GHANA COMMUNICATION TECHNOLOGY UNIVERSITY (GCTU)

FACULTY OF ENGINEERING

DEPARTMENT OF COMPUTER ENGINEERING

PROJECT TITLE:

DESIGN AND IMPLEMENTATION OF CYLINDER HEALTH ANALYSIS AND GAS QUALITY DETECTION

"A PROJECT PRESENTED TO THE DEPARTMENT OF COMPUTER ENGINEERING IN PARTIAL FULFILLMENT OF THE AWARD OF A BACHELOR OF SCIENCE (BSc) DEGREE"

BY:

NAME	STUDENT ID
ADDO GODFRED NANA KWEKU	0401200021
OPOKU NANA KWEKU AFRIYIE	0401200029

SUPERVISED BY:

DR. PHILIP KESEMBE

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DECLARATION

This project is presented as part of the requirements for Bachelor in Computer Engineering awarded by Ghana Communication Technology University. We hereby declare that this project is entirely the result of hard work, research and enquiries. We are confident that this project work is not copied from any other person. All sources of information have however been acknowledged with due respect.

AUTHORS:

ADDO GODFRED NANA KWEKU SIGNATURE………………………

STUDENT ID: 0401200021 DATE: …………………………….

OPOKU NANA KWEKU AFRIYIE SIGNATURE……………………….

STUDENT ID: 0401200029 DATE: …………………………….

SUPERVISOR:

DR. PHILIP KESEMBE SIGNATURE………………………

DATE: …………………………….

HOD:

DR. SAMUEL DANSO SIGNATURE……………………….

DATE: ……………………...............

ABSTRACT

The Cylinder Health Analysis and Gas Quality Detection system is designed to enhance safety and efficiency in the use of gas cylinders by monitoring critical parameters. This project addresses the need for reliable methods to assess cylinder health and gas quality, thereby preventing potential hazards associated with gas leakage or cylinder malfunction.

The system utilizes sensors to measure key indicators: pressure, temperature, and gas concentration. These measurements are processed to determine the condition of the cylinder and the quality of the gas. If the pressure and temperature are within predefined thresholds, the cylinder is deemed in good condition; otherwise, it is marked as poor. Similarly, the gas concentration is evaluated to classify the gas quality as good or poor.

Notifications are provided through LED indicators and an LCD screen, ensuring immediate and clear communication of the cylinder's status. The green LED signifies acceptable conditions, while the red LED alerts users to potential issues. The LCD screen displays concise messages corresponding to the detected conditions.

The system's effectiveness was validated through a series of tests, demonstrating its capability to accurately monitor and report on cylinder health and gas quality. This project offers a practical solution to improve safety protocols and operational efficiency in industries and residential settings that utilize gas cylinders.

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PRES……………………………………………………………………………………..PRESSURE

TEMP………………………………………………………………………………TEMPERATURE

CYL……………………………………………………………………………….....CYLINDER

LCD…………………………………………………………………….LIQUID CRYSTAL DISPLAY

GSM…………………………….… GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS

IOT……………………………………………………………....………… INTERNET OF THINGS

CPU………………………………………………………….… CENTRAL PROCESSING UNIT

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CHAPTER ONE
INTRODUCTION

1.0 BACKGROUND STUDY

Gas quality refers to the composition and characteristics of gases, particularly natural gas and hydrogen, used in various applications such as energy production and transportation. The quality of gas is crucial as it directly impacts the performance of end-use equipment and the safety and security of gas systems (Harmen, Anatoli, & Howard, 2017). For instance, the injection of hydrogen into natural gas networks can affect the pressure distribution and gas composition, which is denoted as gas 'quality' in the network (Harmen, Anatoli, & Howard, 2017). Furthermore, the impact of gas quality extends to end customers and can lead to security problems if not handled properly (Pengfei, et al., 2021).

Cylinder health, on the other hand, is essential for the safe storage and transportation of gases, particularly in medical and industrial settings. Proper handling and maintenance of gas cylinders are critical to prevent accidents and ensure the integrity of the stored gases (Wedad, Mohammed, Mustafa, Emad, & Salam, 2022). For example, in medical settings, safe handling of compressed gas cylinders, particularly medical oxygen, is vital, especially during the coronavirus pandemic, to ensure the continuous and safe supply of oxygen for patient care (Wedad, Mohammed, Mustafa, Emad, & Salam, 2022).

When gas quality and cylinder health are not managed effectively, there can be significant consequences. For instance, in the case of gas quality, the performance of end-use equipment can be compromised, leading to operational inefficiencies and safety hazards (Harmen, Anatoli, & Howard, 2017). Similarly, in the context of cylinder health, improper handling and maintenance can result in gas leaks, potential explosions, and contamination of the stored gases, posing serious risks to both human health and the environment (Wedad, Mohammed, Mustafa, Emad, & Salam, 2022).

In conclusion, ensuring high gas quality and proper cylinder health is paramount for the efficient and safe use of gases in various applications. It is essential to adhere to stringent quality control measures for gases and implement rigorous maintenance and handling protocols for gas cylinders to mitigate potential risks and ensure optimal performance and safety.

1.1 PROBLEM STATEMENT

The manual and periodic methods of cylinder health analysis and gas quality detection present several challenges:

Safety Risks: Manual inspections may not identify issues promptly, leading to potential safety risks such as gas leaks or cylinder failures.

Inability to eliminate potential gas explosions and prevent individuals from inhaling leaked gas further exacerbates these safety concerns.

Downtime: Infrequent testing can result in unexpected downtime due to cylinder failures or reduced gas quality, impacting productivity. The lack of a real-time extraction mechanism to address potential gas explosions adds complexity to minimizing downtime effectively.

Resource Intensive: Manual testing requires human resources and is resource-intensive in terms of time and labor. The absence of automated systems exacerbates the challenge of efficiently managing resources for continuous monitoring and early detection.

1.2 AIM

The project aims to design and implement a Cylinder Health Analysis and Gas Quality Detection.

1.3 OBJECTIVE

The primary objectives of this research project are as follows:

- Develop an automated system for Cylinder Health Analysis and Gas Quality Detection (CHAGQD) capable of continuously monitoring gas cylinders.
- Data Analysis: Implement data analysis algorithms to assess the condition of cylinders and detect changes in gas quality in real time.
- Alert System: Create an alert system that notifies relevant personnel in the event of cylinder health issues or changes in gas quality.
- User Interface: Develop a user-friendly interface for users to access and visualize real-time, ensuring ease of use and accessibility for both technical and non-technical users.

1.4 RESEARCH SIGNIFICANCE

The implementation of the Cylinder Health Analysis and Gas Quality Detection (CHAGQD) system will provide numerous benefits:

- **Enhanced Safety:**
    - Rapid Gas Leak Detection: The CHAGQD system will ensures the swift identification of gas leaks or irregularities in cylinder health, mitigating the potential for accidents and fostering a secure working environment.
- **Improved Productivity:**
    - Reduced Downtime: Continuous monitoring will prevent unexpected cylinder failures or reductions in gas quality, minimizing downtime and production disruptions.
- **Cost Savings:**
    - Streamlined Cylinder Replacement: Accurate assessments of cylinder conditions by the system will prevent premature replacements, resulting in substantial cost savings.
- **Health Protection:**
    - Preventing Gas Inhalation: The CHAGQD system aims to help prevent people from inhaling leaked gas to avoid adverse health conditions, ensuring the well-being of individuals in the vicinity.

1.5 SCOPE OF PROJECT

This study focuses on the design and construction of a Cylinder Health Analysis and Gas Quality Detection. The scope of the project is confined to the utilization of components such as a gas sensor, pressure sensor, temperature sensor, LED lights, a programmable microcontroller, connectors, wireless transceivers, a screen, and a buzzer. Primarily designed for monitoring and detecting LPG gas, the system provides real-time updates on the screen, enabling users to access and monitor the ongoing status. It is tailored for application in both residential and industrial settings where gas is utilized.

1.6 ORGANIZATION OF THE STUDY

The project is structured into five chapters, each addressing specific aspects:

- Introduction (Chapter 1): Provides an overview of the project, including background, problem identification, aim, objectives, scope and significance.
- Literature Review (Chapter 2): Conducts a comprehensive review of existing works and research in the field.
- Research Methodology and System Design (Chapter 3): Details the research methodology, system requirements, specifications, design considerations, selection process, and tools/components used.
- System Implementation and Testing (Chapter 4): Focuses on the implementation and testing process of the proposed system, explaining its functionality.
- Conclusion and Recommendations (Chapter 5): Summarizes the entire study and offers recommendations to enhance efficiency, usefulness, and acceptability.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

Gas quality and cylinder health analysis are critical aspects of industrial and domestic gas utilization. The safe and efficient operation of various processes and appliances heavily depends on the quality of the gas being supplied and the condition of the cylinders storing it. Gas quality encompasses parameters such as composition, purity, and contaminants, which directly impact the performance of combustion systems, equipment longevity, and, most importantly, user safety. On the other hand, cylinder health refers to the structural integrity and maintenance status of gas containers, ensuring they remain reliable and secure throughout their lifecycle.

Understanding and evaluating gas quality involve comprehensive assessments of factors like moisture content, impurities, and composition variations. Such analyses are vital for industries relying on precise gas mixtures for manufacturing processes, laboratories, and medical applications, where even minute variations can lead to significant consequences. Additionally, the increasing use of alternative and renewable gases necessitates continuous research into their properties and potential implications for various applications.

Cylinder health analysis is equally crucial, considering the potential hazards associated with gas leakage or container failure. Regular inspections and testing of cylinders are imperative to ensure their structural integrity and to identify any signs of wear, corrosion, or fatigue that might compromise their safety. Furthermore, advancements in materials science and non-destructive testing methods contribute to enhancing the overall reliability of gas cylinders.

This literature review aims to explore the existing body of knowledge on gas quality and cylinder health analysis, encompassing research on analytical techniques, technological advancements, and regulatory frameworks. By synthesizing and critically analyzing the available literature, this review seeks to provide insights into the current state of understanding, identify research gaps, and propose avenues for future investigation in the realm of gas quality and cylinder health analysis.

2.1 EVOLUTION OF GAS UTILIZATION

The evolution of gas utilization and the development of gas cylinders represent a fascinating journey that intertwines technological advancements, industrial needs, and a growing awareness of safety considerations. The utilization of gases dates back centuries, with early civilizations using natural gases for lighting and heating. However, it wasn't until the 19th century that the systematic production, storage, and distribution of gases became a significant industrial undertaking (truenaturalgas, 2023).

The Industrial Revolution marked a turning point in the demand for various gases, such as oxygen, hydrogen, and acetylene, driven by the expansion of metallurgy, chemical processes, and emerging technologies. As these applications grew, the need for a reliable and portable means of storing and transporting gases became evident. This necessity led to the development of gas cylinders, which were initially simple containers made of materials like iron or steel.

The early gas cylinders were rudimentary compared to today's standards, often lacking the safety features and precision manufacturing techniques implemented in modern designs. Over time, improvements in materials science and engineering led to the development of stronger, lighter, and more durable cylinders. The introduction of seamless steel cylinders in the early 20th century marked a significant milestone, enhancing both safety and efficiency.

2.2 CYLINDER SAFETY AND GAS HANDLING

The importance of maintaining safe practices in gas handling and storage cannot be overstated. Gas cylinders store substances under high pressure, making them potential sources of hazards if mishandled or neglected. Accidents related to gas leaks, explosions, or cylinder failures underscore the critical need for stringent safety protocols.

Ensuring the safety of gas utilization involves regular inspection, testing, and adherence to standardized procedures. Cylinders must undergo periodic examinations to assess their structural integrity, and advancements in non-destructive testing methods have played a crucial role in enhancing this process. Additionally, the development and implementation of safety valves, pressure relief devices, and other safety features contribute to minimizing risks associated with gas cylinders.

2.3 COMPREHENSIVE OVERVIEW OF COMMON INDUSTRIAL AND RESIDENTIAL GASES: USES, ADVANTAGES, AND DISADVANTAGES

In our homes and industries, we rely on different gases for various jobs, and each gas has its special traits. Knowing how to use these gases safely and effectively is important. Some of the most common industrial gases are carbon dioxide (CO_2), carbon monoxide (CO), and methane (CH_4) (Bada & AKande, 2010). These gases are made a lot because industries are growing quickly. Also, in our homes, we often use methane for heating and cooking (Bada & AKande, 2010).

This comprehensive overview delves into the common gases encountered in homes and industries. The discussion will center on their applications and the precautions necessary for their safe use. The objective is to foster a better understanding of these gases to facilitate their safe and intelligent utilization.

2.3.1 INDUSTRIAL GASES

2.3.1.1 OXYGEN (O_2)

USES:

- Cutting and Welding: Oxygen supports combustion, making it essential for oxy-fuel cutting and welding processes.
- Metal Fabrication: Facilitates metal oxidation and combustion for metal cutting and shaping.
- Medical Applications: Oxygen therapy for patients with respiratory conditions.

ADVANTAGES

- Versatility: Widely used in various industrial applications.
- Enhances Combustion: Boosts the efficiency of combustion processes.

DISADVANTAGES

Combustibility: Oxygen itself is not flammable, but it supports combustion, increasing fire risks.

2.3.1.2 ACETYLENE (C2H2)

USES

- Metal Cutting and Welding: Acetylene is a key component in oxy-acetylene torches for metal fabrication.
- Chemical Synthesis: Used in the synthesis of various organic compounds.

ADVANTAGES

- High Flame Temperature: Provides a high-temperature flame, useful for metal cutting.
- Versatile: Suitable for various welding and cutting applications.

DISADVANTAGES

- Instability: Acetylene is highly unstable in its pure form and requires careful handling.

2.3.1.3 NITROGEN (n2)

USES

- Food Packaging: Used to create a nitrogen-rich environment for food preservation.
- Metal Industry: Inert nitrogen shields metals from oxidation during heat treatments.
- Pharmaceuticals: Used in pharmaceutical manufacturing processes.

ADVANTAGES

- Inertness: Nitrogen is inert and non-reactive, making it suitable for various applications.
- Purity: Can be produced with high purity levels.

DISADVANTAGES

- Asphyxiation Risk: Nitrogen displaces oxygen, posing an asphyxiation risk in confined spaces.

2.3.1.4 ARGON (Ar)

Uses

- Welding: Provides an inert atmosphere for welding, preventing oxidation.
- Electronics Manufacturing: Used in the production of semiconductors.
- Scientific Research: Used in laboratories for various applications.

ADVANTAGES

- Inert: Does not react with most substances, making it suitable for welding.
- Stable: Argon is stable and non-toxic.

DISADVANTAGES

- Cost: Argon can be more expensive than other inert gases.

2.3.1.5 CARBON DIOXIDE (CO_2):

USES

- Beverage Carbonation: Used in the carbonation of beverages.
- Welding: Employed as a shielding gas in some welding applications.
- Fire Suppression: Used in fire extinguishers.

ADVANTAGES

- Abundant: Carbon dioxide is readily available.
- Inexpensive: Generally more cost-effective than some specialty gases.

DISADVANTAGES

- Inhalation Risk: High concentrations can pose respiratory risks.

2.3.2 RESIDENTIAL GASES

2.3.2.1 NATURAL GAS

USES

- Heating: Commonly used for residential heating purposes.
- Cooking: A popular fuel for stoves and ovens.

- Electricity Generation: Used in power plants to generate electricity.

ADVANTAGES

- Abundance: Natural gas is abundant and widely available.
- Clean Burning: Produces fewer emissions compared to some other fossil fuels.

DISADVANTAGES

- Combustibility: As a flammable gas, there is a risk of leaks leading to fire hazards.

2.3.2.2 Propane (LPG)

USES

- Heating: Used as a heating fuel for homes.
- Cooking: Commonly used in stoves and outdoor grills.
- Transportation: Used as a fuel for vehicles.

ADVANTAGES

- Portability: Propane can be stored and transported in tanks.
- Versatility: Suitable for various residential applications.

DISADVANTAGES

- Flammability: Propane is highly flammable, requiring proper handling.

2.3.2.3 METHANE (CH4)

USES

- Natural Gas: Used as a primary component of natural gas for residential heating and cooking.
- Electricity Generation: Used in power plants for electricity production.

ADVANTAGES

- Clean Energy: Methane is considered a cleaner-burning fuel compared to some alternatives.
- Abundance: Natural gas, primarily methane, is abundant and widely distributed.

DISADVANTAGES

- Combustibility: Similar to natural gas, methane is flammable and poses fire risks.

2.3.2.4 BUTANE

USES

- Lighter Fluid: Commonly used in refillable lighters.
- Camping Stoves: Portable butane stoves are popular for outdoor activities.

ADVANTAGES

- Portability: Butane is easily stored in containers for portable use.
- Ease of Ignition: Butane is easily ignited, making it suitable for various applications.

DISADVANTAGES

- Flammability: Butane is highly flammable and requires careful handling.

2.3.2.5 CARBON MONOXIDE (CO):

USES

- Heating: Produced by incomplete combustion, it is a byproduct of heating systems.
- Industrial Processes: Used in certain industrial processes.

ADVANTAGES

- Fuel Indicator: Presence of carbon monoxide can indicate incomplete combustion.

DISADVANTAGES

- Toxicity: Carbon monoxide is highly toxic and poses a significant health risk.

2.4 REVIEW OF RELATED WORKS

This chapter's review of related works provides a thorough analysis of various systems within the field of gas quality monitoring and detection. It delves into the explanation of each system, the methods and approaches employed, implementation details, and highlights both the advantages and limitations. By scrutinizing these related works, valuable insights emerge regarding advancements, challenges, and potential areas for improvement in cylinder health analysis and gas quality detection. This contribution aims to enrich the existing knowledge in the field.

2.4.1 GAS LEAKAGE DETECTION AND ALERTING SYSTEM USING ARDUINO UNO

(Syeda & Prasad, 2020) Designed and constructed a Gas Leakage Detection and Alerting System using Arduino Uno.

This system was designed to address the potential hazards associated with the leakage of LPG gas in various environments, including homes, workplaces, and gas storage containers. The system employs sensors capable of detecting a range of gases, such as propane, iso-butane, LPG, and smoke. When a gas leak is detected, the sensor triggers an alarm unit, specifically a buzzer, providing an audible indication of the presence of LPG volume.

The gas monitoring system is equipped with three sensors, each assigned to a specific zone. If any gas is detected, the Arduino Uno relays signals to the LCD, displaying a warning message such as 'GAS DETECTED AT ZONE' along with the corresponding zone number. Simultaneously, the buzzer and GSM module are activated to alert individuals about the potential danger. In the absence of gas detection, the LCD displays a reassuring message - 'NO GAS DETECTED.'

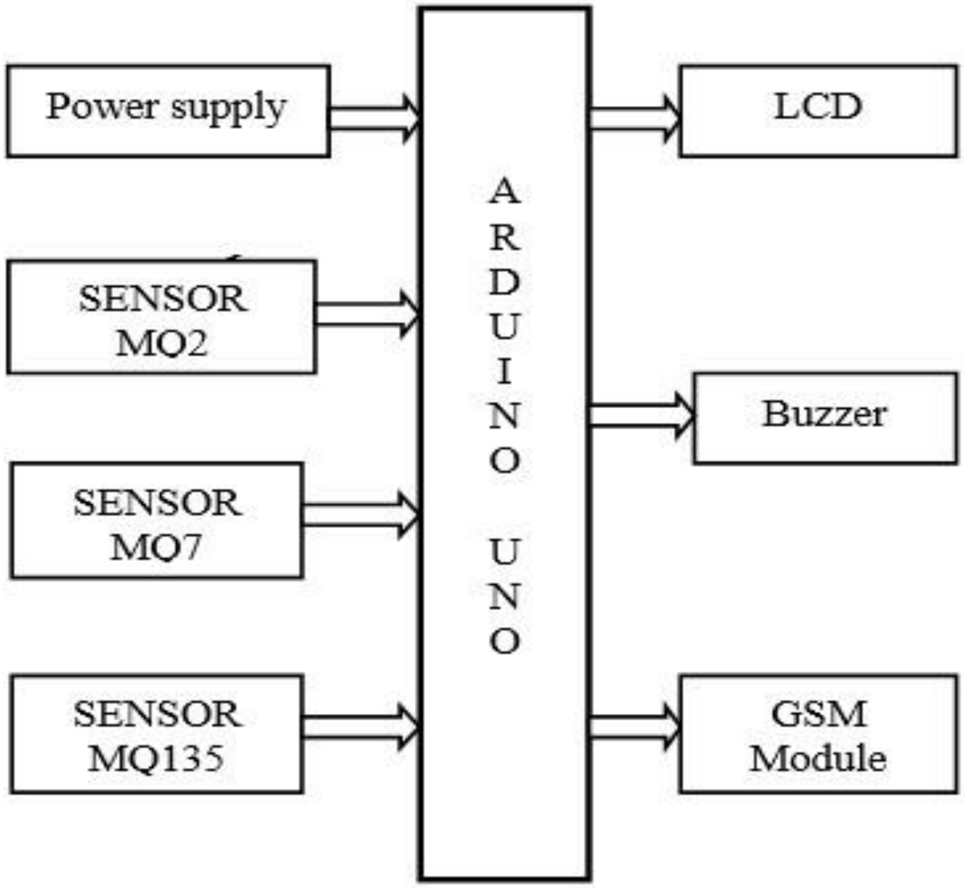


Figure 2.1 Block Diagram of gas leakage detecting and alerting system

Source: (Syeda & Prasad, 2020)

2.4.1.1 SYSTEM COMPONENTS AND FUNCTIONS

Arduino Uno: Acts as the central processing unit of the system. The Arduino Uno interprets signals from gas sensors and triggers appropriate responses.

Gas Sensors (Propane, Iso-butane, LPG, and Smoke): The gas sensors detect a range of gases, including propane, iso-butane, LPG, and smoke. The gas sensors initiate alarm responses upon detecting gas leakage.

Buzzer: The buzzer provides an audible indication of gas presence. It is then activated by the Arduino Uno to alert individuals about gas leakage.

LCD Display: The LCD presents visual feedback and warning messages. It is then activated by the Arduino Uno to display information about detected gas and zone specifics.

GSM Modem: The GSM module enables remote notification through SMS alerts. It is then activated by the Arduino Uno to send alerts to a pre-specified mobile number.

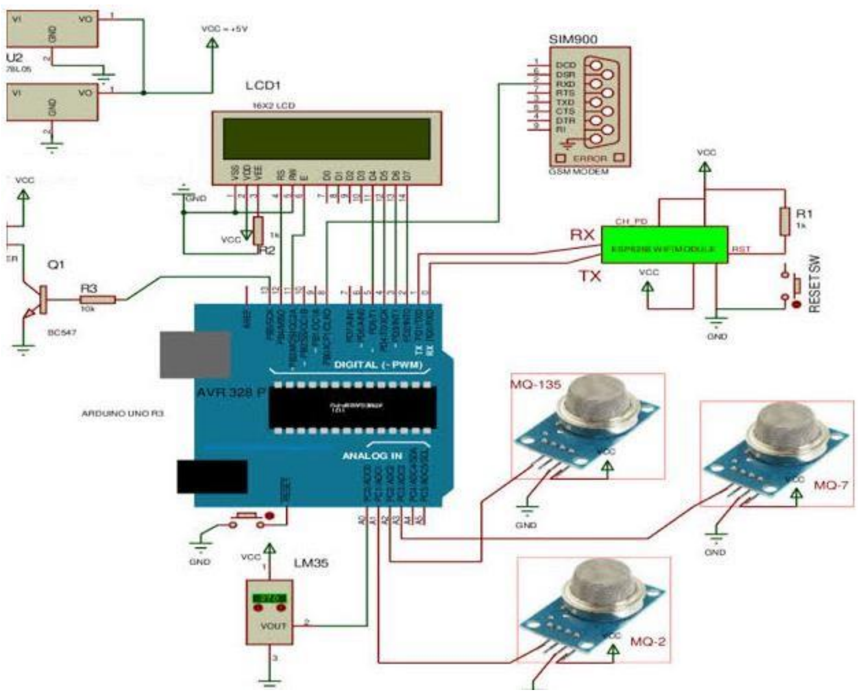


Figure 2.2 Schematic diagram of gas leakage detecting and alerting system using Arduino

Source: (Syeda & Prasad, 2020)

2.4.1.2 ADVANTAGES OF THE SYSTEM

- The system employs multi-gas detection capable of detecting various gases, including LPG, propane, iso-butane, and smoke, enhancing its versatility and applicability in diverse environments.
- The inclusion of both audible (buzzer) and visual (LCD) alerting mechanisms ensures that individuals are promptly notified about gas leaks.

- Utilizing a GSM module enables the system to send SMS alerts to a predefined mobile number, providing a remote notification feature even when individuals are not close to the gas leak.

2.4.1.3 THE LIMITATIONS OF THE SYSTEM

- The LED lights may not effectively indicate varying concentrations of gas leakage, potentially limiting the system's ability to communicate the severity of the gas leak.
- In scenarios with poor network coverage, users may face difficulties in receiving timely SMS alerts, which could impact the effectiveness of remote notifications.
- The system mostly focuses on detecting gas leaks, which is one part of checking how healthy a cylinder is. However, it lacks the necessary features to thoroughly assess the gas quality and overall condition of the cylinder. This means it's unable to monitor essential factors such as gas pressure, temperature control, and other vital aspects of cylinder health, like regular pressure and temperature checks.

2.4.2 COST-EFFECTIVE, AUTOMATED UNIFIED SYSTEM FOR LIQUEFIED PETROLEUM GAS (LPG) BOOKING LEAKAGE DETECTION

(Didpaye & Nanda, 2015) Designed and constructed an Automated Unified System for Liquefied Petroleum Gas (LPG) Booking Leakage Detection. The primary objective of this project was to enhance safety measures within households by effectively monitoring and preventing LPG leakage, thereby reducing the risk of fire accidents, especially in areas where security concerns are paramount.

The system utilizes a gas sensor, specifically the MQ6, to detect any LPG leakage, promptly notifying the user through SMS alerts via the integrated GSM module while activating an alarm simultaneously. Additionally, the system continuously monitors the LPG level within the cylinder using a weight sensor. It autonomously initiates the cylinder booking process through the GSM module. Furthermore, the system incorporates an automatic control mechanism for the LPG regulator, mitigating the potential for blast or fire outbreaks by disconnecting the main power supply through a relay. This comprehensive approach ensures a safer and more secure environment in homes using LPG for various applications.

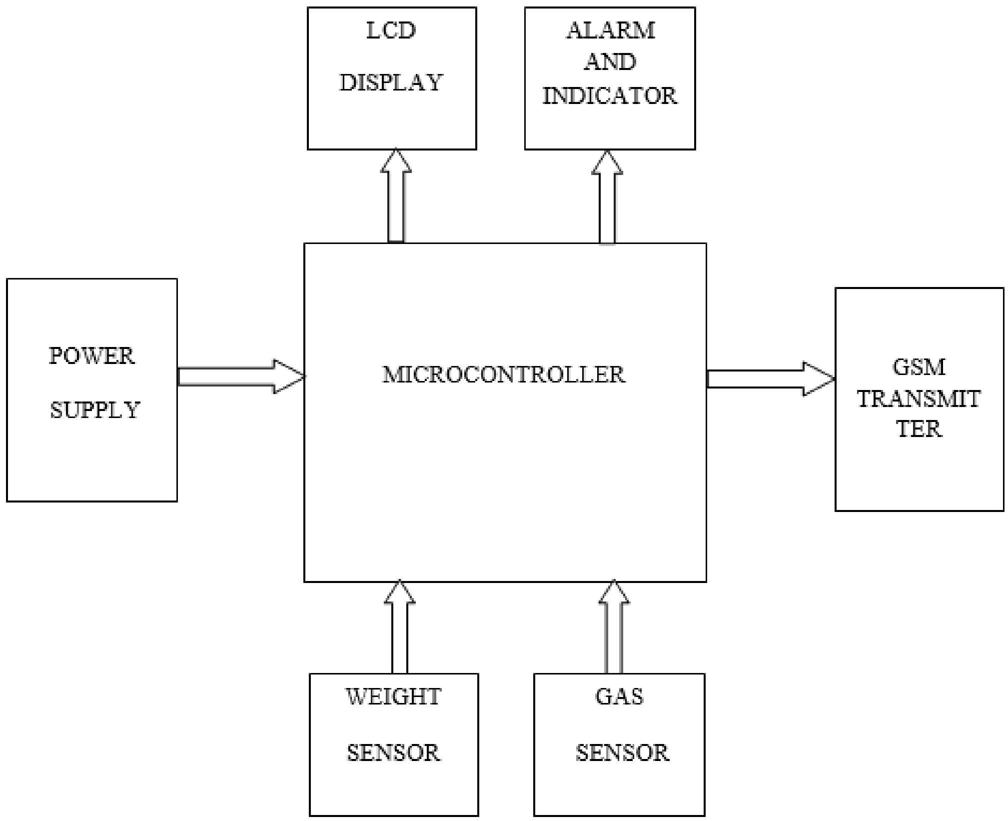


Figure 2.3 Block Diagram of an Automated Unified System for Liquefied Petroleum Gas

Source: (Didpaye & Nanda, 2015)

2.4.2.1 SYSTEM COMPONENTS AND FUNCTIONS

Microcontroller: This high-performance controller continually monitors the LPG gas and interprets the output from the level (weight) sensor.

Power Supply: Responsible for providing the necessary power to drive the system.

Gas Sensor (MQ6): A semiconductor-type gas sensor that effectively detects gas leakage. The sensor's sensitive material is tin dioxide (SnO_2), exhibiting low conductivity in clean air and heightened sensitivity with increasing gas concentration. It operates on a safe and low voltage range of 0-5 volts, suitable for diverse gaseous environments.

Weight Sensor: Utilizing a load cell in conjunction with an L6D weight sensor module, this component measures the gas container's (cylinder) weight. The load cell output activates a relay circuit, generating two logic pulses (for <=7 kg and <= 0.5 kg), subsequently conveyed to microcontroller port pins for gas level detection.

LCD Displays: As the system performs control and monitoring functions, the LCD presents various messages, including gas leakage detection, cylinder refill booking numbers, and displays actions executed by the microcontroller.

Alarm and Indicator: Comprising a buzzer and LED light, this element provides alerts through audible sounds and visual indications.

GSM Transmitter: The communication circuit responsible for notifying users about gas leakage over distances through a GSM module.

2.4.2.2 ADVANTAGES OF THE SYSTEM

- Ability to detect the presence of LPG, propane, and butane gases.
- Ability to display the status of gas leakage through the LCD display.
- Simultaneous monitoring of gas weight and leakage in a gas cylinder.
- Alerting users of gas leakages through both an alarm and a GSM module at a considerable distance.

2.4.2.3 THE LIMITATIONS OF THE SYSTEM

- In the case of bad coverage, users might be unable to receive alerts of gas leakage.
- This system mostly also focuses on detecting gas leaks, which is one part of checking how healthy a cylinder is. However, it lacks the necessary features to thoroughly assess the gas quality and overall condition of the cylinder. This means it's unable to monitor essential factors such as gas pressure, temperature control, and other vital aspects of cylinder health, like regular pressure and temperature checks

2.4.3 MICROCONTROLLER BASED LPG GAS LEAKAGE DETECTOR USING GSM MODULE

(Ankit, Babalu, Atul, & Mr., 2015) Designed and constructed a Microcontroller Based LPG Gas Leakage Detector Using GSM module. This project aimed to address critical issues in the industrial sector, residential spaces, and gas-powered vehicles such as CNG (Compressed Natural Gas) buses and cars. The team proposed a preventive system designed to mitigate accidents associated with gas leakage by strategically placing gas leakage detection devices in vulnerable areas. The primary objective of the project was to develop a device capable of autonomously detecting and preventing gas leakages in susceptible locations.

The system utilizes a gas sensor to detect LPG (Liquefied Petroleum Gas) leakage, employing GSM technology to alert individuals about the issue through SMS. When the concentration of LPG in the air surpasses a predefined threshold, the gas sensor registers the leakage, causing the sensor output to go LOW. The microcontroller detects this change and activates both the LED and buzzer simultaneously. Subsequently, the system notifies the user by sending an SMS to the designated mobile phone.

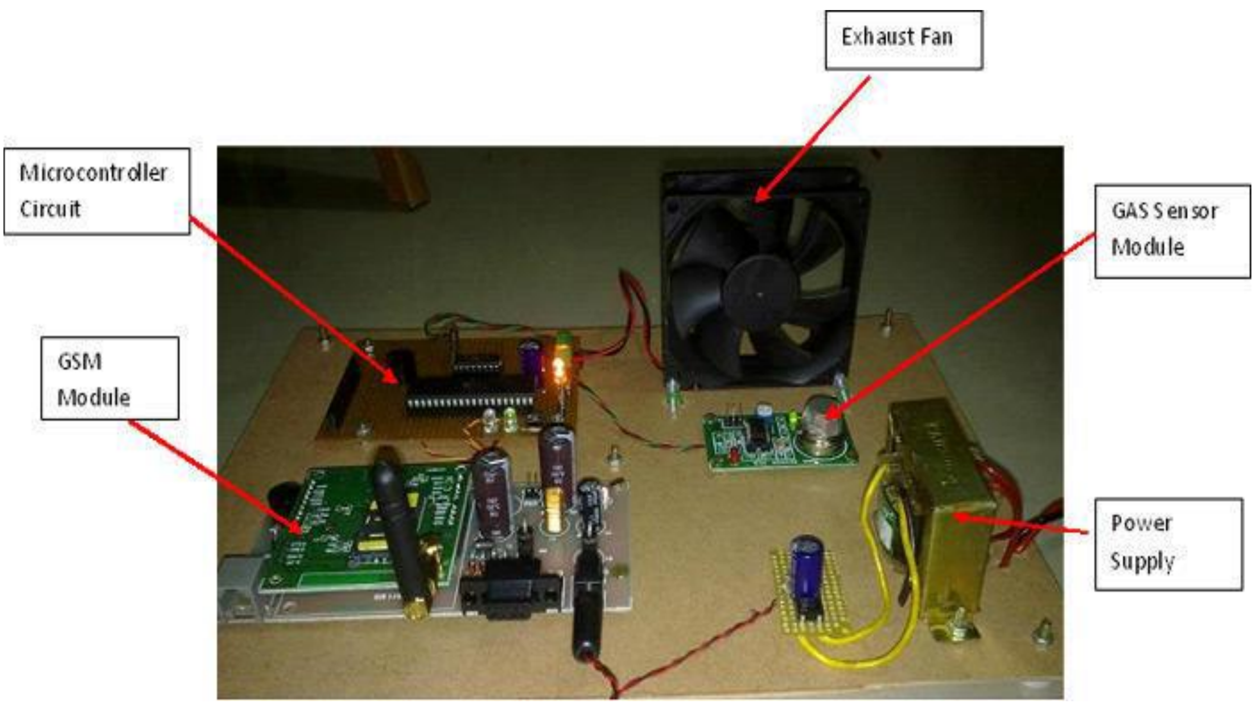


Figure 2.4 Pictorial view of a Microcontroller Based LPG Gas Leakage Detector Using GSM

Source: (Ankit, Babalu, Atul, & Mr., 2015)

2.4.3.1 SYSTEM COMPONENTS AND FUNCTIONS

Power Supply: Responsible for providing the necessary power to facilitate the system's functioning.

Gas Sensor Module: Facilitates the detection of gas presence and transmits this information to the microcontroller.

Microcontroller Circuit: An efficient and high-speed controller continuously monitoring gas leakage detected by the sensor. It conveys information through both a buzzer alert and LED lights.

GSM Module: Utilized for notifying users at a considerable distance through SMS messages sent by a GSM module.

Exhaust Fan: Serves as a gas extraction system, effectively reducing the concentration of gas detected by the sensor.

2.4.3.2 ADVANTAGES OF THE SYSTEM

- Detection Capability: Able to identify the presence of LPG, propane, and butane gases.
- Alert System: Capable of notifying users about gas leakages through an alarm and a GSM module, even at a considerable distance.
- Visual Alert: Provides user alerts through an LED display.

2.4.3.3 THE LIMITATIONS OF THE SYSTEM

- Limited Sensitivity of LED Lights: The LED lights may not effectively indicate varying concentrations of gas leakage.
- Network Dependency: In scenarios with poor network coverage, users may face difficulties in receiving alerts about gas leakage.
- The system mostly focuses on detecting gas leaks, which is one part of checking how healthy a cylinder is. However, it lacks the necessary features to thoroughly assess the gas quality and overall condition of the cylinder. This means it's unable to monitor essential

factors such as gas pressure, temperature control, and other vital aspects of cylinder health, like regular pressure and temperature checks

2.5 CONCLUSION

The evolution of gas monitoring systems has been driven by the imperative to overcome limitations identified in prior research. Previous studies commonly utilized components such as gas sensors, buzzers, and control units to detect the presence of LPG gases, addressing one aspect of cylinder health analysis. However, these studies revealed a notable deficiency in comprehensively assessing gas quality and the overall condition of the cylinder. Key factors such as gas pressure, temperature control, and other vital aspects of cylinder health, including regular pressure and temperature checks, were not adequately monitored.

In contrast, this project endeavors to advance upon these earlier works by introducing additional features aimed at addressing these critical limitations. The proposed system integrates gas detection sensors, pressure, and temperature monitoring capabilities, all wirelessly connected to the main circuit. This circuit incorporates essential components such as LED lights, a screen for concentration indication, and a microcontroller. The microcontroller receives signals from the sensors, updates the display screen, and provides information on the user's device regarding the cylinder's health, gas quality, and related parameters, thereby enhancing user awareness.

CHAPTER THREE

METHODOLOGY

3.0 INTRODUCTION

Systems development methodologies are a set of practices, procedures and rules employed by the ones that work in a discipline. It also outlines the techniques, tools, roles and different activities that system needed to be developed. It can also be said that methodologies are a system which is used to structure, plan and monitor the development of the information system. Choosing the best methodology and the execution of the program envisaged is the ban of most systems developers.

The Software Development Life Cycle underpins most of the actions, phases and development methodologies which, however complex, go through most information systems. Through our process of finding the appropriate methodology to implement our system in its design, we happen to chance upon variety of methodologies and methodologies that we consider fit for our System is the rapid prototyping methodology.

3.1 RAPID PROTOTYPING MODEL

The speedy creation of a full-scale model is rapid prototyping. Rapid prototyping is used in manufacturing to create a tri-dimensional model of product. In addition to providing 3-D simulation for digitally generated products, rapid prototyping may be used until it is manufactured in larger quantities to test the efficacy of a component or product design. Testing may have more to do with a design 's shape or scale than with its strength or reliability, as the prototype may not be constructed from the same material as the final product. Nowadays, prototypes are mostly made using additive layer manufacturing technology, also known as 3-D printing

Rapid prototyping may be used in network design to map the architecture to a new network. For example, a rapid prototype tool called Mininet allows the user to quickly build, communicate, modify, and share a software-defined network (SDN) prototype on a single computer that simulates a network topology using Open flow switches.

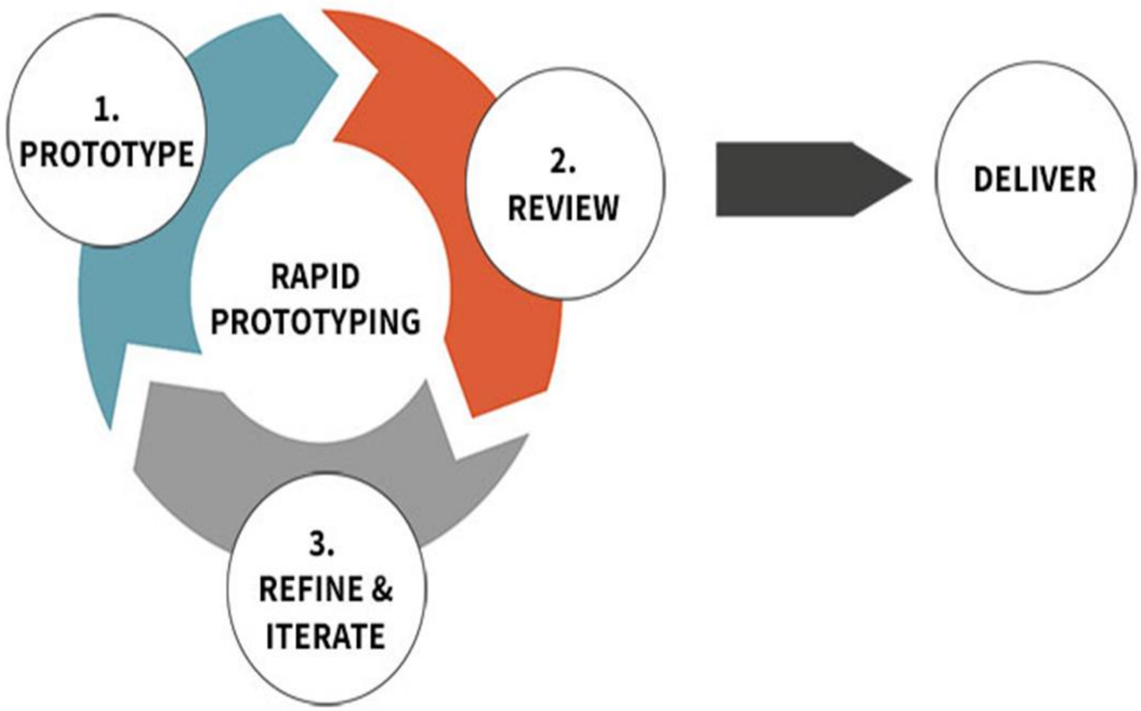


Figure 3.1 The rapid prototype methodology model

Source: https://bigrep.com/applications/engineering-and-rapid-prototyping/

After a near analysis and study, the approach we considered suitable for our work

Was a rapid prototype methodology model. This selection was based on merit, and the following are some of the merits;

- Realizing the Design Concepts

  Rapid prototyping enables designers to bring their concepts into practice beyond virtual simulation. It allows for an understanding of the design's look and feel, rather than simply assuming it through the CAD model. This allows designers to bring forward their ideas before finalization and to incorporate them in their work. It also provides the end-customer with proof of concept, finding a more practical product design rather than merely visualizing the design on the screen.

- Incorporating the Changes Instantly

  Having a physical model in hand, the improvements can be immediately implemented merely by asking the customers for input. Several iterations are expected before the design is finalized. The design further improves with each iterative process, creating trust for both the designer and the end user. This also helps to recognize the real consumer need, making it easier to produce profitable goods with a better acceptability rate.

- Saving Cost and Time
  The cost and time required for developing molds, patterns, and special tools can be eliminated with additive manufacturing. To generate different geometries, the same CAD program and the printing equipment can be used. Unlike traditional prototyping methods such as CNC machining, the quantity of waste generated is minimal, because rapid prototyping only prints the material required to create the object.
- Customizing Designs:
  The most promising advantage of rapid prototyping is the ability to develop tailored products according to the individual requirement. No special tools or procedure are needed to incorporate changes to the design of the product. A minor improvement in the CAD model and stays the same for the entire cycle. This is highly beneficial for suppliers, because it gives the consumer a related interaction with the product they purchase.
- Minimizing Design Flaws

The additive manufacturing offers the opportunity to detect design defects before mass production. The materials used for rapid prototyping closely mimic the properties and strength of the real product, allowing physical testing to be carried out easily. The risks of defects and usability issues should be detected earlier in order to prevent problems that may occur later during manufacturing. The use of rapid prototyping in product design and development is indeed a profitable decision and should be encouraged within the organization of manufacture. In a highly competitive climate, this method will help cost-effectively produce innovative products.

3.2 DESIGN CONCEPT

Gas quality and cylinder health are essential considerations in industries and households where gases are utilized for various purposes. Gas quality refers to the characteristics, purity, and properties of a gas, which are crucial for its safe and effective use in applications such as heating, cooking, manufacturing, and medical procedures. On the other hand, cylinder health pertains to the condition, safety, and overall fitness for use of a gas cylinder, ensuring its integrity to prevent leaks, structural failures, and other hazards associated with gas storage and transport.

3.2.1 DESIGN CONCEPT FOR GAS QUALITY AND CYLINDER HEALTH MONITORING

3.2.1.1 GAS QUALITY MONITORING SYSTEM

The system starts by integrating a gas sensor compatible with microcontroller, such as MQ series sensor, to accurately measure gas concentration. This sensor is then connected to the microcontroller's analog or digital pins for data acquisition. Once the sensor readings are collected, any analog signals from the gas sensor are converted into digital signals, ensuring precise gas concentration readings.

Next, specific levels for acceptable and unacceptable gas concentrations are established, allowing Arduino to compare sensor readings against these thresholds. This comparison helps determine the quality of the gas being monitored.

To visually represent gas quality information, an LCD display is connected to the microcontroller. This display presents messages like "Good Gas Quality" or "Poor Gas Quality" based on the threshold comparisons, making it easier for users to interpret the data.

For enhanced functionality, the system includes an optional data-logging feature. This feature enables the system to record gas sensor readings over time, simultaneously displaying results on the LCD screen and updating a web portal accessible to users. With this capability, users can remotely monitor gas quality trends and fluctuations, gaining valuable insights into system performance and any potential issues.

3.2.1.2 CYLINDER HEALTH MONITORING SYSTEM

To effectively monitor cylinder conditions, pressure and temperature sensors like BMP280 and DS18B20 are employed. These sensors are connected to a microcontroller to gather data on pressure and temperature within the cylinder.

Once the sensor readings are collected, analog-to-digital conversion is performed to process the pressure and temperature data accurately.

To ensure cylinder health, predefined thresholds are established for acceptable pressure levels and temperature ranges. The microcontroller then compares the sensor readings with these thresholds to assess the cylinder's condition.

For enhanced safety, additional sensors or switches can be integrated to monitor cylinder valve and seal statuses. These sensors are connected to the microcontroller for real-time monitoring capabilities.

Visual feedback on cylinder health status is provided through an LCD display connected to Arduino. Messages like "Cylinder Health: Good" or "Cylinder Health: Poor" are displayed based on threshold comparisons, aiding users in understanding the cylinder's condition.

For analysis, optional data logging functionality is implemented. This feature records pressure, temperature, and other relevant data over time, allowing the microcontroller to log this information for further analysis or maintenance tracking.

Below is a block and flow chart diagram of the system.

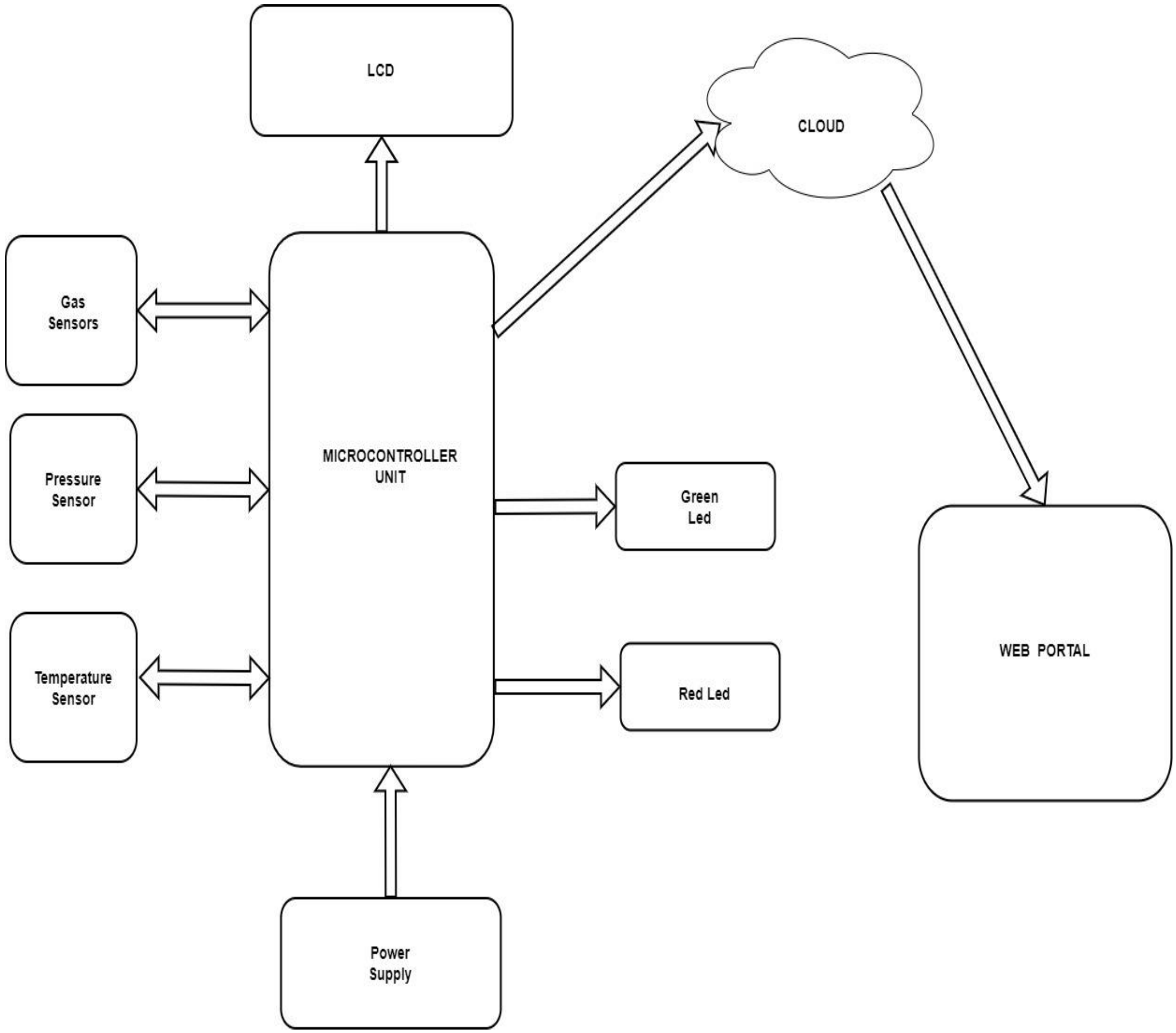


Figure 3.2 Block Diagram of the System

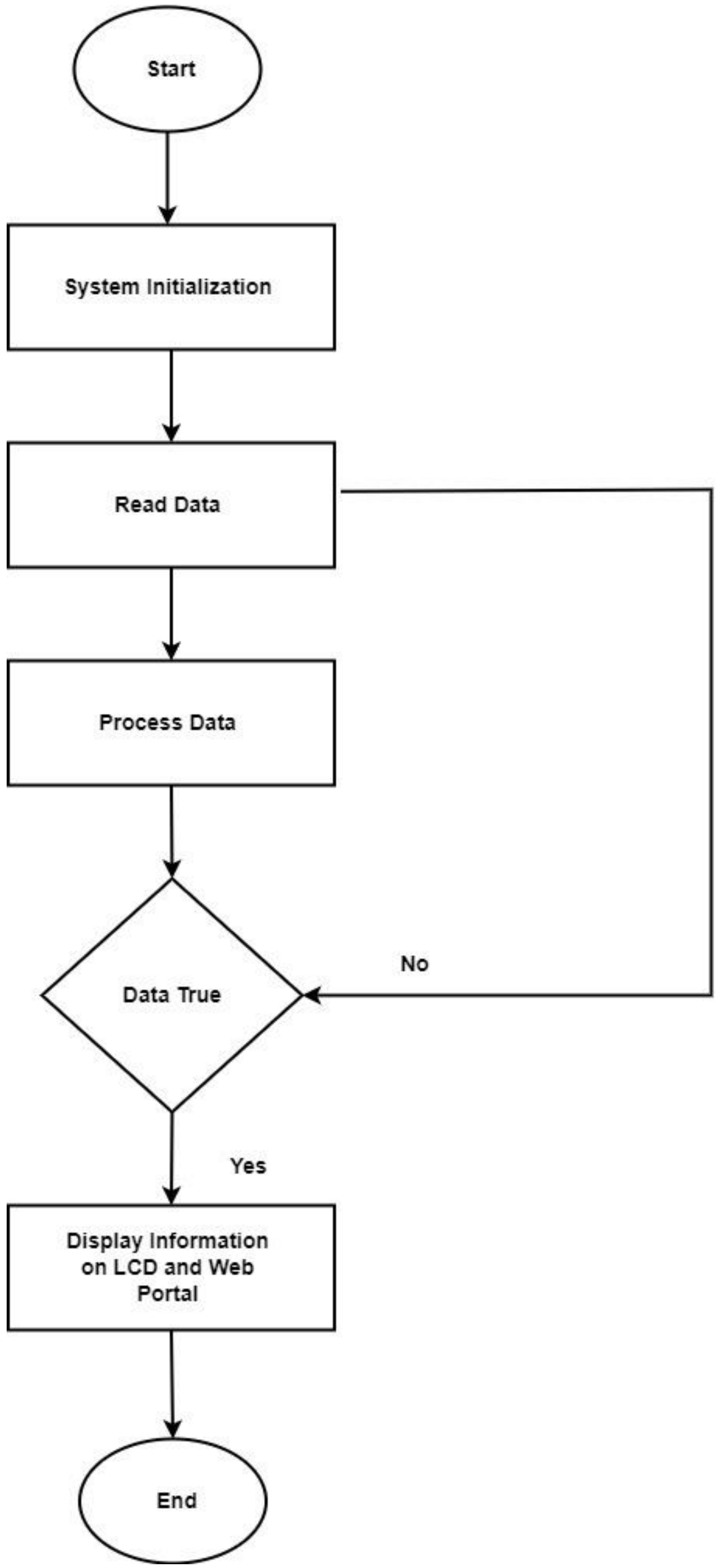


Figure 3.3 Flow Chart Diagram of the System

3.3 SPECIFICATION OF COMPONENTS

3.3.1 THE MICROCONTROLLER UNIT

A microcontroller is an integrated chip that is often part of an embedded system. It includes a Central Processing Unit (CPU), Random Access Memory (RAM), Read Only Memory (ROM), Input/output (I/O) ports, and timers just as a standard computer. They are however small and simple because they are designed to execute only a single specific task so as to control a single system.

Microcontrollers have the advantage of keeping the parts-count and design costs of a system minimal. They are typically designed using complementary metal oxide semiconductor (CMOS) technology. This is an efficient fabrication technique that uses less power and is more immune to power spikes than other techniques. There are also multiple architectures used, but the predominant architecture is Complex Instruction Set Computer (CISC), which allows the chip to contain multiple control instructions that can be executed with a single macro instruction. Some use Reduced Instruction Set Computer (RISC) architecture. This architecture implements fewer instructions, but delivers greater simplicity and lower power consumption.

In this thesis, we used Arduino UNO R3, a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It can be connected to a computer via a USB cable or powered with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards from Arduino in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

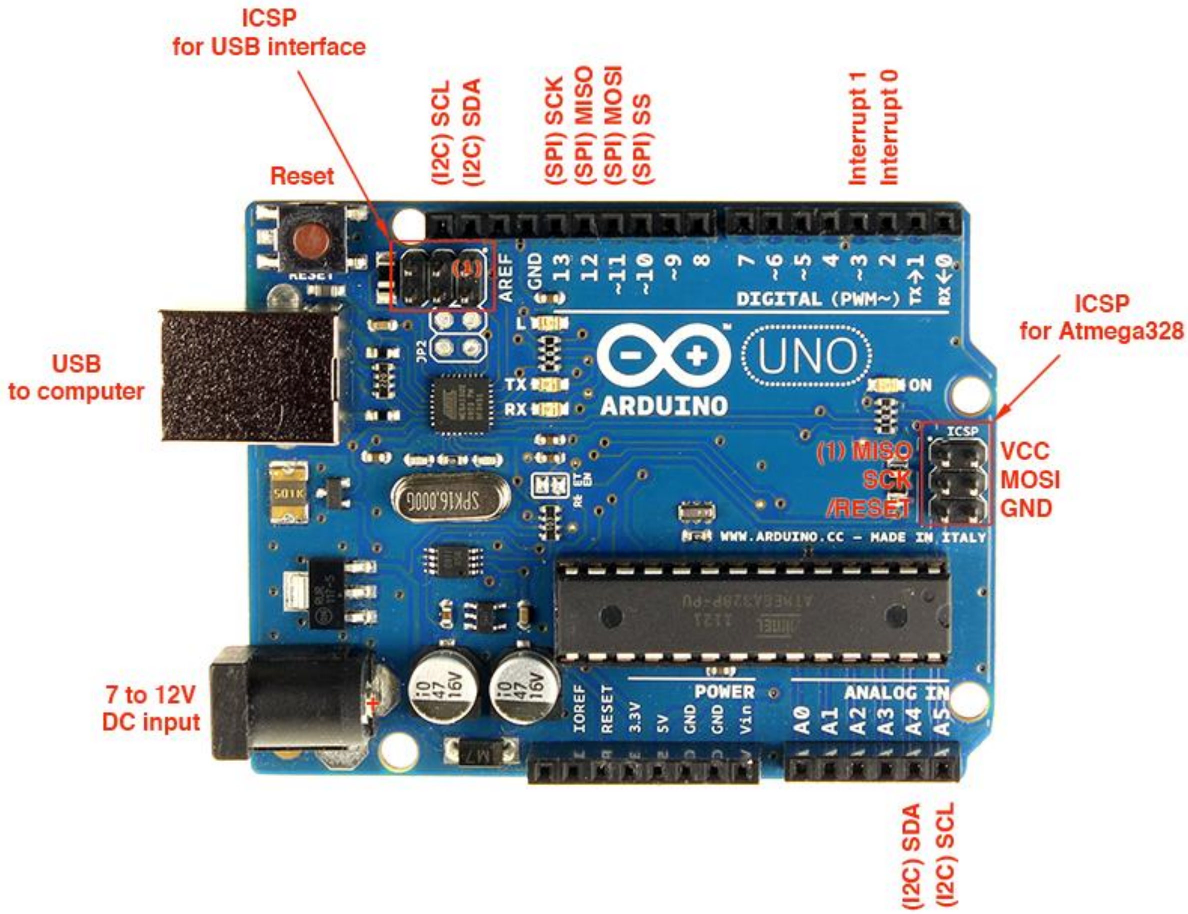
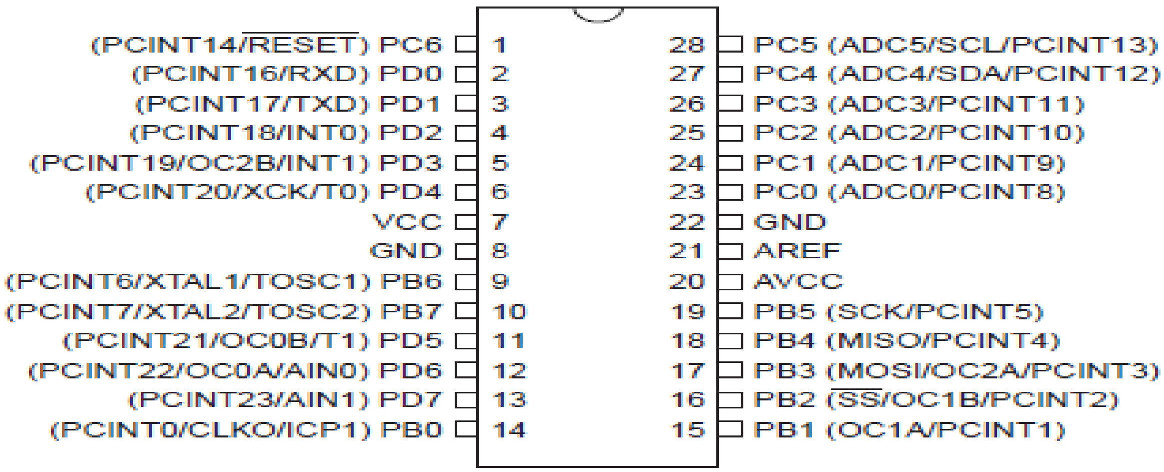


Figure 3.4 Arduino Uno R3



The board has length and width 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Below is the board with its pin indications:

ATMega328 is an 8-Bit Processor in 28 pin DIP package. The ATmega328P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328P achieves throughputs approaching 1 MIPS per MHz allowing the system design to optimize power consumption and processing speed.

3.3.1.1 PIN DESCRIPTIONS

VCC: This is the Digital supply voltage

GND: This is the Ground Pin

Port B (PB7:0) XTAL1/XTAL2/TOSC1/TOSC2: Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit. Depending on the clock selection fuse settings, PB7 can be used as output from the inverting oscillator amplifier

Port C (PC5:0): Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC5.0 output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

PC6/RESET: If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. The electrical characteristics of PC6 differ from those of the other pins of Port C. If the RSTDISBL Fuse is not programmed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running.

Port D (PD7:0): Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally

3.3.1.2 TECHNICAL SPECIFICATIONS

Table 3.1 Arduino UNO R3 Board with its Technical Specifications

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 Ma
DC Current for 3.3V Pin	50 Ma
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader

SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Source: http://arduino.cc/en/Main/ArduinoBoardUno

3.3.2 GAS SENSOR (MQ-6)

MQ-6 is one of the sensor used in this project. The sensitive material of MQ-6gas sensor is SnO_2, which has lower conductivity in clean air. When the target flammable gas exist, the sensor's conductivity gets higher along with the gas concentration rising. Users can convert the change of conductivity to correspond output signal of gas concentration through a simple circuit. MQ-6 gas sensor can detect different kinds of flammable gases, especially those with high sensitivity to LPG (propane). It is a kind of low-cost sensor for many applications.

3.3.2.1 FEATURES OF MQ-6

It has good sensitivity to flammable gas (especially propane) in wide range, and has some advantages such as long lifespan, low cost and simple drive circuit.

3.3.2.2 MAIN APPLICATIONS

It is widely used in domestic gas leakage alarm, industrial flammable gas alarm and portable gas detector.

Figure 3.5 Gas Sensor (MQ-6)

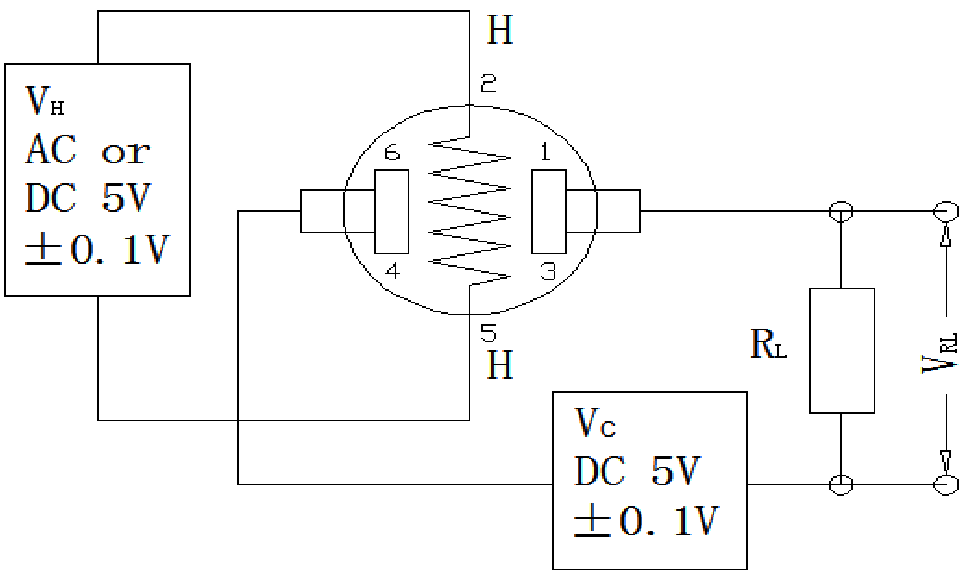


Figure 3.6 Schematics of MQ-6 LPG Gas Sensor

3.3.3 LIQUID CRYSTAL DISPLAY (LCD)

The LCD screen is an electronic display mode that is found in a variety of applications including basic circuit designs. A 16 * 2 LCD display is a very basic module that is widely used in various devices and circuits. These modules are favored over other display devices, such as seven Light Emitting Diode segments (LEDs), because they are both cheap and programmable, and have no limitations on viewing special and even personalized characters. A 16 * 2 LCD with two rows is the one that can display 16 characters per line. In this LCD each character is represented in a 5 * 7 pixel matrix. It has two control registers and application registers.

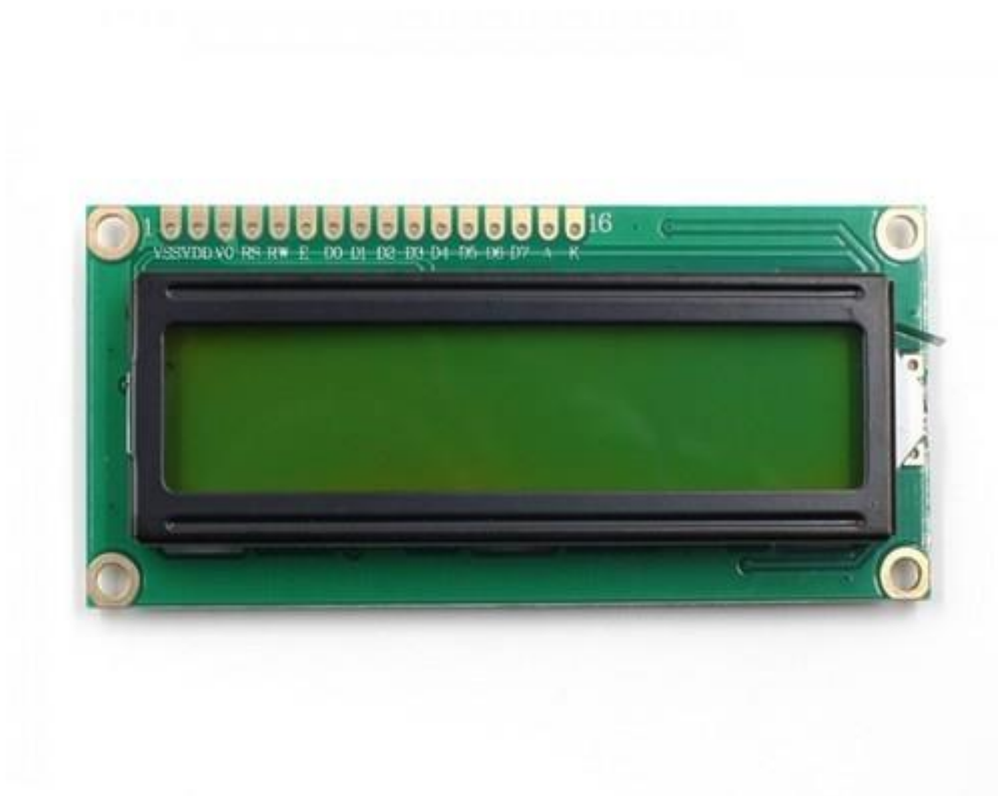


Figure 3.7 Liquid Crystal Display (LCD) Green Screen

3.3.4 TEMPERATURE SENSOR

The DHT22 temperature sensor is a versatile device that accurately measures temperature and humidity levels in various environments. Its compact design and ease of integration make it ideal for applications requiring real-time monitoring of temperature and humidity conditions.

In this of gas quality and cylinder health monitoring systems, the DHT22 sensor plays a crucial role in ensuring optimal operating conditions. By precisely measuring temperature within the gas cylinder, it helps maintain safe storage conditions and prevents exposure to extreme temperatures that could compromise cylinder integrity.

Furthermore, the DHT22 sensor's ability to monitor humidity levels is equally important, as it helps prevent moisture buildup within the cylinder, which can lead to corrosion and other damage over time. The DHT22 temperature sensor provides essential data for maintaining gas quality and ensuring the health and safety of the cylinder, contributing to the efficient operation of the monitoring system. Below is an image of the DHT22 sensor

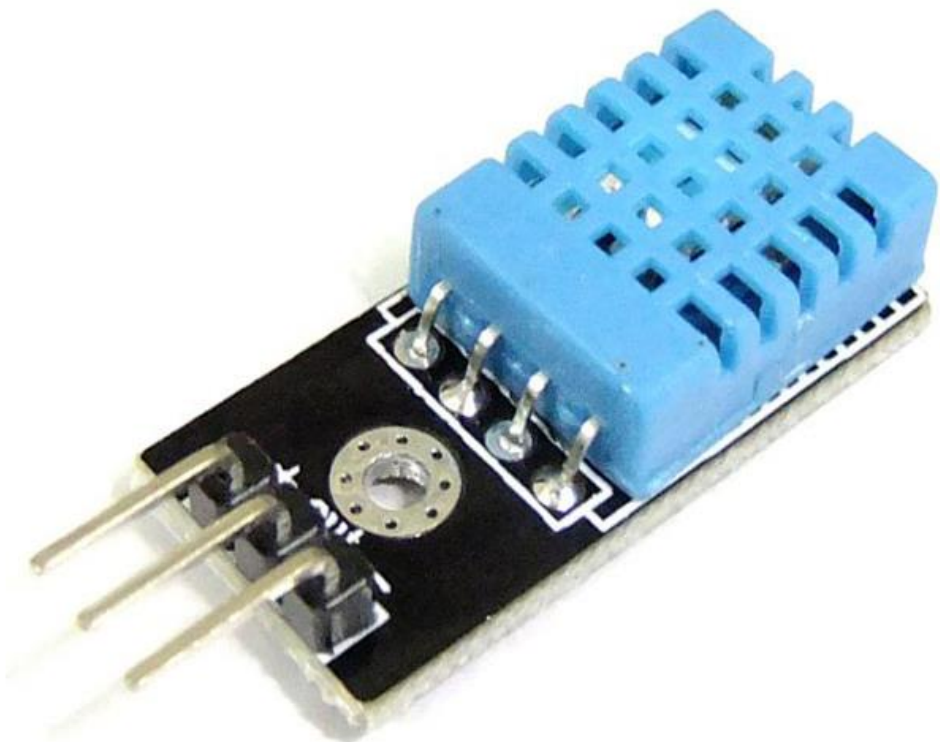


Figure 3.8 DHT22 Sensor

3.3.5 LIGHT EMITTING DIODE (LED)

A diode is an electronic semi-conductor component allowing current to flow in one direction (forward direction) through it. It has two Cathode and Anode electrodes.

An ideal diode has the key function of regulating current-flow path. Current attempting to flow backwards is blocked.

If the voltage is negative across a diode, then no current will flow and the ideal diode looks like an open circuit. In such a case, the diode is said to be biased off or backwards. So long as the voltage is not negative across the diode it will "turn on" and conduct current. Ideally, if it was conducting current (forward biased) a diode would behave like a short circuit (0V over it).

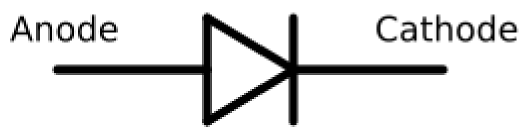


Figure 3.9 Electrical Symbol of a Diode

Nevertheless, the light-emitting diode (LED) is the type of diode that emits visible light when it is in the (forward-biased) "ON" mode. The light is not especially bright, but is monochromatic in most LEDs, occurring at a single wavelength. The production from an LED will vary from red (around 700 nanometers long) to blue-violet (around 400 nanometres). Some LEDs emit energy from infrared (IR) (830 nanometers or longer); such a device is known as an IRED (infrarot emitting diode).

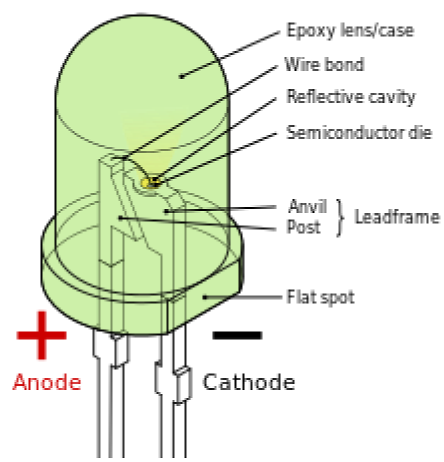


Figure 3.10 Image showing the internal Structure of a Light Emitting Diode

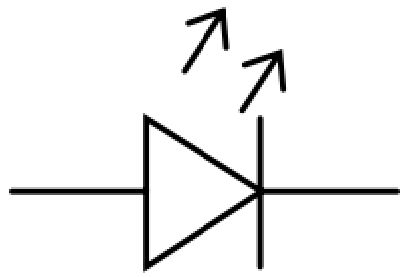


Figure 3.11 Electrical Symbol of a Light Emitting Diode

3.4 SPECIFICATION AND DEVELOPMENT OF TOOLS

3.4.1 ARDUINO INTEGRATED DEVELOPMENT ENVIRONMENT (IDE)

Arduino is a business, project, and user community that develops and produces open-source computer hardware and software kits to create digital devices and interactive objects that can sense and control the world of physics.

In this perspective several vendors have produced a family of microcontroller board designs with different 8-bit Atmel AVR microcontrollers or 32-bit Atmel ARM processors.

Such systems have sets of digital and analog I/O pins which can be interfaced with different boards of expansion (so-called shields) and other circuits. The boards also feature serial communication interfaces for loading programs from personal computers like USB on some models.

The Arduino framework offers an integrated development environment (IDE) based on the Processing project to program these microcontrollers, which includes support for the programming languages C and C++.

As with any integrated development environment (IDE) or interactive development environment, Arduino IDE is a software application, which provides comprehensive software development facilities for computer programmers. This consists of a source code editor, construct automation tools and a debugger, and contains a software cable library (apparently called "Wiring") that simplifies the typically much more complex input and output operations.

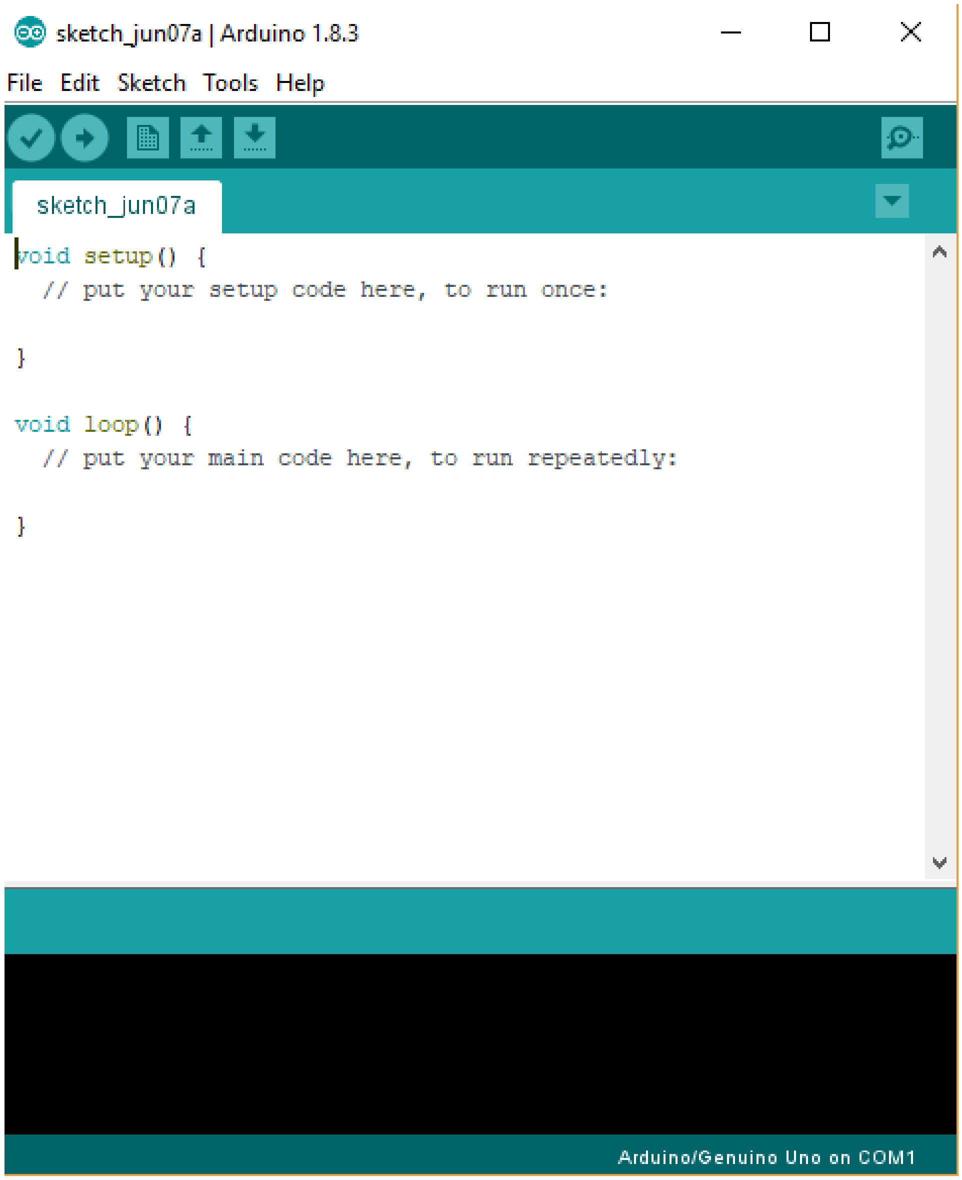


Figure 3.12 Arduino IDE

3.4.2 PROTEUS SIMULATION SOFTWARE

Proteus is a high-performance simulator for Multiple Instruction Multiple Data (MIMD) multiprocessors, which can easily be configured to simulate a wide range of architectures and also reproduce results from real multiprocessors. It provides a modular structure that simplifies customization and independent replacement of parts of architecture and also supports typically multiple implementations of each module hence provides different combinations of accuracy and performance. It also provides repeatability, nonintrusive monitoring and debugging, and integrated graphical output, which result in a development environment superior to those available on real multiprocessors.

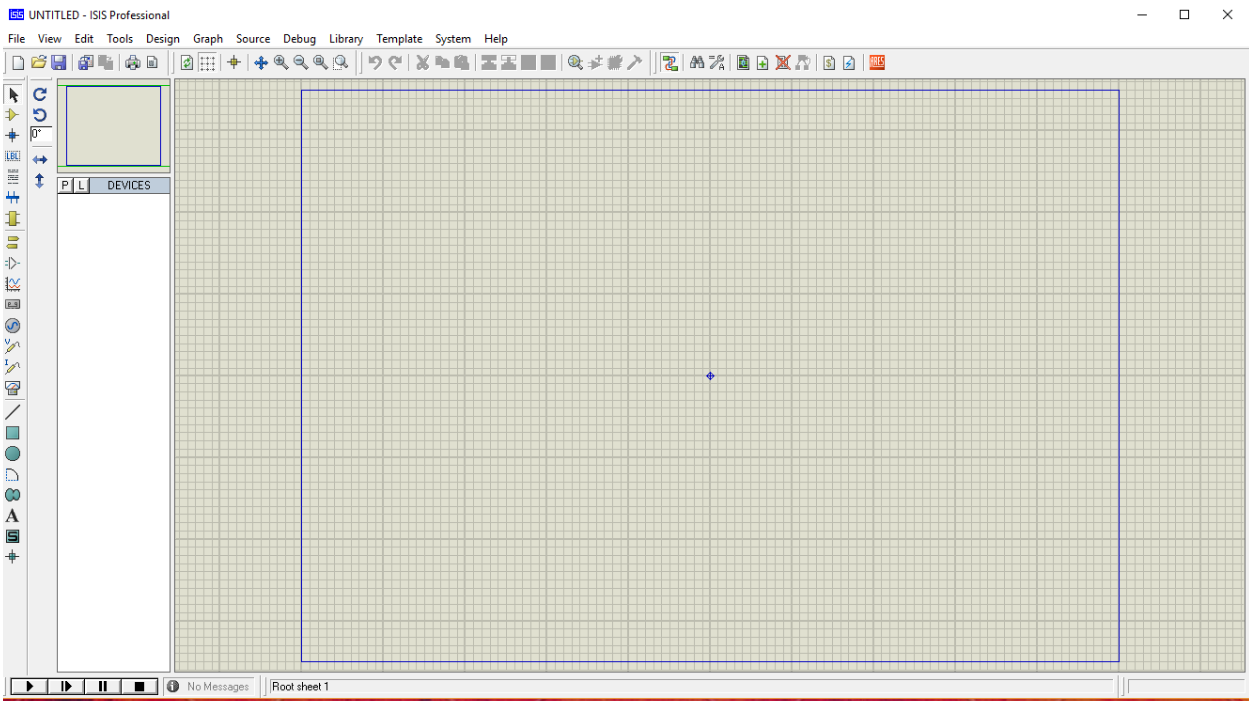


Figure 3.13 Proteus Simulation Software Interface

3.4.3 FRITZING OPEN-SOURCE SOFTWARE

The Fritzing software is an Electronic Design Automation (EDA) tool that allows the designer to record his working breadboard-based prototype with a visual metaphor that imitates the real-world situation of the user and also helps convert the circuit into a functional PCB.

Fritzing provides three alternate views of the circuit, a real-world view of the breadboard, a traditional view of the schematic diagram, and a view of the PCB style.

The default ' breadboard view' offers an abstract description of the growing electronic components, primarily seen from a top view.

The view of the PCB permits the designer to turn the drawing into a Professional circuit board. This allows the user to change the parts positioning and also to monitor the routing process.

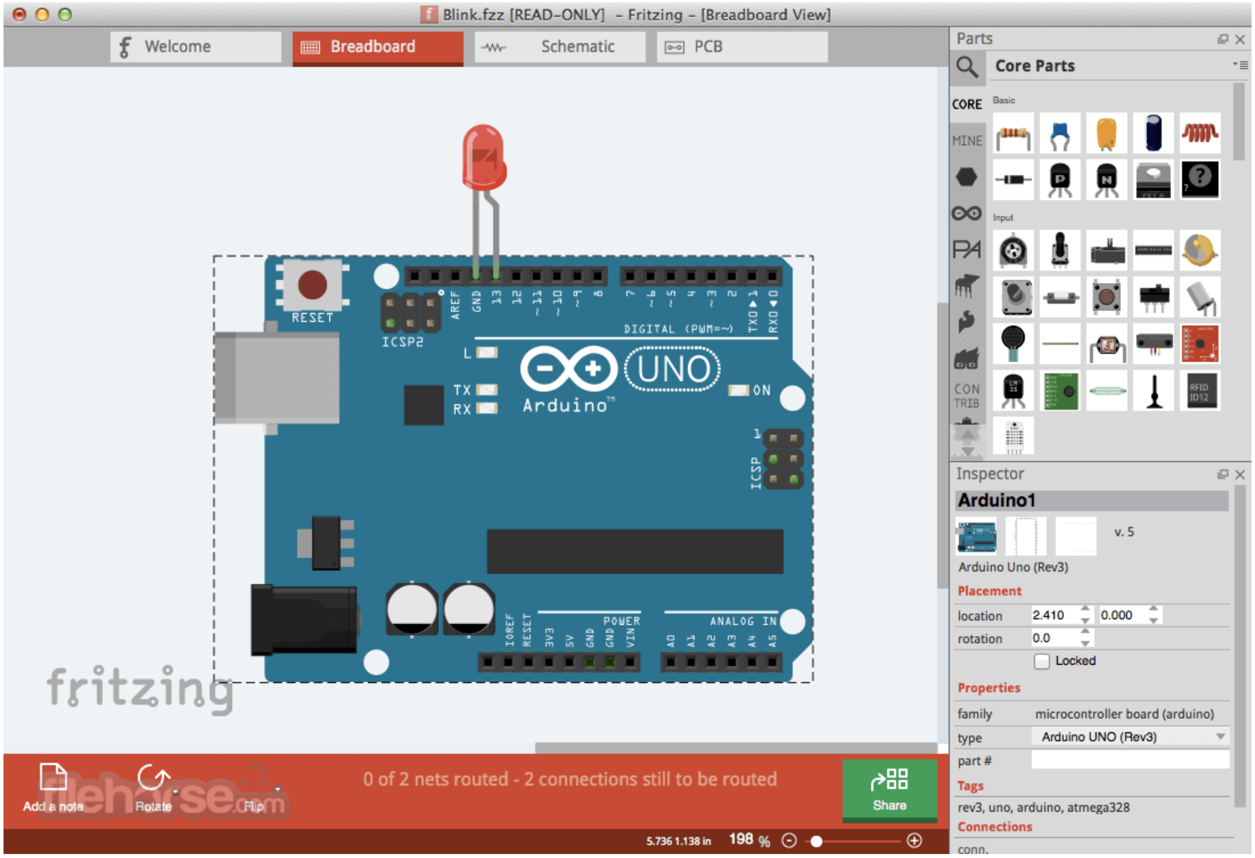


Figure 3.14 Fritzing Simulation interface

CHAPTER FOUR
RESULTS AND ANALYSIS

4.0 INTRODUCTION

This chapter presents the results of the testing phase for the Cylinder Health Analysis and Gas Quality Detection system. This phase is crucial as it involves a detailed examination of the individual components and the overall performance of the system. The system was subjected to a series of tests to evaluate its functionality, accuracy, and reliability.

The objective of this chapter is to provide a comprehensive analysis of the test results, illustrating how well the system meets the design specifications and performs its intended functions. The testing procedures are detailed, the results obtained are presented, and these findings are interpreted to assess the effectiveness of the system.

4.1 TESTING RESULTS OF THE SYSTEM

The system, Cylinder Health Analysis and Gas Quality Detection, as explained earlier in Chapter three, focuses on monitoring and evaluating the health of gas cylinders and the quality of the gas they contain. While there are numerous factors involved in such analysis, our implementation is specifically limited to three key parameters: pressure, temperature, and gas level.

4.1.1 CYLINDER HEALTH

Pressure and Temperature: These are critical indicators of a cylinder's health. The pressure inside the cylinder and the temperature of the gas are continuously monitored. If both the pressure and temperature readings fall within predefined safe thresholds, the cylinder health is considered "Good." If either of these readings deviates from the acceptable range, it indicates a potential issue, and the cylinder health is marked as "Poor."

4.1.2 GAS QUALITY

The quality of the gas is assessed by measuring the concentration of specific gases within the cylinder. If the gas concentration is within the predefined safe limits, the gas quality is deemed "Good." Conversely, if the gas concentration exceeds this threshold, it signals a deterioration in gas quality, and it is marked as "Poor."

4.1.3 SYSTEM OPERATION

Pressure Monitoring: A pressure sensor is installed on the cylinder to continuously measure the internal pressure. This data is compared against the low and high-pressure thresholds to determine if the pressure is within a safe range.

- Temperature Monitoring: A temperature sensor is attached to the cylinder to measure the gas temperature. This measurement is compared to low and high-temperature thresholds to ensure it remains within safe limits.
- Gas Concentration Monitoring: A gas concentration sensor detects the levels of specific gases within the cylinder. This reading is compared to a set threshold to evaluate gas quality.

4.1.4 EVALUATION LOGIC

If the pressure and temperature are within their respective thresholds, the system signals that the cylinder health is "Good." If either parameter falls outside its threshold, the system signals that the cylinder health is "Poor."

Similarly, if the gas concentration is within the defined safe limits, the gas quality is considered "Good." If the gas concentration exceeds the threshold, the gas quality is considered "Poor.

4.1.5 MODIFICATIONS FOR INITIAL TESTING PHASE

To ensure the feasibility and safety of our Cylinder Health Analysis and Gas Quality Detection system during the initial testing phase, we made certain modifications to the components and the testing environment.

4.1.5.1 TEMPERATURE MEASUREMENT

Initially, we intended to use a specific gas temperature sensor. However, due to the unavailability of this component, we opted for the DHT22 sensor. The DHT22 sensor is capable of measuring ambient temperature and humidity, which we used as an approximation for the gas temperature inside the cylinder. This allowed us to proceed with the prototype development without compromising on the accuracy of the temperature readings.

4.1.5.2 PRESSURE CALIBRATION

For the pressure monitoring aspect of our system, we calibrated the pressure sensor to provide a simplified binary output for easier interpretation:

Output '1': Indicates that the pressure is above the set threshold.

Output '0': Indicates that the pressure is below the set threshold.

No Output (Neither '1' nor '0'): Implies that the pressure is within the safe, acceptable range, meaning the pressure is okay.

This binary calibration method simplifies the logic required for evaluating cylinder health based on pressure readings, ensuring that our prototype can reliably indicate whether the pressure is within safe limits.

4.1.5.3 TESTING WITH LIGHTER

In order to mitigate the risk associated with testing the system using actual gas cylinders, we used a lighter as a substitute. Lighters contain gas within a small cylinder, making them a practical and safe alternative for our initial tests. By using a lighter, we were able to validate our system's functionality without the danger of a potential explosion, ensuring a safe and controlled testing environment.

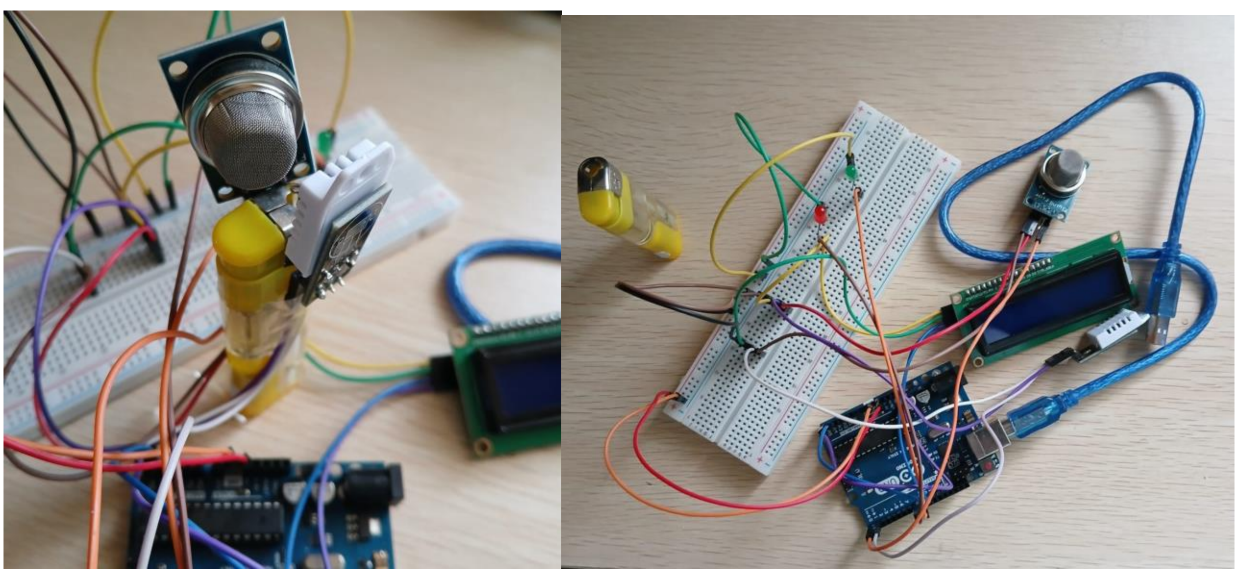


Figure 4.1 General Components of the System

Source: Author’s Photograph 2024

4.1.6 SYSTEM WORKFLOW

When the system is powered ON, a welcome message is displayed on the LCD screen with the caption "CYLINDER HEALTH GAS QUALITY DE…" as in figure 4.2 below.

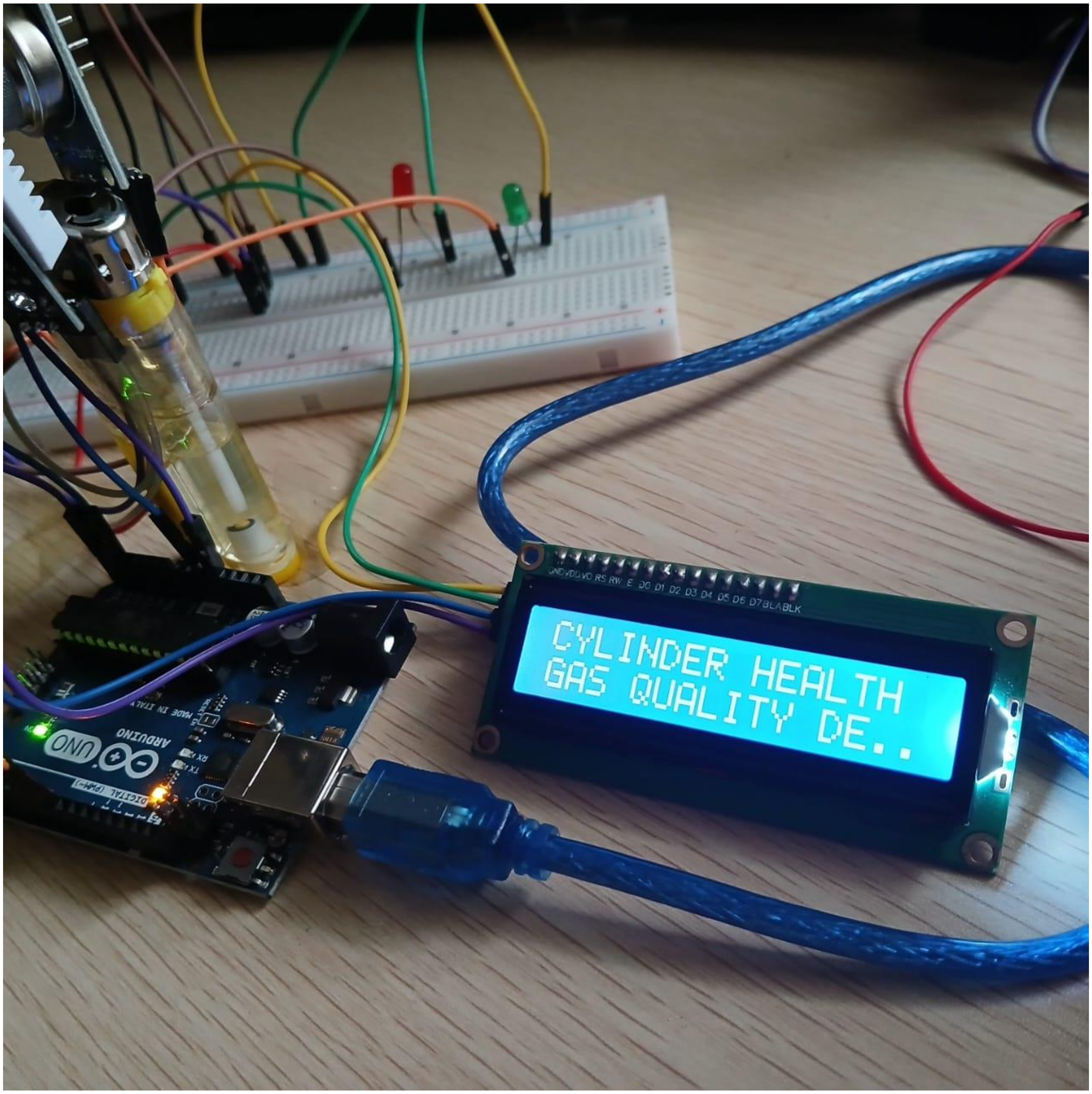


Figure 4.2 A welcome message

Source: Author's Photograph 2024

Due to the limitations of the 16x2 LCD screen used in this project, which can display a maximum of 16 characters per row across 2 rows for a total of 32 characters, it was not possible to show the full project title, “Cylinder Health Analysis and Gas Quality Detection”. Consequently, we abbreviated the project title to “CYLINDER HEALTH GAS QUALITY DE…” to fit the constraints of the display while still conveying the main aspects of the project.

After the welcome message, the system begins by evaluating the state of the gas cylinder and assessing the gas quality. The system performs checks on two critical parameters: Pressure (Pres) and Temperature (Temp). Based on the results of these checks, the system provides visual and textual feedback through the LED indicators and the LCD screen.

The system continuously monitors the pressure and temperature values. If both values are within the acceptable thresholds.

If Both Parameters Are Within Thresholds:

- The Green LED is activated to indicate that everything is functioning properly.
- The LCD Screen displays the message: “Pres|Temp Okay | Cyl Health Good” as shown in Figure 4.3.
- “Pres” stands for Pressure
- “Temp” stands for Temperature
- “Cyl” is a shortened form for Cylinder Health, due to the limited character space on the LCD screen.

This message confirms that both the pressure and temperature are within acceptable ranges, and thus the cylinder's health is deemed “Good.”

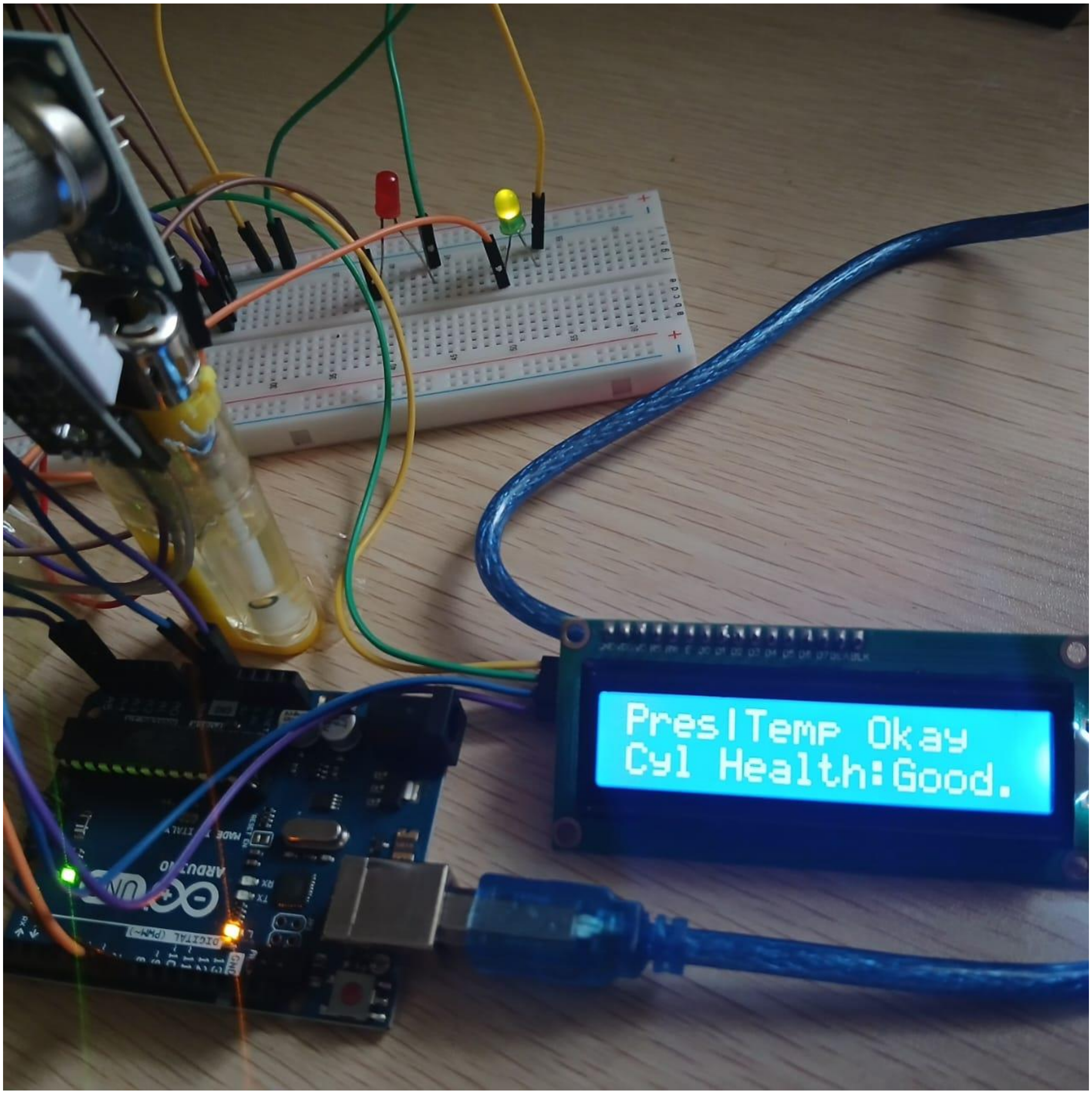


Figure 4.3 Test Result when Cylinder Health is Good condition.

Source: Author's Photograph 2024

If Either Parameter Is Out of Range:

- The Red LED is triggered to signal that there is a problem.
- The LCD Screen displays the message: "Pres|Temp N Okay | Cyl Health: Poor" as in figure 4.4 below.

- “N Okay” stands for “Not Okay,” indicating that the pressure and temperature do not meet the required thresholds.
- “Cyl Health: Poor” means that the cylinder’s condition is considered poor due to the failure of either pressure or temperature to meet the threshold criteria.

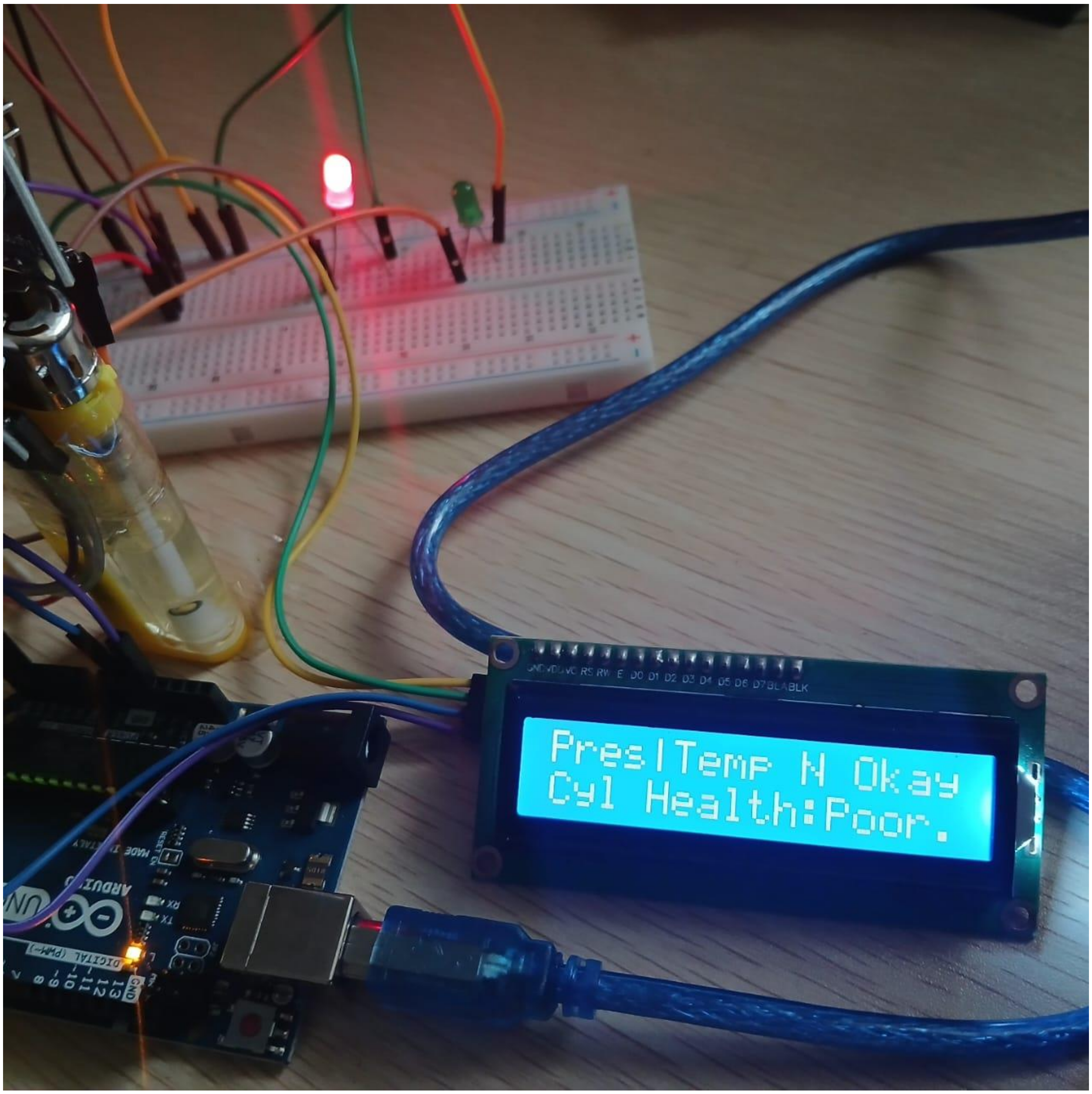


Figure 4.4 Test Result when Cylinder Health is in Poor Condition

Source: Author’s Photograph 2024

In addition to monitoring cylinder health, the system also assesses the gas quality by evaluating the gas concentration. This is a crucial aspect of the system as it ensures the quality of the gas being used. The gas concentration is measured and compared against a predefined threshold to determine whether the gas quality is acceptable or poor.

The system checks the gas concentration to determine if it meets the established threshold value.

If Gas Concentration Meets or Exceeds the Threshold:

- Green LED Activation: The green LED will light up to indicate that the gas quality is acceptable.
- LCD Display Message: The LCD screen will show the message: "Gas Conc Okay | Gas Quality: Good" as in figure 4.5 below.
- "Gas Conc Okay" means that the measured gas concentration is at a level that is considered acceptable.
- "Gas Quality: Good" confirms that the gas quality is satisfactory based on the concentration measurements.

Figure 4.5 Test Result when Gas Concentration is Good

Source: Author’s Photograph 2024

If Gas Concentration Falls Below the Threshold:

- Red LED Activation: The red LED will turn on to signal that there is a problem with the gas quality.
- LCD Display Message: The LCD screen will display the message: “Gas Conc N Okay | Gas Quality: Poor” as in figure 4.6.

- “Gas Conc N Okay” indicates that the gas concentration is not meeting the required standards.
- “Gas Quality: Poor” signifies that the gas quality is inadequate based on the concentration levels.

Figure 4.6 Test Result when Gas Concentration is Poor

Source: Author’s Photograph 2024

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.0 CONCLUSION

The project's objective of developing a Cylinder Health Analysis and Gas Quality Detection system has been successfully achieved. The system effectively:

- Monitors the pressure and temperature of the cylinder to analyze its condition as either poor or good.
- Evaluates the gas concentration to determine its quality as either good or poor.
- Provides notifications through LED indicators and displays results on the LCD screen..

These functionalities have been validated by the test results presented in Chapter 4. When properly implemented, this system can enable the immediate recipient to fulfill their commitments with ease.

5.1 RECOMMENDATIONS

While the project was successfully completed, there are areas where improvements can be made. The following recommendations are suggested:

- Implementing rechargeable power circuits to enhance the system's reliability and sustainability.

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APPENDIX

Programming Source codes of the system.

```
#include <Wire.h>

#include <Adafruit_Sensor.h>

#include <Adafruit_BMP280.h>

#include <OneWire.h>

#include <DallasTemperature.h>

#include <LiquidCrystal_I2C.h>



// Pin Definitions

#define ONE_WIRE_BUS 2

#define GAS_SENSOR_PIN A0



// Thresholds

#define PRES_LOW_THRESH 800.0 // Low pressure threshold in hPa

#define PRES_HIGH_THRESH 1200.0 // High pressure threshold in hPa

#define TEMP_LOW_THRESH -20.0 // Low temperature threshold in °C
```

```
#define TEMP_HIGH_THRESH 60.0 // High temperature threshold in °C

#define GAS_CONC_THRESH 300 // Gas concentration threshold value



// Sensor Objects

Adafruit_BMP280 bmp280;

OneWire oneWire(ONE_WIRE_BUS);

DallasTemperature tempSensor(&oneWire);

LiquidCrystal_I2C lcd(0x27, 16, 2);



void setup() {

  Serial.begin(9600);

  lcd.begin(16, 2);

  lcd.init();

  lcd.backlight();



  if (!bmp280.begin()) {

    Serial.println(F("No BMP280 sensor detected"));

    while (1);
```

```
  }

  tempSensor.begin();
}

void loop() {
  // Read pressure
  float pressure = bmp280.readPressure() / 100.0F;

  // Read temperature
  tempSensor.requestTemperatures();
  float temperature = tempSensor.getTempCByIndex(0);

  // Read gas concentration
  int gasConc = analogRead(GAS_SENSOR_PIN);

  // Determine Cylinder Health
  String cylHealth = "Good";
```

```
  if (pressure < PRES_LOW_THRESH || pressure > PRES_HIGH_THRESH || temperature < TEMP_LOW_THRESH || temperature > TEMP_HIGH_THRESH) {
    cylHealth = "Poor";
  }

  // Determine Gas Quality
  String gasQual = "Good";
  if (gasConc > GAS_CONC_THRESH) {
    gasQual = "Poor";
  }

  // Display values on LCD
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Cyl Hlth:");
  lcd.print(cylHealth);
  lcd.setCursor(0, 1);
  lcd.print("Gas Qual:");
  lcd.print(gasQual);
```

```
  delay(2000);
}
```