Microprocessor Interfacing & Programming - Lab

Project Report

GAS LEAKAGE DETECTOR

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Table of Contents

Introduction

Gas leakage is one of the most common and hazardous safety concerns in both residential and industrial environments. Incidents involving undetected gas leaks can result in catastrophic consequences, including fires, explosions, and health hazards due to toxic fumes. To address this issue, the Gas Leakage Detection System is designed to provide a real-time, reliable, and cost-effective solution for detecting and notifying users about the presence of hazardous gases. The project uses MQ-2 gas sensors, a PIC18F458 microcontroller, and simple alarm mechanisms to ensure timely detection and alert.

The main idea behind this project is to create a system that not only detects gas leaks but also pin-points the location of the leak in a multi-sensor setup. The system employs multiple MQ-2 sensors placed strategically in different zones, with each sensor linked to a specific location (i.e. kitchen, garage, shop). When a leak is detected, the system immediately triggers an alarm and displays the specific location of the leak on an LCD. The project also leverages the interrupt-driven design of the microcontroller for real-time processing.

Key Related Concepts

1. **Gas Sensors (MQ-2):**
    - **Purpose**: The MQ-2 sensor is a versatile gas sensor that detects gases like LPG, propane, methane, and hydrogen by measuring their concentration in the air.
    - **Working Principle**: It works on the principle of conductivity change. In the presence of gases, the sensor's resistance varies, producing a voltage output proportional to the gas concentration.
    - **Significance**: Its high sensitivity and rapid response time make it suitable for real-time safety applications.
2. **Microcontroller (PIC18F458):**
    - **Purpose**: Acts as the brain of the system by processing the sensor signals, generating alarms, and controlling the LCD.
    - **Features**: Includes analog-to-digital conversion (ADC) for reading sensor output, interrupt handling for immediate responses, and multiple I/O pins for peripheral interfacing.
    - **Significance**: The PIC18F458 is ideal for embedded systems requiring efficient multitasking and control, making it a robust choice for this project.

3. **Output Devices:**
   - **Buzzer**: Provides an audible alarm to alert users.
   - **LEDs**: Visually indicate the affected zone corresponding to the sensor that detected the leak.
   - **LCD**: Displays detailed information.

4. **Interrupts**:
   - **Purpose**: Interrupts enable the microcontroller to prioritize gas leak detection over other tasks, ensuring immediate response.
   - **Significance**: This feature ensures that the system responds to leaks as soon as they occur, improving reliability and user safety.

Significance:

The importance of this project lies in its potential to save lives and prevent property damage. Conventional gas detectors often lack localization capabilities, leaving users unaware of the exact location of the leak. By incorporating multiple sensors and precise zone mapping, this project addresses that limitation, making it suitable for larger areas like factories, offices, and multi-room homes.

Additionally, the project emphasizes cost-effectiveness and simplicity, ensuring that it can be adopted widely, even in low-income households or small-scale industries.

Introduction

Multi-Sensor Localization with Modular Design

Unlike basic gas detection systems that rely on a single sensor for an entire area, this project introduces a modular design where multiple sensors are used to monitor specific zones. Each sensor is mapped to a predefined location, allowing for precise identification of the leakage source. This concept is particularly useful in complex environments like factories or multi-story buildings, where pinpointing a leak's location is critical for timely corrective action.

1. **Working**:
   - Each sensor operates independently and is connected to a unique input on the microcontroller.
   - When a sensor detects a gas leak above the threshold, the microcontroller immediately triggers the corresponding alarms and displays the location on the LCD.

2. **Advantages**:
   - **Enhanced Safety**: Quick identification of the leakage source ensures faster mitigation.
   - **Scalability**: The system can be expanded by adding more sensors to cover larger or more complex areas.
   - **Cost-Effectiveness**: Modular design reduces the need for expensive centralized systems.

3. **Significance**:
   - This new approach combines the simplicity of individual gas detectors with the sophistication of advanced monitoring systems. It bridges the gap between low-cost household detectors and expensive industrial setups, making it accessible and efficient.

By combining well-established concepts (gas sensors, microcontrollers) with this innovative approach, the project delivers a solution that is practical, reliable, and forward-thinking.

Problem Analysis

The core problem addressed in this project is the detection of gas leaks in environments where the presence of hazardous gases such as LPG (Liquefied Petroleum Gas), propane, methane, or hydrogen can lead to severe accidents, including fires, explosions, and health hazards. The project aims to create an automated system that can detect gas leaks, alert users in real-time, and identify the location of the leak, thus ensuring a swift response to mitigate potential dangers.

In many homes, industrial settings, or laboratories, gas leaks can occur unnoticed, particularly if the leak is minor or if the gas dissipates quickly into the environment. Often, traditional gas detectors provide a general alarm without identifying the source, making it difficult for users to determine the exact location of the leak. This can lead to delays in taking appropriate actions like turning off gas valves, evacuating the area, or calling emergency services.

Key Issues in the Problem

1. **Detection of Gas Leaks**:
   - Gas leaks are not always immediately noticeable, especially in confined spaces. The risk of unnoticed leaks can be high, especially in kitchens, factories, or labs.
   - Gas sensors should be highly sensitive and capable of detecting even low concentrations of dangerous gases before they reach hazardous levels.

2. **Localization of the Gas Leak**:
   - In large environments or multi-room buildings, it is crucial to know exactly where the leak is occurring. Without localization, users must manually search for the source, which is inefficient and dangerous.

3. **Real-Time Response**:
   - A delay in detecting and responding to gas leaks can have dire consequences. The system should instantly alert the user and provide specific information about the location of the leak.

4. **Reliability and Accuracy**:
   - The gas detection system should be accurate, ensuring that only actual gas leaks trigger the alarm. False alarms due to environmental factors like humidity or temperature changes should be minimized.

Problem Analysis

5. **Cost-Effectiveness**:
    - For widespread adoption, the solution must be cost-effective. The system needs to balance functionality with affordable materials and components.

The project proposes a Gas Leakage Detection System that solves the aforementioned issues by integrating multiple gas sensors (e.g., MQ-2) and a microcontroller (PIC18F458). Here is how the system addresses the core challenges:

1. **Gas Leak Detection**:

- **Multiple MQ-2 Sensors**: The MQ-2 sensor is chosen for its sensitivity to a range of gases (such as LPG, methane, and smoke). The sensor detects the presence of gas by measuring the change in its resistance when exposed to gas particles.
- **Microcontroller Processing**: The PIC18F458 microcontroller reads analog signals from each MQ-2 sensor using its Analog-to-Digital Converter (ADC). When the sensor detects gas concentration above a set threshold, the microcontroller processes the signal and triggers the alarm mechanism.

2. **Localization of the Leak:**

- **Multiple Sensor Zones**: Multiple MQ-2 sensors are placed strategically in different zones within the environment (e.g., kitchen, living room, lab, etc.). Each sensor is connected to a separate pin of the microcontroller and corresponds to a specific zone.
- **Alarm with Location**: When a gas leak is detected, the microcontroller notifies the user of the exact zone in which the leak has occurred. This is displayed on an LCD screen and signaled with LEDs (for visual feedback) and a buzzer (for auditory alerts).

3. **Real-Time Response:**

- The interrupt-driven design ensures that the microcontroller immediately responds to any gas leak detection. The microcontroller continuously monitors the sensor inputs, and if a threshold is breached, it interrupts the normal process to handle the emergency response.
- The system ensures that the gas leak is detected promptly and an alert is issued immediately without delay, allowing the user to take preventive actions in time.

4. **Reliability and Accuracy**:

- **Calibration of Sensors**: The MQ-2 sensors can be calibrated to adjust sensitivity levels based on environmental factors like temperature or humidity. This helps ensure the system remains reliable even in varying conditions.
- **Threshold Setting**: The system allows customization of the sensitivity threshold, enabling it to detect only significant gas concentrations that could pose a danger while avoiding false positives.

5. **Cost-Effectiveness**:

- The components selected for the project are affordable and widely available, making the overall system cost-effective. The use of a microcontroller simplifies the design and reduces the need for expensive specialized equipment.
- By using common off-the-shelf components (such as the MQ-2 sensors and the PIC18F458 microcontroller), the system remains within budget without compromising on performance.

To summarize, the Gas Leakage Detection System solves the problem of undetected gas leaks and unsafe working environments by:

1. Using multiple MQ-2 gas sensors to detect a range of gases in different zones, ensuring full coverage and real-time monitoring.
2. Employing the PIC18F458 microcontroller to read and process sensor data, determine whether a leak exists, and respond immediately.
3. Providing a clear indication of the gas leak's location through an LCD screen and visual (LED) and audio (buzzer) alarms, ensuring the user can take quick corrective action.
4. Minimizing the risk of false alarms by calibrating sensors and setting thresholds based on the environmental needs.

This approach not only ensures timely detection and response but also introduces a scalable solution that can be extended to larger environments or more complex setups by adding more sensors

Design Requirements

The design requirements for the **Gas Leakage Detection System** focus on effectively addressing the problem of gas leak detection, localization, and alerting the user in real-time. This section discusses the necessary inputs, outputs, and constraints to meet the project objectives.

Inputs

1. **Gas Concentration**:

- **Source**: The environment where gas leaks might occur (kitchen, industrial spaces, laboratories, etc.).
- **Measurement**: The gas sensors (i.e. **MQ-2**) detect the presence and concentration of gases such as LPG, methane, and hydrogen in the air. The sensors output an **analog signal** proportional to the gas concentration.

2. **Threshold for Detection**:

- A predefined threshold concentration determines when the system should trigger an alert. This threshold can be adjusted based on safety standards for the specific environment.

3. **Environmental Conditions**:

- Parameters such as temperature and humidity that might influence sensor readings. Calibration is required to mitigate environmental impacts on sensor accuracy.

Outputs

1. **Alert Mechanisms**:

I. **Visual Alerts**:

- An **LCD display** to indicate the zone where the gas leak has been detected, along with details of the detected gas concentration.
- **LED Indicators** corresponding to each sensor zone to visually highlight the affected area.

II. **Auditory Alerts**:

- A **buzzer** or alarm system to provide immediate notification to users about a gas leak.

2. **Localized Leak Information**:

- Each sensor corresponds to a specific area or zone (e.g., kitchen, shop, garage etc.). When a leak is detected, the system identifies and displays the specific zone of the leak on the LCD.

3. **Emergency Notifications (optional)**:

- If advanced functionality is included, such as wireless communication, the system can send alerts to a mobile device or an alarm monitoring system.

Constraints

1. **Detection Accuracy**:

- The sensors must reliably detect gas concentrations above the predefined safety threshold while avoiding false positives caused by normal environmental conditions.

2. **Real-Time Response**:

- The system must continuously monitor sensor readings and provide alerts within a minimal delay (<1 second) once a gas leak is detected.

3. **Sensor Placement**:

- Sensors must be placed in optimal locations to ensure accurate detection of gas leaks. For example, LPG (heavier than air) sensors should be installed closer to the ground, while methane (lighter than air) sensors should be placed near the ceiling.

4. **Cost Constraints**:

- The system must be designed using affordable components without compromising its reliability. This ensures the system remains accessible for domestic and small-scale industrial use.

5. **Size and Scalability**:

- The design must be compact and scalable to allow for easy installation in various environments. The system should support additional sensors if coverage needs to be extended to larger areas.

Input-Output Relationship

Input	**Output**
Analog gas concentration signal	LCD display showing gas concentration and location of the leak
Threshold crossing detected	LED indicator for the affected zone
Threshold crossing detected	Buzzer alarm activation
Normal operation (no leak)	System remains silent (no alarm)

Design Requirements

Design Goals

1. **Efficiency**:

- Ensure the system processes sensor input quickly and accurately to provide real-time alerts.

2. **Reliability**:

- The system should operate consistently, with minimal false alarms or missed detections.

3. **User-Friendliness**:

- Provide clear and intuitive outputs (e.g., zone names on the LCD display, distinct LED colors for alerting).

4. **Safety**:

- The system should provide sufficient warning for users to respond before gas concentrations reach hazardous levels.

Design Constraints Breakdown

Constraint Type	Details
Physical Constraints	Sensor placement and system size must suit the environment.
Environmental Constraints	Sensors should work reliably under temperature and humidity variations.
Cost Constraints	The design must use affordable components to ensure accessibility.
Performance Constraints	The system must detect leaks within 1 second and provide accurate alerts.
Scalability Constraints	Should be able to add more sensors for larger or more complex environments.

By addressing these design requirements, the system ensures accurate, reliable, and cost-effective detection and alerting of gas leaks in real-world environments.

Feasibility Analysis

Feasibility analysis evaluates whether the proposed **Gas Leakage Detection System** can be effectively designed and implemented within the constraints of time, cost, and resources. This section assesses the project's practicality to determine whether it is viable to achieve the desired goals.

1. Technical Feasibility

The project requires electronic components (e.g., sensors, microcontroller, and display modules) and software tools for design and implementation. A breakdown of technical aspects indicates that the system is feasible:

I. **Availability of Components**:

- Gas sensors like MQ-2 is widely available and relatively inexpensive.
- A microcontroller such as PIC is versatile and cost-effective for real-time gas detection applications.
- Peripheral devices like buzzers, LCD displays, and LEDs are easy to procure and integrate.

II. **Technical Expertise**:

- Knowledge of microcontroller programming (using assembly or C language) is required. This expertise is manageable given familiarity with tools like **MPLAB** and basic embedded systems concepts.

III. **Infrastructure Requirements**:

- The system requires a workspace equipped with basic electronics tools such as soldering kits, multi-meters, and power supplies, all of which are accessible.

The hardware-software integration and system testing stages are technically feasible and within the team's skill set.

2. Time Feasibility

The project must adhere to deadlines to ensure timely completion. The following timeline outlines the time management plan:

I. **Component Procurement**:

- All required components, such as gas sensors, microcontrollers, LCDs, LEDs, and supporting components (resistors, capacitors, etc.), can be acquired within a week.

II. **Design Phase**:

- Hardware circuit design and microcontroller programming will take approximately two weeks. This includes writing and debugging code to process sensor input and trigger alerts.

III. **Prototyping and Testing**:

- Assembling the hardware prototype, testing sensor accuracy, and calibrating thresholds will require approximately three weeks. Iterative improvements will also be made during this stage.

IV. **Final Implementation and Documentation**:

- The final system assembly and documentation (including flowcharts, results, and performance analysis) can be completed in the last week.

Total Estimated Time: **7 Weeks**
Given this timeline, the project is feasible within the allocated duration if tasks are managed efficiently.

3. Cost Feasibility

The system's cost must remain affordable to ensure accessibility for both domestic and industrial applications.

Software:

- If using MPLAB , no additional cost is incurred for programming and debugging tools.

Cost Management:

- High-quality components should be prioritized within budget constraints. Lower-cost alternatives may compromise system reliability, particularly in safety-critical applications. The project fits within a low-to-medium budget range, making it feasible for small-scale users and academic purposes.

4. Resource Feasibility

The project requires resources such as:

I. **Personnel**:

- A small team of 2–3 individuals with knowledge of microcontroller programming and circuit design is sufficient. MPLAB assembly language code on pic18F458. And proteus software simulation.

II. **Physical Workspace**:

- A small electronics lab or a home workspace with tools such as soldering iron, multimeter, and breadboards.

III. **Support Resources**:

- Online tutorials, datasheets, and reference materials for gas sensors and microcontroller usage.

5. Risk Management and Constraints

I. **Resource Constraints**:

- Limited access to high-precision gas sensors or advanced tools could slightly affect system accuracy. To mitigate this, calibration and optimization are critical.

II. **Risk of Delays**:

- Potential delays in hardware delivery or debugging issues might extend the timeline. Buffer periods must be added to the schedule to account for such risks.

III. **Cost Overruns**:

- Unforeseen expenses, such as replacing damaged components during testing, might slightly exceed the budget. Proper handling and careful assembly can minimize this risk.

6. Feasibility Outcome

I. **Achievability**:

- Based on the analysis, the system is technically, temporally, and financially feasible.

II. **Critical Success Factors**:

- Effective time management and accurate execution of the design plan are essential.

Possible Solutions

To address the problem of gas leakage detection and its associated risks, there are several potential solutions based on different technologies and designs. These solutions vary in terms of complexity, accuracy, and reliability. Below is an analysis of the possible solutions, followed by a justification for the chosen approach.

Solution 1: Basic Gas Sensor with Alert System

I. **Description**:

- This solution uses a gas sensor (e.g., MQ-2 or MQ-135) connected to a microcontroller (PIC18F458). When gas levels exceed a certain threshold, the system activates a buzzer and LED indicator to alert users.

II. **Advantages**:

- Cost-effective and simple to design.
- Suitable for small-scale applications such as homes or small offices.
- Requires minimal power and components.

III. **Disadvantages**:

- Lacks advanced features such as real-time monitoring or data logging.
- Not scalable for industrial applications.
- Limited user interaction or flexibility in adjusting detection thresholds.

Solution 2: Advanced Gas Detection System with IoT Integration

I. **Description**:

- This solution uses the same gas sensor but integrates an IoT module (e.g., ESP8266 or GSM module). Gas leakage data is transmitted wirelessly to a mobile app or cloud platform for real-time monitoring and alerts.

II. **Advantages**:

- Enables remote monitoring and control through smartphones or computers.
- Scalable and suitable for larger applications such as factories or office buildings.
- Allows data logging for long-term analysis of gas levels.

III. **Disadvantages**:

- More expensive due to additional IoT components.
- Requires internet connectivity, which might not be feasible in all areas.
- Increased design and implementation complexity.

Possible Solutions

Solution 3: Gas Detection System with Automatic Shutdown

I. **Description**:

- This solution uses a gas sensor with a relay module to control a shut-off valve or electrical appliances. When gas levels exceed the threshold, the system not only alerts users but also automatically shuts down the gas supply or power to prevent further risks.

II. **Advantages**:

- Provides proactive safety measures by stopping gas flow or disconnecting appliances.
- Reduces the risk of fire or explosion in the event of a leak.
- Effective for both domestic and industrial environments.

III. **Disadvantages**:

- Requires more components, such as solenoid valves, which increase cost.
- Relatively complex to design and implement.
- Requires precise calibration to avoid false shutdowns.

Solution 4: Hybrid Gas Detection System

I. **Description**:

- Combines the features of Solutions 2 and 3 by integrating IoT monitoring with automatic shutdown capabilities. It alerts users, logs data remotely, and simultaneously prevents hazards by shutting off the gas supply.

II. **Advantages**:

- Comprehensive safety solution covering all aspects: detection, alerting, monitoring, and prevention.
- Suitable for high-risk environments where safety is critical, such as chemical plants or large residential complexes.

III. **Disadvantages**:

- Highest cost due to multiple components and functionalities.
- Requires advanced technical expertise for design and maintenance.
- Implementation may require significant time and effort.

Possible Solutions

Comparison of Solutions

Criteria	Solution 1	Solution 2	Solution 3	Solution 4
Cost	Low	Medium	Medium to High	High
Complexity	Low	Medium	Medium	High
Scalability	Limited	High	Moderate	High
Effectiveness	Moderate	High	High	Very High
Suitability for IoT	Not applicable	Yes	Not applicable	Yes
Automatic Prevention	No	No	Yes	Yes

Solution: Gas Detection System with Automatic Shutdown (Solution 3)

Among the possible solutions, **Solution 3: Gas Detection System with Automatic Shutdown** is chosen for the following reasons:

I. **Safety Priority**:

- This solution provides proactive safety by automatically cutting off the gas supply or electrical appliances, reducing the risk of fire or explosions.

II. **Cost-Effectiveness**:

- While slightly more expensive than Solution 1, it remains more affordable and practical than the Hybrid or IoT-integrated systems.

III. **Simplicity with Reliability**:

- Compared to IoT-enabled systems (Solution 2), it is simpler to design and does not rely on internet connectivity, making it suitable for areas with limited access to technology.

IV. **Scalability**:

- Although designed for domestic applications, the system can be scaled for industrial settings by upgrading components such as valves and relays.

V. **Balanced Features**:

- It strikes a balance between cost, complexity, and effectiveness, ensuring feasibility for immediate implementation without sacrificing functionality.

Preliminary Design

The preliminary design of the gas leakage detection system with automatic shutdown involves creating a logical structure that defines how the system works. This includes using various components like sensors, microcontrollers, alarm systems, and actuators (relay and shut-off valve) arranged in a functional sequence.

Functional Components

1. **Gas Sensor (e.g., MQ-2/MQ-135)**:
   - Detects the presence of gases (e.g., LPG, methane, carbon monoxide) and generates an analog signal based on the gas concentration.
2. **Microcontroller (e.g., PIC or Arduino)**:
   - Processes the signal from the gas sensor and determines whether the gas concentration exceeds the predefined safety threshold.
3. **Alarm System**:
   - Triggers a buzzer and/or LED indicator to alert users in case of gas leakage.
4. **Relay Module**:
   - Controls the shut-off valve or electrical appliances based on the microcontroller's output.
5. **Shut-off Valve**:
   - Automatically cuts off the gas supply when a leak is detected.
6. **Power Supply**:
   - Provides necessary voltage levels for all components to function.(5 volts power supply on proteus).

Preliminary Design

Flowchart of the Design

START

↓

Power ON System

↓

Read Gas Sensor Data

↓

Is Gas Concentration
Above Threshold?

↓ ↓

YES **NO**

↓ ↓

Trigger Alarm **Continue Monitoring**
Detected Not-detected

↓

Activate Relay

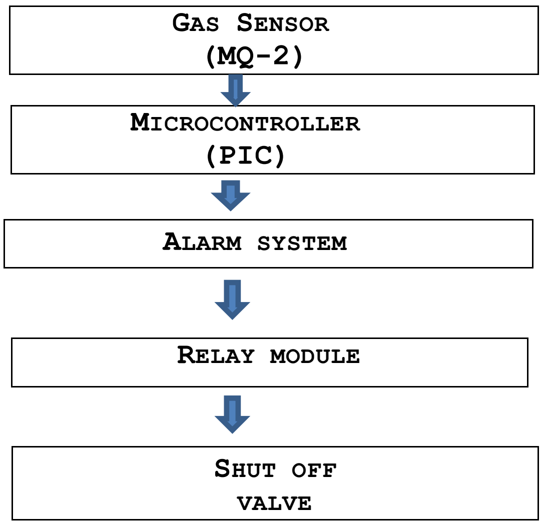
↓

Close Valve

↓

Continue Monitoring

Block Diagram



Preliminary Design

System Operation Flow

The system works as follows:

I. The gas sensor continuously monitors the air for the presence of hazardous gases.
II. The sensor's analog output is sent to the microcontroller, where it is converted to a digital signal.
III. The microcontroller compares the sensor data against a predefined threshold.
IV. If the gas concentration exceeds the threshold:
   - The microcontroller activates the alarm system.
   - Simultaneously, it triggers the relay to close the shut-off valve.
V. If no gas is detected or the concentration is below the threshold, the system remains in monitoring mode.

Explanation of the Flowchart and Block Diagram

1. **Gas Sensor**:
   - This is the primary sensing unit of the system. It continuously measures the concentration of gases in the air and sends the data as an analog signal to the microcontroller.
2. **Microcontroller**:
   - Acts as the brain of the system. It reads the gas sensor's data, processes it, and decides whether to trigger the alarm and shut-off mechanisms.
3. **Alarm System**:
   - Provides an immediate alert through a buzzer or LED indicators, notifying the user of potential danger.
4. **Relay Module**:
   - An electromechanical switch controlled by the microcontroller. When triggered, it activates the shut-off valve.
5. **Shut-off Valve**:
   - A solenoid valve that cuts off the gas supply, ensuring safety in the event of a leak.
6. **Power Supply**:
   - Powers the entire system, ensuring that all components work reliably

Design Description

The design description provides a detailed explanation of each component or block in the gas leakage detection system. Each block plays a critical role in ensuring the system functions seamlessly to detect gas leaks and mitigate potential hazards by triggering alarms and shutting off the gas supply.

1. *Gas Sensor*

- **Purpose**: To detect the presence of hazardous gases like LPG, methane, or carbon monoxide.
- **Working Principle**: Sensors like MQ-2 or MQ-135 work based on the change in electrical resistance when exposed to specific gases. This change is translated into an analog voltage signal.
- **Output**: When it is on than it triggers buzzer, alarm and LCD and when it is off than it displays not detect on displays.
- **Significance**: It acts as the primary input to the system, ensuring real-time monitoring of gas concentration levels in the air.

2. *Microcontroller*

- **Purpose**: To process the sensor's data and control the overall system.
- **Working Principle**:
  - ➢ The microcontroller (PIC) reads the sensor's analog signal, converts it to a digital value (using an ADC), and compares it with a predefined threshold.
  - ➢ If the gas concentration exceeds the threshold, the microcontroller triggers appropriate actions (alarm and shut-off valve).
- **Key Features**:
  - ➢ ADC for analog-to-digital conversion.
  - ➢ GPIO pins for controlling external devices like relays and alarms.
  - ➢ Software programmability for setting thresholds and handling inputs/outputs.
- **Significance**: It is the brain of the system, making all decisions based on sensor input.

3. *Alarm System*

- **Purpose**: To alert users immediately when a gas leak is detected.
- **Components**:
  - ➢ Buzzer: Emits a loud sound to grab attention.
  - ➢ LED Indicator: Provides a visual signal.
- **Working Principle**:
  - ➢ The microcontroller sends a HIGH signal to the buzzer and LED pins when the gas concentration exceeds the safety threshold.
- **Significance**: Provides both auditory and visual alerts to warn users of a dangerous situation.

Design Description

4. Relay Module

- **Purpose**: To act as a switch, enabling the microcontroller to control high-power devices like the shut-off valve.
- **Working Principle**: Relays use an electromagnetic coil to open or close circuits. When the microcontroller outputs a HIGH signal, the relay activates and closes the circuit to power the shut-off valve.
- **Key Features**:

  - Electrically isolated from the microcontroller using an opto-coupler.
  - Can handle higher current and voltage levels than the microcontroller.

- **Significance**: Allows low-power control signals from the microcontroller to control high-power devices safely.

5. Shut-off Valve

- **Purpose**: To automatically close the gas supply when a leak is detected.
- **Working Principle**: Typically, solenoid valves are used. When the relay provides power, the solenoid actuates, closing the valve and cutting off the gas supply.
- **Significance**: Provides a physical safety measure to stop the flow of gas, preventing further escalation of the situation.

6. Power Supply

- **Purpose**: To provide the required voltage and current for all system components.
- **Working Principle**: Converts AC mains power to DC voltage levels suitable for the components
- **Significance**: Ensures reliable operation of all components without interruptions.

7. Output

When heat sensor detect gas at any location than it displays the location where gas is detected and also buzzer and led turn on. If there is no leakage, then it displays ‘not detected any’ on lcd.

Design Description

Block Descriptions and Interconnections

Gas Sensor to Microcontroller

- The sensor continuously measures gas levels and outputs an analog signal.
- The microcontroller uses its ADC to convert the analog signal into a digital value.
- This data is compared with a predefined safety threshold.

Microcontroller to Alarm System

- If the gas concentration exceeds the threshold, the microcontroller sends a HIGH signal to the buzzer and LED pins.
- The buzzer produces an audible alarm, and the LED provides a visual indicator.

Microcontroller to Relay Module

- The microcontroller controls the relay module by sending a HIGH or LOW signal.
- A HIGH signal activates the relay, powering the shut-off valve.

Relay Module to Shut-off Valve

When the relay is activated, it provides power to the solenoid valve, causing it to close and stop the gas flow.

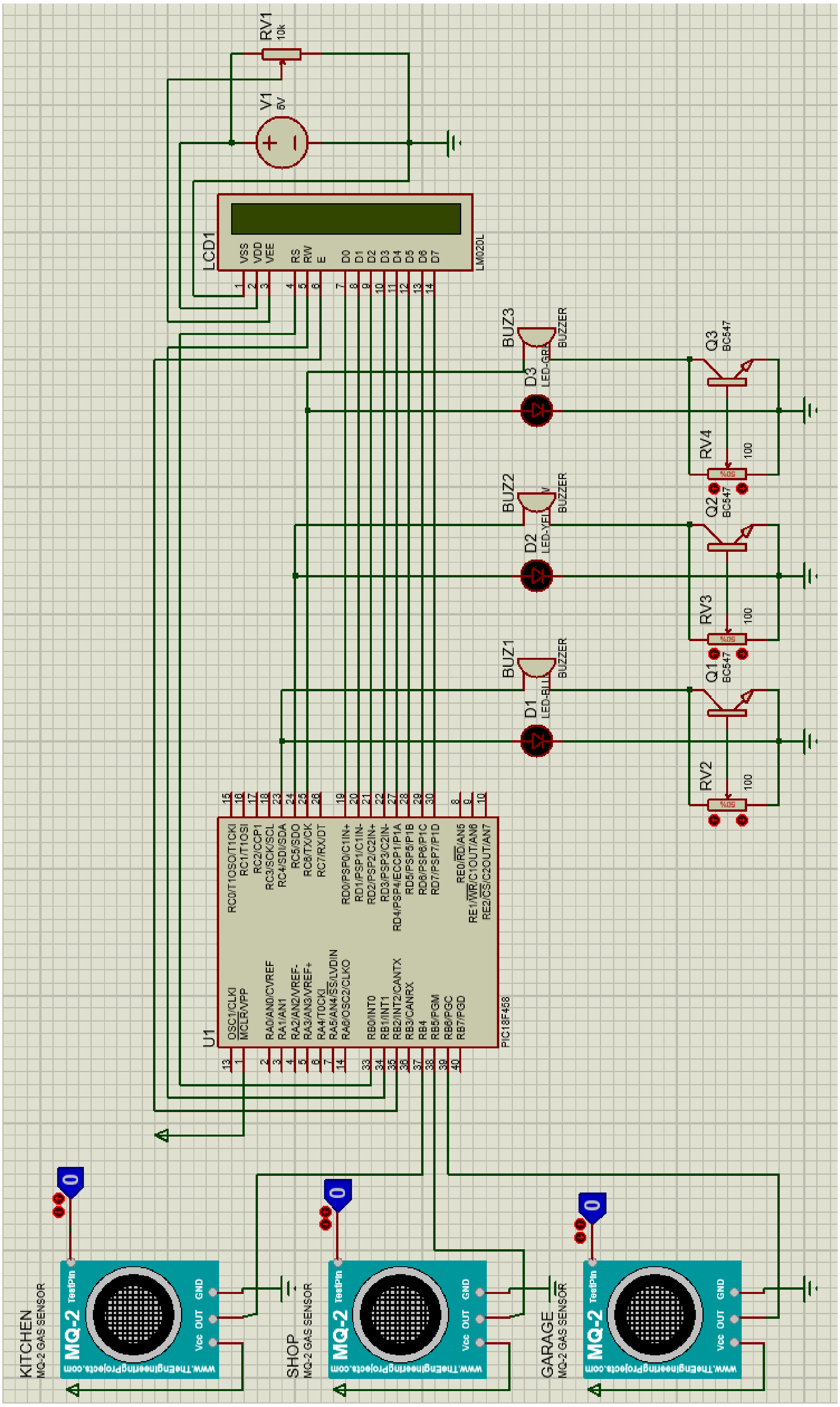
Power Supply to All Components

- The power supply ensures all components receive the appropriate voltage and current:
- 5V for the microcontroller, buzzer, and LEDs.
- 12V for the relay and shut-off valve.

System Highlights

- **Safety**: Combines early detection (sensor) with immediate response (alarm and shut-off valve).
- **Automation**: Operates automatically without user intervention, minimizing response time in emergencies.
- **Modularity**: Each block is independent, allowing for easy maintenance and upgrades.

Software Simulation



Code

```
LIST P=18F458
#INCLUDE <P18F458.INC>
COUNTER EQU 0X85

ORG 0000H
GOTO MAIN

ORG 0008H
BTFSS INTCON,RBIF
RETFIE
GOTO ISR

ORG 0100H
MAIN:
;OUTPUT LED+BUZZER
BCF TRISC,4
BCF TRISC,5
BCF TRISC,6
;SENSOR INPUT
BSF TRISB,4
BSF TRISB,5
BSF TRISB,6
;INTERRUPTS
BSF INTCON,GIE
BSF INTCON,RBIE
BCF INTCON,RBIF

;LCD INIT
BCF TRISB,0
BCF TRISB,1
BCF TRISB,2
CLRF TRISD

LCD_INIT:
MOVLW 0X38
CALL COMMAND
CALL DELAY
MOVLW 0X0C
CALL COMMAND
CALL DELAY
MOVLW 0X06
CALL COMMAND
CALL DELAY
MOVLW 0X01
CALL COMMAND
CALL DELAY
```

```
AGAIN:
NOP
GOTO AGAIN

ISR:
ORG 0200H
MOVFF PORTB,PORTC

BTFSC PORTB,4
CALL DETECTED1
BTFSC PORTB,5
CALL DETECTED2
BTFSC PORTB,6
CALL DETECTED3

BCF INTCON,RBIF
RETFIE

DETECTED1:
MOVLW 'D'
CALL DATA_WRT
CALL DELAY
MOVLW 'E'
CALL DATA_WRT
CALL DELAY
MOVLW 'T'
CALL DATA_WRT
CALL DELAY
MOVLW 'E'
CALL DATA_WRT
CALL DELAY
MOVLW 'C'
CALL DATA_WRT
CALL DELAY
MOVLW 'T'
CALL DATA_WRT
CALL DELAY
MOVLW 'E'
CALL DATA_WRT
CALL DELAY
MOVLW 'D'
CALL DATA_WRT
CALL DELAY
MOVLW ':'
CALL DATA_WRT
CALL DELAY
```

Code

```
MOVLW 'K'
CALL DATA_WRT
CALL DELAY
MOVLW 'I'
CALL DATA_WRT
CALL DELAY
MOVLW 'T'
CALL DATA_WRT
CALL DELAY
MOVLW 'C'
CALL DATA_WRT
CALL DELAY
MOVLW 'H'
CALL DATA_WRT
CALL DELAY
MOVLW 'E'
CALL DATA_WRT
CALL DELAY
MOVLW 'N'
CALL DATA_WRT
CALL DELAY
RETURN

DETECTED2:
MOVLW 'D'
CALL DATA_WRT
CALL DELAY
MOVLW 'E'
CALL DATA_WRT
CALL DELAY
MOVLW 'T'
CALL DATA_WRT
CALL DELAY
MOVLW 'E'
CALL DATA_WRT
CALL DELAY
MOVLW 'C'
CALL DATA_WRT
CALL DELAY
MOVLW 'T'
CALL DATA_WRT
CALL DELAY
MOVLW 'E'
CALL DATA_WRT
CALL DELAY
MOVLW 'D'
CALL DATA_WRT
CALL DELAY
MOVLW ':'
CALL DATA_WRT
CALL DELAY
MOVLW ' '
CALL DATA_WRT
CALL DELAY
MOVLW 'S'
CALL DATA_WRT
CALL DELAY
MOVLW 'H'
CALL DATA_WRT
CALL DELAY
MOVLW 'O'
CALL DATA_WRT
CALL DELAY
MOVLW 'P'
CALL DATA_WRT
CALL DELAY
MOVLW ' '
CALL DATA_WRT
CALL DELAY
MOVLW ' '
CALL DATA_WRT
CALL DELAY
RETURN

DETECTED3:
MOVLW 'D'
CALL DATA_WRT
CALL DELAY
MOVLW 'E'
CALL DATA_WRT
CALL DELAY
MOVLW 'T'
CALL DATA_WRT
CALL DELAY
MOVLW 'E'
CALL DATA_WRT
CALL DELAY
MOVLW 'C'
CALL DATA_WRT
CALL DELAY
MOVLW 'T'
CALL DATA_WRT
```

Code

```
CALL DELAY
MOVLW 'E'
CALL DATA_WRT
CALL DELAY
MOVLW 'D'
CALL DATA_WRT
CALL DELAY
MOVLW ':'
CALL DATA_WRT
CALL DELAY
MOVLW 'G'
CALL DATA_WRT
CALL DELAY
MOVLW 'A'
CALL DATA_WRT
CALL DELAY
MOVLW 'R'
CALL DATA_WRT
CALL DELAY
MOVLW 'A'
CALL DATA_WRT
CALL DELAY
MOVLW 'G'
CALL DATA_WRT
CALL DELAY
MOVLW 'E'
CALL DATA_WRT
CALL DELAY
MOVLW ' '
CALL DATA_WRT
CALL DELAY
RETURN

COMMAND:
BCF PORTB,0
BCF PORTB,1
MOVWF PORTD
BSF PORTB,2
NOP
BCF PORTB,2
CALL DELAY
RETURN


DATA_WRT:
BSF PORTB,0
BCF PORTB,1
MOVWF PORTD
BSF PORTB,2
NOP
BCF PORTB,2
CALL DELAY
RETURN

DELAY:
MOVLW 0X0F
MOVWF COUNTER
LOOP:
DECFSZ COUNTER,F
GOTO LOOP
RETURN

END_PROG:
END
```

Experimental Results

Setup

a. Hardware:

- PIC18F458 microcontroller
- Gas sensors connected to PORTB pins (RB4, RB5, RB6)
- LEDs and buzzers on PORTC pins (RC4, RC5, RC6)
- 16x2 LCD connected to PORTD

b. Functionality:

- Gas sensors provide input signals to PORTB.
- Corresponding LEDs and buzzers indicate the presence of gas.
- The LCD displays the detected location ("Kitchen," "Shop," "Garage") or "Multiple" if more than one sensor is triggered.

Observations

1. **Single Detection:**

   When RB4 is triggered:

   - ➢ LED and buzzer on RC4 activate.
   - ➢ LCD displays:

   ```
   DETECTED: KITCHEN
   ```

   Similar behavior observed for RB5 (Shop) and RB6 (Garage).

2. **Multiple Detections:**

   When RB4 and RB5 are triggered simultaneously:

   - ➢ LEDs and buzzers for both locations activate.
   - ➢ LCD displays:

   ```
   MULTIPLE
   KITCHEN, SHOP
   ```

   Observed behavior is consistent for other combinations of sensors.

3. **Timing:**

   The delay subroutine is sufficient for stable LCD operation, but may need optimization in high priority scenarios.

4. **Interrupt Handling:**

   The ISR handles multiple signals effectively without missing interrupts.

Performance Analysis

Strengths

1. **Real-time Responsiveness:** The use of hardware interrupts ensures timely detection and response to gas leaks.
2. **User-Friendly Display:** The LCD clearly communicates the detected location, aiding quick decision-making during emergencies.
3. **Modular Design:** Each functionality (detection, output activation, LCD update) is implemented in separate subroutines, making the program readable and maintainable.
4. **Scalability:** Additional sensors can be integrated by modifying the ISR logic and display routine.

Limitations

1. **Noisy Environments:** Lack of de-bounce handling can cause false triggers. Implementing de-bounce logic or using hardware-based de-bounce circuitry can enhance reliability.
2. **Multiple Detection Handling:** While it identifies multiple leaks, the LCD output format for multiple detections can be improved for better readability (e.g., scrolling text or multi-line display).
3. **Power Efficiency:** Continuous polling and active LEDs/buzzers may drain battery-operated systems faster. Optimizing delays and using low-power modes can mitigate this.
4. **Hardcoding:** Detected locations are hardcoded. For scalability, location names could be parameterized using an external EEPROM or configuration table.

Optimization Suggestions

1. **Interrupt Prioritization:** Implementing high-priority interrupts for critical detections can improve responsiveness.
2. **LCD Display Enhancement:** Adding a scrolling mechanism or using multiple pages on the LCD for better representation during multiple detections.
3. **Fault Tolerance:** Incorporate redundancy checks (e.g., validating sensor data over a few cycles) to ensure accuracy.

Overall Performance

- The system provides an effective solution for gas leak detection with visual, auditory, and textual feedback mechanisms.
- For real-world deployment, addressing environmental noise, improving power efficiency, and optimizing user feedback mechanisms will enhance reliability and user satisfaction.

Future Scope

The gas leakage detection system, as designed, addresses safety concerns effectively by detecting gas leaks, raising alarms, and shutting off the gas supply. However, there is significant potential for enhancing its functionality and usability. The future scope of this project involves incorporating advanced technologies and extending its application to broader domains. Below are detailed aspects of the future scope and potential improvements:

1. Integration with IoT (Internet of Things)

- **Current Limitation**: The system functions locally, and notifications are limited to physical alarms.
- **Improvement**:

➢ Integrate the system with IoT platforms to enable remote monitoring and notifications.
➢ Use Wi-Fi or GSM modules to send alerts (via SMS, email, or mobile app notifications) to the user's smartphone or cloud dashboard.

- **Significance**: Enhances safety by allowing users to monitor gas levels in real-time and receive instant alerts, even when they are away from the premises.

2. Enhanced Gas Sensor Sensitivity

- **Current Limitation**: The system uses a single gas sensor (e.g., MQ-2), which may not effectively detect a wide range of gases or operate optimally under all environmental conditions.
- **Improvement**:

➢ Add multi-gas sensors capable of detecting other hazardous gases like ammonia (NH3), sulfur dioxide (SO2), or hydrogen sulfide (H2S).
➢ Use advanced sensors with higher sensitivity and lower response times.

- **Significance**: Broadens the system's application in industries, where multiple toxic gases may be present.

3. Battery Backup for Power Supply

- **Current Limitation**: The system relies on mains electricity, making it non-functional during power outages.
- **Improvement**: Incorporate a rechargeable battery backup or solar power supply to ensure uninterrupted operation.
- **Significance**: Guarantees reliability during emergencies, especially in areas with unstable power supply.

4. Machine Learning for Predictive Analysis

- **Current Limitation**: The system only reacts to gas leaks but does not provide predictive insights.
- **Improvement**:

➢ Employ machine learning algorithms to analyze gas concentration trends over time and predict potential leaks before they occur.
➢ Train the system to differentiate between safe and hazardous gas levels with higher accuracy.

- **Significance**: Shifts the system from reactive to proactive safety measures, reducing risks even further.

Future Scope

5. Automatic Ventilation Control

- **Current Limitation**: The system only focuses on shutting off the gas supply and raising alarms.
- **Improvement**:

➢ Add controls for exhaust fans or ventilation systems that automatically activate to disperse accumulated gas.
➢ Integrate CO2 or air-quality sensors to monitor the overall air quality and maintain a safe environment.

- **Significance**: Provides an additional layer of safety by minimizing the concentration of leaked gas.

6. Miniaturization and Portability

- **Current Limitation**: The system is designed as a stationary device, which limits its deployment.
- **Improvement**: Miniaturize the hardware to make it portable, allowing use in small, confined spaces such as vehicles, kitchens, or temporary setups.
- **Significance**: Expands the application to mobile and temporary environments.

7. Integration with Smart Home Systems

- **Current Limitation**: The system operates independently and is not compatible with smart home ecosystems.
- **Improvement**:

➢ Enable compatibility with smart assistants like Amazon Alexa or Google Home.
➢ Use protocols like Zigbee or Z-Wave for seamless integration with existing smart home devices.

- **Significance**: Increases usability and convenience for modern households.

8. Application in Industrial Settings

- **Current Limitation**: The current design is tailored for domestic use.
- **Improvement**:

➢ Scale the system to industrial applications by using more robust sensors and components.
➢ Add features to handle high-pressure gas pipelines or hazardous environments like chemical plants and refineries.

- **Significance**: Extends the application to industries, preventing large-scale gas leaks and ensuring worker safety.

9. Data Logging and Analytics

- **Current Limitation**: The system does not record or analyze historical data.
- **Improvement**:

➢ Implement data logging to store gas concentration levels and leak events over time.
➢ Use analytics to generate reports, helping users understand trends and improve safety protocols.

- **Significance**: Provides actionable insights for preventive maintenance and better safety management.

Future Scope

10. Improved User Interface

- **Current Limitation**: The system relies on basic LEDs and buzzers for user interaction.
- **Improvement**:

➢ Add an LCD or OLED display to show real-time gas concentration, system status, and alerts.
➢ Use touch or button-based interfaces for easier user control.

- **Significance**: Enhances the user experience, making the system more intuitive and informative.

11. Cost Optimization

- **Current Limitation**: Some components, like high-end sensors and IoT modules, can increase costs.
- **Improvement**:

➢ Explore alternative components or open-source solutions to reduce costs without compromising performance.
➢ Develop mass production strategies to make the system more affordable.

- **Significance**: Makes the system accessible to a larger audience, especially in low-income or developing regions.

Conclusion

In conclusion, the Gas Leakage Detection System developed in this project presents an effective and reliable solution to mitigate the risks associated with gas leaks in both residential and industrial environments. Through the integration of a gas sensor module, a PIC microcontroller for data processing, and an LCD display for real-time alerts, the system provides a comprehensive mechanism for early detection of gas leaks. The alarms (buzzer and LED) and the display alerts provide timely notifications to users, enhancing safety and preventing potential hazards such as fires, explosions, and toxic exposure.

Key Takeaways from the Results

- **Effectiveness in Detection**: The system successfully detects gas leaks and immediately activates alarms, making it highly efficient in responding to potential threats. It provides an alert in the form of a visual display on an LCD, ensuring that the location of the leakage is clearly communicated to users. The system's ability to trigger both audible and visual alarms ensures that users in various environments are promptly notified.
- **Accuracy and Reliability**: The gas sensor module used in this design is critical to the system's accuracy in detecting gas levels. The use of interrupts within the PIC microcontroller ensures that the system responds in real-time to changes in gas concentration. This ensures reliability, especially in time-sensitive scenarios where delay could lead to catastrophic results.
- **Practical Implementation**: The system has been designed with practical, user-friendly features that can be adapted to both residential and industrial applications. By incorporating basic components such as the gas sensor, PIC microcontroller, and standard actuators (buzzer and LED), the system remains cost-effective while maintaining high reliability.
- **Social and Environmental Impact**: The system's design has far-reaching positive implications for public safety and environmental protection. By detecting leaks early, the system helps prevent dangerous incidents and reduces the environmental impact of gas emissions, contributing to a safer and more sustainable society.

Limitations

While the system has proven to be effective, there are some limitations that need to be addressed:

- **Sensitivity and Calibration**: The gas sensor's sensitivity could be improved for detection at lower gas concentrations. Calibration of the sensor must also be performed regularly to maintain its accuracy over time.
- **Power Consumption**: The system is designed to run continuously, and its power consumption may be a concern for long-term usage, particularly in environments where power is limited. Power-saving mechanisms could be introduced to enhance the system's sustainability.
- **Privacy Concerns**: If expanded into more advanced systems integrated with IoT, concerns about data privacy and security need to be taken seriously, ensuring that sensitive data is protected from unauthorized access.

Overall Evaluation and Conclusion

The Gas Leakage Detection System successfully addresses the problem of gas leaks by providing an efficient and reliable solution that enhances safety in both residential and industrial settings. The design integrates easily available components, ensuring the solution is cost-effective while still offering significant safety benefits.

The project demonstrates the importance of timely gas leak detection in preventing potential hazards. The results obtained from this design suggest that, when fully implemented, this system could save lives, prevent injuries, and reduce damage to property.

Despite the few challenges regarding sensor sensitivity, power consumption, and privacy concerns, the developed solution shows considerable promise for future applications. The system's simplicity, affordability, and reliability make it an excellent choice for enhancing safety, especially in environments where gas leaks pose a significant threat. Further improvements in sensor accuracy, energy efficiency, and data security will increase the system’s impact, extending its applicability and effectiveness.

Future Considerations

To ensure continuous improvement and adaptation to evolving needs, future versions of the system could include:

- **IoT Integration**: To allow remote monitoring and alerts via mobile apps or web platforms, providing real-time updates on gas levels and alarm statuses.
- **Energy Efficiency**: The implementation of low-power designs to allow for prolonged system operation in off-grid or remote areas.
- **Smart Calibration**: Automatic calibration techniques for the gas sensor to maintain accuracy without requiring manual intervention.

By incorporating these advancements, the Gas Leakage Detection System can continue to evolve, offering a more sophisticated and adaptable solution for improving safety in both homes and workplaces.