SUMMER INTERNSHIP REPORT

on

LPG Detection System

Duration: June 24, 2024 to July 19, 2024

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July, 2024

Certificate

This is to certify that the internship project entitled **"LPG Detection System"** was successfully completed by the following students from various colleges in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (B.Tech) under the internship program at AICTE IDEA Lab-Guru Gobind Singh Indraprastha University New Delhi - 110078.

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Declaration

We hereby declare that the project work presented in this internship report, entitled **"LPG Detection System"** is entirely our own work and has not been submitted for any degree or diploma from this or any other institute for partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (B.Tech).

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Abstract

This report works on the development of an IoT-based LPG detection and prevention system. The project was influenced by the increasing cylinder leakage incidents and explosions around the world. Equipped with highly sensitive sensors, this system shall be able to detect LPG leaks in a very short time. In the event of detection, it initiates preventive measures like, the cylinder regulators would be turned off automatically and switch on the exhaust fans to diffuse the leaked gas for avoiding breakouts of fire and explosion. This immediate and automatic kind of response mechanism improves the safety at domestic and commercial levels.

We have a lot of goals for the future with this project including integrating machine learning algorithms so that we can enhance accuracy of detection as well as practice predictive maintenance. This makes the system able to look at historical patterns of gas level and thereby be able to foresee an upcoming gas leak which would be another level of protection. Designing a mobile application is also in the pipeline whereby the user will have the ability to monitor and control the system from a remote location. The app shall send real-time alerts to users, which they can act on promptly, therefore ascertaining the management of safety on a continuous basis. The convergence of IoT technology with advanced analytics in the project makes it a very powerful safety system. This report clearly illustrates how new technologies can provide greater standards of safety in the workplace and acts as a blueprint for further improvements in the system, which will be implemented to make it more effective and user-friendly.

Keyword: LPG Detection, IOT, Home Safety, Internet of Things, Technology

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1. Introduction

The Internet of Things has been the pervading attention over the past decade since it is transforming many domains or facets of everyday life with respect to enhanced safety, ease, and efficiency. IoT technology has made inter-device communication seamless, thereby enabling automation and smarter decision-making processes in various applications. Hazardous gas leak detection is one critical application with respect to home safety[10]. Liquefied Petroleum Gas, is primarily used in the household for cooking and heating purposes. While being relatively safe, excessive leakage has huge risks associated with it in terms of potential fires and health hazards due to inhalation. The **"LPG Detection System"** is a state-of-the-art IoT project developed to take care of these safety concerns by providing a robust solution for the early detection of LPG leakage within houses and around gas cylinders. This system will detect the LPG and trigger all the automatic preventive measures against such threats, which include shutting off regulators and turning on the exhaust fan. It is one of the home safety methods in which modern sensors, microcontrollers, buzzers, and wireless communication technologies have been applied.

The various advantages of the system in terms of detection are stated below:

1. Early warning systems like this can prevent disastrous occurrences by efficiently and quickly responding to any possible danger.

2. IoT integration provides real-time monitoring and alert systems that send notifications to the smartphone or other connected devices of a home owner, thus keeping him informed even when he is far from his home.

The various dimensions concerning design, functionality, and implementation that exist in the LPG Detection System are duly covered in the report and are as follows:

1. It covers all the technical components used, the methodology adopted for detection of gas, and the automated responses that result in safety measures in case of a leak.

2. It points toward the requirement of such systems at home and gives an idea about the probable benefits in the future.

3. This project focuses mostly on the development of a reliable and efficient LPG detection solution, which can get embedded in any modern house and help accident prevention by providing reassurance to the users.

4. The report will also discuss practical applications and possible market impact that could result from the LPG Detection System, its scalability, and adaptability in various home environments, cost-effectiveness considerations, and user-friendliness. It also gives an overview of the future developments in IoT and how these can be used further to support gas detection systems in providing enhanced safety within homes.

This report proves the feasibility and efficacy of the LPG Detection System in smart home safety infrastructure. The system shall forge a new frontier in home safety with IoT technologies and give peace of mind by reducing related risks of LPG to the user.

2. Architectural Overview

The various component used in the LPG Detection System their architecture, pin diagram and working are as follows :

2.1 Arduino Uno R3

The Arduino Uno R3 is a widely used open source microcontroller board based on ATmega328P. It has 14 digital input/output pins, out of which 6 can be used as PWM outputs, 6 analog inputs, 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. It supports a large number of sensors, actuators, and shields; hence, this board is great for both beginners and advanced users for creating interactive projects. Uno R3 may be powered via USB or through an external power supply and is programmed via the Arduino IDE that supports C/C++ programming languages.

2.1.1 Architecture

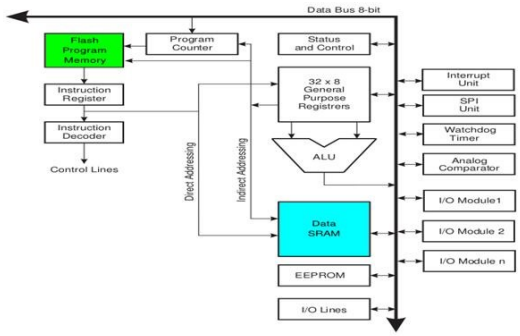

Figure 2.1: Arduino UNO Architecture[1]

Arduino Uno R3 Architecture description:

1. Flash Memory: 32 KB is available for the program code.
   RAM: 2 KB is allotted for variables and runtime data.
   EEPROM: 1 KB available for non-volatile data storage.
   Function: Executing programs and managing peripheral and external device communications.

2. Communications
   Serial Communication:
   TX (Transmit) and RX (Receive): Pins 0 and 1 for serial data transfer.

USB-to-Serial Converter:
ATmega16U2: Handles USB to serial signal translation for the ATmega328P.

3. Crystal Oscillator
   Frequency: 16 MHz is used to manage the clock pulses.
   Accuracy: Mainly responsible for correct time and coordination of actions in all respect.

4. Voltage Regulators
   Description: The voltage regulators stabilize the applied input voltage and produce a stable output of 5V and 3.3V, ensuring stable performance.

2.1.2 Pin Diagram

Pin Description of Arduino Uno:

1. Digital I/O Pins
   Total Pins: There are a total of 14 digital pins available (numbered 0-13).
   PWM Capable: Digital Pins 3, 5, 6, 9, 10, and 11 Used for generating Pulse Width Modulation (PWM) signals.

2. Analog Input Pins
   Number: 6 analog input pins.
   Voltage Range: 0 to 5 volts.
   Resolution: 10-bit ADC with 1024 levels.

3. Power Pins
   VIN: Input for external power (7-12V DC).
   5V and 3.3V Outputs: Regulated voltage outputs.

4. GND: Ground pins.

5. ICSP Header
   Function: It's function is to program the ATmega328P.
   Programming: Allows access to firmware updating and other advanced features for use in programming of controller.

6. USB Connector and Barrel Jack
   USB connector: Connected to PC and responsible for the serial communication and through it acts as a power supply.
   Barrel Jack: Available from adapters to have an external source of power supply.

7. Reset Button
   Function: It resets the microcontroller.

8. LED Indicators
   Power LED: It is power indicator on the UNO board.
   TX/RX LEDs: It depicts the transmission and reception of data processed.
   Built-in LED (Pin 13): Very useful for the initial testing; can see the output visually.

9. Other Pins
   AREF : Analog Reference - The voltage used by the ADC for conversion.
   SDA/SCL: I2C is available for the communication pins.
   IOREF: Acts as reference voltage for the I/O pin compatibility

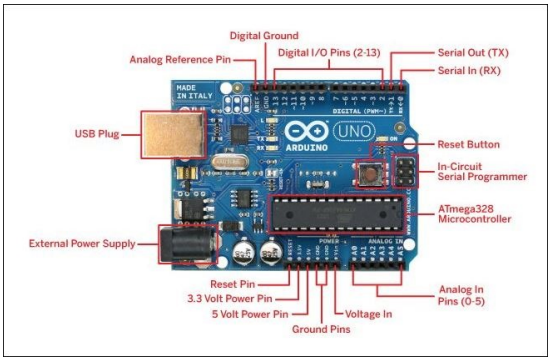

Figure 2.2: Ardiuno UNO Pin Diagram[2]

2.2 ESP 8266

The ESP8266 is a low-cost microchip that features a full TCP/IP stack and microcontroller capability, designed by Espressif Systems. Being inexpensive and flexible makes this module one of the main applications in IoT. Here are some major points about ESP8266:

1. Modules and Versions: There are various modules for the ESP8266, like the tiny ESP8266 Serial Wireless Transceiver module, the ESP-12, and the ESP8266 Olimex module. The type of module to be used depends on the requirements of the project in use; this could include the number of GPIOs available and how easily they can be integrated into a breadboard [11].

2. Hardware Requirements: The ESP8266 requires quite a few pieces of hardware to be used. This includes the ESP module itself, a dedicated 3.3V power supply, a 3.3V FTDI USB module for programming purposes, a breadboard, jumper wires, ensuring it's well powered at a minimum of 300mA for stable operation [11].

3. Programming: The ESP8266 can be programmed using the Arduino IDE, making it very approachable to a large base of users who are familiar with Arduino. It would involve setting up an ESP8266 board manager within Arduino and configuring the board for uploading code via a USB connection [11].

4. Applications: ESP8266 is an IoT microcontroller used in various applications from controlling LEDs, reading data from sensors, data logging to cloud services, to remote control of devices. It can apply in all projects that require internet connectivity and remote control [11].

2.2.1 Architecture

The ESP8266 microcontroller deals with Tensilica L106 32-bit RISC processor at 80 MHz and the chips can be overclocked up to 160 MHz. This Harvard memory architecture processor is in such a way separated from instruction memory and data memory that it's much easier to process them without wasting time. The ESP8266 has 64 KB of instruction RAM, 96 KB of data RAM, and up to 16 MB of external flash memory for program storage space. It can be considered as the 17 GPI pins of which 11 are operational and one is analog output as well, SPI, I2C, UART, and 1-Wire communication interfaces. As a result, it is equipped with the Wi-Fi module which implements the 802.11 b/g/n standard and hence, this is how the ESP8266 gets connected to the IoT without wires. Moreover, it is the software stack that encapsulates the TCP/IP protocol suite aiming no-hassle network connectivity, and communication, the ESP8266 is a popularly used, and multifunctional mostly occupied solution in embedded and IoT applications.

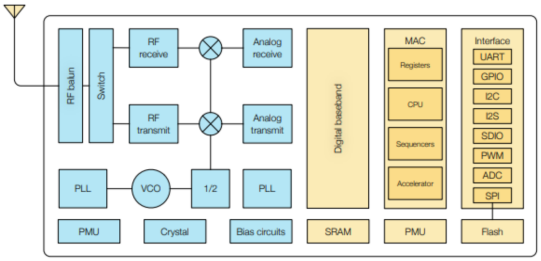

Figure 2.3: ESP 8266 Architecture[3]

2.2.2 Pin Diagram

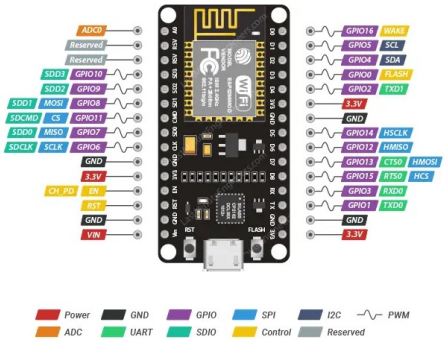

Figure 2.4: ESP Pin Diagram[4]

ESP 8266 Pin Description:

1. VIN: Voltage input
   Function: Can be used to supply NodeMCU with an external 5V power supply

2. 3V3: 3.3V output
   Provides power from the onboard voltage regulator.

3. RST: Reset
   Function: A low is needed to to reset the module

4. EN: Enable pin
   Function: Can enable chip with a high signal (3.3V)

5. TX (D10, GPIO1): UART Transmit
   Function: Transmits the serial data

6. RX (D9, GPIO3): UART Receive
   Function: Receives the serial data

7. D0 (GPIO16): General-purpose I/O

8. D1 (GPIO5): General-purpose I/O (SCL)
   Function: Usually used for I2C clock

9. D2 (GPIO4): General-purpose I/O (SDA)
   Function: Generally used as I2C

10. D3 (GPIO0): General-purpose I/O
    Function: As a rule, the lake is derived from both I/O

11. flash D4 (GPIO2): General-purpose I/O

12. D5, D6, D7: General-purpose I/O
    Function: Area used mainly to store a large amount of SPI clock

13. A0: Analog input and controls for Logitec gaming piece.

2.3 MQ 2 Sensor

MQ2 is a gas sensor used to identify many different gases, including but not limited to LPG, methane, alcohol, hydrogen, and smoke. The application of this gas sensor is in both consumer and industry sectors, using gas leakage detection equipment.

Working Principle:
An MQ2 sensor basically heat the coil , which reacts with the gases then change in resistance occured . This change in resistance can be measured as an analog output.

Key Components:

1. Heater Element: This element heats up the sensing element.

2. Sensing Element: Made up of the metal oxide semiconductor, which reacts with gases—in most cases, tin dioxide (SnO2).

3. Analog Output: The sensor produces an analog voltage, which can be read on the analog input of a microcontroller.

Connection:

1. VCC: Voltage input (Crucially 5volts).
2. GND: Ground
3. AOUT: Analog voltage output proportional to the gas concentration.
4. DOUT: Digital voltage output at TTL level which is set at predetermined concentrations of gas.

Figure 2.5: MQ 2 Gas Sensor[5]

2.4 Servo Motor

A servo motor is designed to impart precise control of motion parameters angular as well as linear position, velocity, and acceleration. It is equipped with a feedback mechanism that allows for the precise control, unlike regular motors that only convert electrical energy into mechanical motion.

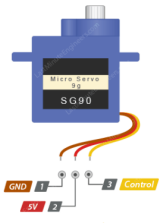

Figure 2.6: Servo Motor [6]

Common Servo Motor Pinout:

1. Ground (GND): Used in connection to ground in the control system and joins towards the power supply. Incorporation of the electrical circuit is necessary to be included in the servo to ensure its operation. Color of wire is often colored black or brown.
2. Power (VCC): This is the pin that joins the power supply, which mainly ranges between 4.8-6V for the majority of the most common small servos. It is designed to produce sufficient energy so that the ordinary ones can be active enough. Color of Wire is mostly red in color.

3. Control Signal (PWM): It is what receives the control signal; in PWM (Pulse Width Modulation) the pulse determines the duration limit of the pulse to establish the coordinate position of the servo. Color is generally Yellow, Orange, White

Internal parts of a Servo motor:

1. DC Motor: It emphasizes electrical energy to mechanical motion, to the gear.

2. Gearbox: The gear ratio reduces the motor speed and increases the torque so that the gear mechanism of the output shaft can be positioned in the exact position.

3. Potentiometer: The potentiometer provides the real-time position report of the actual position of the output shaft to the control circuit.

4. Control Circuit: This circuit manipulates the input signal and through a comparison with the help of an actual position report, it changes the position of the motor.

Gear Mechanism in Servo Motors:
The gear helps to convert the output from the DC motor of the high speed and low torque to give an output of low speed and high torque for effective controlling. The type of material that can be fabricated to make the gears is either metal or plastic. The metal ones are more rugged and can be able to bear high torque.

2.5 Peripheral Components

The peripheral devices are used in the LPG Detection System to provide visual and audio alerts. They are- LCD (Liquid Crystal Display), It has data of sensor reading available in 16x2 or 20x4 character format widely used in the embedded systems. We have also integrated LED (Light Emitting Diode), this diode emit light when powered by a current signal and are widely used for status indicators or visual alerts. Covered by Buzzer, A buzzer emits sound when voltage is applied, used for alarms or notifications. Available in active and passive types, they are versatile for different audio requirements in embedded systems.

2.5.1 LCD

In the Given Figure, this 16-pin LCD forms a common display device used with projects in electronics that are capable of displaying information in a combination of text and numbers. It is applied so widely because it is inexpensive and simple to interface with microcontrollers, like Arduino.

Pin description of the 16 Pins of LCD:

1. Pin 1 VSS—ground (0V); This is where you would connect the ground or negative terminal of your power supply.

2. Pin 2 VDD Power +5V Supply: This goes to the positive terminal of your power supply.

3. Pin 3 V0 Contrast adjustment: This is an adjustment for contrast in the display. You typically connect this to the middle terminal of a potentiometer.

4. Pin 4 Register Select: This pin toggles between command mode (0) and data mode (1). In command mode, you write various directions to the LCD. In data mode, you send the actual text to display.

5. Pin 5 Read/Write: This pin selects read or write mode. Writing data of the LCD is accomplished by grounding this pin.

6. Pin 6: (E): Enable. This pin enables writing to the registers. It triggers the LCD to read the data lines.

7. Pins 7 to 14 (D0-D7): Data lines. These pins carry the data you want to displayed on the LCD. In 4-bit mode, you only use pins D4-D7, which corresponds to Pins 11-14.

8. Pin 15 (A): Anode (+) of the LED backlight. This pin should be connected through a resistor to the positive terminal of the power supply.

9. Pin 16 (K): Cathode (-) of the LED back light. Ground this to complete the back light circuit

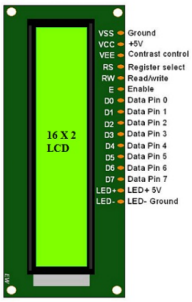

Figure 2.7: 16X2 LCD Display [7]

Features:

1. Alphanumeric Display: The display is capable of displaying alphabetic and numeric characters; hence it's perfect for showing messages, sensor readings, and menu options.

2. Backlight: An inbuilt backlight in the LCD lights up the characters and graphics to be clear in every kind of lighting conditions.

3. Resolution: The display also comes in 16x2 or 20x4, meaning a capacity for displaying 16 characters in two lines or 20 characters in four lines.

4. Interface: It is connected by a parallel interface to communicate with the board and hence easy to interface and program.

Working:
The 16-pin LCD works by sending signals from the Arduino board into its pins. The LCD controller then interprets the given signals to display the respective words or graphics on screen. The backlight lights up for visibility by the user.

2.5.2 LED

A Light Emitting Diode, or LED, for short, is a two-lead semiconductor light source. It is a p-n junction diode that emits light when activated by an applied voltage.

LED Pin structure
An LED has two leads:

1. Anode (Positive Pin): This is the longer of the two leads and is connected to the positive side of the power supply.
2. Cathode (Negative Pin): A shorter pin than the anode is used to connect to the negative of the power source.

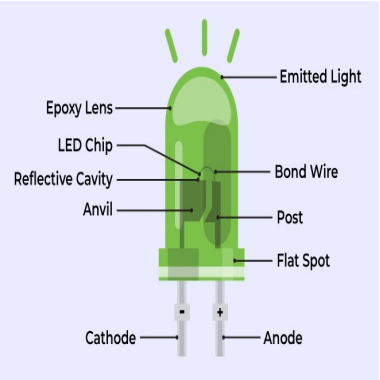

Figure 2.8: LED [8]

Working Principle of an LED:

1. Forward Bias: On applying a positive voltage to the anode, we can allow the current to flow on the LED
2. Electron-hole recombination: When electrons and holes are reunited ,the energy is released in the form of light, through photons.
3. Emitting Photon: The wavelength of the light color depends on the material, that is, the semiconductor material that is currently in use.

Characteristics of LEDs:

1. Voltage: An Led typically operates at 1.8V to 3.3V.
2. Current: It requires a current-limiting resistor (10-30mA).
3. Brightness: The brightness is directly proportional to forward current.
4. Lifespan: It usually exceeds 50,000 hours.

Applications of LEDs:

1. Indicator Lights: Used in electronic devices.
2. Displays: Component of seven-segment, dot matrix, and OLED screens.
3. Lighting: General, automotive, and backlighting.
4. Communication: Applied in infrared LEDs in remote controls and optical communication.

2.5.3 Buzzer

A mini buzzer is a commonly used electronic device that produces sound when an electric current passes through it, commonly used in electronic projects for audio feedback or alerts to gain output based information.

Buzzer Pin Diagram:
A mini buzzer has two leads:

1. Positive Pin (VCC): The longer lead of the buzzer is connected to the positive side of the power supply grid.
2. Negative Pin (GND): The shorter lead of the buzzer is connected to the negative side of the power supply grid.

Figure 2.9: Buzzer [9]

Buzzer Working Principle:

1. Electromechanical Buzzers:
   The working of an electromechanical buzzer is based upon passing an electric current through a magnetic coil inside it that generates a magnetic field that causes the diaphragm to vibrate which in results produces sound through a mechanical movement.
2. Piezoelectric Buzzers:
   The working of an piezoelectric buzzer is based upon applying an electric voltage to a piezoelectric material inside the buzzer, which in return causes it to deform and then creates mechanical vibrations in the diaphragm that finally produces sound through these vibrations.

Characteristics of Buzzers:

1. Voltage: They generally operates at 3-12V.
2. Current: Usually compatible with 10-30mA.
3. Frequency: Their sound frequency is around 2kHz to 4kHz.
4. Volume: The volume is a general function varying with voltage and frequency.

3. Motivation

The motivation behind the development of a LPG Detection System was the growing concern over the safety and well being of the households that rely on Liquefied Petroleum Gas (LPG) for their daily chores. Despite its widespread use and benefits, LPG poses significant risks if not properly managed.

Following are some cases where LPG leakage in household that caused significant damage toi life and property:

1. **Cylinder Blast Ghaziabad, June 24**[12]
   A blast in Gas cylinder due to LPG leakage while cooking lead to high damage to life and property. This incident resulted in death of a woman and her two daughters.

2. **Explosion in a suburban home in Sydney, May 2023**[13]
   The house was destroyed and three family members were injured after it blew up due to a gas leak. Consequently, a gas safety investigation was initiated underlining the importance of having a trustworthy gas detection system.

Following are the stats provided by various national and international organisation on incidents caused due to LPG leakage and their impact on households globally:

1. In India, the Ministry of Petroleum and Natural Gas documented over 1,000 fatalities due to LPG cylinder explosions in 2022 alone.

2. A study by the World Health Organization (WHO) indicates that household gas explosions account for a significant percentage of all residential fires.

3. The Australian Bureau of Statistics (ABS) documents around 150 to 200 LPG-related incidents annually. These incidents result in about 5 to 10 fatalities and approximately 50 to 70 injuries each year.

Thus it is necessary to implement a LPG detection and an automated prevention system in households to reduce the gas leakage incidents and ensure safety of people and property.

This led us to the prototype development of a LPG detection and automatic prevention system which would be feasible to replicate, implement easily in households and also efficient in detection and preventive measures.

4. LPG Sentinel

The **LPG Sentinel** is an IOT prototype of a LPG Detection system along with various automated prevention system to reduce the risk LPG leakage possesses like explosions and health issues.

4.1 Project Description

4.1.1 LPG detection using Arduino Uno

Our project began with a extensive research about the components needed for an LPG gas detector, during which we identified the key components that would be important, such as the Arduino UNO R3, a buzzer (for audio alert), and other components like aLCD and LEDs (for visual alert) and MQ-2 Sensor to detect LPG levels. Initially, we constructed a model using the Arduino which provided an alert when a high amount of LPG was detected.

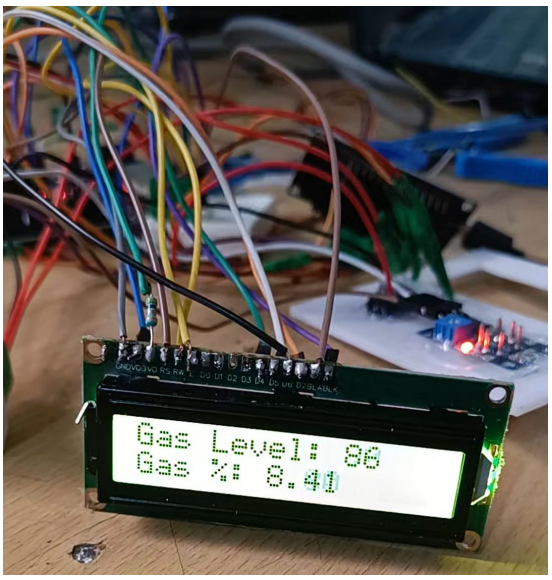

Figure 4.1: Arduino Setup

4.1.2 Connection Using ESP and Preventive Systems

Now we wanted to provide mobile and web alerts so we decided to opt for the ESP8266 due to its Wi-Fi capabilities which provided wireless communication between the device and the user's phone or any device such as a laptop or tablet.

Ultimately, we integrated both the Arduino and ESP modules; the ESP facilitated Wi-Fi connectivity for sending alerts via email and mobile notifications using the Blynk app, whereas the Arduino orchestrated the other tasks, including the triggering an exhaust fan if the gas levels exceeded the threshold set in the critical zone. We meticulously developed three distinct levels—safe, warning, and critical—utilizing the Blynk app and Arduino programming to trigger preventive measures such as turning off regulator and turning on the exhaust fan to reduce LPG concentration.

Figure 4.2: LPG Detection Set Up

4.1.3 Final LPG Detection and Prevention Model

After designing the basic operational model, we considered making the most compact but safe prototype with enough clearances to avoid all hazards. The measurements of the casing that was supposed to hold all the components were noted, and acrylic sheets cut on an laser engraver machine were chosen for the case enclosure. Initial trials showed inadequate clearances, so the measurements were revised and the case was re-cut with the laser machine. The final assembly involved meticulously integrating all components, resulting in a functional and efficient LPG gas detector prototype. Along the way of development, several problems arose, such as making Wi-Fi stable and detected accurate levels for gases. We did so by iterative testing and troubleshooting. We have learned from these processes not only in terms of technical capabilities but also how precision and safety are important traits when developing a device applicable in the real world. It ended with a dependable prototype that has been well-tested and is now ready to respond in order to alert against potential gas-related incidents. Further steps in application UI and website development were taken. An application UI was developed to illustrate how the application would look.

Also, the front-end design of the website was created, which is to be integrated with the back-end. On the website options to control the device, its preventive systems, an emergency call option will be available, along with the data display that is received by the sensor.

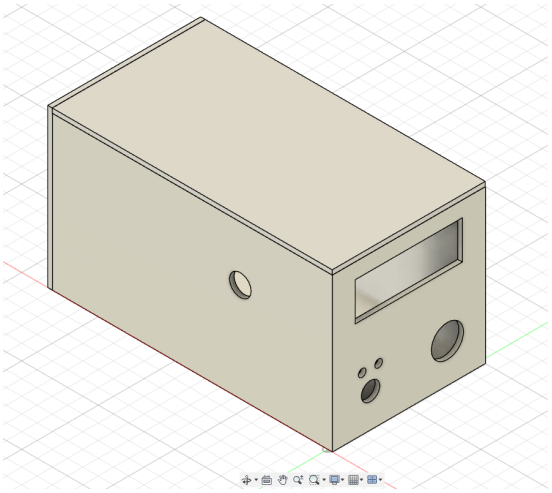

Figure 4.3: CAD Model

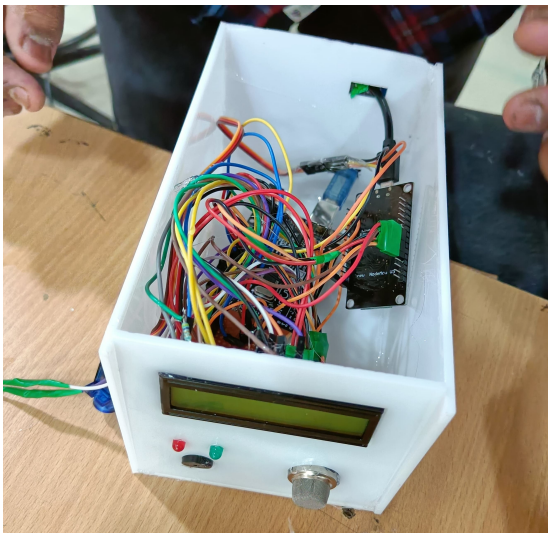

Figure 4.4: Final Setup

4.2 Future Goals

There are many future plans for the prototype to develop it into a more reliable, accurate and better product that would ensure safety of the person. This includes various advancement and development in technologies.

Following are the planned future advancement in the LPG Detection system:

1. **Enhanced Sensitivity and Accuracy**
   Developing sensors with better detection capabilities to identify even small amount of LPG, improving response time and accurate measurement.

2. **Machine Learning Integration**
   Implementation of such algorithms to predict potential leaks based on usage pattern and historic data and providing preemptive warnings.

3. **App and Web development**
   Currently wireless alerts are provided through third party application (Blynk). The main future goal would to develop a whole application integrated with the device along with a website so that it can be accessed remotely from any place in the world and live LPG tracking could be easily implemented. Initial steps for the app and web development are taken in which a UI is developed for the application and front-end of the website is also developed which when integrated with the back-end on the server can read data from the device and can also be remotely controlled by it.

4. **Affordability**
   A products works in the market only if it is affordable by the general public. Thus the main task of further development in parallel to other development would be to make this device affordable so that every person could implement it in their households.

5. **Improved energy efficiency**
   Designing of detectors that consume less power and are highly power efficient to ensure the product's Eco-friendly nature and contribute towards Global Neutralisation.

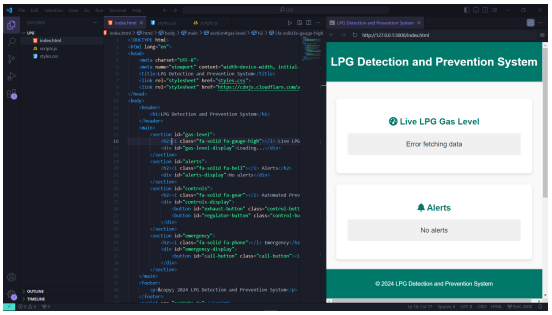

Figure 4.5: Web Design 1

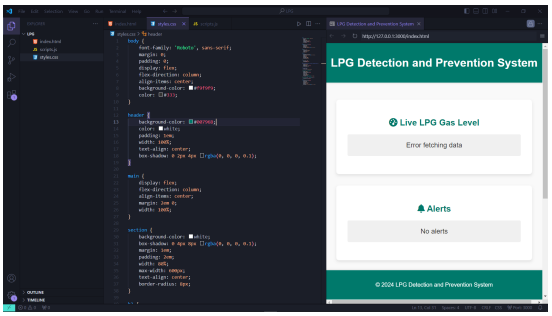

Figure 4.6: Web Design 2

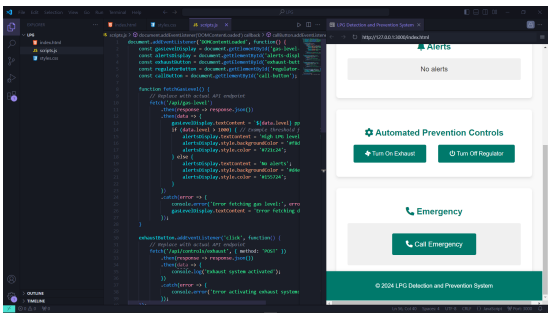

Figure 4.7: Web Design 3

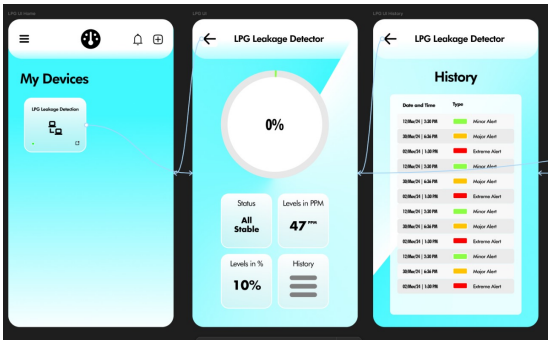

Figure 4.8: App UI

4.3 Conclusion

In a nutshell, our LPG detection and automatic prevention IoT project successfully integrated both hardware and software in dealing with gas safety. Integrating the Arduino Uno R3 and the ESP8266 resulted in a reliable system capable of real-time gas level monitoring and a remote alert system. The prototype is compact and well-designed, with precise measurement and safety protocols. Through iterative testing, the Wi-Fi stability and detection accuracy increased, hence making the device reliable and able to prevent gas-related incidents. This project details the potential for IoT solutions to bring more safety and automation into everyday environments.

Youtube link to the Demo and Explanation video of our project: LPG Detection System

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