IOT BASED MANHOLE-MONITORING-SYSTEM

ABSTRACT

This project focuses on the development of an IoT-based manhole monitoring system designed to enhance urban safety and prevent hazardous incidents. Utilizing a NodeMCU CP2102 microcontroller, the system integrates several key sensors, including a BMP180 pressure sensor and a DHT11 temperature sensor, to monitor environmental conditions within manholes. The hardware setup is constructed on a long breadboard, with the components connected using 10 male-to-male and 10 male-to-female connectors, along with a B-type USB data cable for power and data transmission.The primary objective is to detect abnormal changes in pressure and temperature, which may indicate blockages, gas leaks, or other dangerous conditions. Data collected from the sensors is transmitted in real-time to the ThingSpeak platform, an IoT analytics service, where it is stored, processed, and visualized. Alerts are generated and sent to a connected smartphone when the system identifies readings that deviate from predefined safety thresholds. This proactive monitoring approach allows for prompt maintenance and timely interventions, reducing the risk of accidents and improving public safety.The integration of ThingSpeak not only facilitates remote monitoring but also provides a robust mechanism for data logging and analysis, enabling long-term trend analysis and predictive maintenance. The use of widely available and cost-effective components ensures that the system is affordable and scalable, making it suitable for deployment in urban areas with extensive underground infrastructure. This IoT-based solution offers a scalable, cost-effective, and efficient method for urban infrastructure management. It enhances safety, reduces maintenance costs, and ensures the seamless operation of urban drainage systems. Future enhancements could include integrating more advanced sensors, implementing machine learning algorithms for predictive maintenance, and expanding the system to monitor other critical urban infrastructure elements.This project demonstrates the potential of IoT technologies to revolutionize infrastructure monitoring, offering a practical solution to the challenges of urban safety management.

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CHAPTER 1

INTRODUCTION

1.1 Background and Motivation

Manholes are critical components of urban infrastructure, providing access to underground utilities and services. However, they can pose significant risks if not properly monitored, including potential hazards from gas leaks, fires, and structural failures. Traditional inspection methods are often inadequate due to the inaccessibility and hazardous environment inside manholes. With the advancement of IoT (Internet of Things) technology, there is an opportunity to develop a real-time monitoring system that can enhance safety, prevent accidents, and optimize infrastructure management.

1.2 Objectives

The primary objective of this project is to design and implement an IoT-based manhole monitoring system that utilizes various sensors to collect environmental data and transmit it to a cloud platform for real-time monitoring and analysis. The specific objectives are:To monitor atmospheric pressure, temperature, gas levels, and smoke within manholes. ,To provide real-time data visualization and alerting through the ThingSpeak platform.,To improve safety and operational efficiency in urban infrastructure

1.3 purpose

The purpose of this design is to track the drainage system using the sensor. When the sewage system is obstructed, water overflows, or the drainage lid is removed, sensors monitor the drainage and send the data to a nearby municipal corporation official via integrated Wi-Fi, where the water overflow and gas value are presented live in the cloud for later examination. The Blynk Server also provides the drainage's GPS location. The sewage system exhibits instability and uncertainty due to multivariable, nonlinear, temporal variation, and random treatment processes. This model's purpose is to create a low-cost, customizable solution for detecting obstructions and stinky or foul-smelling gases.An integral part of any drainage system is the access points into it when it comes to cleaning, clearing, and inspection. Metropolitan cities have adopted underground drainage system and the city's municipal corporation must maintain its cleanliness.

1.4 motive

The primary motive of this project is to design and implement an IoT-based manhole monitoring system that utilizes various sensors to collect environmental data and transmit it to a cloud platform for real-time monitoring and analysis, Monitoring and controlling the city utilities, resources and the services using the new monitoring technologies is a strategy named "Smart City". To clear this point, smart city can be defined as mentioned " Smart City is a city which functions in a sustainable and intelligent way, by integrating all its infrastructures and services into a cohesive whole and using intelligent devices for monitoring and control, to ensure sustainability and efficiency". Generally, monitoring utilities have two types: automatic and manual. Automatic type means that no human effort has to be done to monitor these utilities; however, the monitoring system is designed to send the data via wireless or wired systems. The other type is manual monitoring, which is based on a human effort to go to the utility location for monitoring regardless of the technologies used to monitor. Automated monitoring systems cost less and are very fast in comparison to the manual ones. However, they are still in the early stages because of several challenges. It is noteworthy that monitoring systems based on IoT cloud which is used for Smart city applications are called nowadays "IoT device". The IoT device for monitoring MC normally needs to be placed beneath the MC to prevent any harm to pedestrians or the traffic and is connected to the base station then to the cloud. Information is then transferred to the organisation that is concerned about the manhole cover and the utilities under .

CHAPTER 2

LITERATURE SURVEY

2.1 Interfaces from Literature Survey

In 2012 ,The design space of wireless sensor networks, Wireless Communications, Author: Romer, K. Mattern , In the recent past, wireless sensor networks have found their way into a wide variety of applications and systems with vastly varying requirements and characteristics.As a consequence, it is becoming increasingly difficult to discuss typical requirements regarding hardware issues and software support. This is particularly problematic in a multidisciplinary research area such as wireless sensor networks, where close collaboration between users, application domain experts, hardware designers, and software developers is needed to implement efficient systems. In this paper we discuss the consequences of this fact with regard to the design space of wireless sensor networks by considering its various dimensions. We justify our view by demonstrating that specific existing applications occupy different points in the design space.

In the year 2011 ,Towards the Implementation of IoT for Environmental Condition Monitoring in Home, Author: Kelly S.D.T, Suryadevara, N.K, Mukhopadhyay S.C ,In this paper, we have reported an effective implementation for Internet of Things used for monitoring regular domestic conditions by means of low cost ubiquitous sensing system. The description about the integrated network architecture and the interconnecting mechanisms for reliable measurement of parameters by smart sensors and transmission of data via internet is being presented. The longitudinal learning system was able to provide self-control mechanism for better operations of the devices in monitoring stage. The framework of the monitoring system is based on combination of pervasive distributed sensing units, information system for data aggregation, reasoning and context awareness. Results are encouraging as the reliability of sensing information transmission through the proposed integrated network architecture is 97%. The prototype was tested to generate realtime graphical information rather than a test bed scenario 11

In the year 2013,Monitoring Smart City Applications using Raspberry PI Based on IoT, Authors: Prof. S A.Shaikh 1, Suvarna A. Sonawane, the Smart city is the development goal to monitor the quality of resource in the city to improve good management and faster development of the city required necessity is to upgrade healthy and safe cities that delivering real time services and latest facility to implement the concept of smart city use IoT concept by which easy wireless communication is possible. The system consist of sensors, collect different types of data from sensors and transfer to the Raspberry Pi3 controller. The acquired output from the controller is sent to the control room through the E- mail and also display on the personal computer.

In the year 2015 ,Manhole Detection and Monitoring System Using IOT, Authors:Mr.ManeHarshavardhan,Mr.Nimbaler, ChougulePushpraj Babaso , Mr.Ghatage Abhishek Dundappa, Ms.Saundatte M .G Manhole detection and monitoring system using IOT it is a very useful system to all of us by this we detect manhole condition in this system. We used the different components like water flow sensor ,gas sensor , temperature and humidity sensor . This project overcome the demerit of paper by detecting drainage water flow speed rate by installing water flow rate sensor at the intersection of nodes when there is a blockage in a particular road there is variation in the flow of drainage in water which when across the seat value will display the alerts in the managing station by the system. we protect the health of municipality working staff. In this system we use different components this components is very high output and input components and very efficiency component buy this components and this system we detect any problem occur in manhole without any man.In our manhole detection and monitoring system project we have detect the flow of water, toxic gases, sense the humidity and temperature in the manhole and they send the IOT message to municipal corporation. In this system we have also reduce the work of man power and easy to handle situation.In previous system man had to go inside the drainage system and clean the garbage but in the new system the work has been made easier and safe by reducing those things.

In the year 2009, Manhole cover monitoring system over IOT,Authors:Wesam Moneer Rasheed,Raed Abdull, Development of smart cities and implementation of automated manhole covers has gained much importance in previous years. A number of incidents occur regarding the safety and security of people due to the 12 issues of manhole cover (MC). Uncovered holes pose a great challenge to citizens and can cause safety hazards to underground structures. To prevent accidents from manhole-cover an intelligent manhole cover management system has been introduced as a basic platform in smart cities.Developing cities usually do not focus on opened manhole covers and are not monitored properly. These manholes can be a great threat to lives and assets in a number of ways. Manholes can be filled with some toxic and hazardous materials and underground structures can get affected from these materials. Systems need to be developed to monitor the lids of manhole covers to avoid accidents. Developments are made to replace traditional and manual methods with IoT based automated monitoring systems .The issue of poorly managed and stolen gas well covers is becoming an alarming situation in different countries. The existing manhole cover systems are found to be covering single monitoring parameters, have immature technology and contain inefficient analysis capabilities to find and eradicate issues regarding manhole covers and security.

In the year 2008,Manhole explosion and its root causes,Author:Glen Bertini .The phrase “manhole events” is a euphemism for fires and explosions that occur in utility manholesin urban areas. All fires and explosions require three elements: fuel, oxygen (or another oxidizer), and an ignition source. Further, the fuel and oxygen must be within a specified range of concentrations to support combustion. Figure1 lists most of the significant compounds (flammable or not) that are likely to be encountered in a manhole environment and, where applicable, their upper and lower explosive limits (UELs and LELs, respectively).

In the year 2015, Secure Manhole Monitoring system Employing sensor and GSM Techniques, Author: N Nataraja; R Amruthavarshini; N L Chaitra; K Jyothi; N Krupaa; S S M Saqquaf . Nowadays manhole problems in the populated cities is the major issues. Opening of manholes due to breakage of manhole cover, manhole explosions are major threat in recent days. Manhole cover opening leads to accidental fall of vehicles, pedestrians leading to accidents or loss of life. Manhole 14 opening detection and alerting is mainly based on detecting the manholes which are opened due to overflow of sewage / rain water during heavy rainfall and alerting When a manhole opening is detected either due to overflow of sewage water, increase in pressure or temperature, it leads to the breakage of the manhole lids. To avoid such incidents even before it could affect the public, an alerting system is built wherein the buzzer alerts the surrounding and sends the sensed data to the managing authorities using GSM techniques.So, they can take precautionary action to close the manhole considering public safety. In 2016 Sugato Ghosh; Indranil Das; Deepanjana Adak; Nillohit Mukherjee; Raghunath Bhattacharyya worked on "Development of selective and sensitive gas sensors for manhole gas detection".worked on Loss of life of the workers inside manhole is a common problem for many parts of the world. To resolve this issue a portable, low cost, simple manhole gas detection unithas been designed and developed which is capable to detect the poisonous gases like carbon monoxide, hydrogen sulfide, and explosive gas like methane within a minute and raise alarm if the concentration of any gas is beyond the threshold limit.

In the year 2006, Development and Test of Manhole Cover Monitoring Device Using LoRa and Accelerometer. Authors: He-sheng Zhang; Lei Li; Xuan Liu,The monitoring device is installed under the manhole cover, three key problems, how to 13 measure the tilt angle or state of resources °. For the second problem, long range (LoRa) is adopted. A 433-MHz whip antenna is designed to overcome the shield of manhole cover and the absorption of electromagnetic waves of the earth. The field tests show that the effective communication distance has been extended more than 700 m by using the whip antenna. In addition, the parameter spreading factor (SF) and bandwidth (BW) are configured. For the third problem, sleep mode is used and input output (IO) pin is configured.

CHAPTER 3

SYSTEM COMPONENTS

3.1 NodeMCU CP2102

Description: The NodeMCU CP2102 is an open-source development board based on the ESP8266 microcontroller, which includes built-in Wi-Fi capabilities. It facilitates easy programming and connectivity to the internet via a USB-to-UART bridge.

Role in the Project: Acts as the central controller for the IoT system, processing sensor data and transmitting it to the ThingSpeak platform.

Fig - 3.1 NodeMCU

3.2 BMP180 Pressure Sensor

Description: The BMP180 is a high-precision barometric pressure sensor with an I2C interface. It measures atmospheric pressure and can be used to infer altitude changes.

Role in the Project: Monitors pressure changes within the manhole, which can indicate potential flooding or structural issues.

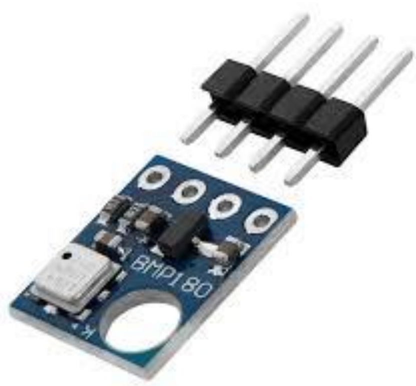

Fig - 3.2 BMP180

3.3 DHT11 Temperature Sensor

Description: The DHT11 sensor measures temperature and humidity with a digital output. It provides basic environmental data with moderate accuracy.

Role in the Project: Measures temperature and humidity inside the manhole, helping to detect unusual temperature fluctuations that could indicate problems.

Fig - 3.3 DHT11

3.4 MQ-7 Gas Sensor

Description: The MQ-7 sensor is designed to detect carbon monoxide (CO) levels. It provides an analog output that varies with CO concentration.

Role in the Project: Monitors CO levels to detect potentially dangerous gas leaks that could pose health risks or lead to explosions

Fig- 3.4 MQ-7

3.5 MQ-3 Smoke Sensor

Description: The MQ-3 sensor detects smoke and other combustion gases. It provides an analog output that varies with the concentration of smoke.

Role in the Project: Detects smoke levels within the manhole, helping to identify fire hazards or other combustion-related issues.

fig -3.5 MQ-3

CHAPTER 4

System Design and Architecture

4.1 Circuit Design

Components: NodeMCU CP2102, BMP180, DHT11, MQ-7, MQ-3, breadboard, connectors, and USB **data cable.**

Connections: The sensors are connected to the NodeMCU through the breadboard using male-to-male and male-to-female connectors. The BMP180 connects via I2C, while the DHT11, MQ-7, and MQ-3 connect to GPIO pins.

4.2 Data Collection and Transmission

Data Acquisition: Each sensor collects specific environmental data (pressure, temperature, CO, smoke). The NodeMCU reads this data and processes it.

Data Transmission: The NodeMCU transmits the collected data to the ThingSpeak platform via Wi-Fi. Data is sent using HTTP requests or MQTT protocol.

Fig -4.2 Data Collection and Transmission

4.3 Data Visualization and Alerts

ThingSpeak Integration: Data is visualized on the ThingSpeak dashboard, where users can view real-time graphs and charts.

Alerts: Alerts are configured based on predefined thresholds for pressure, temperature, gas, and smoke levels. Automated notifications can be sent when conditions exceeds

CHAPTER 5

IMPLEMENTATION

5.1 Hardware Setup

Assemble the components on the breadboard, ensuring correct connections between sensors and the NodeMCU. Verify the circuit design and ensure stable connections.

5.2 Software Development

Programming: Write and upload code to the NodeMCU using the Arduino IDE. Include libraries for each sensor and configure the ThingSpeak API for data transmission.

Configuration: Set up ThingSpeak channels and fields to receive and visualize data. Configure alert thresholds and notifications.

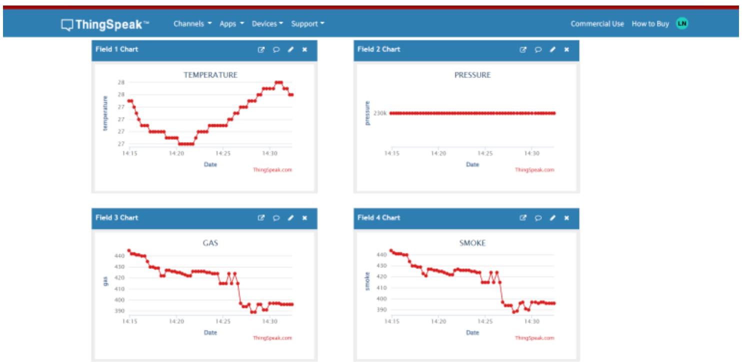

Fig- 5.1 output

5.3 Testing and Validation

Conduct tests to ensure that each sensor functions correctly and provides accurate data. Simulate different conditions to verify that the system responds appropriately and sends alerts as needed.

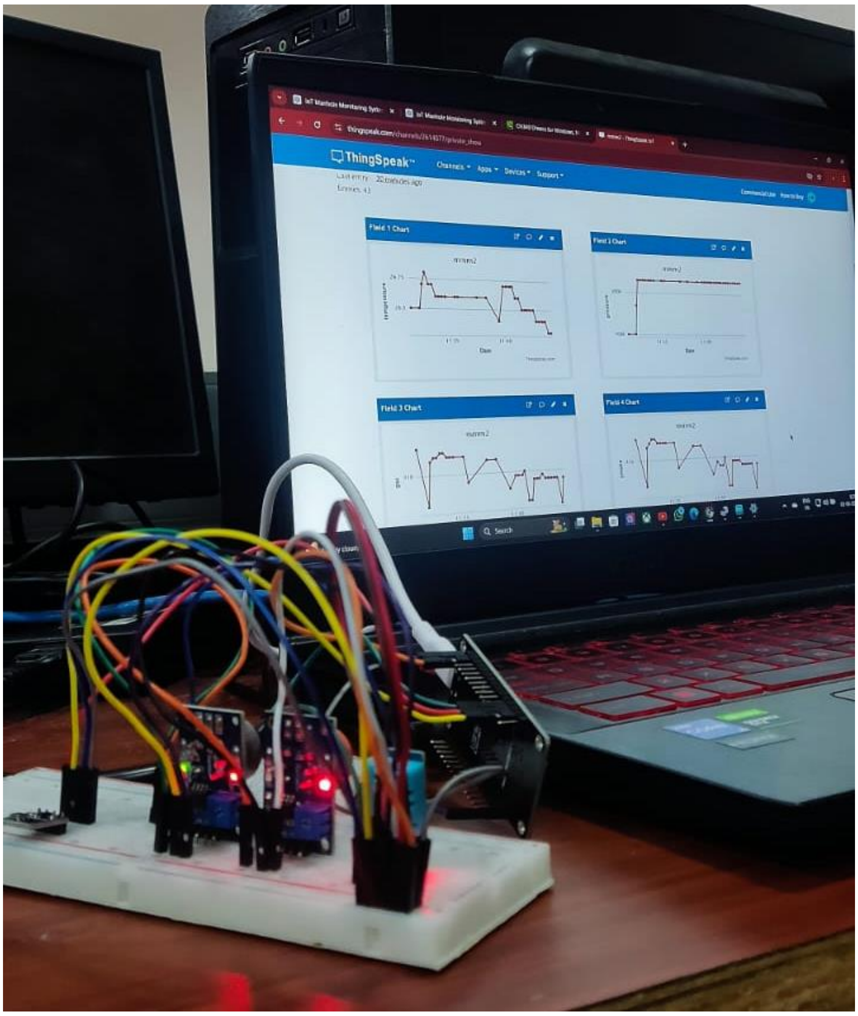

Fig- 5.2 Testing and Validation

CHAPTER 6

RESULT AND ANALYSIS

6.1 Data Analysis

Visualization: Analyze the data visualizations on the ThingSpeak dashboard to assess sensor performance and system reliability. In this system we used a different sensor, if any problem occurs in band holder centuries since this problem and send the information to the microcontroller and Microcontroller is given information and by Wi-Fi module this is for information said to the authorized person.

Alerts and Notifications: Review the effectiveness of the alert system in detecting and responding to abnormal conditions. through Alert and the officials could easily locate which manhole is having the problem and could take appropriate steps. Also, Arduino Mega updates the live values of all the sensors.We have included an array of sensors for complete monitoring of the manhole cover so that such accidents can be prevented.This project includes a gas cover to monitor the gas emitted from the sewage systems so that toxicity can be monitored.

6.2 Performance Evaluation

• Evaluate the system’s ability to monitor manhole conditions effectively, including the accuracy of sensors and the reliability of data transmission and alerting, In our project we have overcome these drawbacks in both existing systems. We are creating an edge network instead of the internet. We have constructed the manhole detection system through attaching an array of sensors like tilt sensor, Gas sensor, Float sensor, etc. and also attach an esp8266 with this 19 system. We have programmed this esp8266 as an access point which provides its own network without the internet. If the user is present in this area, the manhole detection system automatically sends the sensor's data to the user via web or mobile application alert messages without internet. The following are some of the key advantages of the proposed method: In this proposed method, there is no need to spend money on the internet. Whole system is working like a local network by edge computing.

CHAPTER 7

FUTURE WORK

7.1 System Enhancements

Explore the addition of additional sensors, such as water level sensors, to expand the system's capabilities.

Develop a mobile application for real-time monitoring and alert notifications**.**

7.2 Integration and Scaling

Consider integrating the system with other smart city infrastructure and IoT networks for broader application and data sharing.

Scale the system for deployment across multiple manholes and urban areas. Full implementation of the system and attaching it to manhole cover with testing is one of the main future work targets . The effect of the opamps internal circuit with different technologies and design on the proposed systems opens a new route for more improvement of the system, especially from the power consumption point of view. Studying the same design concept in radio frequency range to reduce the power consumption of the communication module for the IoT device design.Using diodes in the coupling of the proposed systems will be studied to investigate their effects on the performance of the proposed systems. This point is very attractive which gives the proposed system the richness to design secured DAQ module with two or more different chaotic sequence with low-power consumption. Furthermore, this type of connection is very suitable for the FPAA design, which is based on a switching capacitor design concept.

CHAPTER 8

CONCLUTION

The IoT-based manhole monitoring system effectively enhances safety, maintenance, and environmental protection by providing real-time data on critical parameters within manholes. The integration of NodeMCU CP2102 with various sensors and ThingSpeak offers a cost-effective, scalable solution for urban infrastructure management. The system demonstrates significant potential for improving public safety and operational efficiency in monitoring and maintaining manhole infrastructure.

The main aim in this research is to investigate and design a low-power IoT - based manhole cover monitoring system to be used for smart city applications taking into consideration the IoT device design requirements and challenges. To reach this aim and based on investigation done by this research, compressive sensing was studied as it was proved from other applications its ability to reduce the power consumption for IoT device by reducing the sampling rate of the used ADC. As a first step in this research, MC types and issues have been investigated deeply.

Based on this investigation, a new detailed classification of manhole cover issues with the current monitoring systems is proposed. This classification presents good guidance for the modern governments to identify the main requirements to improve the safety and the security for their societies. Also, this classification gives a new vision for the researchers who work in the smart city's underground and road monitoring applications. It was concluded from this classification and investigation that analogue to digital converter found in DAQ module is the main source for consuming power for the MC automated monitoring system. In this research, a low power automated MC monitoring system with IoT device design requirements was the target to be suitable for Smart City's application. Compressive sensing framework proved in several applications its ability to reduce the power consumption for monitoring systems by using low sampling rate ADC. The CS based ADC is named analogue to information converter (AIC).

The AIC has become more attractive to the IoT device designers because the heart of the AIC is a pseudorandom number generator (PRNG) which can be used for the data security.However, most of the current PRNG circuit found in the AIC circuit design is implemented by digital circuit which has drawbacks which are: a) power consumption,

b) using the digital PRNG at AIC analogue frontend mainly required isolation between the analogue part and the digital part by using separate power supplies and separate grounds.

The present research focused on using an analogue PRNG to overcome the digital PRNG issues for AIC. 49 In this research, two analogue chaotic oscillators are proposed by using one of the main blocks of the FPAA (FPAA proved its ability to implement CS signal reconstruction algorithms with low-power consumption) which is the opamp Schmitt trigger. The heart of the two proposed systems is two new modifications of the opamp Schmitt trigger to mimic biological oscillators. The proposed systems are based on coupling oscillators, which are inspired by the neuroscience field. While this research is not the first research which studies the coupling oscillator, but it is the first that introduces the waveshaping technique to design coupling chaotic oscillator without the need of using differential equations for modelling. This point opens a new route for designing chaotic oscillators based on relaxation oscillators.Furthermore, the proposed systems can both be implemented on the same PCB using only 2 opamps with switches to act as selectors for the RC coupling network and the connected nodes. This point is very attractive which gives the proposed system the richness to design secured DAQ module with two or more different chaotic sequence with low-power consumption. Furthermore, this type of connection is very suitable for the FPAA design, which is based on a switching capacitor design concept.

CHAPTER 9

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APPENDIX

SOURCE CODE:

```
#include <ThingSpeak.h>

#include <Wire.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_BMP085_U.h>
#include "DHT.h"
#include <ESP8266WiFi.h>
#include "ThingSpeak.h"

#define DHTPIN D3
#define DHTTYPE DHT11

DHT dht(DHTPIN, DHTTYPE);
Adafruit_BMP085_Unified bmp = Adafruit_BMP085_Unified(10085);

// WiFi credentials
const char* ssid = "A70";
const char* password = "hppy6602";

// ThingSpeak settings
const char* server = "api.thingspeak.com";
unsigned long myChannelNumber =2641342;
const char* myWriteAPIKey = "DC8Z22LNQMPGZWGX";

// Sensor pins
#define MQ7_PIN A0
#define MQ3_PIN A0 // Change to another pin if using a multiplexer

WiFiClient client;
```

```
void setup() {
  Serial.begin(115200);
  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println("Connecting to WiFi...");
  }

  Serial.println("Connected to WiFi");

  ThingSpeak.begin(client);

  dht.begin();
  if (!bmp.begin()) {
    Serial.print("Could not find a valid BMP085 sensor, check wiring!");
    while (1);
  }
}

void loop() {
  float temperature = dht.readTemperature();
  float pressure;
  bmp.getPressure(&pressure);

  int mq7_value = analogRead(MQ7_PIN);
  int mq3_value = analogRead(MQ3_PIN);

  Serial.print("Temperature: ");
  Serial.print(temperature);
  Serial.print(" °C, Pressure: ");
  Serial.print(pressure);
```

```
  Serial.print(" Pa, MQ-7: ");
  Serial.print(mq7_value);
  Serial.print(", MQ-3: ");
  Serial.println(mq3_value);

  ThingSpeak.setField(1, temperature);
  ThingSpeak.setField(2, pressure);
  ThingSpeak.setField(3, mq7_value);
  ThingSpeak.setField(4, mq3_value);
  if (temperature > 26 || pressure > 101325) { // Example thresholds
    Serial.println("ALERT! Abnormal conditions detected.");
  }

  ThingSpeak.writeFields(myChannelNumber, myWriteAPIKey);

  delay(2000); // Wait 20 seconds to update again
}
```