DESIGN AND FABRICATION OF A SOLAR POWERD SMART GAS DETECTOR

BY

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DEPARTMENT OF MECHANICAL ENGINEERING

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CERTIFICATION

This is to certify that this research project presented to the department of Mechanical Engineering was conducted by Daniel Lugard, Bateren Godswill, Michael Pius and Ekoh Robert Bright, all affiliated with the department of Mechanical Engineering, Faculty of Engineering, University of Benin, Benin City, Edo State, Nigeria, Under the guidance and supervision of Professor Sufianu Adeiza Aliu.

Sign…………………………….... ……………………………....
PROF. SUFIANU ADEIZA ALIU Date
PROJECT SUPERVISOR

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DR. I. B. OWUNNA Date
PROJECT COORDINATOR

Sign…………………….... ………………………....
PROF. G.E. SAJERE Date
HEAD OF DEPARTMENT

DEDICATION

All thanks to God almighty for His guidance, protection and provision with all that was necessary for the success of this project and our studies.

Our heartfelt gratitude goes to our families whose support and encouragement have been the backbone of our academic pursuits. We're grateful for our supervisor Professor Sufianu Adeiza Aliu for his commitment in his supervision and guidance in making this project a success.

To the department of mechanical engineering whose guidance and dedication in leading us through various trainings and lectures has played a pivotal role in shaping the individuals we have become.

This report is dedicated to all those who have inspired and supported us along the way. Your belief in our abilities has a great impact on passion for learning and striving for excellence.

ACKNOWLEDGEMENT

As a group, we would like to express our deepest gratitude, first and foremost, to God Almighty, who makes all things beautiful in His time. He has granted us the grace, strength, and wisdom to carry out this project work.

We also extend heartfelt thanks to our families for their unwavering support and understanding throughout this journey. Their words of wisdom and encouragement have been very valuable in navigating the challenges of this project.

Additionally, we acknowledge our supervisor, Professor Sufianu Adeiza Aliu, for his unwavering support, encouragement, and guidance. His words of admonition have made carrying out this project less stressful and more educative.

We sincerely appreciate the Department of Mechanical Engineering of the University of Benin for providing us with the opportunity to undertake this task. Your commitment to academic excellence has laid the foundation necessary for this project.

Furthermore, we thank the Faculty of Engineering for fostering an environment conducive to learning and innovation. Your dedication to the advancement of education has greatly enriched our academic experience, and we are committed to upholding the values instilled in us.

Lastly, we extend our gratitude to all individuals who directly or indirectly contributed to this project. Your assistance and collaboration have been very helpful and a major impact on its success, and we do not take any of the contributions for granted.

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ABSTRACT

A gas Detector is an electronic device that is installed in a building to detect the presence of gas to prevent fire outbreak. An automatic alarm system is designed to detect the unwanted presence of gas by monitoring environmental changes associated with combustion. In general, an alarm system is classified as either automatically actuated, manually actuated, or both. Automatic alarm systems are intended to notify the building occupants to evacuate in the event of a gas leakage or other emergency, report the event to an off-premises location in order to summon emergency services, and to prepare the structure and associated systems to control the spread of fire and gas. The gas detector system composes of a light dependent resistor (LDR) which works as a gas sensor. Light dependent resistor is a type of resistor with high resistance in the presence of light and which reduces in its resistance when gas passes through the surface. The aim of this project is to design and construct a fire alarm for a building that will detect the presence of gas leakages in a building.

CHAPTER ONE

INTRODUCTION

1.1 Background of The Study

The design and fabrication of smart gas detectors represent a critical endeavor in enhancing safety and efficiency across various industries and domestic environments. Traditional gas detection systems often rely on manual monitoring or simple alarm mechanisms, which may not provide real-time data or advanced analytics capabilities. This can lead to delayed responses to gas leaks, potential hazards, and inefficiencies in resource management.

Smart gas detectors, on the other hand, integrate advanced sensing technology with intelligent data processing and communication capabilities. These detectors can continuously monitor gas levels, detect leaks in real-time, and transmit data to central monitoring systems or mobile devices. Additionally, they can analyze historical data to identify trends, predict potential hazards, and optimize maintenance schedules

Traditional gas detection systems often rely on grid electricity, which can be unreliable or inaccessible in remote areas. Additionally, they may lack real-time monitoring capabilities and data analysis functionalities. By harnessing solar energy, these systems can operate autonomously, reducing dependency on conventional power sources and enabling continuous monitoring in remote locations.

Furthermore, the incorporation of smart technology enhances the functionality of gas detectors by enabling real-time data collection, analysis, and remote monitoring. This allows for early detection of gas leaks, prompt response to emergencies, and proactive maintenance, ultimately improving safety measures and reducing the risk of accidents and environmental hazards.

The design and fabrication of a solar-powered smart gas detector require interdisciplinary knowledge in areas such as electronics, renewable energy systems, sensor technology, and data analytics. By combining expertise from these fields, researchers and engineers can develop innovative solutions that address the challenges associated with conventional gas detection systems.

This study aims to explore the feasibility and effectiveness of integrating solar power with smart gas detection technology, with a focus on enhancing safety, efficiency, and sustainability in various industrial and domestic applications. Through experimental testing and performance evaluation, valuable insights can be gained to guide the development of reliable and cost-effective solar-powered smart gas detectors for practical implementation.

1.2 Statement of The Problem

Despite the critical importance of gas detection systems for ensuring safety and environmental protection in various industries and domestic settings, existing solutions often suffer from limitations such as dependency on grid electricity, lack of real-time monitoring capabilities, and insufficient integration of renewable energy sources. Additionally, conventional gas detectors may not effectively address the challenges of remote deployment or provide intelligent data analysis functionalities. Therefore, there is a pressing need to develop a solar-powered smart gas detector that can operate autonomously, continuously monitor gas levels in real-time, and utilize advanced data analytics for early detection of leaks and proactive maintenance.

1.3 Aim and Objectives

Aim:

The aim of this project is to design and fabricate a solar powered smart gas detector capable of real-time monitoring, intelligent data analysis, and seamless integration with existing safety systems to enhance safety and efficiency in various industrial and residential environments.

1.4 Objectives

The objectives of this project are Sensor Selection and Integration, Development of Intelligent Algorithms, Power Management Optimization, Prototype Fabrication and Testing.

1.5 Scope of The Study:

Sensor Technology, Data Analysis and Algorithm Development, Power Management, Prototype Fabrication and Testing.

1.6 Justification of Study

The design and fabrication of smart gas detectors are essential for improving safety, efficiency, and environmental sustainability in various industries and applications. This study aims to address these critical needs by developing innovative solutions that leverage cutting-edge technology to detect and mitigate gas-related risks effectively.

It is also essential for the following reasons

Enhanced Safety: Gas leaks pose serious risks to human health, safety, and the environment. Smart gas detectors equipped with advanced sensing technology and intelligent data analysis capabilities can detect leaks in real-time, enabling prompt response and minimizing the potential for accidents and injuries.

Efficient Resource Management: Traditional gas detection systems often rely on manual monitoring and periodic maintenance, which can be time-consuming and inefficient. Smart gas detectors can continuously monitor gas levels, analyze data trends, and optimize maintenance schedules, leading to improved resource management and cost savings.

Environmental Protection: Gas leaks not only endanger human health but also contribute to air pollution and environmental degradation. By detecting leaks early and accurately, smart gas detectors can help mitigate the environmental impact of gas emissions and support sustainability initiatives.

Remote Monitoring and Control: In many industrial and residential settings, gas detection is required in remote or hazardous environments where human access is limited. Smart gas detectors equipped with wireless communication capabilities enable remote monitoring and control, allowing for real-time data transmission and decision-making from a centralized location.

Technological Innovation: The development of smart gas detectors involves interdisciplinary research and innovation in areas such as sensor technology, data analytics, wireless communication, and power management. Advancements in these fields can lead to the creation of more reliable, efficient, and cost-effective gas detection solutions.

CHAPTER TWO

LITERATURE REVIEW

2.1. Liquified Petroleum Gas (LPG)

Liquified petroleum Gas (LPG) is a flammable mixture of hydrocarbon gases used in heating appliances, cooking equipment, and vehicles. It is odourless and easily detectable due to the addition of ethyl mercaptan. LPG is derived from fossil fuels and is classified as hazardous due to its explosive potentials. The development of electronic gas detectors has improved safety by detecting leaks using chemically infused paper. Current methods include optical sensor methods, cable sensors, negative pressure, vapour sampling, signal processing, mass volume, and pressure point analysis.

2.2. Gas Detector

A gas detector is a device that specifically detects the presence of gases in an environment, often playing a crucial role in safety systems. It functions by generating a signal upon encountering a target gas, which can then trigger alarms or other warning mechanisms to alert people in the vicinity. This early warning is essential as many gases can be hazardous or even lethal to humans and animals at certain concentrations.

There are various types of gas detectors designed to identify a broad spectrum of gases, including: Combustible gases, such as methane, propane, and butane, which can cause explosions

Flammable gases which can easily catch fire, Toxic gases, such as carbon monoxide, hydrogen sulfide, and ammonia, which can poison people, Oxygen depletion, which can cause suffocation.

Gas detectors are used in a wide variety of industries, including Oil and gas production, Chemical manufacturing, Mining, Firefighting, Construction, Homes (to detect carbon monoxide leaks).

Gas detectors are vital for maintaining safety and preventing accidents in industrial and residential settings. Conventional gas detection systems typically use basic alarm systems, which may lack real-time data and advanced analytics. Exploring innovative materials and ways to replace conventional smoke and gas detection systems is the key aspect of this project. An automatic smart gas detectors that combine advanced sensing technology with intelligent data processing and communication capabilities. This literature review aims to provide an overview on key technologies and research in the design and fabrication of automatic smart solar powered smoke and gas detectors.

Fig. 2.1 Gas Detector.

2.3. Classification Of Leakages Detection

Leakage detection is a process used to monitor leaks, with three main categories: automated detection, manual detection, and semi-automated detection. Automated detection involves monitoring leaks without human intervention, while manual detection requires human operation. Semi-automated detection requires input or assistance. Technology used in leakage detection can be classified into direct and indirect methods. Direct methods use handheld detectors, while indirect methods use airplane-mounted optical imaging devices for gas emanation measurements.

Sensor Technology: Smoke and gas sensors are crucial components in this project. They come in various types, such as electrochemical, semiconductor, infrared, and optical sensors. Each type offers different benefits in terms of sensitivity, selectivity, response time, and cost. For instance, electrochemical sensors are highly sensitive and selective but may need periodic calibration, while semiconductor sensors provide fast response times and long-term stability. Researchers have investigated advanced sensor technologies to enhance the precision and dependability of gas detection systems (Kim et al., 2018).

Data Analysis and Algorithm Development: Smart smoke and gas detectors utilize intelligent algorithms for real-time data analysis, including gas concentration measurement, trend analysis, and anomaly detection. These algorithms enable proactive maintenance, predictive analytics, and optimization of gas detection processes (Hua & Akiyama, 2020).

Power Management: Efficient power management is crucial for ensuring continuous operation of smart gas detectors. Battery optimization techniques, low-power modes and energy generation methods have been employed to extend the operating lifespan of the design of the detection system. Power management systems must balance the need for continuous monitoring with the constraints of limited power resources (Ahmadi et al., 2019).

Fabrication and Testing: Comprehensive testing and validation were conducted to evaluate the functionality, reliability, and accuracy of the detectors in various environmental conditions and gas concentrations. This trial was conducted to assess the performance of the sensor and identify areas for improvement.

Durability: This is based on how long the components can withstand certain extreme exposure and aging. The use of quality components and the protection of the most fragile components will contribute greatly to a longer life span of the project. Careful handling and installation of the system also helps in longer lasting operation by the system.

2.4. Major Components of Gas Detector

2.4.1 Gas Sensors: Gas sensors are the core components responsible for detecting the presence of hazardous gases in the environment. These sensors can detect various gases such as carbon monoxide (CO), methane (CH4), hydrogen sulfide (H2S), and others. Gas sensors operate based on principles such as electrochemical, semiconductor, infrared, and optical sensing (Kim et al., 2018). For the sole purpose of actualizing the aim of this project, the sensors were programmed to detect liquefied petroleum gas (LPG) and smoke.

Fig. 2.2. MQ2 gas sensor

2.4.2 LCD Display

Gas detectors rely on a crucial component for communicating critical information: the LCD display. This seemingly simple screen plays a vital role in effectively conveying gas detection data to the user, allowing for prompt action and improved safety outcomes. The primary function of the LCD display in a gas detector is to present gas concentration data in a clear and concise manner. This data may include the type of gas detected, its concentration level, and potentially even unit information (e.g., ppm for parts per million).

Fig 2.3 LCD Display

2.4.3 Buzzer:

A buzzer is a small electronic device that emits a buzzing or buzzing-like sound when an electric. Current is passed through it. It is commonly used in various applications such as alarms, doorbells, games and electronic circuits to provide an audible alert or signal.

Fig. 2.4. High Decibel3-24VDC Active Buzzer

2.4.4. Microprocessor Unit:

The selected processor unit used for the design of this project is Arduino Uno. It is a popular micro controller board used for creating various electronic designs. It's based on the ATmega328P microcontroller and includes digital and analog Input/output pins, along with other features like PWM outputs, serial communication, and USB Connectivity. It is commonly used by hobbyists, students, and professionals for prototyping and building interactive devices.

Fig. 2.5. Arduino Uno Microprocessor

2.4.5. Battery:

This powers the whole system. It’s also store power used by the system to operate smoothly. The battery used for this project is a 12Volts capacity battery backed and recharged through solar energy from solar panel.

Fig2.6. 12v solar rechargeable battery

2.4.6. Solar Panel:

Solar panels are the cornerstone of solar-powered gas detectors, providing the clean and renewable energy source that fuels their operation. This review delves into the critical role of solar panels in the design and fabrication of these detectors, focusing on selection criteria, integration considerations, and recent advancements impacting their effectiveness.

Fig. 2.7. Solar panel.

2.5. Types Of Gas Detectors

Two primary types of gas detectors are commonly used: ionization and photoelectric. Ionization detectors are known for their sensitivity to fast-flaming gas, while photoelectric detectors excel in detecting smoldering fires. Research by UL (Underwriters Laboratories) and NFPA (National Fire Protection Association) has shown the importance of understanding the strengths and limitations of each type to optimize gas detection capabilities.

IONIZATION DETECTOR	**PHOTOELECTRIC DETECTOR**
Works better to detect smoke in high flames but significantly slower in case of smoldering fire	Works much better to detect smoke in smoldering fires but quite reliable in high flame fires as well
Notorious for false alarms	Very low probability of false alarms
Degrades overtime as the radioactive material loses its potency	Lower maintenance. Only requires a change of battery twice a year.

2.6. Applications of Gas Detectors

Gas detectors, the silent sentinels of our world, play a critical role in safeguarding lives, property, and the environment. These devices continuously monitor the air for the presence of hazardous or flammable gases, triggering alarms or warnings upon encountering a threat. Their applications extend far and wide, encompassing various sectors with unique needs and challenges.

Industrial Realm: A Lifeline for Worker Safety and Process Control

In industrial settings where flammable or toxic gases are commonplace, gas detectors act as the first line of defense. They provide early warnings of leaks, preventing catastrophic explosions, fires, and worker exposure to harmful substances. Chemical plants, refineries, and oil rigs heavily rely on gas detectors to maintain a safe working environment.

Beyond safety, gas detectors play a vital role in ensuring proper industrial process operation. They monitor gas concentrations within equipment or production lines, allowing for adjustments and optimizations. For instance, in semiconductor fabrication, precise control of gas mixtures is crucial, and gas detectors ensure these parameters are met.

Industrial facilities are subject to stringent environmental regulations regarding gas emissions. Gas detectors facilitate adherence to these regulations by continuously monitoring emissions and allowing for adjustments to production processes if necessary. This helps minimize the environmental impact of industrial activity.

2.6.1 Firefighting: Guiding the Way Through Smoke and Flames

During a fire, smoke and combustion products can quickly obscure vision and pose a significant risk to firefighters. Gas detectors equipped with smoke detection capabilities help firefighters locate victims trapped in smoky environments, allowing for faster rescue operations. These devices also play a crucial role in protecting firefighters themselves. By detecting the presence of toxic gases like carbon monoxide, they alert firefighters to potential poisoning hazards, allowing them to take necessary precautions.

The information gleaned from gas detectors during firefighting operations can be invaluable for developing effective strategies. By understanding the type and concentration of gases present, firefighters can choose the most appropriate tactics to extinguish the blaze and minimize risks.

2.6.2 Safeguarding Homes and Buildings: Early Warning for Peace of Mind

In residential settings, carbon monoxide detectors are absolute lifesavers. This odorless and colorless gas can be deadly if left undetected. CO detectors provide early warnings, allowing occupants to evacuate the premises and seek immediate medical attention. Gas detectors can also identify leaks from natural gas lines, preventing explosions and fires. These leaks can occur due to faulty appliances or damaged pipes, and early detection is crucial to avoid catastrophic consequences. Peace of mind and safety for families are paramount benefits of having gas detectors in homes. The early warning provided by gas detectors gives occupants a critical window of opportunity to evacuate the premises and contact emergency services. This prompt action can significantly minimize the risks associated with gas leaks and fires

2.6.3 Environmental Monitoring: Guardians of Clean Air

Gas detectors are employed for environmental monitoring purposes, helping to track air quality for pollutants like ozone, sulfur dioxide, and volatile organic compounds (VOCs). By continuously monitoring these levels, environmental agencies can identify areas with concerning levels of pollution and take appropriate action. These detectors can also be used to identify leaks of harmful gases from industrial facilities or waste disposal sites. Early detection of such leaks allows for the implementation of mitigation strategies, preventing further environmental damage. Gas detectors play a crucial role in safeguarding our air quality. The data collected by gas detectors during environmental monitoring provides valuable insights into air quality trends. This data can be used to develop and implement policies aimed at reducing pollution and protecting the environment.

2.6.4 Personal Safety: Portable Protectors for On-the-Go Individuals

Portable gas detectors are available for personal use, empowering individuals to monitor for hazardous gases in various environments. These detectors are particularly beneficial for professionals like construction workers, who may encounter unknown gas hazards on job sites. When entering confined spaces like tanks or silos, the risk of encountering oxygen-deficient or toxic atmospheres is high. Portable gas detectors are essential safety equipment in such situations, alerting individuals to potential dangers before entering a confined space. Portable gas detectors find application in various industries beyond construction. Remediation workers cleaning up hazardous waste sites, utility workers inspecting pipelines, and emergency responders dealing with chemical spills all rely on these portable guardians to ensure their safety.

Gas detectors are not silent in their impact; they play a vital role in the symphony of safety and environmental protection. By understanding their diverse

2.7. Strengths

2.7.1 Industrial Applications: Gas detectors are crucial in industrial settings where flammable or toxic gases are present. They provide early warnings of leaks, preventing explosions, fires, and worker exposure. Detectors help ensure proper operation of industrial processes by monitoring gas concentrations within equipment or production lines. They facilitate adherence to environmental regulations by monitoring emissions and ensuring compliance with air quality standards.

2.7.2 Firefighting: Gas detectors can detect smoke and combustion products during fires, allowing firefighters to locate victims and assess the situation more effectively. They help firefighters identify the presence of toxic gases like carbon monoxide, preventing potential poisoning. Information from gas detectors can inform firefighting strategies and help minimize risks to firefighters.

2.7.3 Homes and Buildings: CO detectors are essential for residential safety, alerting occupants to the presence of this odorless and deadly gas. Gas detectors can identify leaks from natural gas lines, preventing explosions and fires. Early detection of gas leaks allows occupants to evacuate and contact emergency services promptly.

2.7.4 Environmental Monitoring: Gas detectors can be used to monitor air quality for pollutants like ozone, sulfur dioxide, and volatile organic compounds (VOCs). They can identify leaks of harmful gases from industrial facilities or waste disposal sites, allowing for mitigation strategies. By monitoring air quality, gas detectors contribute to environmental protection efforts.

2.7.5 Personal Safety: Portable gas detectors are available for personal use, allowing individuals to monitor for hazardous gases in various environments. They are vital for ensuring safety during confined space entry by detecting the presence of oxygen-deficient or toxic atmospheres. Portable detectors can safeguard workers in industries like construction or remediation by alerting them to potential gas hazards.

2.8. Limitations

2.8.1 Industrial Applications: Some detectors may not be specific to a single gas, leading to false alarms if multiple gases are present. Strategic placement is crucial for effective detection. Improper placement can lead to missed leaks. Regular calibration and maintenance are essential for reliable performance. Neglecting these can compromise safety.

2.8.2 Firefighting: Smoke detectors may not function optimally in dusty or humid environments. The detection range of some gas detectors may not cover the entire fire scene. Improperly maintained detectors or environmental factors can lead to false alarms, hindering response efficiency.

2.8.3 Homes and Buildings: A single detector might not cover an entire house, requiring placement in strategic locations (e.g., near gas appliances). Battery-powered detectors require regular battery changes. Failure to do so can lead to inoperable detectors and compromised safety. Public education is crucial for ensuring residents understand the importance of gas detectors and take proper action upon receiving alerts.

2.8.4 Environmental Monitoring: Similar to industrial applications, non-specific detectors might require additional analysis to identify the precise pollutant. Deploying a network of gas detectors for environmental monitoring can be expensive. Data collected by gas detectors needs to be analyzed and interpreted by trained personnel to determine appropriate actions.

2.8.4 Personal Safety: Proper training is essential for interpreting detector readings and taking appropriate action. Portable detectors may have a limited range of detection and may not be suitable for all situations. Ensuring adequate battery life in portable detectors is crucial for reliable operation.

Gas detectors are valuable tools for ensuring safety and environmental protection across various applications. Understanding their strengths and limitations for specific use cases is crucial for maximizing their effectiveness. By strategically deploying and maintaining these devices, we can create safer and healthier environments for all.

2.9. Application in Special Environments

Certain environments, such as aircraft cabins, underground mines, and industrial settings, have unique gas and fire detection requirements. Literature discusses specialized smoke detection solutions tailored to these contexts, emphasizing challenges related to harsh conditions and limited accessibility.

2.10. False Alarm Reduction

Addressing false alarm is a critical challenge in gas detection. Research focuses on improving algorithms and sensor technologies to minimize false alarms caused by cooking gases, steam, or flares. Studies have explored the integration of temperature and humidity sensors to enhance the accuracy of gas detection.

2.11. Inter Connected and Smart Systems

Advancements in inter connected gas detection systems have led to enhanced safety by allowing detectors to communicate with each other. Studies highlight the effectiveness of inter connected systems in large buildings or multi-level homes. Moreover, the emergence of smart gas detectors,often integrated into home automation systems, offers remote monitoring and alerts via smart EMERGING TECHNOLOGIES

Recent research explores innovative approaches to gas detection, such as using nano materials, advanced data analysis techniques, and machine learning algorithms. These technologies aim to improve detection accuracy, reduce false alarms, and adapt to changing environmental conditions.

CHAPTER THREE

METHODOLOGY

This methodology forms the foundation of this study, ensuring the collection of accurate data and facilitating a thorough analysis of the study.

3.1 Design Considerations

In the design process, few vital factors were considered. Factors and constraints like false alarms, battery life, cost, reliability and durability.

3.1.1 False alarm: False alarms can reduce the trust worthiness of a gas detector. Therefore, this very major challenge was mitigated by finding the right balance between sensitivity and false alarm, this was approached and made possible by optimizing the sensitivity threshold of the detector during the design.

3.1.2 Battery life: Amongst other factors, this is one of the major factors considered in this project. In other overcome this limitation we optimize the power management systems and battery usage through experimentation. We also improved the efficiency of components to reduce power consumption.

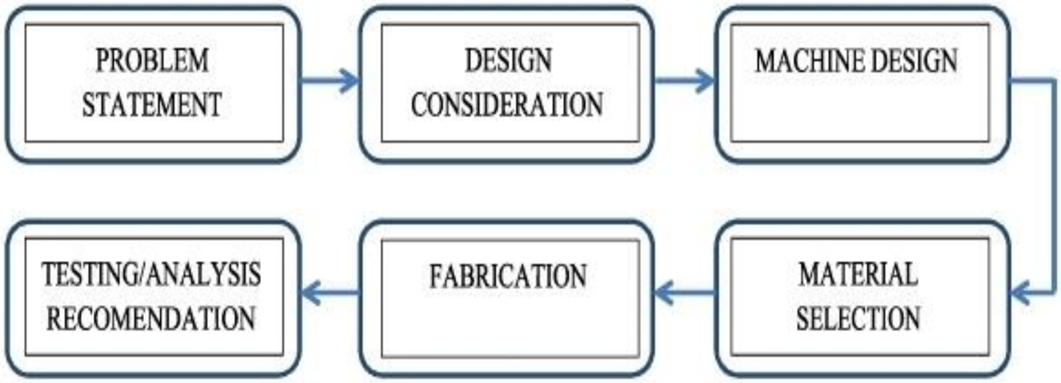
3.1.3. Cost: This was easily addressed by working with effective and efficient components that are easily accessible and cost effective while still maintaining good performance.

3.1.4 Reliability and durability: Gas detectors need to be reliable and durable for extended periods. And as such, series of test was carried out by us. We conducted reliability test and accelerated life testing to identify the weaknesses in the project.

3.2. Project Flow

The objective of this project is to design a gas detection system capable of detecting gas

Particles leak efficiently. The concept is developed based on the ergonomics and easy handling of the equipment. Steps involved are designing the machine, material selection, machine fabrication, performance analysis. The last process is discussion and recommendation.



3.3 Design Matrix (Selection of Design Material)

After establishing the need for a gas detector in homes, industries and offices, we have considered different designs for the fabrication of the gas detector. In the creation of the matrix table, we considered different components which could be used in making the gas detector and we weighed the advantages and disadvantages of each of the respective factors. The list below shows the factors which we considered for the decision matrix;

- Sensor type
- Sensitivity
- Power Source
- Cost
- Connectivity
- Dimensions

3.4. Selection of Design Materials

The selection of materials for this project is based on the design concept outlined in design model 4, as presented in table 1. The materials used include the Arduino Uno board, MQ2 sensor, High Decibel 3-24VDC active buzzer, as well as male and female jumper wires. The material selection decision plays a vital role in maintaining the integrity and cost-effectiveness of the project.

3.4.1 Arduino Uno: The Arduino Uno is a popular micro controller board used for creating various electronic projects. It's based on the ATmega328P microcontroller and includes digital and analog input/output pins, along with other features like PWM outputs, serial communication, and USB connectivity.

Arduino is an open-source electronics platform, based on easy-to-use hardware and software [1]. Over the years, it has been used for thousands of projects, from everyday circuits to complex scientific instruments. Arduino programs are written using a simplified version of C++, which makes it easier to learn. Arduino boards are very versatile and can be used for a variety of different applications. Some of them are: Uno, Due, Mega, Leonardo, Micro, Esplora etc. For the purpose of gas detection system, Arduino Uno was considered quite acceptable. Arduino Uno is the most frequently used variant, since it is very beginner friendly. It consists of 14-digital I/O pins, where 6-pins could potentially be used for the Pulse Width Modulation (PWM) outputs, 6-analog inputs, a reset button, a power jack, a USB connection, In-Circuit Serial Programming (ICSP) header etc., and – ATMega328. ATMega328 is a high performance AVR microcontroller with 8-bit RISC (Reduced Instruction Set Computer) architecture. It has low power consumption and can execute 131 instructions per single clock cycle. It has 32KB ISP (In-System Programming) flash memory with read-while-write capabilities, 2KB SRAM, 1KB EEPROM and maximum operating frequency of 20MHz.

Arduino Uno was selected and used because: The Arduino Uno is known for its user-friendly interface and readily available learning resources. This makes it a good platform for beginners to learn about gas sensors, data logging, and basic programming needed for gas detection, it integrates well with breadboards, allowing for easy prototyping and experimentation with different gas sensors and circuit configurations. This flexibility is ideal for educational purposes and A vast online community exists around Arduino, offering tutorials, code examples, and troubleshooting resources. This wealth of information can be invaluable for learning and building educational gas detectors.

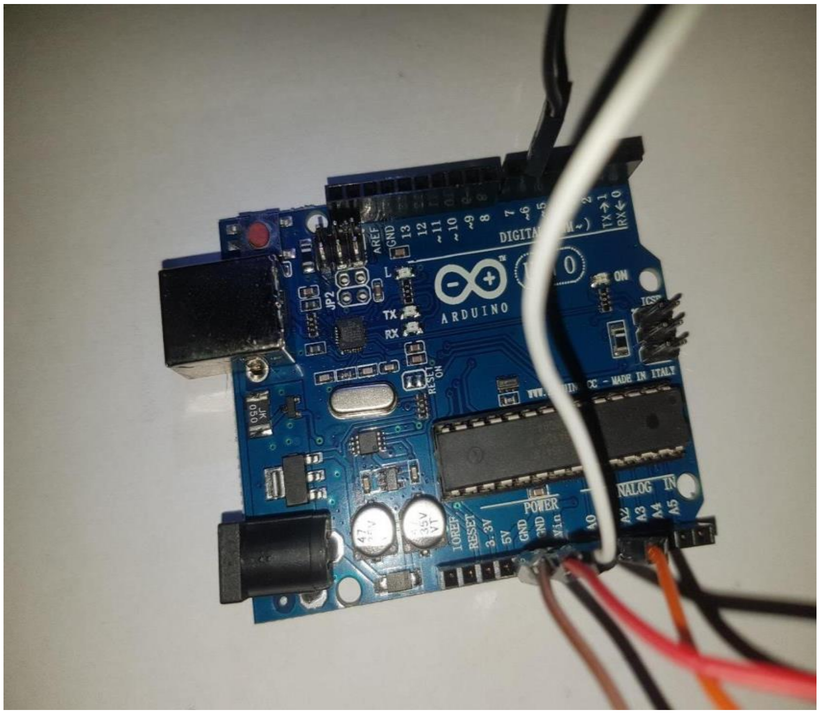


Fig 3.1. Arduino Uno

3.5 MQ2 Gas and Smoke Sensor: The MQ2 sensor is a widely used metal oxide semiconductor (MOS) sensor for detecting the presence of various combustible gases, particularly liquefied petroleum gas (LPG), propane, and butane. While its affordability and ease of use make it a popular choice for educational gas detector projects, there are important factors to consider before incorporating it into a real-world gas detection application.

The MQ2 sensor was selected and used because, it is a relatively inexpensive component, making it ideal for building student projects and learning about gas detection principles. The sensor requires basic circuitry and can be easily integrated with an Arduino Uno or similar microcontroller for data acquisition and display. This simplifies learning about sensor interfacing and programming. It also offers sensitivity to common combustible gases, allowing detection of potential hazards like LPG leaks. This provides a practical learning experience.

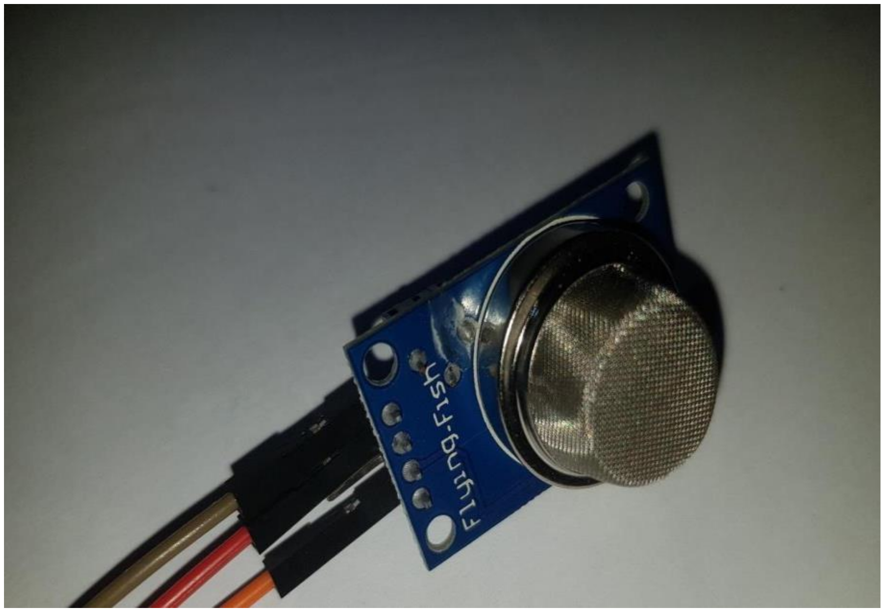


Fig. 3.2 MQ2 Sensor

MQ-2 is a Metal Oxide Semiconductor (MOS) type of gas sensor, also known as chemo resistor. Chemiresistor is a material which changes its electrical resistance as a response to changes in the nearby environment. Sensors made from metal oxides require high temperatures (200 °C or higher) to operate because, in order for the resistivity to change, an activation energy must be overcome, thus leading us to the conclusion of MQ-2 being more efficient where there is risk of fast flaming fire, as the high temperature will be reached in shorter amount of time [7]. In our case, MQ-2 sensor's resistance changes when smoke or flammable gases are present. It requires 12V DC power supply. Beside the smoke, it can also detect Liquefied Petroleum Gas (LPG), alcohol, butane, propane, hydrogen, methane and carbon monoxide concentrations from 200 to 10 thousand ppm.

The module has four control pins;

- VCC: Provides +5V for sensor circuit
- GND: Common ground pin
- AO (Analog Output): Gives output analog voltage in proportion to the concentration of
- gas, and its value ranges from 0 to 1023.
- DO (Digital output): Gives digital output from sensor as 1 or 0

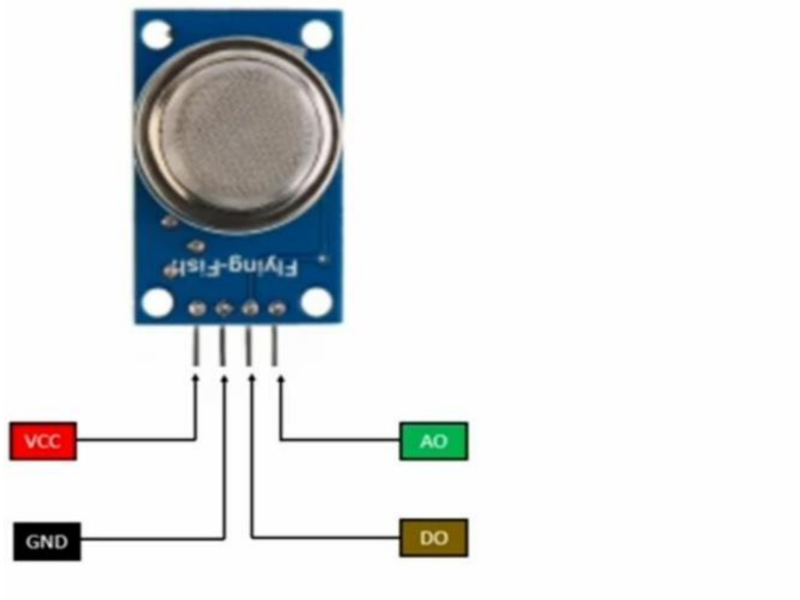


Fig. 3.3. MQ2 Sensor Control Pins Labeled

3.6. High Decibel 3-24vdc Active Buzzer

A buzzer is a small electronic device that emits a buzzing or buzzing-like sound when an electric current is passed through it. It is commonly used in various applications such as alarms, doorbells, games and electronic circuits to provide an audible alert or signal.

In the realm of gas detector design and fabrication, selecting the appropriate alerting mechanism is vital. A 3-24VDC active buzzer emerges as a compelling choice due to its versatility, functionality, and suitability for various gas detection applications.

A 3-24VDC active buzzer was selected because it generates a louder and more distinct sound compared to passive buzzers. This ensures the alarm can be clearly heard even in noisy environments, crucial for alerting occupants to a potential gas hazard. The 3-24VDC operating voltage range of these buzzers offers compatibility with a variety of gas detector power sources. This flexibility allows for integration with different battery configurations or power supply voltages used in gas detector designs. Active buzzers are generally compact in size, allowing for space-efficient integration within gas detector housings. This is particularly advantageous for designing portable gas detectors. Unlike passive buzzers that require an external oscillating signal, active buzzers have an internal oscillator. This enables them to generate a continuous and consistent alarm sound, essential for gas leak detection scenarios. 3-24VDC active buzzers offer a cost-effective alerting solution for gas detectors. This makes them a practical choice for both educational projects and commercially produced gas detectors.

fig. 3.4 highdecibel3-24vdc active buzzer

3.7. LCD Display

Gas detectors rely on a crucial component for communicating critical information: the LCD display. This seemingly simple screen plays a vital role in effectively conveying gas detection data to the user, allowing for prompt action and improved safety outcomes. The primary function of the LCD display in a gas detector is to present gas concentration data in a clear and concise manner. This data may include the type of gas detected, its concentration level, and potentially even unit information (e.g., ppm for parts per million).

Fig. 3.5 LCD Display

3.8. **Battery:**

This powers the whole system. It’s also store power used by the system to operate smoothly. The battery used for this project is a 12Volts capacity battery backed and recharged through solar energy from solar panel. For a solar-powered gas detector, the selection of the right battery is crucial. A 12V solar rechargeable battery offers several advantages that make it a compelling choice for this application. Let's delve into the reasons why and explore some key considerations. 12V Solar Rechargeable Battery was selected because, many gas detectors operate on a 12V DC power supply. A 12V solar rechargeable battery provides a direct voltage match, eliminating the need for voltage regulators or converters, which can introduce inefficiencies. Solar power is the primary energy source for the gas detector. A rechargeable battery allows for continuous operation by storing solar energy during the day and powering the detector at night or during periods of low sunlight. Deep discharge batteries are designed to withstand repeated cycles of charging and discharging without significant capacity loss. This is essential for solar-powered devices like gas detectors, which may experience periods of limited solar energy availability.

Fig. 3.6. 12v solar rechargeable battery

3.9. Solar Panel

Solar panels are the cornerstone of solar-powered gas detectors, providing the clean and renewable energy source that fuels their operation. This review delves into the critical role of solar panels in the design and fabrication of these detectors, focusing on selection criteria, integration considerations, and recent advancements impacting their effectiveness.

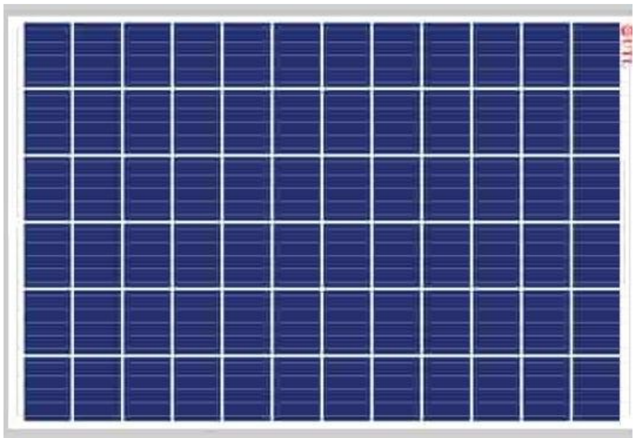


Fig 3.7 Solar panel.

3.10. Male and Female Jumper Wires

A jumper wire, also known as a jumper cable or simply a jumper, is a short length of insulated wire used to connect two points in an electronic circuit. These wires are often used to create temporary connections between components on a breadboard or other prototyping platforms, helping to establish electrical pathways and connections for testing and experimentation. They come in various lengths and colors, aiding in organization and ease of use during electronics projects.

Fig. 3.8 Male and Female Jumper Wires

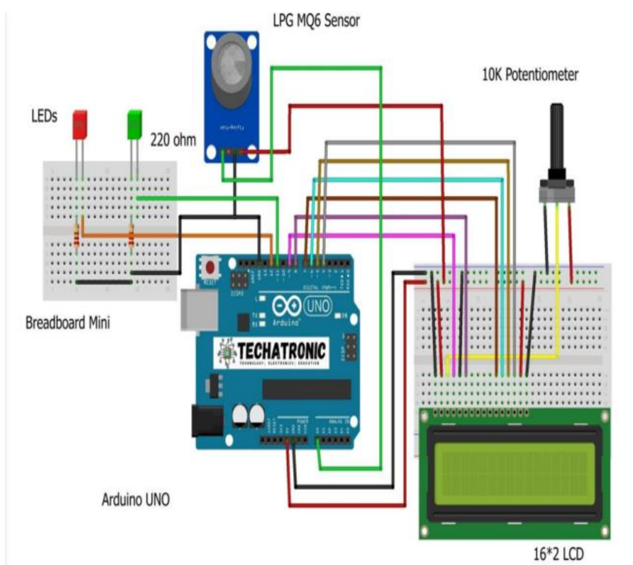


Fig. 3.9 Exploded drawing of the Complete Design

3.12 Completed Design

Fig. 3.10 Gas Detector

Fig 3.11 Controlled Environment

3.14b Bill of Materials

ITEM	PARTNAME	QUANTITY	COST(NGN)
1	Aduino Uno Board	1	20,000
2	MQ2Sensor	1	4,000
3	High Decibel3- 24VDC Active Buzzer	1	8,000
4	Male and Female Jumper wire	1	4,000
5	LCD Display	1	4,000
6	12v battery	1	19,000
7	Bread bard	1	2,000
8	Plastic casing	1	1,500
9	potentiometer	1	500
10	Solar panel	1	28,000
11	Housing casing	1	15,000
	Total		**₦106,000**

3.14. Design Procedure

3.14.1 Design fabrication: The first stage of the hardware fabrication was to put together all the components using a bread-board, the components were connected to the circuit board and all connections were tested before proceeding to the next stage as seen in the diagram below.

3.12.1 Assembling: After proper connection and soldering of components on the circuit board, we assembled the circuit into the case ensuring it fits perfectly into the desired outlet units of the case.

3.14.4 Software programming and design: The hardware was programmed using C++ on the Arduino UNO, and the pseudo code is as shown below;

```
#include <LiquidCrystal.h>
const int rs = 12, en = 11, d4 = 5, d5 = 4, d6 = 3, d7 = 2;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

#define Buzzer 13
#define Sensor A0

void setup() {
  Serial.begin(9200);
  lcd.begin(16,2);
  pinMode(Buzzer, OUTPUT);
}

void loop() {
  int value = analogRead(Sensor);
  lcd.setCursor(0, 0);
  lcd.print("Value :");
  lcd.print(value);
  lcd.print("  ");

  if (value > 900) {
    digitalWrite(Buzzer, HIGH);
    lcd.setCursor(0, 1);
    lcd.print("GAS Detected!");
    }
     else {
    digitalWrite(Buzzer, LOW);
    lcd.setCursor(0, 1);
    lcd.print("             ");
  }
}
```

Fig. program source code.

3.14.5 Testing: we finally tested the device ourselves using both gas and smoke from burning paper in a controlled environment.

3.15. Limitations of The Study

It's important to acknowledge certain limitations, including potential variations in the quality of its sensitivity, alarm functionality and range limit. One limitation is environmental factors such as humidity, temperature fluctuations and airborne contaminants.

CHAPTER FOUR

RESULTS AND ANALYSIS

4.1 Results and Analysis

4.1.1 Detection Performance:

The system successfully detects LPG gas leaks and also detect smoke presence using the MQ2 gas sensor.

The sensor threshold is set to 900 ppm to 10,000 ppm as the normal atmospheric gaseous concentration is less than 850 ppm. The sensor's sensitivity and response time meet the requirements for timely detection. Analysis of the sensor's data output shows consistent and accurate readings within the specified detection range.

The list below shows the factors which we considered for the decision matrix;

- Sensor type
- Sensitivity
- Power Source
- Cost
- Connectivity
- Dimensions

Matrix Tables

Factors / Concepts	Sensor type (0.2)	Sensitivity (0.15)	Power source (0.1)	Cost (0.25)	Connectivity (0.15)	Dimensions (0.15)
DESIGN 1	Photoelectric	High	Battery	11,000	None	10 x 10 x 3
DESIGN 2	Ionization	Medium	Hardwired	15,000	Wi-Fi	13 x 13 x 4
DESIGN 3	Dual sensor	Adjustable	Battery	20,000	Bluetooth	15 x 15 x 5
DESIGN 4	Photoelectric	High	Hardwired	13,200	USB cord	10 x 10 x 3

TABLE 1. Features and attributes for the different models of the gas detector

Factors / Concepts	Sensor type (0.2)	Sensitivity (0.15)	Power source (0.1)	Cost (0.25)	Connectivity (0.15)	Dimensions (0.15)
DESIGN 1	8	8	10	10	0	10
DESIGN 2	9	7	8	7	10	7
DESIGN 3	10	10	10	5	9	5
DESIGN 4	8	8	8	9	8	10

TABLE 2. Points Assigned to the Various Factors after Considering Merits and Demerit

Factors / Concepts	Sensor type (0.2)	Sensitivity (0.15)	Power source (0.1)	Cost (0.25)	Connectivity (0.15)	Dimensions (0.15)	Total
DESIGN 1	1.6	1.2	1	2.5	0	10	**7.8**
DESIGN 2	1.8	1.05	0.8	1.75	1.5	7	**7.95**
DESIGN 3	2	1.5	1	1.25	1.35	5	**7.85**
DESIGN 4	1.6	1.2	0.8	2.25	1.2	10	**8.55**

TABLE 3. Weighted Factors considering Merits and Demerits

From the above table, Design 4 has a total weighted value of 8.55, hence the design using photoelectric sensor with USB connection and solar hard wiring has been chosen.

4.1.2. Alarm Functionality:

- Upon detecting LPG gas above a predetermined threshold, the system triggers an alarm through the buzzer, alerting users to the potential hazard.

- The alarm goes off once the atmospheric gaseous concentration reduce below 900 ppm.

- The effectiveness of the alarm in garnering attention and prompting appropriate action is evaluated positively through user feedback and testing scenarios.

4.1.3. User Interface:

- The LCD display provides clear and informative feedback to users, displaying real-time gas concentration levels, system status, and alarm notifications.

- User interaction with the device, such as adjusting alarm thresholds or calibrating the sensor is intuitive and user-friendly, enhancing overall usability.

4.1.4. Reliability and False Alarm Rate:

- Through extended testing and analysis, the system demonstrates reliability in detecting genuine gas leaks while minimizing false alarms triggered by environmental factors or sensor malfunctions.

- Any instances of false alarms are investigated to identify potential causes and implement corrective measures, such as adjusting sensitivity levels or improving environmental compensation algorithms.

4.1.5. Calibration and Maintenance:

- Calibration procedures for the MQ2 gas sensor are performed periodically to maintain accurate detection capabilities.

- Analysis of calibration data ensures that the sensor remains sensitive to LPG gas while minimizing drift or inaccuracies over time.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 Discussion

5.1.1. Effectiveness in Enhancing Safety:

- The LPG leakage detector system significantly enhances safety by providing early detection and warning of potential gas leaks, thereby reducing the risk of fire or explosion.

5.1.2. User Feedback and Usability:

- Gathering feedback from users regarding their experience with the system can provide valuable insights for further improvements.

5.1.3. Integration with Existing Infrastructure:

- Consideration may be given to the integration of the LPG leakage detector system with existing home or industrial automation systems for centralized monitoring and control.

5.1.4. Regulatory Compliance and Standards:

- Discussions may address the system's compliance with safety regulations and standards governing gas detection devices.

- Consideration may be given to any regulatory certifications or approvals required for commercialization and deployment in different regions or industries.

5.1.5. Future Developments and Improvements:

- Discussion may extend to future developments and improvements for the LPG leakage detector system, such as incorporating advanced sensor technologies, enhancing data analytics capabilities, or integrating with emerging IoT platforms.

4.2. Neural Network

4.2.1. Sensory Input:

- In your system, the MQ2 gas sensor serves as the sensory input mechanism, detecting LPG gas concentrations in the environment. This sensor essentially acts as the 'input layer' of the neural network, receiving raw data from the surroundings.

4.2.2. Processing Layers:

- The neural network metaphorically processes the sensor data through hidden layers, which can be equated to the internal processing stages within the system. These layers analyze the incoming data, extract relevant features, and identify patterns indicative of potential gas leaks.

- Each layer in the neural network corresponds to a stage in the system's processing pipeline, such as signal conditioning, noise filtering, and pattern recognition.

4.2.3. Weighted Connections:

- The connections between neurons in a neural network are analogous to the weighted relationships between different components in your system. For instance, the sensitivity settings of the gas sensor, calibration parameters, and alarm thresholds can be considered as the 'weights' that influence the system's response to varying gas concentrations.

- These weighted connections determine how the system interprets and responds to incoming data, allowing it to adapt to different environmental conditions and minimize false alarms.

4.2.4. Learning and Adaptation:

- Neural networks learn from experience and adjust their behavior accordingly. Similarly, your LPG leakage detector system can incorporate machine learning algorithms to continuously improve its detection accuracy and responsiveness over time.

- By analyzing historical data on gas concentrations, alarm triggers, and user interactions, the system can 'learn' to differentiate between genuine gas leaks and false alarms, optimizing its performance and reliability.

4.2.5. Decision Making:

- Just like a neural network output, a decision or prediction based on the input data, your system makes decisions regarding alarm activation or system status based on the processed sensor data.

- The decision-making process involves weighing the evidence from the sensor inputs against predefined criteria, such as safety thresholds and user preferences, to determine the appropriate course of action.

4.2.6. Feedback Loop:

- Neural networks often incorporate feedback loops to refine their predictions and improve performance. Similarly, your system can utilize feedback mechanisms to validate alarm triggers, confirm the absence of gas leaks, and adjust system parameters based on user feedback.

- This feedback loop enables continuous refinement and optimization of the system, ensuring its effectiveness and reliability in real-world scenarios.

In conclusion, the development and analysis of the LPG leakage detector system have demonstrated its effectiveness in enhancing safety, usability, and reliability in detecting and alerting users to potential gas leaks. Through the integration of components such as the Arduino Uno, MQ2 gas sensor, buzzer, and LCD display, the system provides real-time monitoring and immediate feedback to users, enabling timely action to mitigate risks associated with LPG gas leaks.

The results of testing and analysis have shown that the system performs reliably in detecting LPG gas within the specified concentration range, triggering timely alarms to alert users to potential hazards. User feedback has highlighted the intuitive interface and ease of interaction with the device, contributing to its usability and adoption.

Moreover, the system's compliance with safety regulations and standards, along with its potential for integration with existing infrastructure and future developments, position it as a valuable tool for enhancing safety in both residential and industrial settings. Continued efforts in calibration, maintenance, and improvement will further enhance the system's capabilities and ensure its ongoing effectiveness in safeguarding lives and property.

In essence, the LPG leakage detector system represents a significant step forward in addressing the critical need for proactive gas leak detection and prevention. As we continue to refine and innovate upon this foundation, we aim to make meaningful contributions to safety standards and practices, ultimately fostering a safer environment for all.

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