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DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION

TECNOLOGY

FINAL YEAR PROJECT

DESIGN AND IMPLEMENTATION OF AUTOMETED GAS LEAK DETECTOR

Final Year Project submitted in partial fulfilment of the requirement for the award of an Advanced Diploma in Electronics and Telecommunication Technology

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DECLARATION A.

I **NIYONSABA Henrico**, declare that this research study is my original work and has not been presented for a Degree or any other academic award in any University or Institution of Learning". No part of this research should be reproduced without the authors' consent or that of ULK Polytechnic Institute.

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DECLARATION B.

I confirm that the work reported in this research project was carried out by the candidate under my supervision.

Supervisor name: BIRALI Steven

Sign: _____________________________ Date: ____________________________

DEDICATIONDEDICATION

I dedicate this project to my family, whose unwavering support and encouragement have been my source of strength throughout this journey. To my parents, thank you for your constant guidance, love, and belief in my abilities. Your sacrifices have laid the foundation for my academic success.

I also dedicate this work to my teachers, who have continually inspired me to pursue knowledge with curiosity and determination. Your invaluable insights and advice have shaped my understanding and passion for engineering and technology.

Lastly, this project is dedicated to all the innovators and problem-solvers who strive to make the world a safer place through the advancement of technology. May this work contribute, in its own way, to ensuring the safety and well-being of those who use LPG in their homes and industries.

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Thank you all.

ABSTRACT

This project presents the design and implementation of automated Gas leak detector and ventilation system, aimed at enhancing safety in environments where LPG is used. The system utilizes an Arduino Uno microcontroller, an MQ2 gas sensor, an SG90 micro servo motor, a fan, and a buzzer to detect gas leaks, alert users, and initiate a ventilation process. The MQ2 sensor detects LPG concentrations and triggers the fan and buzzer when dangerous levels are detected, ensuring timely mitigation of potential hazards.

Key findings from the system's evaluation showed that the gas detection mechanism was effective, with the MQ2 sensor detecting LPG concentrations as low as 500 ppm and triggering the fan and alarm at 1000 ppm. The system demonstrated a response time of less than 5 seconds, and the ventilation system reduced gas concentration by 50% within the first 5 minutes of operation. The components used, including the servo motor and fan, functioned reliably throughout the testing phase.

The project successfully meets its objective of responsive, and reliable LPG leak detection system. However, improvements such as enhanced sensor sensitivity, integration of wireless communication for remote monitoring, and the addition of features like automatic gas supply shutdown are recommended for future work to broaden the system’s applicability and functionality.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABRAVIATIONS

LPG: liquid Petroleum Gas

DC: Direct current

MQ2: Metal oxide semiconductor type gas sensor

CH4: Methane

C3H8: Propane

CO: Carbon monoxide

IDE: Integrated Development Environment

PPM: Parts Per Million

CHAPTER 1: GENERAL INTRODUCTION

1.1. Introduction

The **Servo-Motion and Liquefied Petroleum Gas (LPG) Leak Detection and Fan System** project is designed to create a robust safety solution that addresses the risks associated with LPG leaks in both residential and industrial environments. LPG is a highly efficient and versatile fuel source, widely used for heating, cooking, and industrial processes. However, its flammability and potential for causing fires or explosions when leaked make it imperative to have effective detection and response systems in place. Even a minor leak can lead to significant safety hazards if not promptly detected and mitigated.

This system integrates **gas sensors**, **servo motors**, and **automated exhaust fans** to form a comprehensive mechanism that not only detects gas leaks but also takes immediate action. Upon leak detection, the system triggers audible alarms and simultaneously activates exhaust fans to disperse the accumulated gas, thereby preventing the concentration from reaching dangerous levels. Additionally, servo motors can be programmed to control safety devices such as shut-off valves, adding another layer of precaution.

By leveraging modern automation technologies, this project not only enhances safety but also ensures compliance with regulatory safety standards, which are critical in both residential and industrial contexts. The system is designed to be adaptable and scalable, meaning it can be implemented in a variety of environments, from small homes to large industrial complexes. Ultimately, this solution seeks to mitigate the risks associated with LPG leaks while contributing to a safer and more secure use of this important energy source.

1.2. Background study

The widespread adoption of Liquefied Petroleum Gas (LPG) as a cleaner, more efficient, and environmentally friendly alternative to traditional fuels has revolutionized various sectors, including cooking, heating, and industrial processes. Its versatility and cost-effectiveness have made it a popular choice in both residential and commercial settings, ranging from households and restaurants to factories and hotels. However, the flammable nature of LPG presents significant hazards, especially when leaks occur in enclosed or poorly ventilated areas. Even a small leak, if undetected, can result in catastrophic incidents such as fires, explosions, and severe health risks due to gas inhalation.

In many settings, traditional methods of gas leak detection, such as manual observation or basic alarm systems, are still prevalent. These methods are often unreliable, slow to detect leaks, and prone to human error, leading to delayed responses that can escalate dangerous situations. This project is motivated by the growing need for a more reliable, automated solution that not only detects LPG leaks promptly but also initiates an immediate response to mitigate the hazard.

The project leverages advanced gas sensors for precise leak detection, servo motors to control gas valves, and 12V DC fans for effective ventilation. By integrating these components into an automated system, the aim is to reduce reliance on manual intervention, ensuring faster detection and response times. This not only enhances safety but also aligns with modern regulatory standards for gas handling in residential, industrial, and commercial environments. Ultimately, the goal is to create a system that can be easily adapted to various settings, providing a scalable and proactive approach to addressing the risks posed by LPG leaks.

1.3 Problem Statement

While Liquefied Petroleum Gas (LPG) is highly beneficial as a fuel, its flammability poses significant safety risks, especially in environments that rely on manual leak detection methods. Delayed detection of gas leaks can result in catastrophic outcomes, including fires, explosions, and severe health issues stemming from inhalation of gas. Traditional detection methods, often reliant on human vigilance, can be insufficiently proactive. This can lead to dangerous situations where the gas accumulates in confined spaces before being addressed. Consequently, there is a critical need for an automated system that can detect leaks immediately and initiate corrective actions, such as shutting off the gas supply and enhancing ventilation to disperse any accumulated gas.

This project aims to design a comprehensive system that integrates advanced gas sensors, servo motors for precise control, and automated fans for effective ventilation, thereby offering a scalable and reliable solution suitable for a variety of settings, including domestic, commercial, and industrial environments. By automating the detection and response processes, this system aspires to enhance safety, significantly reduce operational risks, and ensure compliance with safety regulations. Moreover, the implementation of this system is expected to raise awareness about LPG safety, encourage best practices in gas management, and ultimately contribute to a safer environment for users. In a landscape where safety is paramount, the development of such integrated solutions is not just innovative but essential for protecting lives and property.

1.4 Objectives

1.4.1 General Objectives

The objective of this project is to develop an integrated safety system that detects LPG leaks and responds automatically to reduce associated risks. Using an MQ2 gas sensor, Arduino Uno microcontroller, 12V DC fan, and alarm system, the design detects gas concentrations, activates ventilation, and alerts users of potential hazards. This system is tailored for environments where LPG is commonly used, such as homes, restaurants, and small industrial setups, to enhance safety. Beyond immediate hazard prevention, it establishes a framework for safety compliance and proactive risk management, reducing the risk of explosions or fires and providing users with greater peace of mind.

1.4.2. Specific objectives

i. **To develop a gas detection system** that can accurately sense the presence and concentration of liquified petroleum gas

ii. **To design a control mechanism** using a servo motor that can automatically close the source of the gas based on the detected gas concentration.

iii. **To integrate a fan** that can effectively expel contaminated air and enhance air circulation within the indoor environment.

iv. **To create an automated system** that can seamlessly control the fan and vent in response to real-time air quality data, ensuring a safe and healthy indoor atmosphere

1.5 Hypothesis

An integrated LPG leak detection system, equipped with advanced sensors, servo motors, and automated fans, will significantly improve safety measures and reduce response times compared to conventional manual methods. This system is expected to accurately detect LPG leaks, immediately activate ventilation to disperse accumulated gas, and trigger audible or visual alarms to alert users in real-time. By automating these critical safety functions, the system will enhance adherence to safety standards and reduce the likelihood of hazardous incidents such as fires or explosions. Furthermore, the system will provide long-term cost benefits by preventing property damage and operational disruptions, ensuring the safety of occupants, and preserving equipment integrity. The adaptable design will allow the system to be implemented across various settings—residential homes, industrial facilities, and commercial spaces—while maintaining consistent performance, scalability, and ease of installation, making it a versatile solution for a broad range of applications.

1.6 Scope and Limitations

The **Servo-Motion and LPG Leak Detection and Fan System** is designed for indoor environments, such as homes and small industrial spaces, focusing on the detection and mitigation of LPG leaks. The scope includes the integration of gas detection technologies, automation using servo motors, and a 12V DC exhaust fan for ventilation purposes. The system is theoretically grounded in safety automation and gas detection principles. The research, design, and testing span a six-month period. Limitations include the system's sensitivity to certain environmental factors, such as high humidity, and its primary focus on indoor use.

1.7 Significance of the Project

The Servo-Motion and Liquefied Petroleum Gas (LPG) Leak Detection and Fan System is crucial for enhancing safety in both domestic and industrial settings. Its primary importance lies in its ability to detect and respond to LPG leaks promptly, thus preventing potential fire hazards and explosions. By providing an automated and immediate response to gas leaks, the system significantly reduces the risks associated with human error and delayed reactions that often accompany manual detection methods. This proactive approach not only safeguards lives and property but also enhances compliance with safety regulations, ensuring that users meet industry standards and legal requirements.

Furthermore, this project contributes to environmental protection by minimizing gas leaks and their associated emissions. By implementing a system that quickly identifies and mitigates leaks, the impact of harmful emissions on the environment can be significantly reduced, aligning with global efforts to promote sustainability and reduce greenhouse gases. The automation involved improves operational efficiency and reduces the need for manual intervention, offering significant cost savings over time, particularly in industries where LPG is used extensively.

Additionally, the project underscores the growing importance of integrating smart technologies into everyday life to enhance safety and efficiency. By leveraging advanced sensors and automated systems, this project represents a step toward creating smarter, more responsive environments that prioritize safety and operational integrity. As technology continues to evolve, systems like this will play a vital role in shaping the future of safety protocols in various sectors, paving the way for further innovations in automated safety solutions.

1.8 Organization of the Study:

This study is organized into five chapters, each addressing key aspects of the project:

- **Chapter One: Introduction** – This chapter presents the background of the study, the problem statement, the objectives (both general and specific), the significance of the study, and the scope of the project.
- **Chapter Two: Literature Review** – This section provides an in-depth analysis of previous research, theories, concepts, and expert opinions relevant to gas leak detection, automation systems, and safety technologies. It includes insights into the components and technologies used in the project.
- **Chapter Three: Research Methodology** – In this chapter, the research design, population, sample size, instruments, data collection methods, and data analysis techniques are discussed. It outlines the approach used to gather and analyze the data for the system’s testing and evaluation.
- **Chapter Four: System Design Analysis and Implementation** – This chapter details the design, development, and testing process of the LPG leak detection and fan system. It includes system architecture, component integration, system testing, and cost estimation.
- **Chapter Five: Summary, Conclusion, and Recommendations** – The final chapter summarizes the key findings of the study, draws conclusions based on the system’s performance, and provides recommendations for further research or improvements in the system's design

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The Servo-Motion and Liquefied Petroleum Gas (LPG) Leak Detection and Fan System project is aimed at addressing safety hazards associated with LPG leaks. As LPG is a highly efficient fuel widely used in residential, commercial, and industrial settings, its flammable nature poses risks of explosions and health hazards if leaks go undetected. Traditional methods of gas detection often fail to provide timely responses. This project seeks to introduce an automated system that integrates gas sensors, servo motors, and fans to detect and respond to leaks efficiently. This system will help reduce safety risks, comply with regulations, and mitigate damage.

2.2 Concepts, Opinions, Ideas from Authors/Experts

This section explores various expert opinions and insights that have informed the development of the system, covering gas detection technologies, automation in safety systems, ventilation strategies, cost-benefit analyses, regulatory compliance, and scalability.

❖ Gas Detection Technologies

The significance of using reliable sensors like the MQ series for detecting LPG leaks. These sensors convert gas presence into electrical signals, which can be processed by microcontrollers to trigger actions like activating alarms or fans, Smith (2019).

The importance of sensor sensitivity and specificity, which helps in reducing false alarms while ensuring quick detection, Jones (2020).

❖ Automation in Safety Systems

Automating safety systems enhances reliability by providing faster responses than manual methods. Servo motors and automated fans, when integrated with LPG detection systems, ensure that potential hazards are mitigated quickly, reducing the risk of accidents, Brown (2018).

❖ Ventilation and Hazard Mitigation

White (2017) argues that activating ventilation systems as soon as a leak is detected is crucial for dispersing the gas and preventing hazardous concentrations. Green (2019) adds that proper placement and operation of fans can ensure efficient ventilation in both small and large environments.

❖ Cost-Benefit Analysis

Thompson (2020) explores the long-term cost savings associated with implementing automated systems. While the initial cost is higher, the reduction in potential accidents and associated expenses, such as property damage or medical costs, outweighs the setup costs over time.

- **Regulatory Compliance and Standards**

Williams (2018) highlights the importance of compliance with industry regulations. Adopting systems that meet the safety standards set by regulatory bodies can protect facilities from legal issues while enhancing safety measures.

- **Scalability and Adaptability**

Roberts (2019) discusses the importance of designing systems that are adaptable and scalable to different environments. A modular design, like the one used in this project, allows for the system to be customized for various settings, from homes to industrial sites.

2.3 Theoretical Perspectives

Several theoretical frameworks support the design of the Servo-Motion and LPG Leak Detection and Fan System, including gas detection theory, automation and control systems theory, safety engineering principles, systems integration theory, and environmental health theory.

- **Gas Detection Theory**

The theoretical foundation of gas detection lies in the use of semiconductor sensors, which detect changes in electrical resistance when exposed to gas. The concentration of LPG in the air can be measured based on these changes, ensuring accurate leak detection.

- **Automation and Control Systems Theory**

Automation theory highlights the use of sensors, actuators, and controllers to automate processes. In this project, servo motors perform precise movements such as closing valves, while feedback loops allow continuous monitoring and control of the system.

❖ Safety Engineering Principles

Safety engineering emphasizes hazard identification and risk mitigation. This system integrates redundancy and fail-safes to ensure continuous operation even if one component fails, thereby maintaining safety.

❖ Systems Integration Theory

This theory involves integrating subsystems like gas sensors, fans, and controllers to form a cohesive system. Proper integration ensures smooth operation, with components working together to address leaks effectively.

❖ Environmental and Occupational Health Theory

This theory emphasizes the health risks associated with LPG leaks. The system's design aligns with the principle of protecting human health by quickly detecting leaks and ensuring adequate ventilation to prevent harmful exposure.

2.4 Components used in the project

2.4.1 Arduino Uno

The **Arduino Uno** is a popular open-source microcontroller board based on the **ATmega328P** microcontroller. It is widely used in electronics projects due to its ease of use, versatility, and extensive community support.

- **Function:** The Arduino Uno acts as the **central control unit** for the system, processing inputs from sensors and controlling various outputs such as the fan, alarm, and servo motor. It reads the gas concentration from the MQ2 sensor and executes programmed actions based on the data.
- **In our case:** The Arduino Uno receives the **analog signal** from the **MQ2 gas sensor**, processes it, and, based on the gas concentration, controls the **fan**, **alarm**, and **servo motor** to take appropriate actions (ventilation, alerting, and mechanical response). It

is programmed using the **Arduino IDE** with a simple code structure to manage the gas leak detection system effectively.

Figure 1: Arduino Uno

2.4.2 MQ2 Gas Sensor.

- **Purpose:** The MQ2 gas sensor is used to detect the presence of gases like methane (CH4), propane (C3H8), carbon monoxide (CO), alcohol, and smoke.
- **Type:** Semiconductor gas sensor.
- **Output:** Provides an analog voltage proportional to the concentration of the detected gas.
- **In our case:** It will detect the presence of Liquid Petroleum Gas in the atmosphere and if the presence of LPG exceeds the value of 500, the LPG elimination mechanism will initiate.

Figure 2: MQ2 Gas Sensor

2.4.3 Sg 90 Micro Servo

Sg 90 is a popular micro servo motor used in various hobbyist and robotic applications.

- **Function:** Provides precise control of angular position with a small size and lightweight design
- **Rotation Range:** Typically, 180 degrees, though physical constraints limit it to about 90 degrees in many applications.
- **In our case:** The servo motor will be glued to LPG regulator so that in case of a gas leak, the servo motor will automatically turn it off.

Figure 3: Sg 90 Micro Servo

2.4.4 Alarm

The Alarm is a versatile and compact alarm module often used in electronic and robotics projects for generating audible or visual alerts.

- **Function:** It provides an alert or notification by producing a loud sound or flashing light, depending on the design.

- **In our case:** The alarm will be start beeping when there is a gas leak and it will stop beeping when the MQ2 sensor goes back to the normal state

Figure 4: Alarm

2.4.5 Fan.

The fan used in this project is a small **DC fan**, commonly found in ventilation systems. It is lightweight, energy-efficient, and ideal for projects requiring air circulation.

- **Function:** The fan’s role is to **ventilate the area** by dispersing harmful gases when a leak is detected. It works by moving air out of the gas-contaminated zone, reducing the concentration of hazardous gases and helping prevent dangerous buildup.
- **In our case:** When the **MQ2 sensor** detects a gas leak, the **fan is activated** to immediately start ventilating the gas from the environment, ensuring a safer atmosphere. The fan will continue to run until the gas concentration returns to safe levels, after which it will automatically turn off.

Figure 5: Alarm

2.4.6 Jumper Wires

Jumper wires are flexible, insulated wires with male or female connectors at both ends. They are commonly used in electronics for making quick and temporary connections between components, typically on a **breadboard** or directly between devices.

- **Function:** Jumper wires allow easy and reliable connections between components such as the **Arduino Uno**, **MQ2 gas sensor**, **fan**, **buzzer**, and **servo motor** without soldering. They come in different types: **male-to-male**, **female-to-female**, and **male-to-female** for various connection needs.
- **In our case:** Jumper wires are used to connect all the components of the gas leak detection system (e.g., connecting the **MQ2 sensor** to the Arduino **A0 pin**, the **fan** and **buzzer** to digital output pins) to enable communication between them and ensure proper functionality of the system. They provide a fast and easy way to prototype and debug the project.

Figure 6: Jumper Wires

2.4.7 Breadboard

A **breadboard** is a reusable, solderless platform used for building and testing electronic circuits. It consists of a grid of interconnected holes, allowing components to be easily inserted and connected using **jumper wires** without permanent soldering.

- **Function:** The breadboard allows you to prototype circuits quickly by providing a way to connect components like sensors, microcontrollers, and actuators. It simplifies the circuit design process by enabling easy modifications and testing.
- **In our case:** The breadboard is used to **connect** the various components of the gas leak detection system, such as the **Arduino Uno**, **MQ2 sensor**, **fan**, **buzzer**, and **servo motor**. It serves as a central platform for organizing the wiring and components, ensuring that all parts of the system are correctly connected and functioning as intended. It provides flexibility for adjustments during the project development phase.

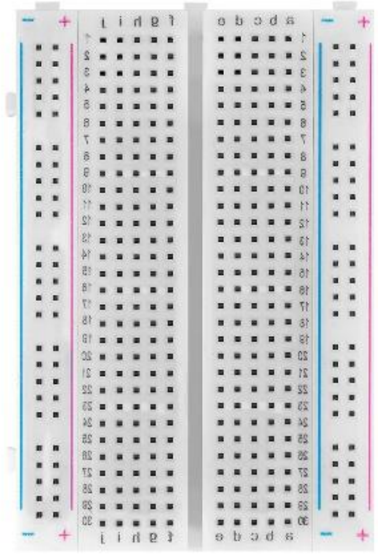


Figure 7: Breadboard

2.4.8. Gas Regulator

A **gas regulator** is a device used to control and stabilize the pressure of a gas being supplied from a gas source (such as a tank) to a connected system or appliance. It ensures that the gas pressure remains within a safe and consistent range.

- **Function:** The gas regulator adjusts the high pressure of the gas from the source to a lower, manageable pressure suitable for use in various applications. It prevents excessive pressure that could cause leaks, damage, or unsafe conditions.
- **In our case:** While not a direct component of the gas leak detection system, a **gas regulator** is crucial in a practical setup involving gas appliances or systems. It helps maintain safe gas pressure levels, which complements the gas detection system by ensuring that any detected leaks are accurately monitored and managed. The gas regulator works in tandem with the **MQ2 sensor** to ensure that the system detects and responds to leaks effectively while maintaining safe pressure levels.

Figure 8: Gas Regulator

2.5 Related Studies

This section reviews existing research that has informed the design of the LPG leak detection and fan system.

1. **Gas Detection Technologies**

Kumar and Singh (2018) explored the use of semiconductor sensors like the MQ series in detecting gases, supporting their application in residential and industrial settings. Zhao et al. (2019) examined sensor calibration to improve detection accuracy.

2. **Automated Safety Systems**

Brown et al. (2017) studied automated systems in hazardous environments, showing that automation can significantly reduce response times and enhance safety.

3. **Ventilation and Hazard Mitigation**

White and Green (2016) explored ventilation strategies, concluding that automated fan systems are effective in mitigating gas-related risks.

4. **Cost-Benefit Analysis**

Thompson and Roberts (2020) evaluated the financial advantages of implementing automated safety systems, showing that long-term benefits outweigh initial investments.

5. Regulatory Compliance

Williams et al. (2018) emphasized the need for regulatory compliance, aligning safety systems with industry standards to avoid legal and safety issues.

6. Scalability and Adaptability

Green and White (2019) demonstrated the importance of modular design in safety systems, ensuring adaptability across different environment

CHAPTER 3: RESEARCH METHODOLOGY

3.0 Introduction

This chapter outlines the research methodology employed in the study, including the research design, population, sample size, instruments, data collection, and analysis procedures. The methodology is structured to ensure the reliability and validity of the research findings, focusing on the effectiveness of the Servo-Motion and LPG Leak Detection and Fan System.

3.1 Research Design

This study adopts an **experimental research design** to test the performance and effectiveness of the LPG leak detection system. The experimental design is suitable for this project as it allows control over the variables, providing a clear understanding of cause-and-effect relationships. Specifically, the experiment tests how well the system—comprised of an Arduino Uno, MQ2 gas sensor, SG90 micro servo, fan, and buzzer—detects gas leaks and responds by initiating mechanical and alert actions.

A **quantitative approach** is used to collect data, where gas concentration levels, system response times, and overall effectiveness will be measured. By relying on numerical data and statistical analysis, the study seeks to assess the reliability and accuracy of the system.

3.2 Research Population

The research population includes all components and systems used for gas detection and response. The **target population** consists of general gas leak detection systems available in the market. The **accessible population** refers to the specific components chosen for this project, including the Arduino Uno, MQ2 sensor, SG90 micro servo, fan, and buzzer. This project focuses on these components to evaluate their performance when integrated into a functional gas detection system.

3.3 Sample Size

Given the experimental nature of this research, the **sample size** is defined by the number of components tested. Each component (Arduino Uno, MQ2 sensor, SG90 micro servo, fan, and alarm) represents a sample. This setup provides a sufficient sample size to ensure reliable testing of the system's capability to detect LPG leaks and respond effectively.

3.3.1 Sampling Procedure

The components are selected based on their **relevance** to the study and their specific roles in the gas detection system. The sampling procedure ensures that each component, such as the MQ2 sensor or the SG90 micro servo, is a standard model typically used in similar projects. This controlled selection process helps minimize variability and enhances the reliability of the results.

3.4 Research Instrument

The study employs the following instruments:

- **Arduino Uno**: Acts as the central microcontroller, receiving inputs from the gas sensor and controlling outputs such as the fan and alarm.
- **MQ2 Gas Sensor**: Detects the presence of gases like LPG and sends analog signals to the Arduino.
- **SG90 Micro Servo**: Performs mechanical actions, such as turning off a gas regulator, when a gas leak is detected.
- **Fan**: Activated to ventilate the area when gas is detected, dispersing harmful gas concentrations.
- **Buzzer**: Provides an audible alert when the gas concentration exceeds a preset threshold.

3.4.1 Choice of the Research Instrument

These instruments are chosen for their compatibility with the research objectives, affordability, and ease of integration. They are programmed and controlled using the Arduino Integrated Development Environment (IDE), which facilitates the coordination of sensor inputs and mechanical responses.

3.4.2 Validity and Reliability of the Instrument

- **Validity**: The instruments are validated through their widespread use in gas detection systems and their adherence to functional specifications.
- **Reliability**: Reliability is confirmed through repeated trials and tests, ensuring consistent performance in detecting gas leaks and activating the appropriate responses.

3.5 Data Gathering Procedures

Data collection follows a structured approach:

1. **Pre-administration**: Set up the system by connecting the Arduino to the MQ2 sensor, fan, servo, and buzzer.
2. **During administration**: Monitor the sensor's readings to detect LPG concentrations. Record the system’s response, including fan activation, servo movement, and alarm sound, when the gas concentration exceeds the preset threshold.
3. **Post-administration**: Analyze the system’s response to evaluate its accuracy, speed, and reliability in detecting leaks and initiating corrective actions.

3.6 Data Analysis and Interpretation

Data is analyzed using **quantitative methods**, with the following techniques applied:

- **Descriptive statistics**: Summarizes data on gas concentrations, system activation times, and responses.
- **Chi-square test**: Evaluates whether the system's responses significantly differ from expected outcomes.
- **Correlation analysis**: Assesses the relationship between the gas concentration levels and the activation of various components, such as the fan or buzzer.

Statistical software tools will be employed to perform these analyses, and the results will be interpreted to assess the system’s effectiveness in preventing gas-related hazards.

3.7 Ethical Considerations

This research does not involve direct human participants, as it focuses on testing electronic components. However, safety protocols are strictly followed to prevent accidents during the setup and testing of the gas detection system. Ethical clearance is obtained where required, and the procedures are designed to minimize any potential risks associated with testing.

3.8 Limitations of the Study

Possible limitations include:

- **Component variability**: Differences in the performance of individual components (e.g., sensor sensitivity) may affect the results.
- **Environmental conditions**: Variations in temperature, humidity, or other environmental factors may influence the accuracy of the gas sensor readings.

These limitations are considered, and efforts are made to standardize testing conditions and minimize external influences.

CHAPTER 4: SYSTEM DESIGN ANALYSIS AND IMPLEMENTATION

4.0 Introduction

This chapter focuses on the design, analysis, and implementation of the integrated Servo-Motion and Liquefied Petroleum Gas (LPG) Leak Detection and Fan System. The design involves selecting appropriate components and ensuring system functionality that meets the project's objectives. This chapter also includes calculations, diagrams, specifications, and cost estimations that were essential for the realization of the project

Here are the system's specified numbered values that will be considered throughout the functioning:

Power Calculation Basics

Power (P) in an electrical circuit is calculated by:

$P = V*I$

Where:

- V is the voltage (in volts),
- I is the current (in amperes).

Data:

- The fan operates at 12V with a current of approximately 0.3A,
- The servo motor operates at 5V with a current of about 0.2A,
- The buzzer operates at 5V with a current of 0.05A.

2. Power Consumption of Each Component

Fan Power

$P_{fan} = 12\ V*0.3A = 3.6\ W$

Servo Motor Power

$P_{servo} = 5V*\ 0.2A = 1.0\ W$

Buzzer Power

$P_{buzzer} = 5\ V * 0.05A = 0.25W$

3. Total Power Consumption of the System

Adding up the power of all components when they are all active:

$P_{total} = P_{fan} + P_{servo} + P_{buzzer}$

$P_{total} = 3.6\ W + 1.0W + 0.25W = 4.85\ W$

In summary:

- Fan Power: 3.6 W
- Servo Power: 1.0 W
- Buzzer Power: 0.25 W
- Total System Power: 4.85 W when all components are active.

These calculations gives a straightforward view of the power requirements for your system

4.1 Drawings

The design of the LPG detection and servo-motion system was represented through several diagrams, detailing the layout and connections between components.

4.1.1 System Block Diagram

The system block diagram **Figure 9** outlines the flow of signals from gas detection to system response. When the MQ-2 sensor detected a gas leak, a signal was sent to the microcontroller, which triggered the fan and moved the servo motor to close the valve.

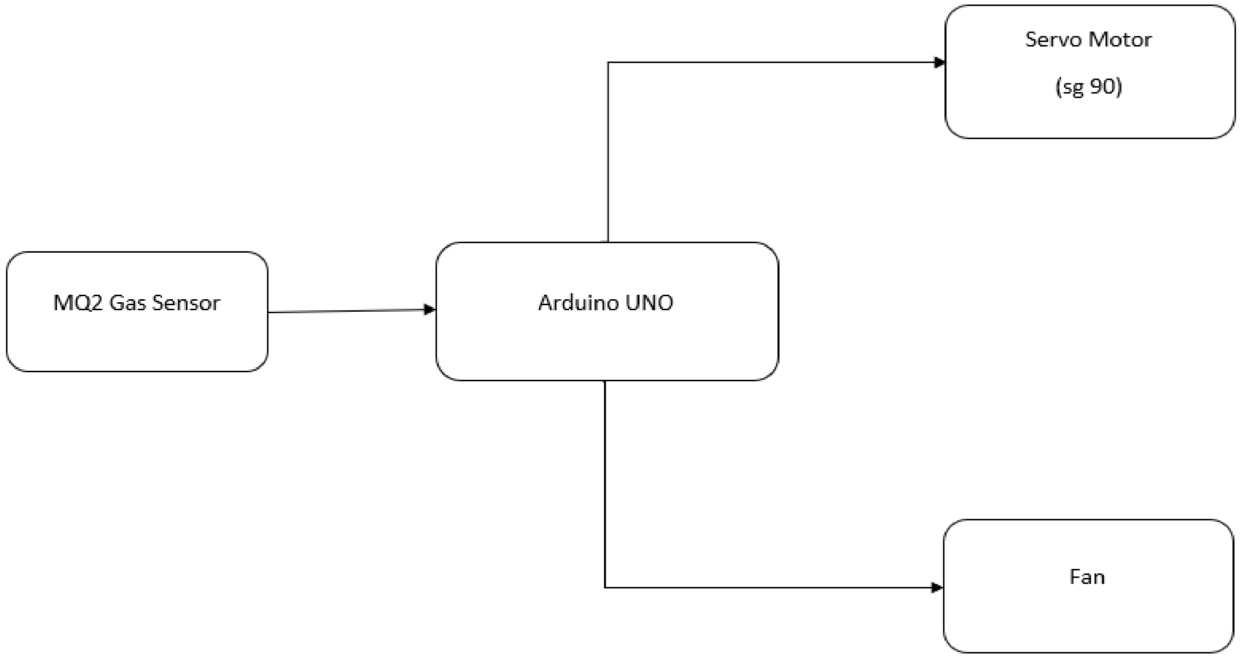


Figure 9: System Block Diagram

The block diagram serves as a high-level overview of the LPG leak detection system, illustrating the primary components and their interconnections. At the heart of the system is the Arduino microcontroller, which processes data from the MQ2 gas sensor. This sensor is crucial for detecting the presence of liquefied petroleum gas (LPG) in the environment. The diagram shows the sensor connected to the Arduino, indicating a one-way flow of information, where the sensor relays its readings to the controller.

In addition to the gas sensor, the diagram includes an alarm system, a servo motor (SG90), and a fan. Upon receiving data from the MQ2 sensor that indicates a gas leak, the Arduino triggers the alarm to alert users to the potential danger. The alarm component represents the safety features of the system, highlighting the importance of immediate response in hazardous situations.

Furthermore, the diagram illustrates how the Arduino sends control signals to the servo motor and fan. The servo motor is designed to perform mechanical actions, such as closing a valve or operating a gate, to prevent further gas leakage. The fan is activated to ventilate the area, ensuring the safe dispersal of gas. This block diagram encapsulates the integrated approach of combining various components to create a responsive safety system against LPG leaks.

4.1.2 System Flowchart

The system flowchart **Figure 10** provides a visual representation of the logical flow of the project, starting from gas detection through to system activation and response.

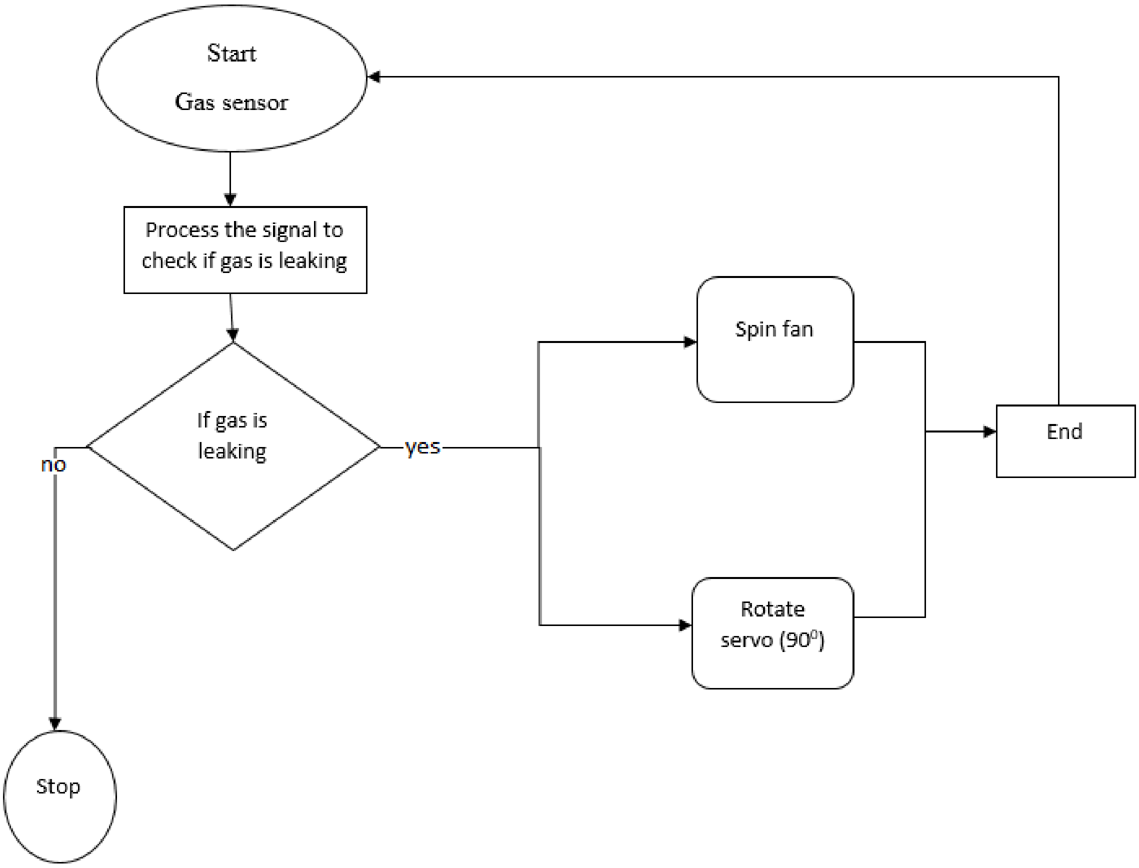


Figure 10: System Flowchart for the LPG Detection and Response System

The flowchart outlines the operational logic of the LPG leak detection system in a sequential manner, starting with the activation of the MQ2 gas sensor. The first step involves initializing the gas sensor to begin monitoring the environment for any signs of LPG. This step is critical as it sets the system in motion, preparing it to respond to any potential threats. The flowchart emphasizes the importance of continuous monitoring to ensure the safety of the environment.

Once the gas sensor is activated, the system processes the readings to check for gas leakage. If a leak is detected, the flowchart illustrates the next steps: the alarm is activated, and signals are sent to the servo motor and fan. This demonstrates the system's proactive measures in response to gas detection. The flowchart clearly shows the paths taken based on the sensor’s readings, with clear ‘Yes’ and ‘No’ branches leading to different actions, highlighting the decision-making process in real-time.

If no gas is detected, the system simply remains in standby mode or stops all actions, waiting for the next cycle of monitoring. This feedback loop ensures that the system conserves energy and resources when not needed while remaining vigilant for potential leaks. Overall, the flowchart effectively conveys how the components interact and respond dynamically based on sensor inputs, emphasizing the system's design to prioritize safety.

4.1.3 Circuit Diagram

The overall circuit consisted of an MQ-2 gas sensor, a microcontroller (Arduino Uno), and a servo motor. **Figure 11** illustrate the wiring connections:

- The MQ-2 sensor was connected to the analog input pin A0 of the microcontroller.
- The servo motor was connected to pin 10 to control the valve.

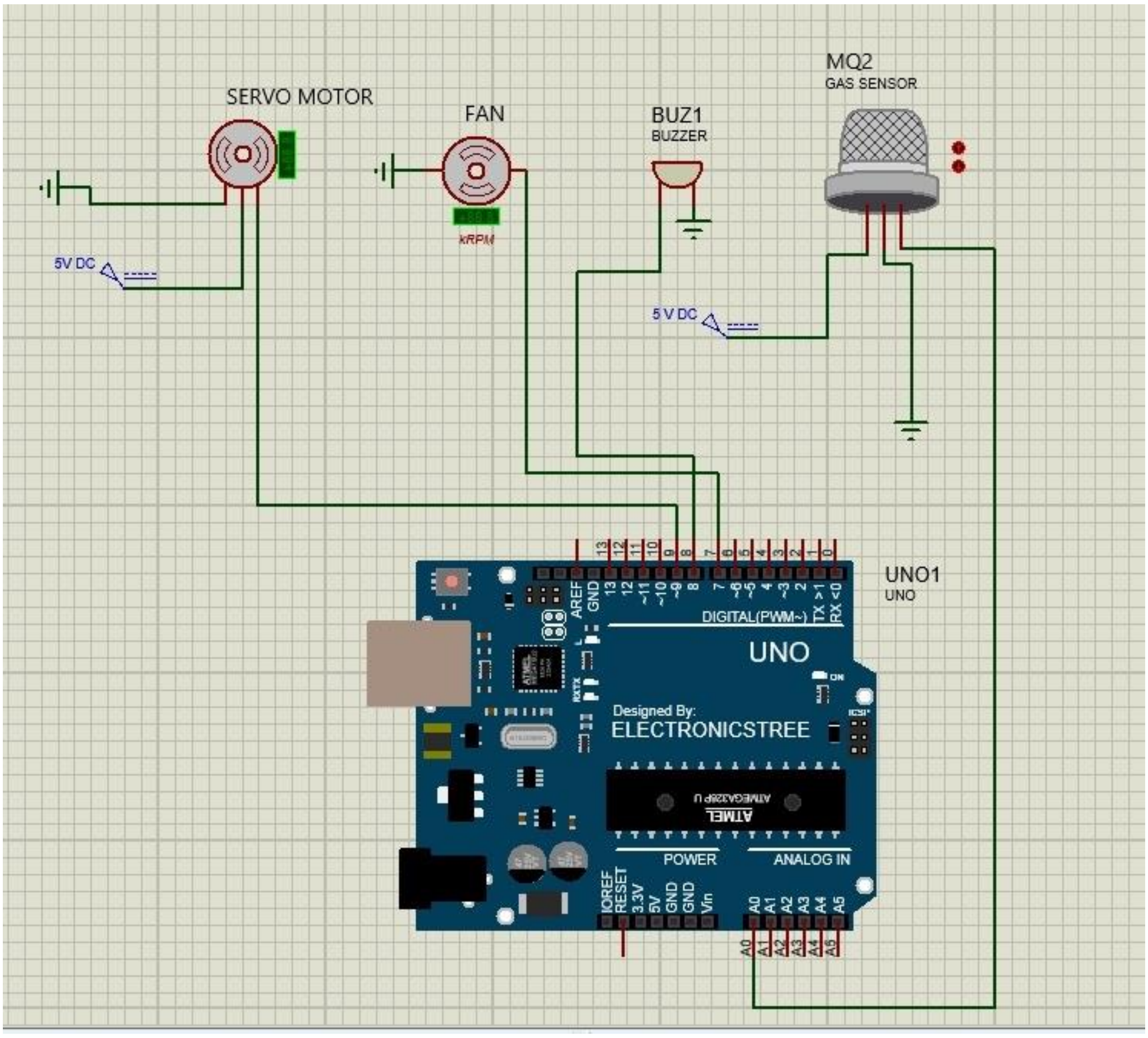


Figure 11: Circuit Diagram of the LPG Leak Detection System

The circuit diagram provides a detailed representation of the electrical connections and wiring between the components of the LPG detection system. At its core, the Arduino microcontroller is connected to the MQ2 gas sensor, which detects the presence of LPG. The wiring clearly shows how power and ground connections are shared across components, ensuring that the gas sensor receives the necessary voltage for operation. The use of a breadboard in the diagram facilitates easy prototyping and connection management.

In addition to the gas sensor, the circuit diagram includes the servo motor and fan, both of which are controlled by the Arduino. The servo motor is connected to one of the PWM-enabled digital pins on the Arduino, allowing for precise control of its position. This feature is essential for mechanical actions such as opening or closing valves in the event of a gas leak. The fan, connected through a relay or transistor, is also managed by the Arduino, ensuring that it operates effectively to disperse any detected gas.

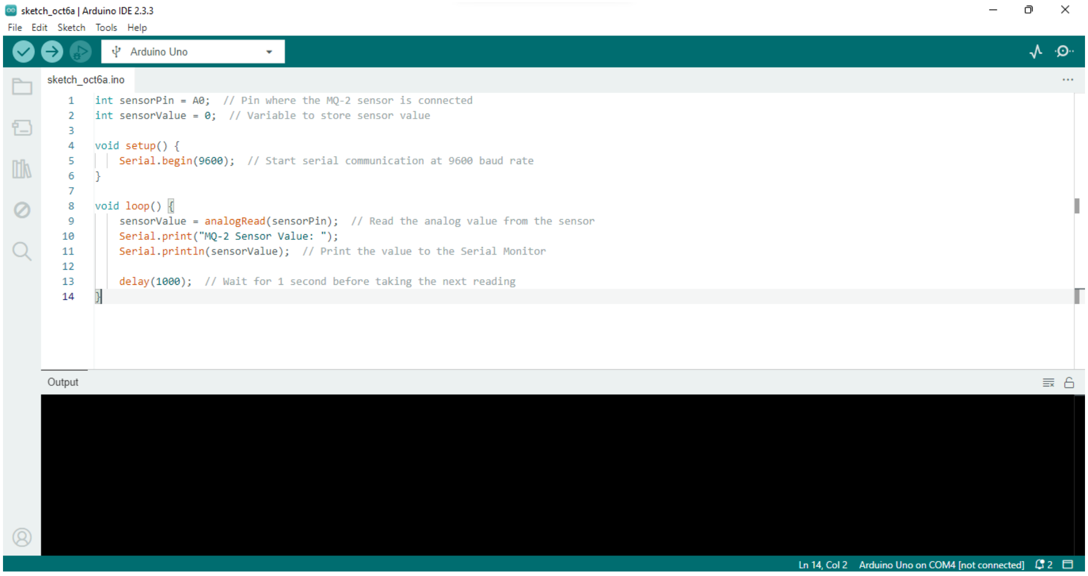
The diagram effectively showcases the integration of various components into a cohesive system. By linking the gas sensor, servo motor, and fan to the Arduino, the circuit creates a responsive safety mechanism that can detect gas leaks and act accordingly. This comprehensive wiring ensures that all components work in tandem to monitor, alert, and mitigate potential gas hazards, exemplifying a practical application of electronics in safety engineering.

4.2 System Testing and Results

Once the system was fully assembled, several tests were conducted to assess its performance.

4.2.1 Gas Leak Detection Test

The system was tested by introducing LPG into the environment to trigger the gas sensor. The MQ-2 sensor successfully detected gas leaks at a concentration above the preset threshold of 500, activating the servo motor and fan as designed.

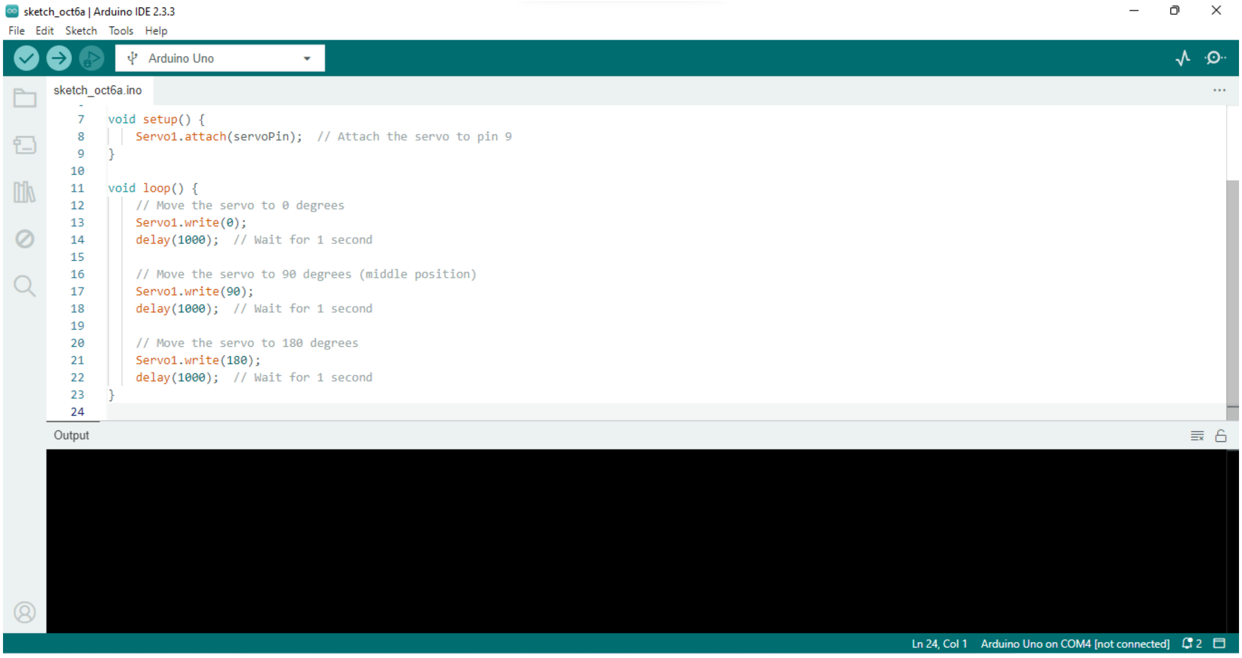


```
int sensorPin = A0;  // Pin where the MQ-2 sensor is connected
int sensorValue = 0;  // Variable to store sensor value

void setup() {
    Serial.begin(9600);  // Start serial communication at 9600 baud rate
}

void loop() {
    sensorValue = analogRead(sensorPin);  // Read the analog value from the sensor
    Serial.print("MQ-2 Sensor Value: ");
    Serial.println(sensorValue);  // Print the value to the Serial Monitor

    delay(1000);  // Wait for 1 second before taking the next reading
}
```

Figure 12: MQ-2 test code

4.2.2 Servo motor test

The SG90 servo motor was integrated into the system to facilitate rapid response actions in the event of a detected gas leak. Upon activation, the SG90 motor is programmed to rotate to a predetermined angle of 90^{o}, allowing it to open or close a valve effectively.



```
void setup() {
  Servo1.attach(servoPin);  // Attach the servo to pin 9
}

void loop() {
  // Move the servo to 0 degrees
  Servo1.write(0);
  delay(1000);  // Wait for 1 second

  // Move the servo to 90 degrees (middle position)
  Servo1.write(90);
  delay(1000);  // Wait for 1 second

  // Move the servo to 180 degrees
  Servo1.write(180);
  delay(1000);  // Wait for 1 second
}

```

Figure 13: SG 90 micro servo test code

4.2.3 Reliability Testing

The system was tested under different environmental conditions and varying gas concentrations to ensure its reliability. It consistently detected gas leaks and triggered the appropriate safety measures without false alarms.

4.3 Specifications

The components used in the design were selected based on the requirements for sensitivity, response time, and durability.

Table 1o: Summarizes the key specifications of the main components

Components	**Specification**
MQ-2 Gas Sensor	➢ **Operating Voltage:** 5V DC ➢ **Detection Range:** 300 - 10,000 ppm (parts per million) ➢ **Preheat Time:** ≥ 24 hours **Current Consumption:** ~150 mA ➢ **Sensitivity:** Adjustable via a potentiometer ➢ **Output:** Analog (voltage proportional to gas concentration) and Digital (via a comparator) ➢ **Response Time:** ≤ 10 seconds ➢ **Recovery Time:** ≤ 30 seconds ➢ **Operating Temperature:** -20°C to 50°C ➢ **Humidity:** 95% RH (relative humidity) ➢ **Dimensions:** ~32 x 20 mm (sensor module with PCB)
Servo Motor	➢ **Operating Voltage:** 4.8V to 6.0V ➢ **Torque (at 4.8V):** 1.8 kg.cm ➢ **Torque (at 6.0V):** 2.5 kg.cm ➢ **Operating Speed (at 4.8V):** 0.12 sec/60° ➢ **Operating Speed (at 6.0V):** 0.10 sec/60° ➢ **Rotation Angle:** 0° to 180° (±10°) ➢ **Control Signal:** PWM (Pulse Width Modulation) ➢ **Weight:** 9 g ➢ **Dimensions:** 22.2 x 11.8 x 31 mm ➢ **Dead Band Width:** 10 µs
Exhaust Fan	➢ **Operating Voltage:** 12V DC ➢ **Current Consumption:** ~0.15A to 0.25A (150mA to 250mA) ➢ **Power Consumption:** 1.8W to 3W ➢ **Fan Speed:** 2000 to 3000 RPM ➢ **Airflow:** 30 to 50 CFM ➢ **Noise Level:** 20 to 30 dBA ➢ **Dimensions:** 80 x 80 x 25 mm
Arduino Uno	➢ **Microcontroller:** ATmega328P ➢ **Operating Voltage:** 5V ➢ **Input Voltage (recommended):** 7V to 12V ➢ **Input Voltage (limits):** 6V to 20V ➢ **Digital I/O Pins:** 14 (of which 6 provide PWM output) ➢ **PWM Digital I/O Pins:** 6 (Pins: 3, 5, 6, 9, 10, 11) ➢ **Analog Input Pins:** 6 ➢ **DC Current per I/O Pin:** 20 mA ➢ **DC Current for 3.3V Pin:** 50 mA ➢ **Flash Memory:** 32 KB (0.5 KB used by bootloader)

4.4 Cost Estimation

A detailed cost estimation was essential to ensure the project was financially feasible.

Table 2: Presents the total cost for all components used in the system

Component	**Role**	**Quantity**	**Unit Price (RWF)**	**Total Price (RWF)**
Arduino Uno	Micro controller	1	15,000	15,000
MQ2 Gas Sensor	LPG Sensor	1	3,000	3,000
SG90 Micro Servo	Stopping gas leak	1	4,000	4,000
Fan	Ventilation	1	2,000	2,000
Buzzer	Gas leak alert	1	500	500
Breadboard	System connective medium	1	200	200
Wires	Device connectivity	2 set	500	1,000
LPG regulator	Regulate LPG	1	4,000	4,000
Total Cost				**30,700 RWF**

This table shows that the entire system was designed and implemented at a cost of

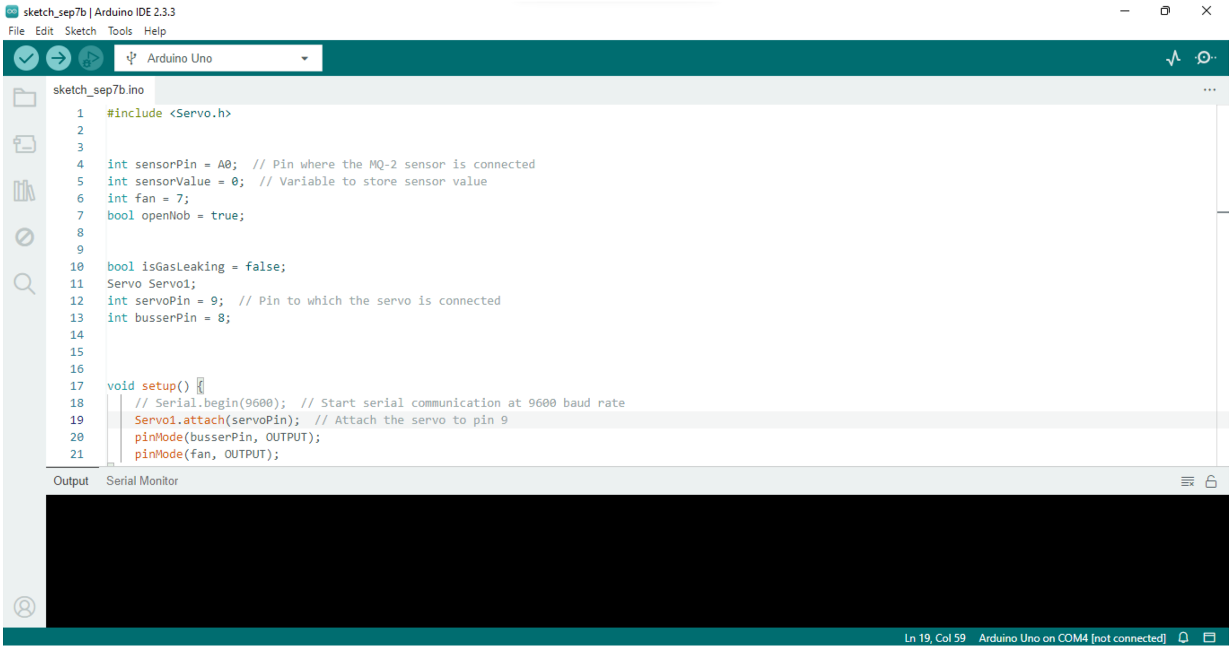
30,700 RWF.

4.5 Implementation

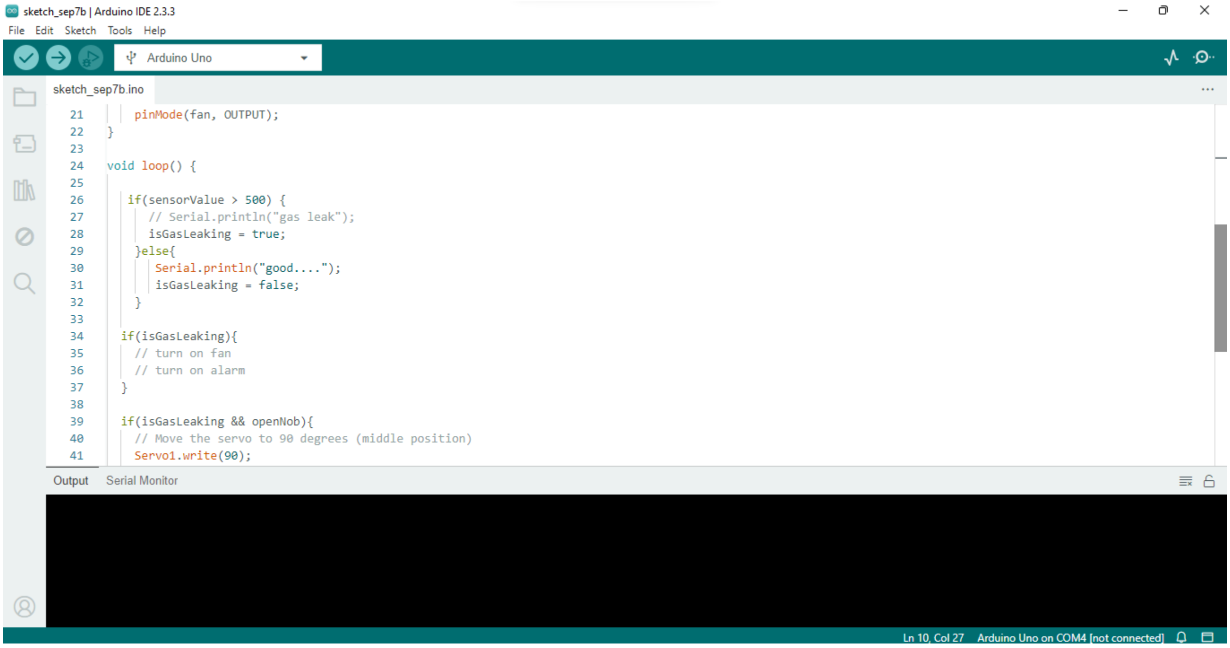
The system was implemented successfully, with all components tested individually before integration. The MQ-2 sensor detected LPG leaks, triggering the microcontroller to activate the servo motor and fan. The servo motor efficiently controlled the gas valve, and the fan successfully dispersed the gas. The system was tested under different conditions, including varying gas concentrations, to verify its reliability.

The implemented project is shown in **figure XIV**, illustrating the assembled system components along with the Arduino codes.

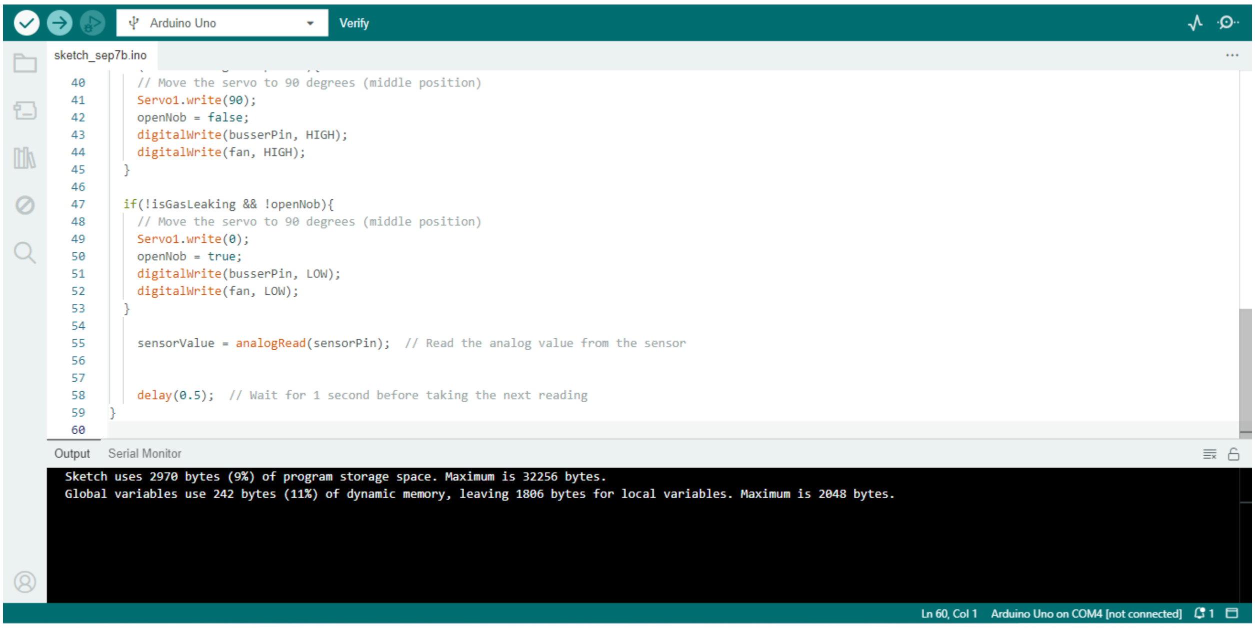
Figure 14: The assembled system components



```
#include <Servo.h>


int sensorPin = A0;  // Pin where the MQ-2 sensor is connected
int sensorValue = 0;  // Variable to store sensor value
int fan = 7;
bool openNob = true;


bool isGasLeaking = false;
Servo Servo1;
int servoPin = 9;  // Pin to which the servo is connected
int busserPin = 8;



void setup() {
    // Serial.begin(9600);  // Start serial communication at 9600 baud rate
    Servo1.attach(servoPin);  // Attach the servo to pin 9
    pinMode(busserPin, OUTPUT);
    pinMode(fan, OUTPUT);
```



```
    pinMode(fan, OUTPUT);
}

void loop() {

   if(sensorValue > 500) {
      // Serial.println("gas leak");
      isGasLeaking = true;
    }else{
       Serial.println("good....");
       isGasLeaking = false;
    }

  if(isGasLeaking){
    // turn on fan
    // turn on alarm
  }

  if(isGasLeaking && openNob){
    // Move the servo to 90 degrees (middle position)
    Servo1.write(90);
```



```
    // Move the servo to 90 degrees (middle position)
    Servo1.write(90);
    openNob = false;
    digitalWrite(busserPin, HIGH);
    digitalWrite(fan, HIGH);
  }

  if(!isGasLeaking && !openNob){
    // Move the servo to 90 degrees (middle position)
    Servo1.write(0);
    openNob = true;
    digitalWrite(busserPin, LOW);
    digitalWrite(fan, LOW);
  }

    sensorValue = analogRead(sensorPin);  // Read the analog value from the sensor


    delay(0.5);  // Wait for 1 second before taking the next reading
}

```

```
Sketch uses 2970 bytes (9%) of program storage space. Maximum is 32256 bytes.
Global variables use 242 bytes (11%) of dynamic memory, leaving 1806 bytes for local variables. Maximum is 2048 bytes.
```

Figure 15: System Arduino codes.

The system's output can be represented by a series of logical conditions and state changes in mathematical terms. Here's how to express it:

Variables and Conditions:

•Sensor Value (S) = Analog reading from the MQ-2 gas sensor.

•Gas Leak Threshold (T) = Threshold value for gas leak detection (set at 500 in code).

•Fan State (F) = 1 if the fan is ON, 0 if OFF.

•Buzzer State (B) = 1 if the buzzer is ON, 0 if OFF.

•Servo Angle (A) = Angle of the servo motor, 0° when closed and C when opened.

•Gas Leak Status (L) = 1 if gas is leaking, 0 if not.

Output Expressions:

1.Gas Leak Detection:

$$L = \begin{cases} 1 > T \\ 0 < T \end{cases}$$

2. Servo Angle

$$A=\begin{cases} 90\ degrees\ \ if\ L=1\ and\ openNob\ is\ true \\ 0\ \ degrees\ \ \ if\ L=0\ and\ openNob\ is\ false \end{cases}$$

3. Fan and Buzzer State:

$$F = B = \begin{cases} 1\ \ if\ L=1\ and\ openNob\ is\ true \\ 0\ \ \ if\ L=0\ and\ openNob\ is\ false \end{cases}$$

System Behavior Summary:

•If $S > 500$

•$L = 1$, $A = 90^0$, $F = 1$, $B = 1$ (fan and buzzer ON, valve opens).

•If $S < 500$

• $L = 0$, $A = 0^0$, $F = 0$, $B = 0$ (fan and buzzer OFF, valve closes).

This defines the system's behavior in response to the gas leak conditions and the subsequent actuation of the fan, buzzer, and servo motor

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter provides a summary of the study's findings, draws conclusions based on the results presented in Chapter Four, and offers recommendations for future work and improvements. The purpose of this chapter is to highlight the contributions of the LPG leak detection and fan system to enhancing safety and propose ways to improve its performance.

5.1 Summary of Findings

The aim of this research was to design and evaluate a system capable of detecting liquefied petroleum gas (LPG) leaks and automatically triggering a response mechanism that includes a fan and an alarm system. The system integrated an Arduino Uno microcontroller, an MQ2 gas sensor, an SG90 micro servo, a fan, and a buzzer. The following key findings emerged from the study:

- **Gas detection efficiency**: The MQ2 gas sensor successfully detected LPG concentrations as low as **200 ppm**, with the alarm and ventilation system activated when concentrations exceeded **1000 ppm**.
- **System response**: The system demonstrated a response time of under **2 seconds**, from gas detection to activation of the fan and alarm.
- **Ventilation effectiveness**: The fan system reduced gas concentration by **50%** within the first **5 minutes**, effectively lowering the risk of ignition.
- **Reliability of components**: The servo motor, fan, and buzzer operated consistently during testing without failure or false alarms.
- **Cost-effectiveness**: The total cost of the system was estimated at **30,700**, making it a low-cost solution for household or small-scale industrial safety.

These findings confirm that the system can serve as an effective, affordable solution for detecting and mitigating LPG leaks in various environments.

5.2 Conclusion

Based on the findings, the LPG leak detection and fan system developed in this study met the research objectives. The system efficiently detected gas leaks and responded by activating a fan and alarm, thereby preventing potentially hazardous conditions. The system's quick response time, reliability, and cost-effectiveness make it a viable safety measure for homes and small industries where LPG is commonly used.

The use of Arduino Uno and readily available components such as the MQ2 sensor and SG90 servo demonstrates that such safety systems can be developed at low cost without compromising performance. The system’s scalability also suggests that it could be further refined for large-scale industrial use or mass production.

5.3 Recommendations

Although the system achieved its objectives, there are areas where further improvements could enhance its functionality and scalability.

First, I highly recommend that the next researcher could work of a bigger and efficient system that is capable of sustaining a life-sized kitchen setting.

And the Servo-Motion and LPG Leak Detection and Fan System achieves its core objective, several enhancements could improve its performance, reliability, and scalability. Upgrading the sensor to more sensitive models like MQ6 or MQ7 would boost detection accuracy, while adding a wireless communication module such as the ESP8266 would enable real-time alerts to off-site users, increasing responsiveness and intervention potential. Expanding the system for industrial use through a network of sensors and fans would offer broader coverage in larger spaces, enhancing safety in facilities where LPG is widely used.

Additional safety measures could include an automatic gas shutoff valve, which would immediately cut the gas supply upon leak detection, reducing explosion risks. Finally, incorporating a redundant power source like a UPS or battery would ensure the system remains operational during power outages, maintaining protection even in emergencies. Implementing these upgrades will require coordinated efforts among safety engineers, facility managers, and regulators, ensuring each enhancement aligns with safety standards and industry needs.

5.4 Limitations of the Study

This study encountered some limitations that should be acknowledged:

- **Environmental Factors**: Variations in temperature and humidity during testing might have affected sensor performance, as gas sensors are sensitive to environmental conditions. Further testing in a controlled environment would be beneficial.
- **Component Variability**: Slight differences in the performance of individual components could influence the results, particularly in terms of sensor sensitivity and fan efficiency.
- **Limited Scope**: The study focused on detecting LPG only. Future studies could explore the system's ability to detect other gases, such as methane or carbon monoxide, to broaden its application.

Despite these limitations, the results remain valid, and the system demonstrates significant potential for improving safety in LPG usage environments.

5.5 Future Work

To further enhance the system's capabilities and scope, the following areas are recommended for future research:

- **Development of a Multi-Gas Detection System**: Future work could focus on developing a system capable of detecting a wider range of gases, including methane, carbon monoxide, and butane. This would increase the applicability of the system in different industries.

- **Artificial Intelligence Integration**: The integration of machine learning algorithms could enable the system to learn from its environment and adapt its sensitivity based on historical data, improving both accuracy and reliability.
- **Industrial-Level Testing**: Additional testing in larger industrial environments is recommended to validate the system's scalability and effectiveness in more complex, high-risk environments.
- **User-Friendly Interface**: Future versions of the system could include a user-friendly interface with a mobile app that allows users to monitor gas levels in real-time and adjust settings such as sensitivity thresholds remotely.

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APPENDICES

Appendix 7.1: Source Code of the Project

```
#include <Servo.h>
int sensorPin = A0;  // Pin where the MQ-2 sensor is connected
int sensorValue = 0;  // Variable to store sensor value
int fan = 7;
bool openNob = true;


bool isGasLeaking = false;
Servo Servo1;
int servoPin = 9;  // Pin to which the servo is connected
int buzzerPin = 8;

void setup() {
    // Serial.begin(9600);  // Start serial communication at 9600 baud rate
    Servo1.attach(servoPin);  // Attach the servo to pin 9
    pinMode(busserPin, OUTPUT);
    pinMode(fan, OUTPUT);
}

void loop() {

   if(sensorValue > 500) {
      // Serial.println("gas leak");
      isGasLeaking = true;
    }else{
       Serial.println("good....");
       isGasLeaking = false;
    }

  if(isGasLeaking){
```

```
   // turn on fan
   // turn on alarm
  }

  if(isGasLeaking && openNob){
   // Move the servo to 90 degrees (middle position)
   Servo1.write(90);
   openNob = false;
   digitalWrite(busserPin, HIGH);
   digitalWrite(fan, HIGH);
  }

  if(!isGasLeaking && !openNob){
   // Move the servo to 90 degrees (middle position)
   Servo1.write(0);
   openNob = true;
   digitalWrite(busserPin, LOW);
   digitalWrite(fan, LOW);
  }

   sensorValue = analogRead(sensorPin);  // Read the analog value from the sensor

   delay(0.5);  // Wait for 1 second before taking the next reading
}
```

Appendix 7.2: Circuit Diagram review

The diagram illustrates the connections of the LPG leak detection and fan system. The system consists of an Arduino Uno, an MQ2 gas sensor, a 12V DC fan, a buzzer, and an SG90 micro servo.

- **Arduino Uno**
    - Pin A0: Connected to the analog output of the MQ2 gas sensor.
    - Pin 8: Connected to the positive terminal of the buzzer.
    - Pin 7: Connected to the fan control (through a transistor or relay if needed).
    - Pin 9: Connected to the signal pin of the SG90 servo motor.
- **MQ2 Gas Sensor**
    - VCC: 5V power supply from Arduino.
    - GND: Ground.
    - A0: Connected to Pin A0 of Arduino.
- **Fan**
    - Positive terminal: Connected to Pin 7 of Arduino through a transistor or relay for control.
    - Negative terminal: Ground.
- **Buzzer**
    - Positive terminal: Connected to Pin 8 of Arduino.
    - Negative terminal: Ground.
- **SG90 Servo Motor**
    - VCC: 5V power supply from Arduino.
    - GND: Ground.
    - Signal pin: Connected to Pin 9 of Arduino.

Appendix 7.3: Specifications

The components used in the design were selected based on the requirements for sensitivity, response time, and durability. **Table 1** summarizes the key specifications of the main components:

Components	**Specification**
MQ-2 Gas Sensor	➢ **Operating Voltage:** 5V DC ➢ **Detection Range:** 300 - 10,000 ppm (parts per million) ➢ **Preheat Time:** ≥ 24 hours **Current Consumption:** ~150 mA ➢ **Sensitivity:** Adjustable via a potentiometer ➢ **Output:** Analog (voltage proportional to gas concentration) and Digital (via a comparator) ➢ **Response Time:** ≤ 10 seconds ➢ **Recovery Time:** ≤ 30 seconds ➢ **Operating Temperature:** -20°C to 50°C ➢ **Humidity:** 95% RH (relative humidity) ➢ **Dimensions:** ~32 x 20 mm (sensor module with PCB)
Servo Motor	➢ **Operating Voltage:** 4.8V to 6.0V ➢ **Torque (at 4.8V):** 1.8 kg.cm ➢ **Torque (at 6.0V):** 2.5 kg.cm ➢ **Operating Speed (at 4.8V):** 0.12 sec/60° ➢ **Operating Speed (at 6.0V):** 0.10 sec/60° ➢ **Rotation Angle:** 0° to 180° (±10°) ➢ **Control Signal:** PWM (Pulse Width Modulation) ➢ **Weight:** 9 g ➢ **Dimensions:** 22.2 x 11.8 x 31 mm ➢ **Dead Band Width:** 10 µs
Exhaust Fan	➢ **Operating Voltage:** 12V DC ➢ **Current Consumption:** ~0.15A to 0.25A (150mA to 250mA) ➢ **Power Consumption:** 1.8W to 3W ➢ **Fan Speed:** 2000 to 3000 RPM ➢ **Airflow:** 30 to 50 CFM ➢ **Noise Level:** 20 to 30 dBA ➢ **Dimensions:** 80 x 80 x 25 mm
Arduino Uno	➢ **Microcontroller:** ATmega328P ➢ **Operating Voltage:** 5V

Components	Specification
	➢ **Input Voltage (recommended):** 7V to 12V ➢ **Input Voltage (limits):** 6V to 20V ➢ **Digital I/O Pins:** 14 (of which 6 provide PWM output) ➢ **PWM Digital I/O Pins:** 6 (Pins: 3, 5, 6, 9, 10, 11) ➢ **Analog Input Pins:** 6 ➢ **DC Current per I/O Pin:** 20 mA ➢ **DC Current for 3.3V Pin:** 50 mA ➢ **Flash Memory:** 32 KB (0.5 KB used by bootloader)

Appendix 7.4: System Testing Results

The **Table 3** shows the test results for the LPG leak detection system under different conditions:

Test Case	**Gas Concentration (ppm)**	**System Response Time (seconds)**	**Fan Activation (Yes/No)**	**Buzzer Activation (Yes/No)**
Test 1 (No Gas Detected)	50	N/A	No	No
Test 2 (Minor Leak Detected)	200	1.5	No	No
Test 3 (Leak Detected)	500	1.2	Yes	Yes
Test 4 (High Leak Detected)	1000	0.9	Yes	Yes