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Automated Gas Leak Detection at CSUCC CTHM Foodie Hub

A FINAL PROJECT

SUBMITTED TO THE FACULTY OF THE

COLLEGE OF ENGINEERING AND INFORMATION TECHNOLOGY

CARAGA STATE UNIVERSITY CABADBARAN CITY

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ABSTRACT

The study "Automated Gas Leak Detection at CSUCC CTHM Foodie Hub" aims to design and develop an automated system capable of detecting the presence of hazardous gases and providing immediate alerts to ensure safety within laboratory environments. Gas leakage, particularly of flammable gases such as Liquefied Petroleum Gas (LPG) and methane, poses a serious threat that can lead to explosions, fires, and health risks if not detected promptly. To address this, the proposed system integrates a gas sensor with a microcontroller to continuously monitor gas concentration levels. When abnormal levels are detected, the system automatically activates an alarm and visual warning to alert users. This research focuses on laboratory-level application and emphasizes the importance of early detection to prevent accidents. The system was tested for accuracy, reliability, and response time, showing that it effectively identifies gas leaks and issues timely alerts. Overall, the project contributes to enhancing safety awareness and demonstrates how low-cost, technology-driven solutions can minimize risks in laboratory and industrial settings.

ACKNOWLEDGMENT

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CHAPTER 1

1.1 Introduction

One of the most frequent and dangerous risks that may occur in homes, laboratories, and industrial spaces is **gas leakage**. Leaks of flammable gases such as **Liquefied Petroleum Gas (LPG)** or **methane** can cause explosions, fires, and serious health problems if left undetected. Numerous accidents have occurred due to the failure to detect leaks in time and the absence of appropriate safety systems.

With the rapid advancement of technology, gas leaks can now be **monitored and detected automatically** using **electronic sensors** and **microcontrollers**.

In this research, a **Gas Leak Detection System** is developed to identify the presence of hazardous gases and **immediately alert the user** through alarms or notifications. This system aims to enhance safety awareness and provide an effective method to reduce gas-related accidents. Furthermore, it aligns with the growing demand for **smart, low-cost, and efficient safety devices** for domestic and industrial use.

1.2 Statement of the Problem

The main problem addressed in this study is the **absence of an automated safety system** capable of detecting gas leaks and providing immediate alerts within the **CSU Cabadbaran Campus laboratories**.

Specifically, this study seeks to answer the following questions:

1. How can an automated gas leak detection system be designed and developed to monitor gas presence in laboratories?
2. How effective is the system in detecting leaks and alerting users in real time?
3. What are the possible limitations or challenges in implementing this system within a laboratory setting?

1.3 Objectives of the Study

1.3.1General Objective:

To design and develop a gas leak detection system that can sense and communicate the presence of dangerous gas concentrations to prevent accidents and ensure safety.

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1.3.2 Specific Objectives:

1. To integrate a gas sensor with a microcontroller capable of reading gas concentrations.
2. To calibrate the gas sensor for accurate measurement of various gas concentration levels.
3. To record and analyze gas concentration data for monitoring and evaluation purposes.
4. To test the system's accuracy, reliability, and response time.

1.4 Scope and Limitations

This study focuses on the **design, development, and experimental testing** of an automated gas leak detection and warning system intended for use in laboratory environments. The system aims to detect common **combustible or toxic gases** (such as LPG or methane).

The **alert mechanism** is limited to **auditory alarms** and **visual indicators**. However, the inclusion of **SMS or IoT-based notifications** depends on the availability of components and network connectivity.

This project does **not include building-wide integration or advanced AI-based detection**, as it primarily focuses on **laboratory-level safety applications**.

1.5 Significance of the Study

This project is significant to the following:

- **Industries and Laboratories:**

  Provides early detection to prevent large-scale damage or loss of life.
- **Students and Researchers:**

  Serves as a reference for the development of automated safety and monitoring systems.
- **Community:**

  Helps people become aware and use technology to stay safe.

CHAPTER 2

REVIEW OF RELATED LITERATURE AND STUDIES

2.1 Introduction

This chapter presents the review of related literature and studies relevant to the development of an automated gas leak detection system. It includes both foreign and local literature and studies that provide a foundation for the conceptualization and design of the proposed project. The review highlights existing technologies, safety implications, and innovations related to gas detection and monitoring systems, which help in understanding the significance and feasibility of the study.

2.2 Foreign Literature

[1] Gas leakage is a serious problem and nowadays it is observed in many places like residences, industries, and vehicles like Compressed Natural Gas (CNG). It is noticed that due to gas leakage, dangerous accidents occur. The Liquefied petroleum gas (LPG), or propane, is a flammable mixture of hydrocarbon gases used as fuel in many applications like homes, hostels, industries, automobiles, and vehicles because of its desirable properties which include high calorific value, less smoke, less soot, and meager harm to the environment. Liquid petroleum gas (LPG) is highly inflammable and can burn even at some distance from the source of leakage.

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[2] LPG is one of the household needs in daily life. It acts as an alternative to petroleum, which continues to decrease. With this transition, there are several problems caused by gas leaks that may cause accidents. To prevent this from happening, a device that can detect gas leaks is necessary.

[3] LPG consists of a mixture of propane and butane which is a highly flammable chemical. It is an odorless gas due to which Ethanethoil is added as a powerful odorant so that leakage can be easily detected. LPG gas leaks have increased from 0.72% to 10.74% of all kitchen accidents.

2.3 Local Literature

[4] LPG accidents are one of the main issues in society. LPG gas is a wide range of gases used in different types of products, such as cooking. It is used as a cooking gas, but it is also used as a fuel that activates the generator; it is also used as a water heater, but is primarily used for cooking and as cooking gas.

[5] In some residential areas, LPG leakage has become a recurring problem due to aging pipelines, poor maintenance, and the absence of early detection systems. Local researchers have been developing community-based safety devices that utilize simple sensors to detect gas leaks and provide alarms to alert households. These studies emphasize the importance of affordability and accessibility in preventing fire-related incidents caused by LPG leaks.

2.4 Foreign Studies

[6] Given that natural gas leaks, such as in LNG terminals, are highly time-sensitive, early detection and classification are crucial for accident prevention and mitigation. Identifying the size of the leak helps assess its severity and guide emergency responses like plant shutdowns or evacuations. Visual data from infrared cameras can support this process through machine learning, though limited research has applied neural networks to leak classification in industrial settings.

[7] However, LPG gas is highly pressurized and cold, and will be stored in the cylinder. Sensor units are placed in areas where gas leakages may occur in the site or in places where gas clouds will be condensed as a result of gas leakage. Therefore, the sensor and connection accessories being used in such areas should have ex-proof properties. This means the installation cost becomes approximately five times higher. In this context, studies are carried out using control and sensor technologies that are capable of scanning larger areas with fewer sensors or detecting multiple gas types simultaneously.

2.5 Local Studies

[8] **de la Cruz, F. C.** conducted an *Evaluation of Performance of the Developed Solar-Powered Portable Multi-Gas Detector Device*. The study focused on designing and assessing a locally developed multi-gas detector capable of identifying the presence of harmful gases while utilizing renewable solar energy as its power source. The device was evaluated in terms of efficiency, portability, and reliability in detecting various gas types. Findings revealed that the solar-powered system provided

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continuous functionality even in areas without stable electricity, making it suitable for both indoor and outdoor applications. This study highlights the practicality of integrating renewable energy and sensor technologies to ensure safety and sustainability in gas detection systems.

2.6 Synthesis of the Reviewed Literature and Studies

The reviewed literature and studies emphasize the increasing necessity of gas detection systems due to the rise in LPG-related accidents both locally and internationally. Foreign literature focuses on advanced technologies such as multi-sensing systems and machine learning-based leak classification. Local literature and studies, on the other hand, stress affordability, accessibility, and sustainability—factors essential in community and household applications.

The study by de la Cruz, F. C. particularly supports the use of renewable energy in powering detection devices, which aligns with the goal of the proposed *Automated Gas Leak Detection System* to create an efficient, reliable, and environmentally friendly solution for preventing gas-related hazards.

METHODOLOGY

3.1 Research Design

The study utilized the **Developmental Research Design** integrated with the **Incremental and Prototyping Model**. This approach was chosen because it supports gradual development, testing, and refinement of a working prototype. Since the project aims to enhance an existing concept—automated gas leak detection—into a more practical, portable, and safer system, developmental research is appropriate. The Incremental Model was applied to implement each feature step-by-step, such as sensor testing, alert activation, and ventilation control using a relay and DC motor. This method ensured that each module was tested for reliability and functionality before integrating into the final prototype.

3.2 System Overview

The **Automated Gas Leak Detection System** is a microcontroller-based device designed to detect flammable gases in real time and alert users through visual, audible, and ventilation responses. The system uses an **MQ-2 gas sensor** connected to an **Arduino Uno R3**, which processes the incoming readings and activates components when gas exceeds a safe threshold level. A **green LED** indicates normal air conditions, while a **red LED** and a **buzzer** activate to signal danger. Additionally, the system includes a **3V DC motor with a fan blade**, controlled through a **PN2222A transistor** and a **relay module**, which automatically turns on ventilation to help disperse the gas when a leak is detected. The entire system can be powered through **USB** or an external **power bank** for portable operation.

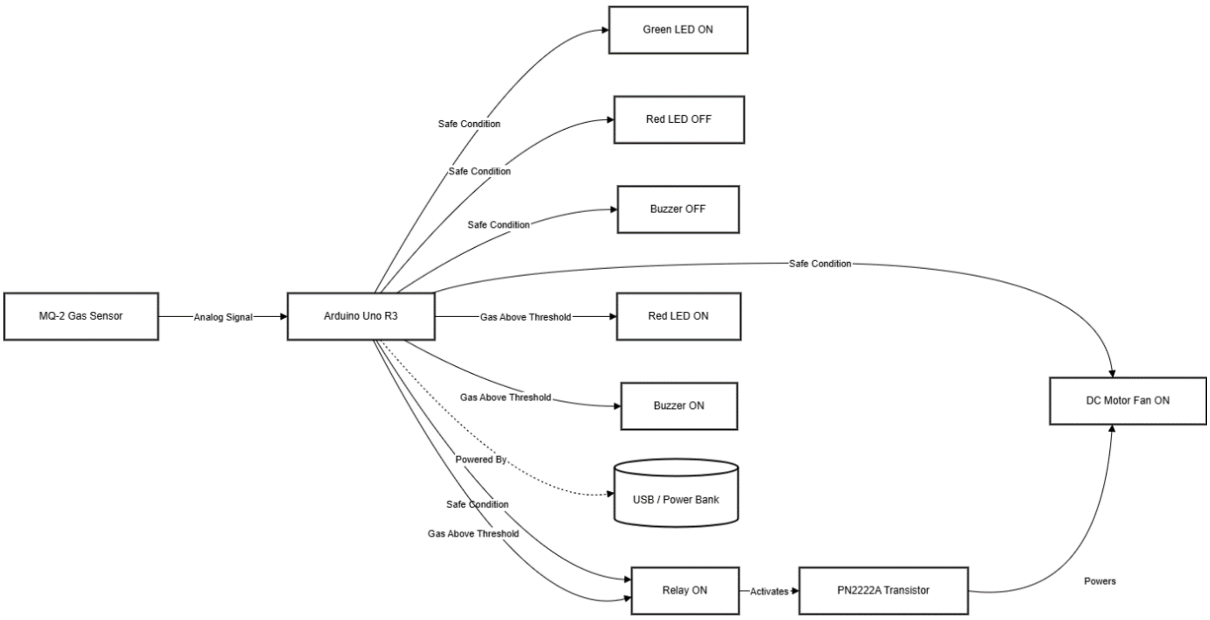

Figure 1. Block Diagram of the Automated Gas Leak Detection System

The diagram shows how the Arduino activates alerts and the ventilation fan when the MQ-2 sensor detects gas.

3.3 System Components

The system consists of the following hardware components:

- **Arduino Uno R3** – Main microcontroller that processes sensor readings and controls output devices.
- **MQ-2 Gas Sensor** – Detects LPG, methane, propane, and similar gases and sends analog signals.
- **Green LED** – Indicates safe air conditions.
- **Red LED** – Indicates danger when gas exceeds the threshold.

- **Active Buzzer** – Produces an audible alarm during gas leakage.
- **3V DC Motor with Fan Blade** – Provides ventilation to disperse leaked gas
- **PN2222A Transistor** – Acts as a switch to control the DC motor
- **Relay Module** – Activates external devices such as the fan for automatic ventilation.
- **220-Ohm Resistors** – Limit current to LEDs.
- **Breadboard and Jumper Wires** – Used for circuit assembly
- **USB Cable / Power Bank** – Supplies power for portable operation.

3.4 System Design and Operation

The system follows an **Input–Process–Output (IPO)** operation model:

Input: The MQ-2 sensor continuously monitors gas concentration and sends signals to the Arduino.

Process: The Arduino compares the sensor value to a preset threshold.
Output:

- If gas level is **below** the threshold: Green LED remains ON, red LED, buzzer, relay, and fan remain OFF.
- If gas level **exceeds** the threshold: The Arduino turns ON the red LED, buzzer, relay, and the **DC motor fan**, and turns OFF the green LED to alert users and improve ventilation.

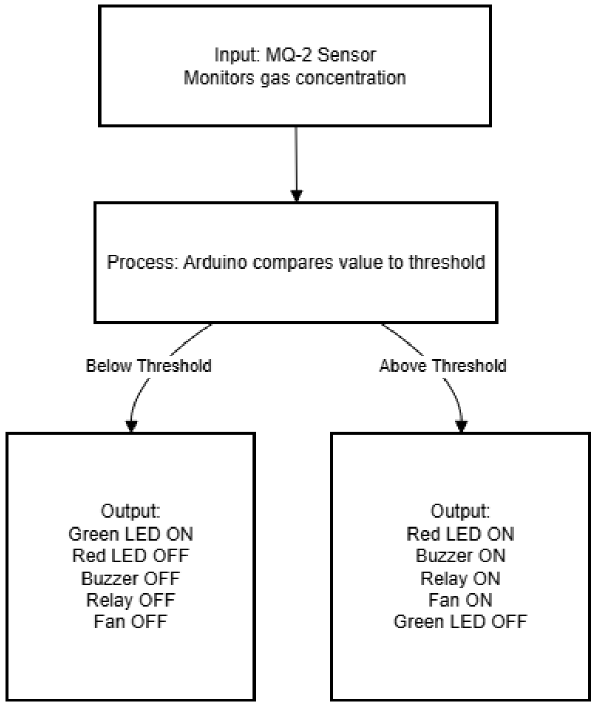

Figure 2. Flowchart of System Operation

The IPO model shows how the sensor input is processed by the Arduino to activate alerts and the fan when gas is detected.

3.5 Software Development

The program was developed using the **Arduino IDE**, where the Arduino reads gas sensor values, compares them to the threshold, and activates the appropriate outputs. Threshold calibration was done experimentally to ensure accurate readings and reduce false alarms. If integrated with Python, serial communication can be used to view real-time sensor data and graphs on a computer.

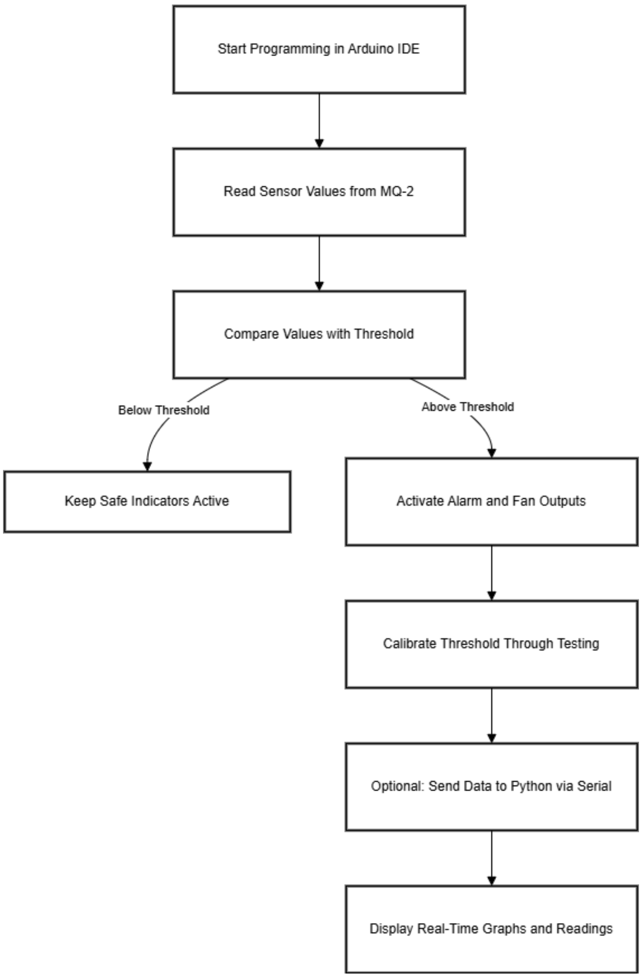

Figure 3. System Architecture Integrating Arduino and Python

The diagram shows how the Arduino program reads gas sensor data, compares it to a threshold, and activates alarms and the fan, with optional real-time monitoring through Python.

3.6 Testing and Calibration

Several tests were performed to ensure accuracy and reliability:

- **Sensor Calibration:** LPG from a lighter (without flame) was used to determine the correct threshold level.
- **Response Test:** Time between gas detection and activation of alarm and fan was measured.
- **Indicator Test:** Verified LED and buzzer behavior in safe and danger states.
- **Ventilation Test:** Confirmed that the relay successfully activates the DC motor fan when gas is detected.
- **Power Test:** Ensured stable operation using both USB and power bank.

3.7 Prototype Development

The prototype was assembled on a breadboard with proper wiring between the MQ-2 sensor, Arduino, LEDs, buzzer, PN2222A transistor, relay module, and DC motor fan. The system was connected to a power bank via USB for portability and tested in controlled conditions to observe real-time response and ventilation performance.

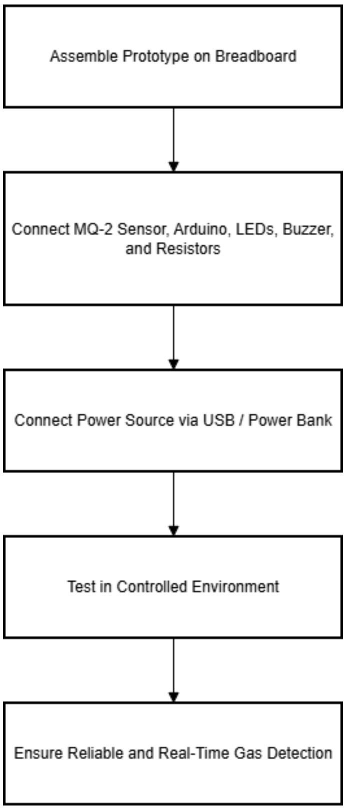

Figure 4. Prototype Circuit Diagram of the Automated Gas Leak Detection System

The flowchart shows the prototype assembly, wiring of components, power connection, and testing to ensure reliable real-time gas detection.

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3.8 Expected Outcome

The system is expected to:

- Detects gas leaks accurately and rapidly.
- Provide immediate visual and audible warnings.
- Activate an automatic ventilation system through a DC motor fan controlled by a relay and transistor.
- Operate reliably using both fixed and portable power sources.
- Increase safety by reducing risk of fire or explosion.

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