing nearby residents and emergency responders.
5. **Voice Alert and Local Alarm System** Add a voice module or loud buzzer with visual LED indicators for immediate on-site awareness, especially in areas where mobile reception is weak or users may not check SMS instantly.

Chapter 8

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