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Figure No. **Figure Description**

List of Tables

List of Abbreviation

1. ESP 32 : Microcontroller
2. MQ2 : Methane Quality Sensor
3. LCD : Liquid-Crystal Display
4. I2C : Inter-Integrated Circuit
5. LPG: Liquified Petroleum Gas
6. 2D/3D: Two-Dimensional / Three-Dimensional
7. I/O LINES : Input Output Lines
8. IOT: Internet of Things

Contents

CHAPTER-1

INTRODUCTION

Gas leakage is a serious problem and nowadays it is observed in many places like residences, industries, and vehicles like Compressed Natural Gas (CNG), buses, cars, etc. It is noticed that due to gas leakage, dangerous accidents occur. The Liquefied petroleum gas (LPG), or propane, is a flammable mixture of hydrocarbon gases used as fuel in many applications like homes, hostels, industries, automobiles, and vehicles because of its desirable properties which include high calorific value, less smoke, less soot, and meager harm to the environment. Liquid petroleum gas (LPG) is highly inflammable and can burn even at some distance from the source of leakage. This energy source is primarily composed of propane and butane which are highly flammable chemical compounds. These gases can catch fire easily. In homes, LPG is used mainly for cooking purposes. When a leak occurs, the leaked gases may lead to an explosion. Gas leakage leads to various accidents resulting in both material loss and human injuries. Home fires have been occurring frequently and the threat to human lives and properties has been growing in recent years. The risks of explosion, fire, suffocation are based on their physical properties such toxicity, flammability, etc.

The number of deaths due to the explosion of gas cylinders has been increasing in recent years. The Bhopal gas tragedy is an example of accidents due to gas leakage. The reason for such explosions is due to substandard cylinders, old valves, no regular checking of gas cylinders, worn out regulators and a lack of awareness of handling gas cylinders.

Therefore, the gas leakage should be detected and controlled to protect people from danger. An odorant such as ethane thiol is added to LPG, so that leaks can be detected easily by most people. However, some people who have a reduced sense of smell may not be able to rely upon this inherent safety mechanism. A gas leakage detector becomes vital and helps to protect people from the dangers of gas leakage There are different gas detection techniques used in this paper a low-cost advanced sensor-based gas leakage detector, alert and control system is proposed and discussed. The system is very efficient, user friendly, portable, small in size and cost effective.

1.1 SCOPE OF THE PROJECT –

A gas detector is a device that detects the presence of gases in an area, often as part of a safety system. A gas detector can sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to leave. This type of device is important because there are many gases that can be harmful to organic life, such as humans or animals.

Gas detectors can be used to detect combustible, flammable and toxic gases, and oxygen depletion. This type of device is used widely in industry and can be found in locations, such as on oil rigs, to monitor manufacturing processes and emerging technologies such as photovoltaic. They may be used in firefighting.

In this work whenever the gas is leaked it is sensed by the sensor and it sends signal through the processor to buzzer. The ppm can be seen in the lcd display. Whenever the gas leakage reaches the ppm of 100 it will send signal to the buzzer and the buzzer will ring and it will alert the people around that the gas is leaking.

CHAPTER-2

LPG Gas Leakage Detection System using ESP-32

2.1 Project Overview-

The project involves the development of a gas detection system consisting of a gas sensor, ESP32 microcontroller, internet connectivity, cloud platform, and user interface. The ESP32 collects data from the gas sensor, processes it, and transmits it to the cloud for analysis. Users can access the system remotely through a web or mobile application to monitor gas levels and receive alerts.

2.2 Working of LPG Gas Detection System using ESP-32-

In our IoT-based LPG Gas Leakage Detection System, we're using the ESP32 microcontroller, which is like the brain of the system. It's responsible for collecting data from our gas sensor, which is the component that can detect if there's any LPG gas leaking. So, if there's a leak, the gas sensor sends a signal to the ESP32.Now, the ESP32 doesn't just sit there with the data. It processes it and then sends it over the internet to what we call a cloud platform. This cloud platform is like a virtual space where all our data goes. Once the data is in the cloud, it's analyzed. If the gas levels are too high, indicating a potential leak, the platform sends out an alert. This alert isn't just a notification that stays in the cloud. It gets sent back to the user, usually through a web or mobile app. So, you could be anywhere and still get a message telling you there's a gas leak at home or wherever the system is installed. So, in simple terms, the ESP32 collects data from the gas sensor, sends it to the cloud, where it's analyzed, and if there's a problem, you get an alert on your phone. It's like having a smart watchdog for your gas safety.

Here is the detailed explanation:

- **Gas Detection:**
  - The system utilizes a gas sensor designed to detect LPG gas leaks accurately. This sensor continuously monitors the surrounding environment for any changes in gas concentration.
  - When the sensor detects a significant increase in gas levels, indicating a potential leak, it sends a signal to the ESP32 microcontroller.
- **Data Processing and Transmission:**
  - Upon receiving the signal from the gas sensor, the ESP32 microcontroller processes the data.
  - The ESP32 is equipped with built-in Wi-Fi capabilities, enabling it to establish an internet connection.
  - It transmits the processed data, including gas concentration levels and sensor status, to a cloud-based platform for further analysis and storage.
- **Cloud-Based Analysis:**

- The cloud-based platform receives the data transmitted by the ESP32 in real-time.
- It performs analysis on the received data, comparing the gas concentration levels against predefined safety thresholds.
- If the gas levels exceed the safe limits, the platform triggers an alert notification.

- **User Interface and Alert System:**
  - Users can access the system remotely through a user-friendly interface, which can be a web application or a mobile app.
  - The interface displays real-time gas concentration levels, sensor status, and any detected gas leaks.
  - In case of a gas leak, the system sends instant alert notifications to the user's device, providing information about the location and severity of the leak.
- **User Response and Control:**
  - Upon receiving an alert, users can take immediate action to address the gas leak.
  - Depending on the severity of the situation, users may choose to shut off the gas supply manually or remotely through the interface.
  - Users can also contact emergency services if necessary, based on the information provided by the system.
- **Continuous Monitoring and Safety Assurance:**
  - The system continuously monitors the environment for any changes in gas concentration levels.
  - By providing real-time monitoring and alerts, the system ensures timely detection of gas leaks, minimizing the risk of fire accidents and health hazards.
  - Users can remotely monitor their premises, ensuring safety even when they are away from home or in large commercial settings.

- **Data Logging and Analytics (Optional):**
  - Optionally, the system can log data over time for further analysis and trend identification.
  - This data can be used to generate insights into gas usage patterns, identify potential leak-prone areas, and optimize safety measures.

2.3 Block Diagram–

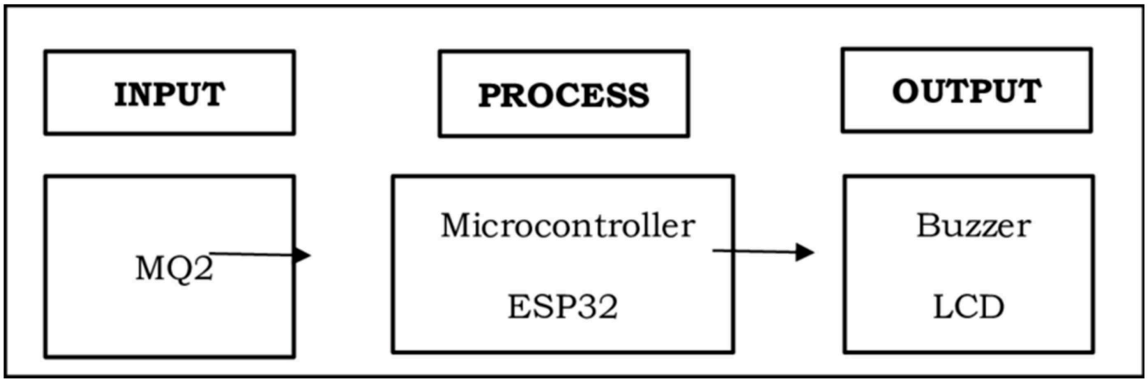

Figure-1 Block Diagram of System

2.4 Components Required –

S.NO	EQUIPMENT	QUANTITY
1.	ESP 32 Microcontroller	1
2.	GAS Sensors (MQ2 Sensors)	1
3.	BUZZER	1
4.	16 x 2 LCD Display	1
5.	I2C Module	1
8.	Bread Board	1
9.	MALE TO MALE/FEMALE WIRE	25

Table 1- Components Required

2.5 Components Description:

2.5.1- ESP-32 Microcontroller:

The ESP32 microcontroller is a powerful and versatile chip developed by Espressif Systems. It's widely used in various IoT (Internet of Things) applications due to its rich feature set, low power consumption, and built-in Wi-Fi and Bluetooth connectivity.

Here's an overview of some key aspects of the ESP32 microcontroller:

1. **Dual-Core Processor:**
   The ESP32 features a dual-core Tensilica Xtensa LX6 processor, which provides ample computational power for running applications and handling communication tasks simultaneously.

2. **Wi-Fi and Bluetooth Connectivity:**
   One of the standout features of the ESP32 is its built-in support for Wi-Fi and Bluetooth communication protocols. This allows devices powered by the ESP32 to connect to wireless networks and communicate with other devices seamlessly.

3. **Low Power Consumption:**
   Despite its powerful capabilities, the ESP32 is designed to operate efficiently in low-power environments. It includes various power-saving features such as multiple sleep modes, which help extend battery life in battery-operated devices.

4. **Rich Peripheral Interface:**
   The ESP32 offers a wide range of peripheral interfaces, including GPIO (General Purpose Input/Output) pins, SPI (Serial Peripheral Interface), I2C (Inter-Integrated Circuit), UART (Universal Asynchronous Receiver-Transmitter), ADC (Analog-to-Digital Converter), and more. This versatility allows developers to interface the ESP32 with a variety of sensors, actuators, displays, and other external devices.

5. **Security Features:**
   Security is a crucial aspect of IoT devices, and the ESP32 includes features such as secure boot, flash encryption, and cryptographic hardware acceleration to help protect against various security threats.

6. Development Environment:

The ESP32 is well-supported by an extensive ecosystem of development tools, including the Arduino IDE, ESP-IDF (Espressif IoT Development Framework), and various third-party development platforms. This makes it relatively easy for developers to get started with ESP32-based projects and access a wealth of resources and community support.

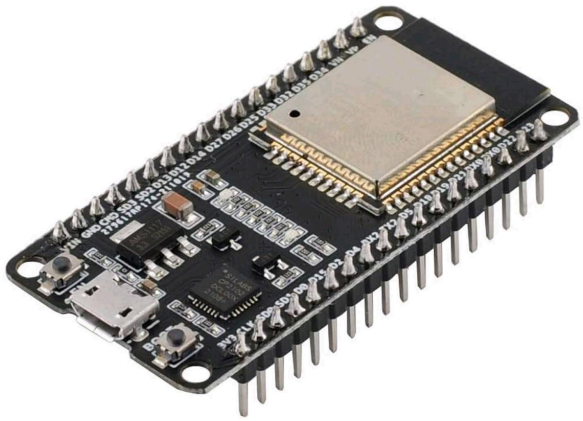

Figure 2: Microcontroller ESP 32

2.5.2- Gas Sensors:

A gas sensor is a device which detects the presence or concentration of gas in the atmosphere. Based on the concentration of the gas the sensor produces a corresponding potential difference by changing the resistance of the material inside the sensor , which can be measured as output voltage . based on this voltage value the type and the concentration of the gas can be estimated.

The type of the gas sensor could detect depends on the sensing material present in side the sensor. Normally these sensors are available as modules with comparators. These comparators can be set for a particular threshold value of gas concentration. When the concentration of the gas exceeds this threshold value the digital pins goes high. The analog pin can be used to measure the concentration of gas.

There are various types of Gas Sensor:

S.no	Sensor	Detects
1.	MQ-2	METHANE, BUTANE, LPG, SMOKE.
2.	MQ-3	ALCOHOL, ETHENOL, SMOKE.
3.	MQ-4	METHANE, CNG GAS.
4.	MQ-5	NATURAL GAS, LPG
5.	MQ-6	LPG, BUTANE GAS.
6.	MQ-7	CARBON MONOXIDE
7.	MQ-8	HYDROGEN GAS
8.	MQ-9	CARBON MONOXIDE, FLAMMABLE GASSES.
9.	MQ131	OZONE.
10.	MQ135	AIR QUANTITY (BENZENE, ALCOHOL, SMOKE).
		And etc.

Table 2- Different Gas Sensors and Gas which it detects

2.5.2.1- MQ2 Sensor:

The MQ2 sensor is a gas sensor module widely used for detecting various types of gases such as LPG, propane, methane, alcohol, smoke, and hydrogen. It operates based on changes in conductivity when exposed to different gases. The sensor consists of a semiconductor element that undergoes changes in resistance when in contact with specific gases. This change in resistance is proportional to the concentration of the detected gas.

The MQ2 sensor can detect a wide range of gases, making it versatile for applications like gas leakage detection, fire detection, air quality monitoring, and industrial safety. It typically operates at room temperature and ambient air pressure, with a warm-up time required after power-on to stabilize readings.

Figure 3: MQ2 Gas Sensor

2.5.3- Buzzer:

A buzzer is an electro-acoustic transducer that converts electrical energy into sound. It typically consists of a housing, a vibrating element (such as a piezoelectric disk or an electromagnetic coil), and electrical contacts.

Function of a buzzer is an audio signalling device which may be mechanical, electro-mechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke. The buzzer is small yet efficient. The component is toadd sound features as an output for LPG gas detection system using ESP32. It is very small and compact 2 pin structure hence to give warning tones while the LPG leak detection.

In this project, buzzer will be active once a MQ2 gas sensor detected a gas leakage in atmosphere.

Figure 4: Buzzer

2.5.4- 16 x 2 Liquid Crystal Display (LCD):

A 16x2 LCD (Liquid Crystal Display) is a common alphanumeric display module widely used in electronic projects and devices. It consists of a grid of 16 columns and 2 rows of characters, allowing for the display of up to 32 characters at a time.

Character LCD pins:

PIN NO	FUNCTION	NAME
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	V_{CC}
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and dataregister when high	RegisterSelect
5	Low to write to the register; High to read from theregister	Read/write
6	Sends data to data pins when a high to low pulseis given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

Table 3 -LCD Pins

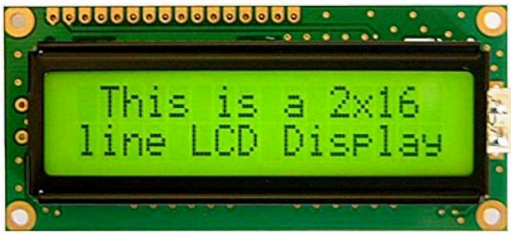

Figure 5: 16x2 LCD Display

2.5.5- I2C Module:

An I2C (Inter-Integrated Circuit) module is a communication interface commonly used in embedded systems and electronic devices to facilitate communication between multiple integrated circuits (ICs) or peripherals. It enables serial communication between devices using a two-wire bus consisting of a serial data line (SDA) and a serial clock line (SCL).

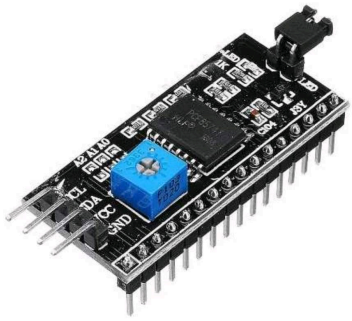

Figure 6: I2C Module

2.5.6-Bread Board:

A breadboard is a tool used in electronics to prototype and test circuit designs without soldering. It consists of a plastic board with holes for inserting electronic components and metal strips underneath to connect them without the need for soldering. It's a great way to quickly assemble and disassemble circuits for experimentation and learning.

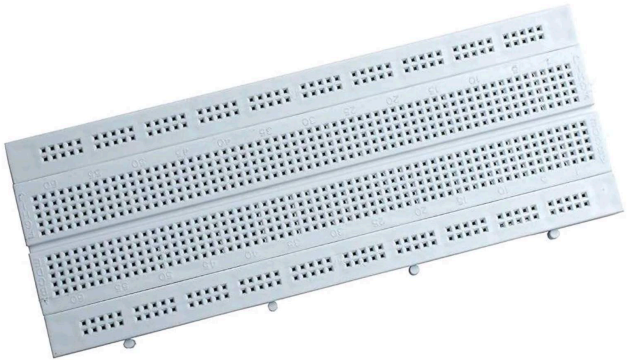

Figure 7: Bread Board

CHAPTER-3

SIMULATION

3.1-Methods:

Circuit schematic of LPG gas leakage detection using ESP32 has been designed by using Proteus suite. The Proteus design suite is a great electrical suite for circuit simulation purposes that containing schematic, simulation as well as PCB designing. In Figure 7 below shown a circuit diagram of LPG gas leakage detection using ESP32 that was designed using Proteus library. Circuit schematic is important to represent all the components of an electrical circuit involved either using the images of the distinct parts or standard symbols.

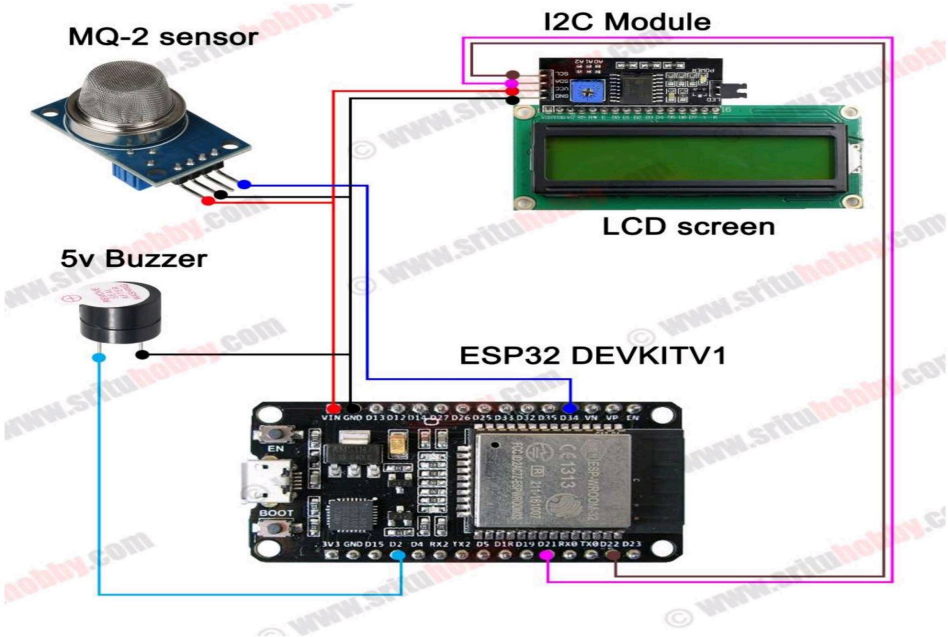

Figure 8: Circuit Diagram of LPG gas leakage detection using ESP32

3.2 Results and Discussion:

This system is using ESP32 as microcontroller to control function of and MQ2 gas sensor. The prototype of development of this system shown on Figure8 and Figure 9. When the gas sensor detects gas leakage in atmosphere, it willgive the digital output in the buzzer and LCD. The detection range of MQ-2 gas sensor is between 300 to 5000 ppm. In Figure 10 shown a coding involved on MQ2, buzzer and LCD if the sensor detect leakage LPG gas by using ArduinoIDE. It is open source software that makes it easy to write code and upload it to the board. Once the sensor output is high, then the buzzer will make warning tones (act as an alarm) and the LCD will show “Gas detected” on the screen. The ESP32 as a microcontroller detect the presence of LPG gas when the voltages signal from the MQ2 sensor beyond a certain level and give warning tones as alarm. Figure 11 show an actual board of LPG gas leakage detection using ESP32.

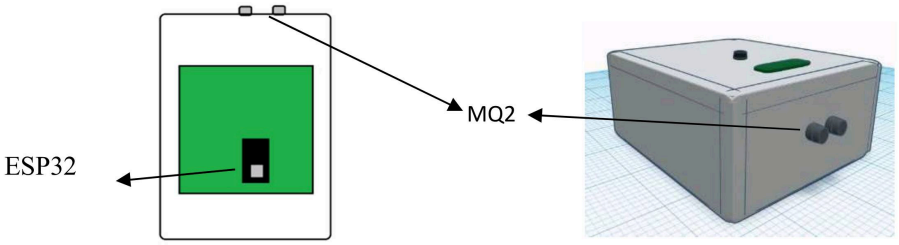

Figure 9: 2D prototype

Figure 10: 3D prototype

Figure 11: Actual product of LPG gas leakage detection using ESP32.

CHAPTER-4

HARDWARE

4.1 Hardware Diagram:

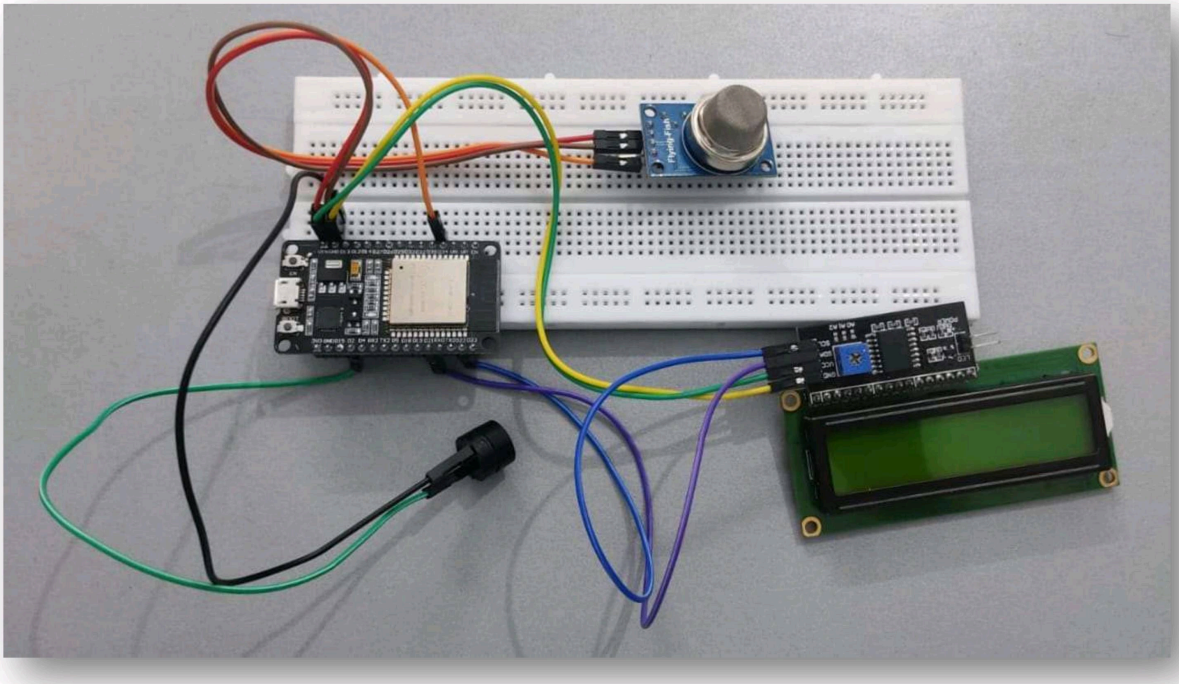

Figure 12 : Hardware Connections of LPG gas leakage detection using ESP32

4.2 Hardware Connection:

The hardware connection for the IoT-based LPG gas detection system using ESP32 involves several components. Firstly, you'll need the ESP32 microcontroller board, which serves as the main control unit. Connect the MQ-2 gas sensor to the ESP32 board using jumper wires. The MQ-2 sensor detects LPG gas and outputs an analog voltage proportional to the gas concentration. Next, connect an LED to the ESP32 board, which will serve as an indicator to show when gas is detected. Additionally, you might want to include a buzzer to provide an audible alarm when gas is detected. Ensure to power the ESP32 board using an appropriate power source, and make sure all connections are secure to prevent any breakdown in functionality. Finally, you may also need to connect the ESP32 board to a Wi-Fi module or module for communication with an IoT platform for data logging or remote monitoring purposes.

4.3 System Flow Chart:

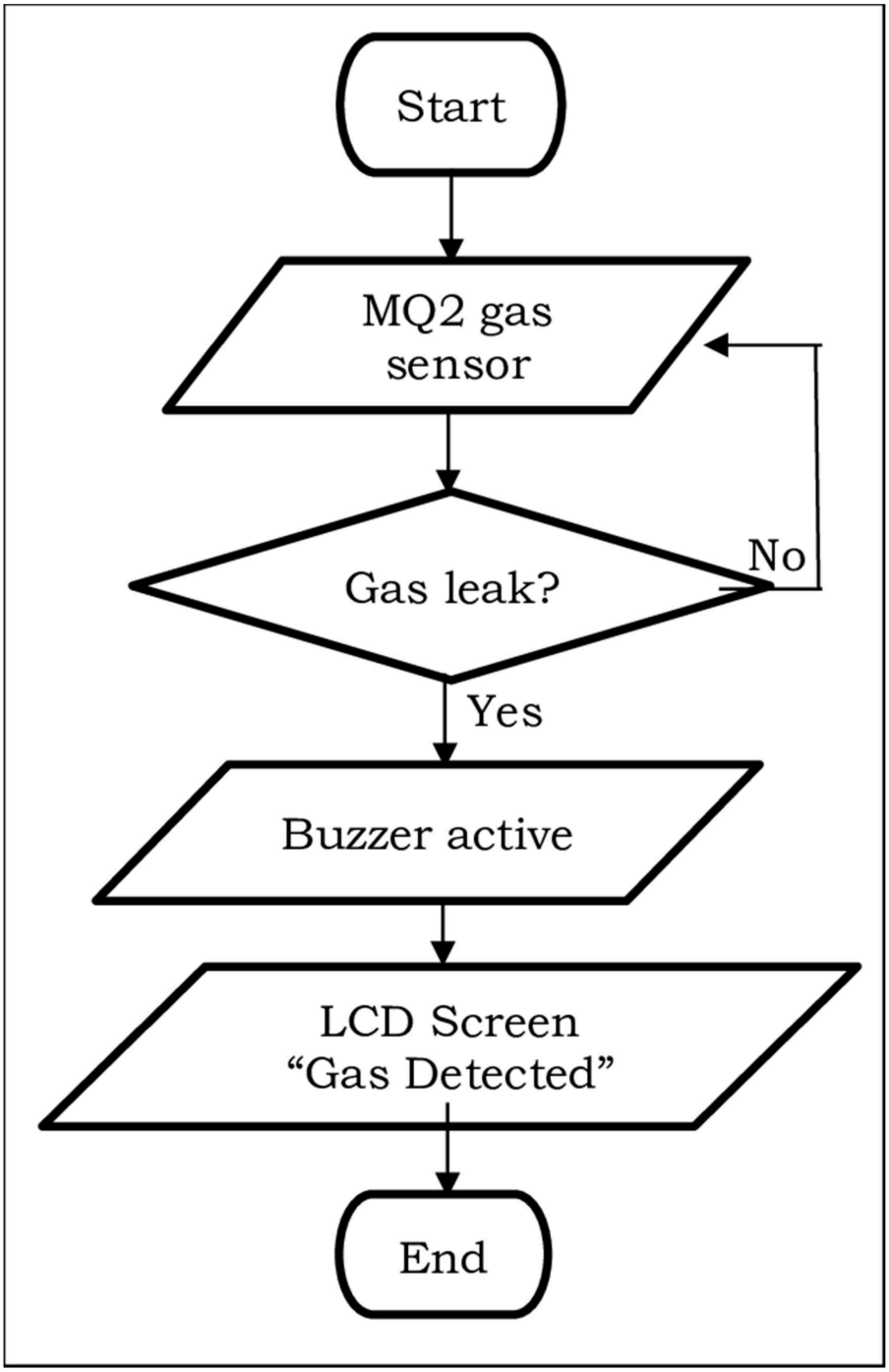

Figure 13: System flowchart

CHAPTER-5

ADVANTAGES AND APPLICATIONS

5.1 Advantages of the system:

- You can monitor the amount of gases in your environment.
- Can escape from higher chance of poisoning, explosion, fire orasphyxiation.
- Get real time -alerts about the gaseous presence in theatmosphere.
- Prevent the fire hazards and explosion.
- Supervise gas concentration levels.
- Ensure workers health.
- Ensure workers health.
- Real-time update about leakage.
- Cost-effective installation.
- Data analytics for improved decision.
- Measure oxygen level accuracy Get immediate gas leak alerts.

5.2 Applications of the system:

1. Harmful Gas Detection:

The sensing of toxic gases such as H2S, Methane, and CO is of great importance in any industry to avoid unwanted leakage and consequences like poisoning or explosions. The presence of these gases can be easily detected in the industrial facilities and commercial

buildings with the help of IoT-powered gas monitoring solution. Moreover, a gas detector or sensor device is a crucial part to carry out safe industrial operations. The sensor-enabled solution helps prevent the high risk of gas 6 explosions and affecting any casualties within and outside the premises.

2. Fire Hazard Prevention:

The gas sensors help detect the concentration of the gases present in the atmosphere to avoid hazardous consequences like fire breakouts. Also, it is an imperative solution to keep the plant workers and equipment safe from fire hazards. It effectively detects the presence of hazardous gases like propane and methane and alerts the plant authorities, preventing the premises from unexpected ignition. Moreover, a gas monitoring solution uses gas analyzers to generate alerts regarding the temperature increase. This allows the management to take immediate actions to curb harmful fire explosions.

3. Oxygen Level Measurement:

Sensing the presence of gases is a necessity to conduct industrial operations as several pitmen had lost their lives due to lack of oxygen in the process of mining explorations. A sudden decrease in the oxygen levels can result in dizziness, brain damage, or even death among the workers working in mines or close-packed industrial premises. A gas monitoring system significantly benefits the industries by maintaining proper oxygen levels that reflect the optimal performance of your workers. This 7 system also creates alerts in real-time about the decreasing oxygen levels,which gives enough time to take necessary measures to evacuate the facilities much before the health gets affected.

4. Residential Safety:

In households, LPG (liquefied petroleum gas) is commonly used for cooking, heating, and other purposes. However, leaks can occur, leading to potential fire hazards or even explosions. A gas detection system installed in homes can promptly detect LPG leaks, triggering alarms to alert residents and allowing them to take necessary actions such as ventilation or shutting off the gas supply.

5. Commercial Kitchens:

Restaurants, hotels, and other establishments with commercial kitchens often use LPG for cooking. Detecting gas leaks in such environments is crucial to prevent accidents and ensure the safety of kitchen staff and customers. Gas detection systems can be integrated into commercial kitchen setups to monitor gas levels continuously and provide early warnings in case of leaks.

6. Industrial Settings:

Industries such as manufacturing, petrochemical, and pharmaceuticals utilize LPG for various processes. Gas leaks in industrial environments can lead to not only fire hazards but also health risks due to exposure to toxic gases. Implementing gas detection systems in industrial settings helps in early detection of leaks, allowing for prompt evacuation and mitigation measures to prevent accidents and protect workers' safety.

7. Warehouses and Storage Facilities:

LPG is often stored in large quantities in warehouses or storage facilities for industrial use or distribution. Monitoring gas levels in storage areas is essential to prevent leaks, which can occur due to equipment malfunction or damage to storage containers. Gas detection systems installed in such facilities help in maintaining safe storage conditions and reducing the risk of accidents.

8. Transportation:

LPG is commonly used as fuel in vehicles, including forklifts, buses, and trucks. In transportation applications, detecting gas leaks is crucial for preventing accidents on the road and ensuring passenger and driver safety. Gas detection systems integrated into vehicles can monitor LPG levels and provide alerts in case of leaks or abnormalities in the fuel system.

CHAPTER-6

CONCLUSIONS

6.1 CONCLUSION:

In conclusion, the development of an IoT-based LPG gas detection system using ESP32 presents a significant advancement in ensuring safety and minimizing the risks associated with gas leaks. This system offers several advantages, including real-time monitoring of gas concentration levels, immediate alerts in case of gas leakage, prevention of fire hazards and explosions, and cost-effective installation. By leveraging the capabilities of ESP32 microcontroller, gas sensors, and cloud-based platforms, this system provides an efficient and user-friendly solution for detecting and controlling gas leaks in various settings.

Furthermore, the applications of this system extend across residential, commercial, industrial, and transportation sectors, addressing the diverse safety needs of different environments. From residential kitchens to industrial facilities and transportation vehicles, the implementation of gas detection systems enhances safety measures, protects lives, and prevents property damage.

Overall, the IoT-based LPG gas detection system offers a proactive approach to gas safety management, enabling timely detection, alerting, and response to gas leaks. By incorporating advanced technology and effective monitoring mechanisms, this system contributes to creating safer environments and reducing the potential risks associated with gas-related accidents and incidents.

6.2 FUTURE SCOPE:

Overall, software and hardware parts of the systems have been developed and tested by introducing a small amount of LPG near gas sensor module. The authors of this paper are currently working to include multi functions with this device. One of the notable future 22 functions of this system is to add a sub system where wastage of gas and the uses of gas can be monitored using this system. The system is flexible as a greater number of sensors and relays can be added to it according to the whole LPG supply setup in those premises. The author is

adding more software based intelligent functions with this system. This is an automatic gas detection, control and alert system. In future this system will have a feature where it can notify the emergency services if any accidents happen. A mobile app and web-based app for real time monitoring also will be added. In the user app for this system many smart features will be added. The overall features will make the system more safe for the users. The system will be optimized for use in many places like the car, the home, industries and many other places. After designing the final prototype with smart multifunctional features, the system will be implemented in real life scenarios as a pilot project. A survey will be done soon before using the system and another one will be done after implementing the system to discover the KPI. Summarizing all the results, finding and analyzing a research article will be done and author has plans to submit into the MDPI sensors journal for review. In the future paper the features of this final product will be compared with the available gas detector systems presented in other article.

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SOURCE CODE

```
//Include the library files
#include <LiquidCrystal_I2C.h>
#include <Wire.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#define sensor 34
#define buzzer 2
//Initialize the LCD display
LiquidCrystal_I2C lcd(0x27, 16, 2);
BlynkTimer timer;

// Enter your Auth token
char auth[] = "**********";
//Enter your WIFI SSID and password
char ssid[] = "**********";
char pass[] = "**********";
void setup() {
  // Debug console
  Serial.begin(115200);
  Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
  lcd.init();
  lcd.backlight();
  pinMode(buzzer, OUTPUT);
  lcd.setCursor(1, 0);
  lcd.print("System Loading");
  for (int a = 0; a <= 15; a++) {
    lcd.setCursor(a, 1);
    lcd.print(".");
    delay(200);
```

```
  }
  lcd.clear();
}

//Get the ultrasonic sensor values
void GASLevel() {
  int value = analogRead(sensor);
  value = map(value, 0, 4095, 0, 100);

  if (value >= 50) {
    digitalWrite(buzzer, HIGH);
    lcd.setCursor(0, 1);
    lcd.print("Warning!  ");
    WidgetLED LED(V1);
    LED.on();
  } else {
    digitalWrite(buzzer, LOW);
    lcd.setCursor(0, 1);
    lcd.print("Normal   ");
    WidgetLED LED(V1);
    LED.off();
  }

  Blynk.virtualWrite(V0, value);
  Serial.println(value);
  lcd.setCursor(0, 0);
  lcd.print("GAS Level :");
  lcd.print(value);
  lcd.print(" ");
}
```

```
void loop() {
  GASLevel();
  Blynk.run();//Run the Blynk library
  delay(200);
}
```