Smart LPG Detection System

A Real-Time / Field-Based Research Project (22CY284) report submitted to the
Jawaharlal Nehru Technological University, Hyderabad

Submitted by

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DEPARTMENT OF CSE (CYBER SECURITY)

CVR COLLEGE OF ENGINEERING

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CERTIFICATE

This is to certify that the Real time/ Field-Based research project (22CY284) report entitled **"**SMART LPG DETECTION SYSTEM**"** is a record of work carried out by **Nenavath Adithya(23B81A6203), Adpula Maruthi Pratap(23B81A6225), Dabbani Praneeth(23B81A6231)** submitted to Department of **CSE (CYBER SECURITY),** CVR College of Engineering, affiliated to Jawaharlal Nehru Technological University, Hyderabad during the year 2023-2024.

Project Guide	**Project Coordinator**	**Head of the Department**
Dr. C Raghavendra	**Dr. B. Prasanthi**	**Dr. M. Sunitha**
Associate Professor	Associate Professor	Professor & HOD
CSE(CS)	CSE(AI&ML)	CSE (CS)

DECLARATION

We hereby declare that the Real time/ Field-Based research project (22CY284) report entitled **“**SMART LPG DETECTION SYSTEM**”** is an original work done and submitted to **CSE (CYBER SECURITY)** Department, CVR College of Engineering, affiliated to Jawaharlal Nehru Technological University, Hyderabad and it is a record of bonafide project work carried out by us under the guidance of **DR. C RAGHHAVENDRA**, ASSOCIATE PROFESSOR**, CSE (CYBER SECURITY).**

We further declare that the work reported in this project has not been submitted, either in part or in full, for the award of any other degree or diploma in this Institute or any other Institute or University.

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Abbreviations

Abbreviation	Full Form
ESP32	Espressif Systems 32-bit Microcontroller
GSM	Global System for Mobile Communications
Wi-Fi	Wireless Fidelity
SMS	Short Message Service
LPG	Liquefied Petroleum Gas
LCD	Liquid Crystal Display
API	Application Programming Interface
IoT	Internet of Things
Blynk	A mobile app for Internet of Things
UART	Universal Asynchronous Receiver Transmitter
LED	Light Emitting Diode
BLYNK	Blynk IoT Platform
SIM	Subscriber Identity Module
AT Command	Attention Command (used for controlling GSM modules)
HTTP	Hypertext Transfer Protocol
JSON	JavaScript Object Notation
HTTP	Hypertext Transfer Protocol

ABSTRACT

This project presents the design and implementation of a Smart LPG Gas Leakage Detection and Alert System using an ESP32 microcontroller. The primary objective is to ensure the safety of homes and industries by monitoring gas levels in real-time and providing instant alerts upon detection of hazardous leakage. The system uses an MQ-6 gas sensor to continuously detect LPG concentration in the environment. If gas levels exceed a predefined threshold, the ESP32 triggers multiple alerts: an emergency SMS is sent via GSM module, a warning call is initiated through the Twilio cloud service, and real-time updates are sent to the Blynk IoT platform. Simultaneously, local alerts are given using a buzzer and an LCD display showing the critical status.

This integrated approach ensures timely human intervention to prevent accidents and enhances the reliability of gas safety systems. The solution is low-cost, scalable, and user-friendly, making it suitable for residential, commercial, and industrial applications. Future upgrades may include automatic gas valve shutoff and enhanced remote monitoring. This project effectively demonstrates the fusion of IoT, cloud communication, and embedded systems to tackle real-world safety challenges.

Keywords:
• Gas Leak Detection
• IoT-based Safety System
• GSM SMS Alert
• Cloud-Based Voice Call (Twilio)
• Smart Home Automation
• Real-Time Monitoring
• Embedded Safety Systems

1. Introduction

The Introduction chapter provides an overview of the project's context, problem statement, objectives, and organization. This chapter sets the stage for understanding the importance of the project and its scope.

1.1 Motivation

The motivation for developing this project stems from the increasing need for smart and automated systems that can detect gas leaks and alert users effectively. The safety of households and industries is a top priority, and this project aims to provide a reliable solution for gas leak detection in real-time.

1.2 Problem Statement

Gas leaks pose a serious risk to safety, health, and the environment. Traditional systems of detecting leaks are either manual or inefficient. There is a need for a smart, automatic gas detection system that can detect gas leaks early and alert users instantly, thereby preventing accidents and damage.

1.3 Project Objectives

The main objectives of this project are:

- To design and implement a smart LPG gas detection system.
- To use IoT technologies for real-time monitoring and alerting.
- To integrate Twilio API for SMS and call notifications.
- To ensure reliability, energy efficiency, and user safety through the developed system.

1.4 Project Report Organization

The project report is structured as follows:

- **Chapter 2** provides a detailed **Literature Survey**, discussing existing work and their limitations.
- **Chapter 3** outlines the **Software and Hardware Specifications** required for the project.
- **Chapter 4** explains the **Proposed System Design**, including architecture and methodologies.
- **Chapter 5** covers the **Implementation & Testing**, including code snippets and test cases.
- **Chapter 6** provides the **Conclusion & Future Scope** of the project, summarizing the achievements and future improvements.

2. Literature Survey

This chapter presents a review of the existing systems and solutions related to LPG gas detection, followed by an analysis of their limitations. The aim is to highlight the gaps in current technologies and propose improvements in the design of our system.

2.1 Existing Work

1. A Smart Approach of LPG Monitoring and Detection System Using IoT

Authors: Nagib Mahfuz, Shawan Karmokar, Md. Ismail Hossain Rana

Journal Name: 11th ICCCNT, 2020

Year of Publication: 2020

Methodology:

The system uses NodeMCU (ESP8266) as the main controller, interfacing with MQ-5 & MQ-6 gas sensors, DHT11 sensor, and a GSM module (SIM800L) for sending alerts. Sensor data is displayed on an LCD screen and uploaded to a web server via PHP and MySQL for remote monitoring. A buzzer alarm is triggered for on-site alerts. The system was simulated using Proteus software before real-world testing.

Drawbacks:

- No phone call alerts.
- No solution for power failure.

Improvements:

- Phone call alerts.
- Battery backup for power failure.

2. LPG Gas Leakage Detection Using ESP32

Authors: OM Ghodke, Swapnil Kadam, Chaitanya Jhoshi, Shrinivas Shitole, Pandhare N.V.

Journal Name: International Scientific Journal of Engineering and Management (ISJEM)

Year of Publication: 2024

Methodology:

The system uses an ESP32 microcontroller with MQ-series gas sensors for LPG detection. Sensor data is processed and monitored in real-time. When leakage is detected, the system triggers email notifications via an SMTP server. Additional components include LED indicators, a buzzer, and a battery switching module for continuous operation. The system was tested for accuracy and efficiency in different environments.

Drawbacks:

- No phone call alerts.
- No temperature monitoring.

  Improvements:
- Phone call alerts.
- DHT11 sensor used for temperature and humidity monitoring.

3. LPG Gas Leakage Detection System

Authors: Ayaan Siddiqui, Dwijesh Y, Faiz Azam, Aditya Wani, Associate Professor Zahid Alam

Journal Name: International Journal of Science, Engineering, and Technology (IJSET)

Year of Publication: 2024

Methodology:

The system utilizes a microcontroller and an MQ-series gas sensor to detect LPG leaks. When a leak is detected, an alert system is triggered, notifying users via SMS alerts. The system includes buzzer-based audible alerts and is designed for residential and commercial applications.

Drawbacks:
- Lacks phone call alerts and power backup, making it less effective during power failures.
- No IoT monitoring.

  Improvements:
- Phone call alerts for faster response.
- Battery backup for power failures.
- Reduced false alarms.
- Smart IoT monitoring.

2.2 Limitations of Existing Work

- **Lack of phone call alerts**: Many existing systems rely on SMS notifications or email alerts, which may not be timely or accessible in critical situations. Phone call alerts provide immediate attention and ensure that the user is notified instantly.
- **No power backup**: Several existing systems do not include power backup solutions. In the event of a power failure, the system stops functioning, which makes it unreliable in emergency situations. Implementing a battery backup would ensure continuous operation during power outages.
- **Limited monitoring features**: Some systems do not provide real-time monitoring features or sensor integration for temperature and humidity. Integrating sensors like DHT11 for temperature and humidity along with gas detection can improve the overall safety and functionality of the system.
- **No IoT monitoring**: While many systems can send SMS alerts, there is a lack of integration with IoT platforms for real-time data monitoring and control. IoT integration can provide

remote monitoring via mobile apps, making it easier for users to receive alerts and take necessary actions.

2.3 Proposed Improvements

Based on the limitations identified in the existing works, the proposed system aims to overcome these drawbacks by implementing the following improvements:

1. **Phone call alerts**: The system will integrate with Twilio for sending real-time phone call alerts when a gas leak is detected, ensuring immediate user notification.
2. **Power backup**: A battery backup system will be included to ensure continuous operation of the system, even in the event of a power failure.
3. **Temperature and humidity monitoring**: By incorporating the DHT11 sensor, the system will monitor both the gas levels and environmental factors like temperature and humidity, providing a more comprehensive safety solution.
4. **IoT monitoring**: Integration with an IoT platform such as Blynk will enable real-time monitoring and control of the system remotely, offering users a mobile interface for managing the system.

3. Software & Hardware Specifications

3.1 Software Requirements

S.No.	Software	Purpose
1	**Arduino IDE**	Used to program the microcontroller (ESP32) using C/C++ language.
2	**Blynk App**	Used for mobile app interface, remote monitoring, and IoT control.
3	**Twilio API**	Sends SMS and makes phone calls for alerting users about gas leaks.

3.2 Hardware Requirements

S. NO	Component	Description
1	ESP32-WROOM-32	Microcontroller for controlling the system and processing data
2	MQ-6 Gas Sensor	Used to detect the presence of LPG gas
3	SIM800L GSM Module	Used for sending SMS alerts and making calls
4	DHT11 Temperature & Humidity Sensor	Used to monitor temperature and humidity levels
5	LM2596 DC-DC Converter	Used for power regulation to ensure stable voltage supply
6	Buzzer	Provides audible alerts in case of gas leakage
7	LCD Display (I2C)	Displays real-time data on gas levels, temperature, and humidity
8	Power Supply	Provides the necessary power to the system
9	Breadboard and Wires	Used for assembling the components
10	SIM Card	Provides cellular connectivity for the GSM module
11	Battery	Powers the system during operation

4. Proposed System Design

4.1 Proposed Methods

The proposed system is designed to detect LPG gas leakage using a gas sensor and immediately alert the users through SMS and a phone call.

The ESP32-WROOM-32 microcontroller reads gas concentration levels from the MQ-6 gas sensor. If the gas level exceeds a predefined threshold, the system sends an SMS using the SIM800L GSM module and initiates a call through a Twilio service.

Additionally, the system monitors environmental conditions like temperature and humidity using the DHT11 sensor. The data is displayed on an LCD screen for real-time monitoring. Audible alerts are provided through a buzzer, and a DC-DC converter (LM2596) is used to ensure a stable power supply to all modules.

This system aims to provide a low-cost, efficient, and smart safety solution to detect and alert gas leaks quickly.

4.2 System Architecture

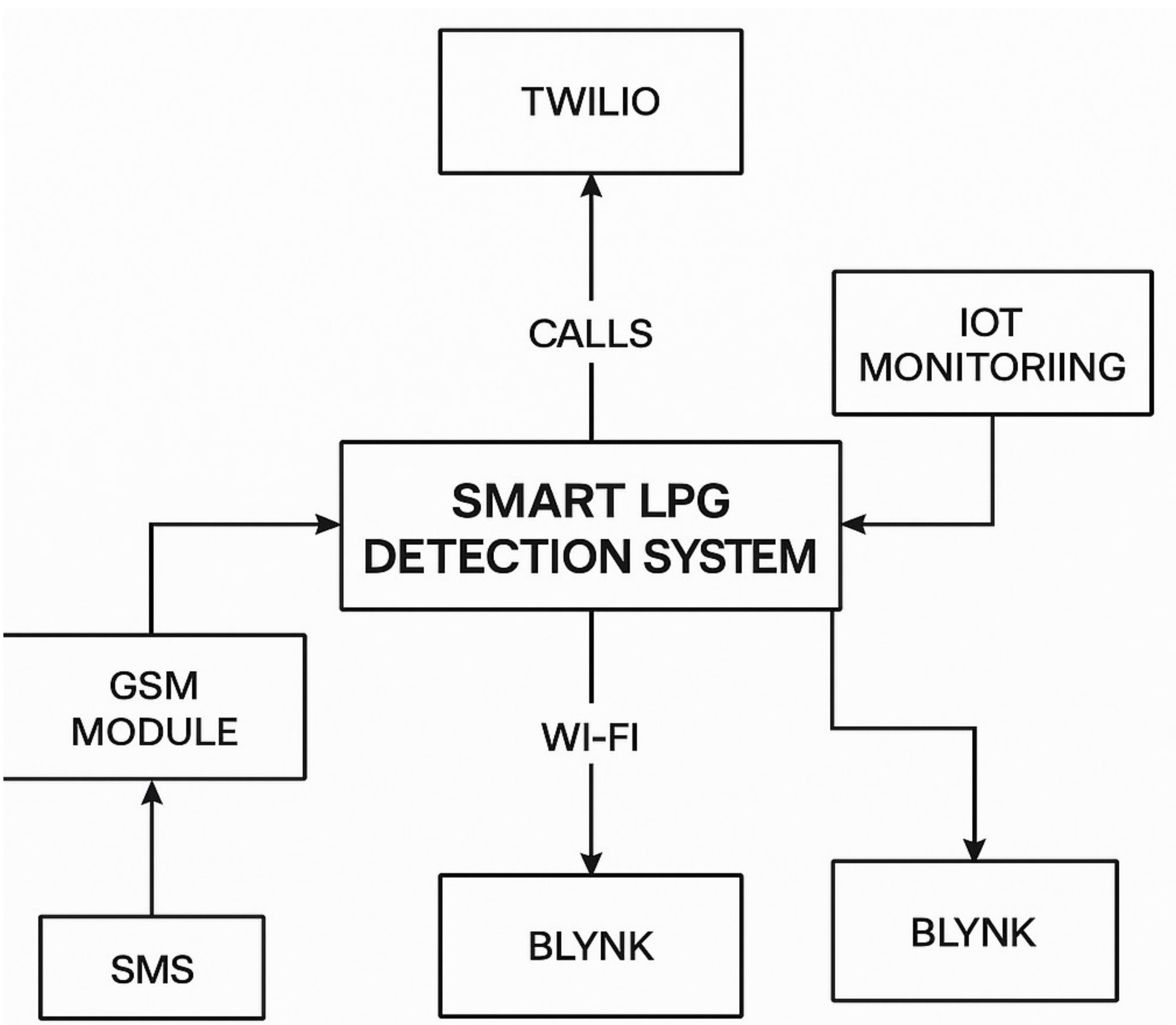

FIGURE 4.1 : System Architecture of SMART LPG DETECTION

System Architecture Diagram

A System Architecture Diagram shows how different hardware and software components are connected and interact with each other.

It focuses on what devices are used, how they are connected, and how data moves between them.

In your Smart LPG Detection System:

- ESP32 reads gas, temperature, and humidity.
- Sends data to Blynk (IoT monitoring) over WiFi.
- Uses Twilio API over WiFi for voice call alerts.
- Sends SMS alerts using GSM module (SIM800L).
- Displays real-time information on an LCD and triggers a buzzer during danger.

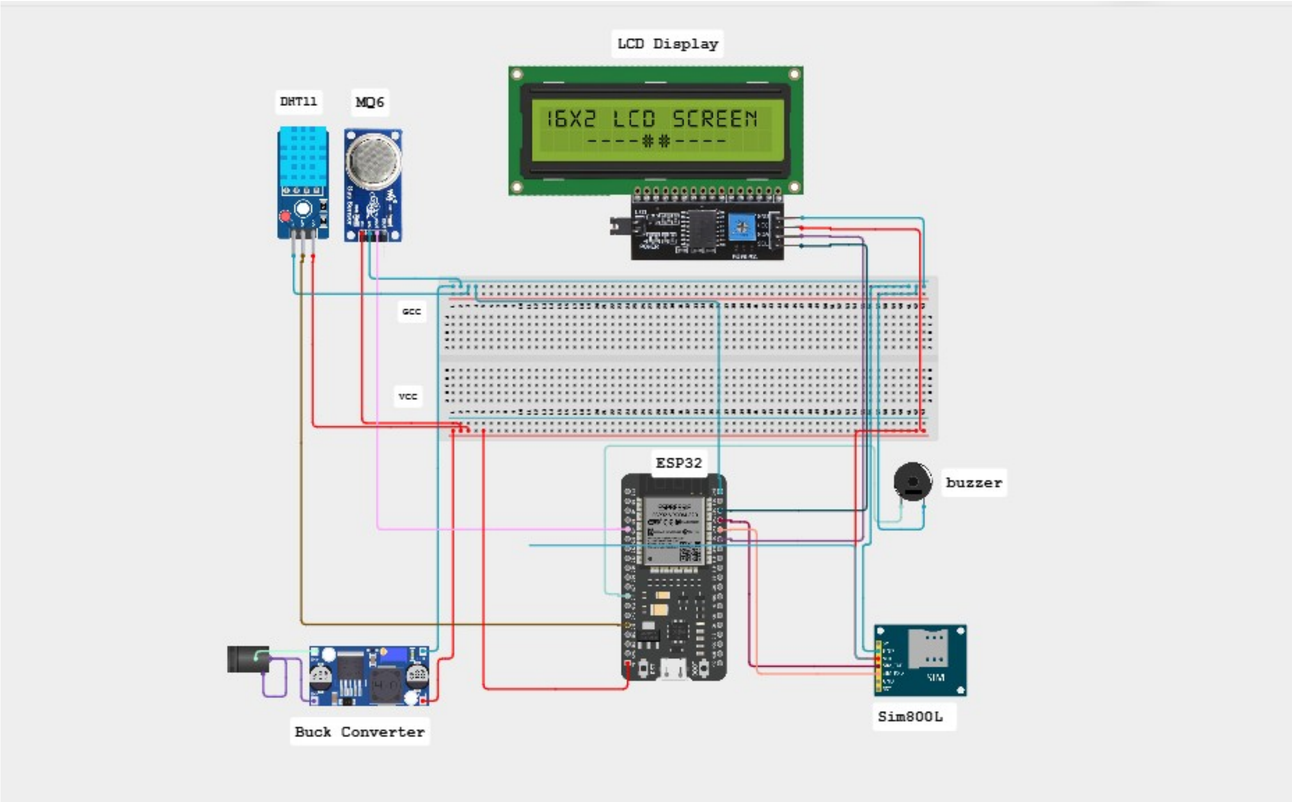

FIGURE 4.2: CIRUIT DIAGRAM of SMART LPG DETECTION SYSTEM

Circuit Explanation: This is a Smart Gas Leakage Detection System based on ESP32. It uses an MQ-6 sensor to detect LPG gas concentration and a DHT11 sensor to measure temperature and humidity. A 16x2 LCD displays real-time gas, temperature, and humidity values. When gas levels exceed a set threshold, the buzzer is activated, an SMS alert is sent, and a call is made through the SIM800L GSM module. A buck converter ensures stable power supply to the ESP32 and GSM module. The system also connects to the Blynk IoT platform over Wi-Fi for remote monitoring. It provides both local and remote safety alerts effectively.

4.3. Data flow Diagram or Flowchart

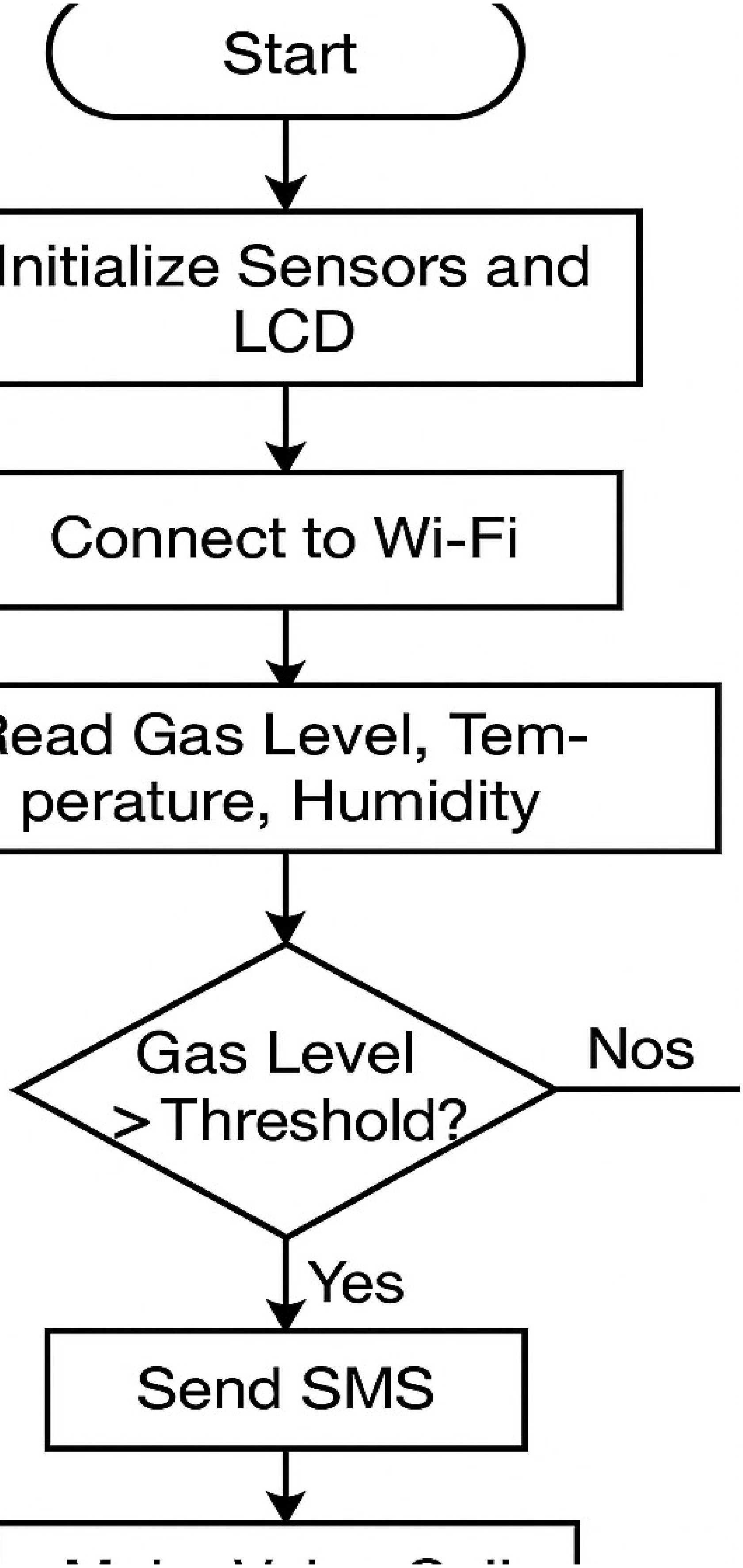

FIGURE 4.2: FLOW CHART OF SMART LPG DETEDTION

Dataflow / Flowchart Diagram

A **Dataflow Diagram (DFD)** or **Flowchart** explains the **sequence of operations** in the system — step-by-step.

It focuses on **how data moves and decisions are made** during execution.

In your system's dataflow:

- ESP32 starts → Connects to WiFi → Initializes sensors and GSM → Continuously reads gas, temperature, humidity.
- Sends updates to Blynk.
- If gas levels are high: it triggers **SMS**, **Voice call**, **Buzzer**, and **LCD warning**.
- Else, it continues normal monitoring.

4.4 Technology Description

The Smart LPG Gas Detection System integrates several modern technologies to achieve efficient and reliable gas leak monitoring, user alerting, and environmental sensing. The core technologies used in the system are explained below:

Microcontroller Technology

The ESP32-WROOM-32 microcontroller serves as the brain of the system. It is a powerful Wi-Fi and Bluetooth-enabled microcontroller that manages sensor data acquisition, processes the readings, sends real-time updates to Blynk IoT platform, and controls the GSM module for sending SMS and triggering calls.

Gas Detection Technology

The MQ-6 gas sensor is employed to detect the presence of LPG gas in the environment. It outputs an analog signal based on the concentration of gas, which the ESP32 reads and processes. If the gas level crosses a safe threshold, the system initiates alert mechanisms.

Wireless Communication Technology

Wi-Fi communication is used for connecting the system to the Blynk platform, allowing remote monitoring through smartphones. Additionally, the SIM800L GSM module enables cellular communication by sending SMS alerts and allowing phone calls in emergency situations.

Power Management Technology

The LM2596 DC-DC buck converter is used for stable voltage regulation, especially for sensitive modules like the SIM800L, ensuring the system's stable operation without damage from power fluctuations. The

battery and LM2596 setup ensures uninterrupted power supply even during main supply failures.

Sensor Technology

The DHT11 sensor is used for measuring environmental temperature and humidity levels. It provides additional environmental monitoring, giving a more complete picture of the surrounding conditions alongside gas detection.

User Interface Technology

An I2C-based LCD display is used to present real-time information such as gas levels, temperature, and humidity. It provides immediate, easy-to-read feedback for users on-site.

IoT and Cloud Integration Technology

Using the Blynk IoT platform, the system provides real-time monitoring and event notification. Users can view the current gas levels, temperature, and humidity on their mobile devices and receive alerts in case of any emergency.

5. Implementation & Testing

5.1 Code Snippets

Below are the important code snippets used for implementing the Smart LPG Gas Detection System:

5.1.1 Sensor Initialization

cpp

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```cpp
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <DHT.h>

#define MQ6_PIN 34
#define DHTPIN 27
#define DHTTYPE DHT11

DHT dht(DHTPIN, DHTTYPE);
LiquidCrystal_I2C lcd(0x27, 16, 2);

void setup() {
  Serial.begin(115200);
  dht.begin();
  lcd.begin(16,2);
  lcd.backlight();
}
```

5.1.2 Gas Detection and Alert

cpp

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```cpp
int gasLevel = analogRead(MQ6_PIN);
if (gasLevel > threshold) {
  sendAlert();
  digitalWrite(buzzerPin, HIGH);
} else {
  digitalWrite(buzzerPin, LOW);
}
```

5.1.3 Sending SMS and Call via GSM (SIM800L)

```cpp
void sendAlert() {
  Serial2.println("AT+CMGF=1");
  delay(100);
  Serial2.println("AT+CMGS=\"+91XXXXXXXXXX\"");
  delay(100);
  Serial2.println("Gas Leak Detected! Take Immediate Action.");
  Serial2.write(26);

  delay(5000);

  Serial2.println("ATD+91XXXXXXXXXX;");
}
```

5.2 Test Cases

The Smart LPG Gas Detection System was tested under different conditions to verify its functionality and reliability. The major test cases and their outcomes are described below:

- **Test Case 1: Wi-Fi Connection Test**
  When the ESP32 was powered ON and Wi-Fi was available, the device successfully connected to the Wi-Fi network and the Blynk server. The expected output was achieved, and the test passed.
- **Test Case 2: Gas Sensor Normal Reading**
  Under normal air conditions with no gas leak, the gas sensor readings remained below the threshold level. No alert was triggered, as expected. The test passed.
- **Test Case 3: Gas Leak Detection and Alert Activation**
  A gas leak was simulated by bringing a gas source close to the sensor. The system successfully activated all alerts: the buzzer turned ON, an SMS was sent, a Blynk notification was triggered, and a Twilio phone call was made. The test passed.
- **Test Case 4: GSM SMS Sending Verification**
  During a simulated gas leak, the system sent an SMS alert to the registered mobile number. The SMS was received correctly, and the test passed.
- **Test Case 5: Twilio Call Verification**
  When a gas leak was simulated, the system made a phone call using Twilio to the registered phone number. The call was received successfully, confirming correct functionality. passed.

- **Test Case 6: DHT11 Sensor Reading Failure**
  To simulate a failure, the DHT11 sensor was disconnected. The system correctly displayed an error message "DHT Fail!" on the LCD screen, indicating sensor failure. The test passed.
- **Test Case 7: LCD Display Functionality**
  During normal operation, the LCD correctly displayed real-time gas levels, temperature, and humidity. The readings were updated properly, and the test passed.

Blynk Dashboard

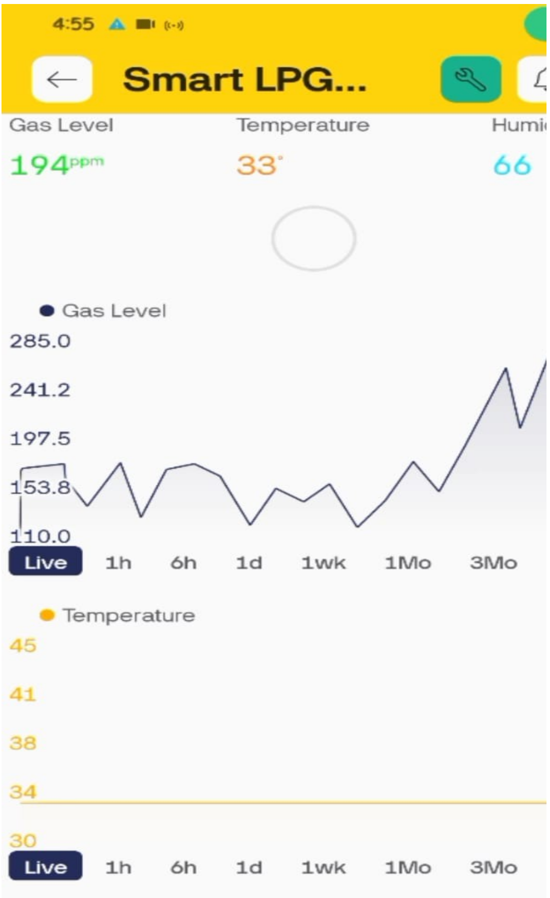

Fig 5.1: Blynk App Dashborad

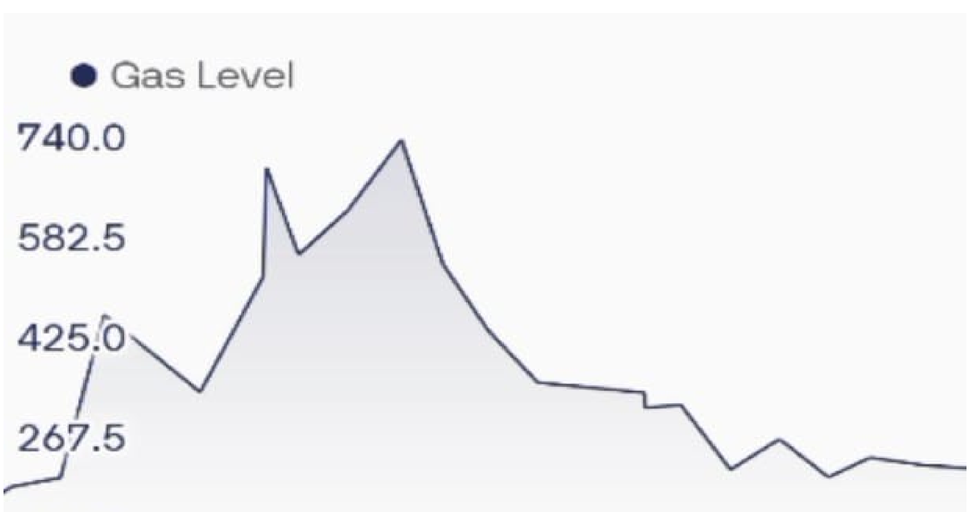

Figure5.2: Graphical Representation of Sensor Data

6. Conclusion & Future Scope

Conclusion:

The Smart LPG Gas Detection System is a comprehensive solution that effectively detects LPG leaks and provides real-time alerts via SMS, phone calls, and Blynk app notifications. The integration of sensors, a GSM module, and IoT capabilities ensures that users are always informed, preventing potential hazards. The system also features temperature and humidity monitoring, making it a robust solution for environmental control. Through the use of low-cost and widely available components, this project presents a practical approach to ensuring safety in homes, industries, and commercial spaces.

Future Scope:

In the future, several enhancements can be made to the Smart LPG Gas Detection System to increase its efficiency and functionality. Some of these potential improvements include:

- Relay Module Integration: By adding a relay module, the system could automatically turn off the solenoid valve in case of a gas leak, ensuring that the gas supply is stopped immediately, preventing further risks.
- Cloud Data Storage: Real-time data, such as gas levels, temperature, and humidity, could be stored on the cloud for long-term analysis and reporting, allowing users to track trends and receive historical data.
- Machine Learning: By implementing machine learning algorithms, the system could predict potential gas leaks based on sensor patterns, enhancing proactive safety measures.
- Mobile App Enhancement: The mobile app interface could be improved with push notifications, event history, and system diagnostics, offering users a more interactive and informative experience.
- Solar Power Integration: Incorporating a solar power backup could make the system more sustainable, ensuring that it operates even in power outages, especially in remote areas.

These additions could further enhance the system's reliability and safety, making it a more complete and self-sufficient solution for gas leak detection and monitoring.

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APPENDIX(SOURCE CODE)

```
// --- Define Blynk Settings ---
#define BLYNK_TEMPLATE_ID "TMPL3XgGLFaR1"
#define BLYNK_TEMPLATE_NAME "Smart LPG Detection"

#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <DHT.h>
#include <WiFi.h>
#include <BlynkSimpleEsp32.h>
#include <WiFiClientSecure.h>
#include <HTTPClient.h>

// --- WiFi and Blynk ---
char auth[] = "YYSyQhi4XFeOK9z2XwukvSgCegLL9gKz";
char ssid[] = "Sri Harsha Boys 1floor";
char pass[] = "Harsha111";

// --- Twilio Settings ---
const char* twilio_account_sid = "ACddb7d9bb107dc76efddb1570c068936f";
const char* twilio_auth_token  = "4bfabfc8937dc95a1ad875bc451e47cc";
const char* twilio_from_number = "+18646190993"; // Your Twilio number
const char* twilio_to_number   = "+919346673991"; // Your phone number
const char* twilio_voice_url   = "http://demo.twilio.com/docs/voice.xml";

// --- Define Pins ---
#define DHTPIN 13
#define DHTTYPE DHT11
#define GAS_SENSOR_PIN 34
#define BUZZER 14
#define MODEM_TX 17
#define MODEM_RX 16
```

```
// --- Initialize Objects ---
DHT dht(DHTPIN, DHTTYPE);
LiquidCrystal_I2C lcd(0x27, 16, 2);
HardwareSerial gsmSerial(1); // UART1 for GSM

// --- Variables ---
const int GAS_THRESHOLD = 2000; // Adjust if needed
bool alertSent = false;

void setup() {
  // --- Serial Communications ---
  Serial.begin(115200);
  gsmSerial.begin(9600, SERIAL_8N1, MODEM_RX, MODEM_TX);

  // --- Initialize LCD and Sensors ---
  lcd.init();
  lcd.backlight();
  dht.begin();
  pinMode(BUZZER, OUTPUT);
  pinMode(GAS_SENSOR_PIN, INPUT);

  // --- WiFi Connection ---
  WiFi.begin(ssid, pass);
  lcd.setCursor(0, 0);
  lcd.print("Connecting WiFi");

  int attempts = 0;
  while (WiFi.status() != WL_CONNECTED && attempts < 20) {
    delay(500);
    Serial.print(".");
    attempts++;
  }

  if (WiFi.status() == WL_CONNECTED) {
    lcd.clear();
```

```
  lcd.setCursor(0, 0);
  lcd.print("WiFi Connected");
  Blynk.begin(auth, ssid, pass);
  delay(2000);
} else {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("WiFi Failed");
  lcd.setCursor(0, 1);
  lcd.print("Check Hotspot!");
  Serial.println("WiFi Connection Failed");
  delay(5000);
}

// --- Check GSM Module ---
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Checking SIM...");
if (checkGSMRegistration()) {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("SIM Ready ✅");
} else {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("SIM Failed");
  lcd.setCursor(0, 1);
  lcd.print("Check SIM Card!");
}
delay(3000);

// --- Welcome Message ---
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("WELCOME TO");
```

```
  lcd.setCursor(0, 1);
  lcd.print("SMART LPG DETECT");
  delay(3000);
  lcd.clear();
}

void loop() {
  Blynk.run();

  int gasLevel = analogRead(GAS_SENSOR_PIN);
  float temp = dht.readTemperature();
  float hum = dht.readHumidity();

  if (isnan(temp) || isnan(hum)) {
    lcd.setCursor(0, 0);
    lcd.print("DHT Fail!");
    lcd.setCursor(0, 1);
    lcd.print("Check Sensor");
    delay(2000);
    return;
  }

  // --- Update Blynk ---
  Blynk.virtualWrite(V0, gasLevel);
  Blynk.virtualWrite(V1, temp);
  Blynk.virtualWrite(V2, hum);

  // --- Print to Serial ---
  Serial.print("Gas: ");
  Serial.print(gasLevel);
  Serial.print(" | Temp: ");
  Serial.print(temp);
  Serial.print("C | Hum: ");
  Serial.print(hum);
  Serial.println("%");
```

```
// --- Show on LCD ---
lcd.setCursor(0, 0);
lcd.print("Gas:");
lcd.print(gasLevel);
lcd.print(" T:");
lcd.print((int)temp);
lcd.print(" ");

lcd.setCursor(0, 1);
lcd.print("Hum:");
lcd.print((int)hum);
lcd.print("%   ");

// --- Gas Leak Detected ---
if (gasLevel > GAS_THRESHOLD && !alertSent) {
  sendSMSAlert();    // GSM SMS
  makeTwilioCall();  // Twilio Voice Call
  Blynk.logEvent("gas_leak", "Gas Leak Detected!");
  alertSent = true;

  digitalWrite(BUZZER, HIGH);
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("!!Gas Leak Det!!");
  lcd.setCursor(0, 1);
  lcd.print("SMS+Call+Blynk ");
  delay(15000);
  digitalWrite(BUZZER, LOW);
}
else if (gasLevel <= GAS_THRESHOLD) {
  alertSent = false;
}

delay(1000);
```

```
}

// --- Send SMS using GSM ---
void sendSMSAlert() {
  gsmSerial.println("AT+CMGF=1");
  delay(500);
  gsmSerial.println("AT+CMGS=\"+919398852259\"");
  delay(500);
  gsmSerial.println("ALERT: Gas Leak Detected! Please check!");
  gsmSerial.write(26); // CTRL+Z
  delay(3000);
}

// --- Make a Voice Call via Twilio ---
void makeTwilioCall() {
  if (WiFi.status() == WL_CONNECTED) {
    HTTPClient http;
    WiFiClientSecure client;
    client.setInsecure();

    String url = "https://api.twilio.com/2010-04-01/Accounts/" + String(twilio_account_sid) +
"/Calls.json";
    String data = "Url=" + String(twilio_voice_url) +
                  "&To=" + urlencode(twilio_to_number) +
                  "&From=" + urlencode(twilio_from_number);

    http.begin(client, url);
    http.setAuthorization(twilio_account_sid, twilio_auth_token);
    http.addHeader("Content-Type", "application/x-www-form-urlencoded");

    int httpResponseCode = http.POST(data);

    if (httpResponseCode > 0) {
      String response = http.getString();
      Serial.println("Twilio Response: ");
```

```
    Serial.println(response);
   } else {
    Serial.print("Error in Twilio Call: ");
    Serial.println(httpResponseCode);
   }
   http.end();
  } else {
   Serial.println("WiFi not connected - Cannot make Twilio call");
  }
}

// --- Check GSM Network Registration ---
bool checkGSMRegistration() {
  gsmSerial.println("AT+CREG?");
  delay(500);
  String response = "";

  while (gsmSerial.available()) {
   response += char(gsmSerial.read());
  }

  Serial.println(response);

  return (response.indexOf("+CREG: 0,1") >= 0 || response.indexOf("+CREG: 0,5") >= 0);
}

// --- URL Encode Helper Function ---
String urlencode(const char* str) {
  String encoded = "";
  char c;
  while ((c = *str++)) {
   if (isalnum(c)) {
    encoded += c;
   } else {
    encoded += '%';
```

```
      char buf[3];
      sprintf(buf, "%02X", c);
      encoded += buf;
    }
  }
  return encoded;
}
```