BACHELOR OF SCIENCE IN ELECTRONIC AND TELECOMMUNICATION ENGINEERING

Design and Implementation of an IoT Based Indoor Air Quality Monitoring System

by

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CERTIFICATE OF APPROVAL

A project entitled " **Design and Implementation of an IoT Based Indoor Air Quality Monitoring System**" is presented by **Md. Didarul AlamToshif**, bearing Matric ID. **T163023**, **Mahmudul Hasan**, bearing Matric ID. **T163009** session of **Spring 2020**, to the Department of Electrical &Telecommunication Engineering (ETE), International Islamic University Chittagong (IIUC). In partial fulfillment of the criteria for the degree of Bachelor of Science in Engineering, it was approved as satisfactory and accepted for the review conducted on the 30th December 2020.

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DECLARATION

It is hereby declared that this work has been done by us and no portion of the work contained in this project has been submitted elsewhere for the award of any degree or diploma.

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Name

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Name

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The most generous and the most merciful, in the name of Almighty. First of all, we are grateful to Almighty, who has given us the power and wisdom to think. We thank our family for their love, their moral and financial support they had given us. This helped us a lot. We would like to give our gratitude to our honorable supervisor Engr. Abdul Gafur, Associat Professor, Dept. of ETE, IIUC who has given us significant suggestions and inspections during the whole process of the work. His invaluable help of constructive comments and suggestions throughout the experiment and project work has contributed to the success of this project. Last but not least we are grateful to our teachers, friends, classmates, seniors, and lab Assistants, who have given us their unlimited support and help in every aspect. We are fortunate to have a nice human being like them beside us.

Authors

ABSTRACT

Smart cities follow different strategies to face public health challenges associated with socio-economic objectives. Buildings play a crucial role in smart cities and are closely related to people’s health. Moreover, they are equally essential to meet sustainable objectives. People spend most of their time indoors. Therefore, indoor air quality has a critical impact on health and well-being. With the increasing population of elders, ambient-assisted living systems are required to promote occupational health and well-being. Furthermore, living environments must incorporate monitoring systems to detect unfavorable indoor quality scenarios in useful time. This paper reviews the current state of the art on indoor air quality monitoring systems based on Internet of Things and wireless sensor networks in the last five years (2014–2019). This document focuses on the architecture, microcontrollers, connectivity, and sensors used by these systems. The main contribution is to synthesize the existing body of knowledge and identify common threads and gaps that open up new significant and challenging future research directions.Air quality monitoring provides raw measurement of gases and pollutant concentrations, which can then be analyzed and interpreted. Air pollution is a concern in many urban areas and be the major reason for respiratory problems among many people, monitoring the air quality may help many distress from respiratory problems and diseases, and thereafter informing engineering and policy decision makers to recover the quality of air. Major contributor’s air causing respiratory problems are Fine particles produced by the burning of fossil fuel, noxious gases, Ground-level ozone g), Volatile organic compounds. A prototype for air pollution monitoring device has been developed to measure the concentration of CO2 and gases, monitoring at a specified rate and communicating, to notify to any wireless device when the threshold of these gases is reached. Though the prototype can be extended across regions for high-fidelity emissions monitoring to explore the effects of environmental factors on intra-hour air quality.

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List of Abbreviation

LPG: Liquefied Petroleum Gas

SDG: Sustainable Development Goals

UN: United Nations

AQI: Air Quality Index

AQHI: Air Quality Health Index

GPRS: General Packet Radio Services

GUI: Graphical User Interface

GPIO: General-Purpose input/output

PCB: Printed circuit board

HTML: Hypertext Markup Language

PHP: Personal Home Page

API: Application Programming Interface

HTTP: Hypertext Transfer Protocol

PPM: Parts Per Million

CHAPTER 1

INTRODUCTION

Atmospheric conditions continue to deteriorate each year due to the growth of civilization and increasing unclean emissions from industries and automobiles. Although air is an indispensable resource for life, many people are indifferent to the severity of air pollution or have only recently recognized the problem . Among various types of pollutants such as water, soil, thermal, and noise, air pollution is the most dangerous and severe, causing climate change and life-threatening diseases. According to the World Health Organization (WHO), 90 percent of the population now breathes polluted air, and air pollution is the cause of death for 7 million people every year . The health effects of pollution are very severe that causes stroke, lung cancer, and heart disease. Furthermore, air pollutants have a negative impact on humans and the earth's ecosystem, as observed in recent global air pollution problems like ozone depletion. Therefore, air quality monitoring and management are main subjects of concern.

According to the United States Environmental Protection Agency (EPA), indoor air is 100 times more contaminated than outside air. Most modern populations spend 80 to 90 percent of their time indoors; therefore, indoor air has a greater direct impact on human health than outside air . Moreover, in contrast to atmospheric pollution, indoor pollutants are about 1000 times more likely to be transmitted to the lungs, causing diseases such as sick building syndrome, multiple chemical sensitivities, and dizziness. Indoor air quality management is very important, as it can prevent exposure through proactive precautionary measures. Therefore, efficient and effective monitoring of indoor air is necessary to properly manage air quality.

Four major gas sensors which are responsible for the most air pollution mostly is being used in the system to know the best result of the whole condition of the air. CO, Humidity are declared to be the most responsible for air pollution and in the system, all are used. Noise sensor is also added to measure the presence of noise in the environment. A server and an android application have been made to know the statistics because now days almost everyone has an android operating device and access to internet.

1.1Motivation

Not a single living thing can survive without air. Air is the most important element for living. According to the Sustainable Development Goals (SDG) by the United Nations (UN) there are seventeen goals to transform the world to clean, healthy and natural way to live in because at this time there are several problems in human life. The SDG says, ensure healthy lives and promote well-being for all at all ages; access to affordable, reliable, sustainable and modern energy for all; sustainable consumption and production patterns; take urgent action to combat climate change and its impacts; conserve and sustainably use the oceans, seas and marine resources, sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.
These are the main reason why the topic was chosen for the research purpose.

1.2Objective

There are few objectives that need to be achieved at the end of this project. The objectives of this project are:

- To design a low cost and portable air quality monitoring system using different types of gas sensors.
- To integrate the sensor, Arduino microcontroller and GSM module to form a complete monitoring system.
- To transmit and receive data via short message service (SMS) using GSM.

1.3Thesis Outline

- Chapter 1 includes introduction, motivation and thesis outline.
- Chapter 2 outlines the previous works done in the field of air pollution.
- Chapter 3 describes the methodology of the proposed model including the specific components and their description.
- Chapter 4 describes result and discussion.
- Chapter 5 concludes the paper stating the challenges were found and the future work of the project.

CHAPTER 2

LITERATURE REVIEW

Pollution is increasing in an alarming rate every day. Air is the most sensitive element of the environment which is polluted momentarily by the elements emitted to air. To know the level of air pollution and air quality this proposed system is a wireless sensor network that works mainly monitoring the pollution happening in a smart city. It is a low budget monitoring system with cheap but efficient sensors.

Some previous works like Smart environment monitoring system [1] on vehicles was introduced on 2015. It basically figured out the emission rate of poisonous gasses which are responsible for air pollution. Industrial air pollution [2] monitoring system for safety and health enhancement was introduced to know the hazardous gasses and their impact. Low cost air quality system [3] was discussed on 2008 as because at that time the sensors were quite expensive and also the system. By using mobile GPRS [4] system air pollution could be detected. Wireless sensor network-based pollution monitoring system in metropolitan cities was introduced to know the air quality [5]. Pollution Dynamic Monitoring System [6] is also done previously.

By reviewing the future researches which has done before we can say that air pollution has increased in an alarming rate. If it is not stopped immediately the whole world is going to face a filthy and extreme weather for the future. There are more pollutions e.g. water pollution, noise pollution, plastic pollution, soil contamination but from the future studies we can say that air pollution is the most alarming issue and this should be studied for the sake of saving the world.

According to World Health Organization: WHO, from smog hanging over cities to smoke inside the home, air pollution poses a major threat to health and climate. The combined effects of ambient (outdoor) and household air pollution cause about 7 million premature deaths every year, largely as a result of increased mortality from stroke, heart disease, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections. More than 80% of people living in urban areas that monitor air pollution are exposed to air quality levels that exceed the WHO guideline level of 10μg/m_3, with low- and middle-income countries suffering from the highest exposures.

The major outdoor pollution sources include vehicles, power generation, building heating systems, agriculture/waste incineration and industry. In addition, more than 3 billion people worldwide rely on polluting technologies and fuels (including biomass, coal and kerosene) for household cooking, heating and lighting, releasing smoke into the home and leaching pollutants outdoors.

From 9 out of 10 people worldwide breathe polluted air. To prevent the air pollution there should be launched green energy. World Health Organization: WHO estimates that ambient pollution alone caused some 4.2 million deaths in 2016, while household air pollution from cooking with polluting fuels and technologies caused an estimated 3.8 million deaths in the same period. So, the idea was to make such a system which will let people know what amount of toxic air is inhaled. This system includes the studies from previous research how much it is important to work on such a topic. To make such a device which will be portable and can easily be installed was the main idea. Android device user and internet user has increased tremendously. For ease of people the result of the device can be seen in a website as well as in android application.

By measuring pollution about air, water and sound on everyday life it would be great significance for the health of human if the level of pollution is measured. For detecting the air pollution different types of pollution monitoring gas sensors will be placed in different points of the city. The main priority will be the polluted area and the area that contains harmful particles to human. These sensors will collect practical data in real time from different affected areas on different gases (for air and water) which are present in the environment e.g. nitrogen dioxide (NO_2), carbon monoxide (CO), methane (CH_4) and humidity. It will also collect data about the pollution level of the sound inside the city. The proposed system allows monitoring mainly air quality and the pollution condition of a smart city on a desktop/laptop computer through an application designed using Graphical User Interface (GUI) programming that gives signal when pollution nature exceeds the acceptable levels.

CHAPTER 3

METHODOLOGY

The Proposed model of the system is as follows. Figure 3 shows how the whole system will work. The block diagram of the system is showing that for a particular area selected how will it work. The device will be set up to take the environmental data and there will be a base standard value. The device will collect data and based on the set values it will show the output. The Fig.3.1 shows the proposed model system.

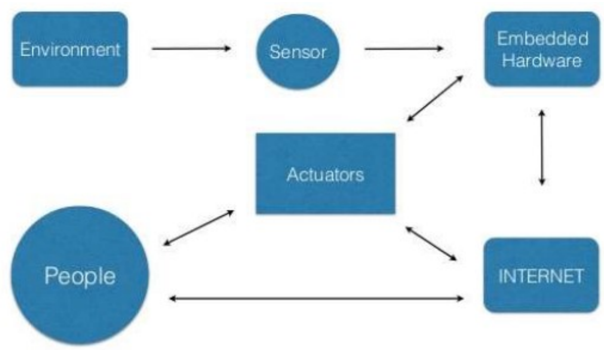

Fig. 3.1. Proposed model of the system [18].

3.1 Proposed Model block diagram

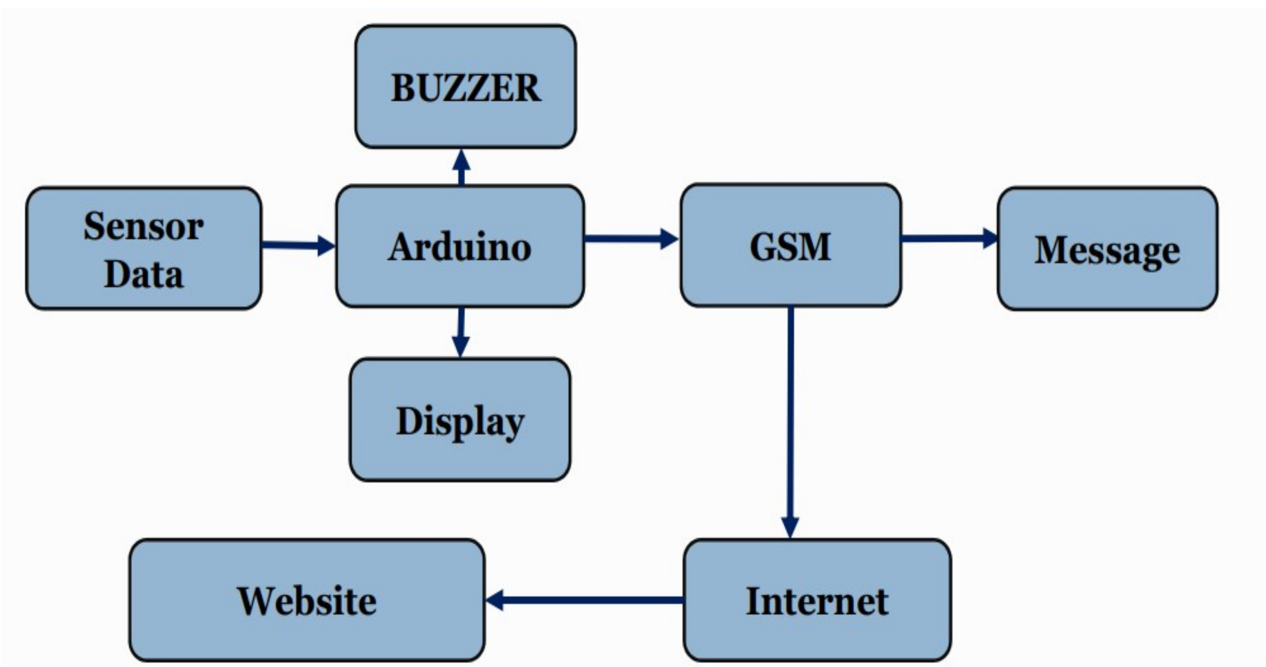

Fig. 3.2. Block diagram for proposed model of the system

The block diagramof proposed model of the system is shown in Fig.3.2. Here three sensors- air quality sensor (MQ 135), temperature and humidity sensor (DHT 22), CO gas sensor (MQ 7) is connected to microcontroller (Arduino Uno) as input and LCD display is connected to see the output of the project. A GSM module is also connected through which we can see the result in think speak web server or to send emergengy alert via SMS.

3.2 Flow Chart of Proposed System

The Fig.3.3 shows the flow chart of the proposed model system.

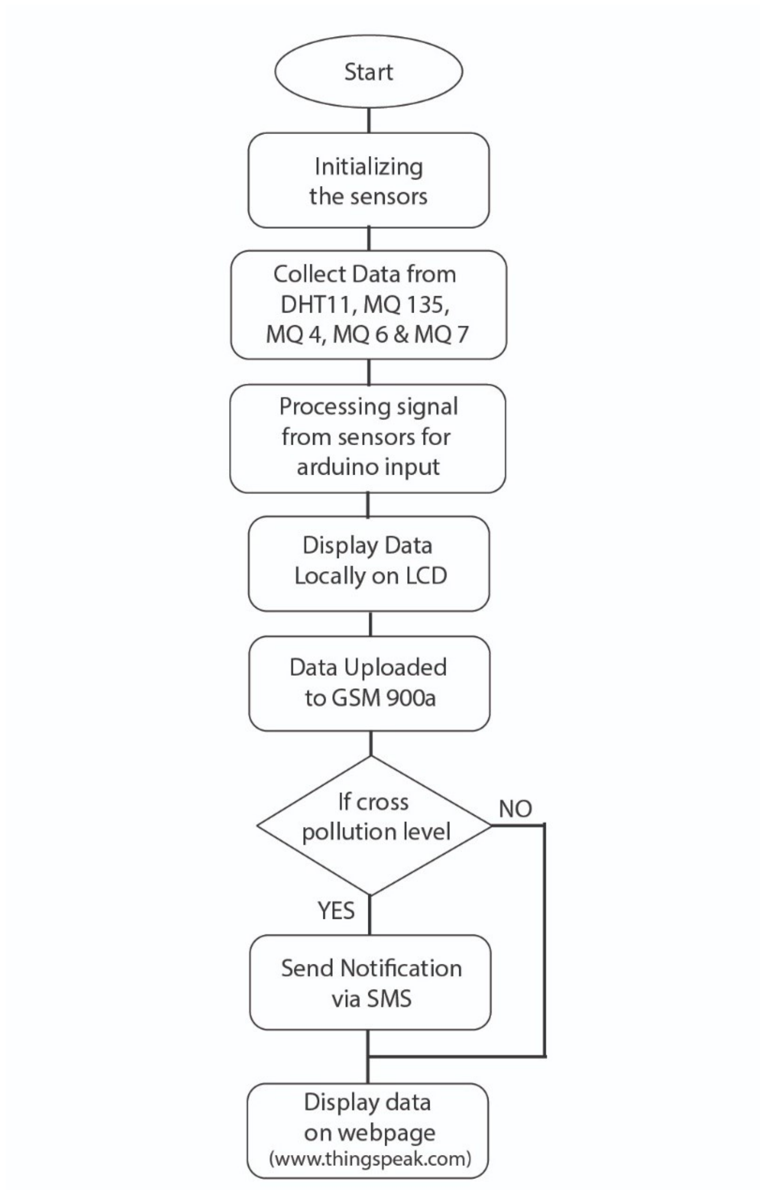

Fig. 3.3. Flow Chart for proposed model of the system

3.3 Circuit Diagram of Proposed System

The Fig.3.4 shows the Circuit Diagram of Proposed System.

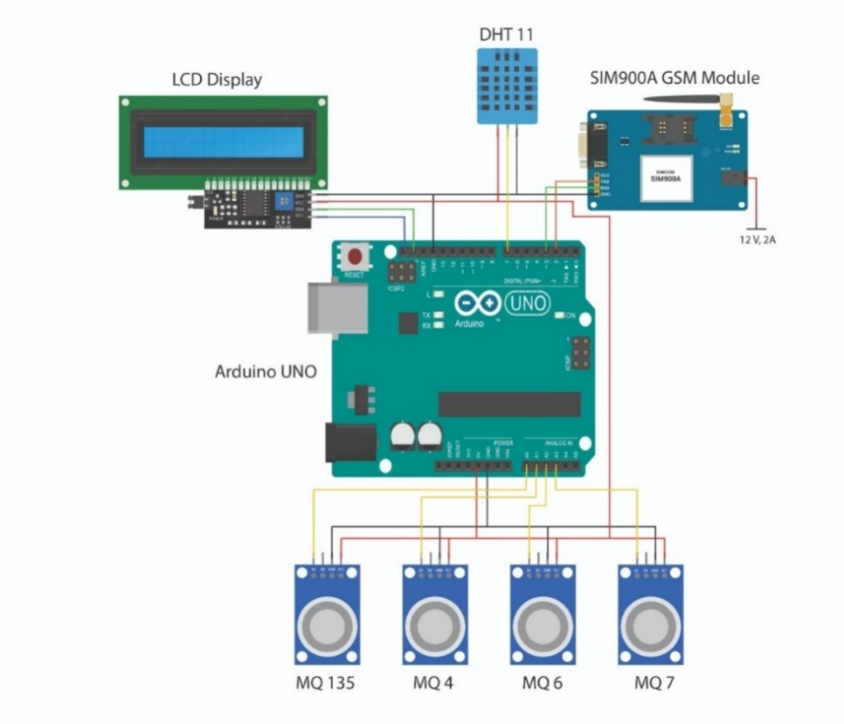

Fig. 3.4. Circuit diagram for proposed model of the system

3.4 Proposed Model in Real Life

The Fig.3.5 shows the Proposed Model in Real Life.

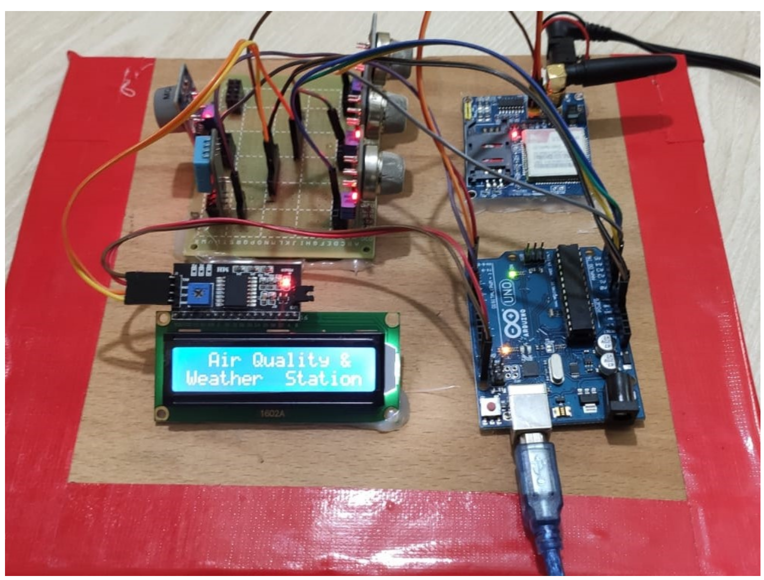

Fig. 3.5. Proposed Model in Real Life

3.5 Components of the Device

It's a device that takes data from the environment that has been selected for our research purpose. The device is built with various sensors and they take data by sensing from the environment. The sensors take analog data from the environment which later is converted into digital with the help of raspberry pi and then sent to the server where all the data are stored.

This device is consisting of the following components:

1. Arduino Uno R3
2. DHT 11 Temperature and Humidity sensor
3. MQ-7 CO Gas sensor
4. MQ 135 Air quality sensor module
5. MQ 4CH4 Gas Sensor
6. MQ 6LPG Gas Sensor
7. GSM Module
8. Breadboard

10 LCD Display

These components are briefly discussed in the following section:

3.5.1 Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P. The Fig.3.6 shows Arduino Uno. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Pin Function of Aurdino Uno are given below:

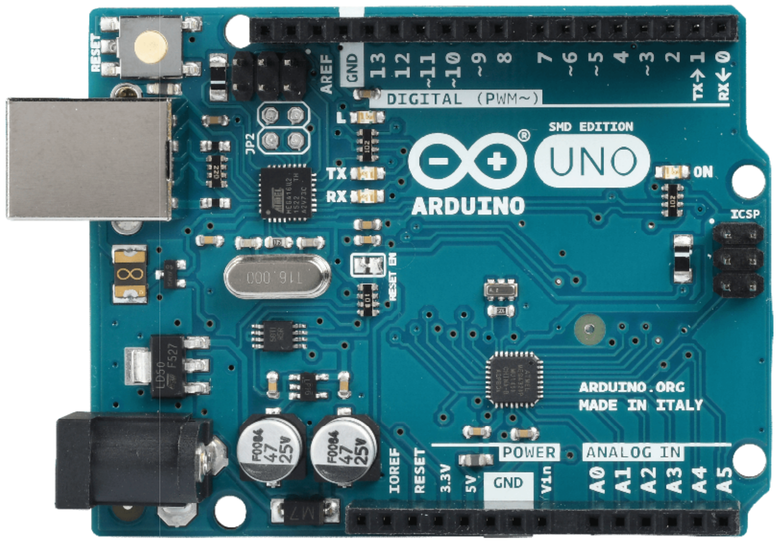

Fig. 3.6. Arduino Uno [13].

Microcontroller : ATmega328

Operating Voltage : 5 V

Input Voltage (recommended) : 7-12 V

Input Voltage (limit) : 6-20 V

Digital I/O Pins : 14 (PWM Output - 6)

Analog Input Pins : 6

DC Current per I/O Pin : 40 mA

DC Current for 3.3V Pin : 50 mA

Flash Memory : 32 KB (for Bootloader - 0.5 KB)

SRAM : 2 KB

EEPROM : 1 KB

Clock Speed : 16 MHz

3.5.2 GSMSIM900A Module

The module is typically connected to +4.0V standard power supply. It can work on +4.5V regulated power and any higher voltage may damage the module. And the power source should be able to deliver a peak current of 2A. The UART interface is established as shown in figure. All you need to do is connect RXD of module to TXD of Arduino and TXD is connected to RXD of ARDUINO. The ground of controller and module must be connected for voltage reference. Here AUDIO IN is connected to MIC and AUDIO OUT is connected to a speaker or headset. And at last we need to connect a working GSM SIM card to the module. On powering the module the NETLIGHT LED will blink periodically to state successful connection. The Fig. 3.7 shows GSM SIM900A Module.

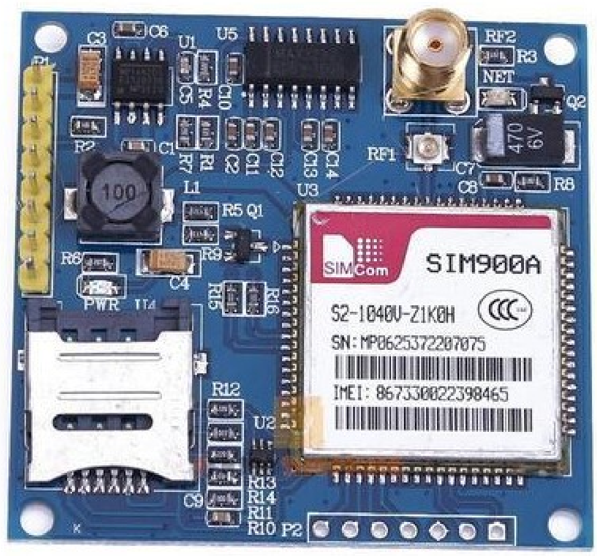

Fig. 3.7. GSM SIM900A Module[14].

After all connections are done,we need to write a program for the microcontroller to exchange data with module. Since data exchange sequence between controller and module is really complex we will use libraries prewritten for the module. You can download libraries for controller or module through their websites. Using these libraries makes the communication easy. All you need to do is download these libraries and call them in programs. Once the header file is included, you can use simple commands in the program to tell the controller to send or receive data. The controller sendsthe data to the module through UART Interface based on protocol setup in libraries. The module sends this data to another GSM user using cellular network. If the module receives any data from the cellular network (or another GSM user) it will transmit it to controller through UART serial communication.

3.5.3 DHT 11 Temperature and Humidity sensor

DHT11 Temperature & Humidity Sensor states a temperature & humidity sensor compound with a calibrated digital signal output. By using the high-class digital-signal acquisition technique and temperature & humidity sensing technology, it guarantees high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, which offers excellent quality, fast response, ant interference ability and cost-effectiveness. The Fig. 3.8 shows DHT 11 Temperature and Humidity sensor.

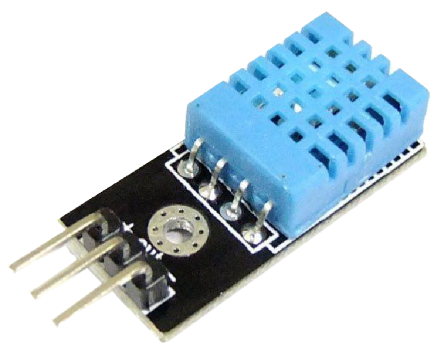

Fig. 3.8. DHT 11 Temperature and Humidity sensor [15].

DHT11's power supply is 3-5.5V DC. When power is supplied to the sensor, it does not send any instruction to the sensor in within one second in order to pass the unstable status. One capacitor valued 100nF can be added between VDD and GND for power filtering.

3.5.4 MQ-7 CO Gas sensor

Fig. 3.9. MQ-7 CO Gas sensor [16].

MQ7 gas sensor is used to detect the presence of Carbon Monoxide. The Fig. 3.9 shows MQ-7 CO Gas sensor. It is also used to detect Methane and other combustible steam. It is low cost and suitable for different application. This sensor is sensitive to flammable gas and smoke. Smoke sensor is given 5 volts to power it. Smoke sensor indicates smoke by the voltage that it outputs, more smoke more output. A potentiometer is provided to adjust the sensitivity. SnO_2 is the sensor used which is of low conductivity when the air is clean. But when smoke exist sensor provides an analog resistive output based on concentration of smoke. The circuit has a heater. Power is given to heater by VCC and GND from power supply. The circuit has a variable resistor. The resistance across the pin depends on the smoke in air in the sensor. The resistance will be lowered if the content is more and voltage is increased between the sensor and load resistor.

3.5.5 MQ135 Air quality sensor module

Fig. 3.10. MQ135 Air quality sensor module [17].

The Fig. 3.10 showsM135 Air quality sensor module.It is an unsafe gas detection component for the family, the environment, suitable for ammonia, aromatic compounds, Sulfur, benzene vapor, smoke and other gases harmful gas detection, gas-sensitive element test. Air quality sensor is for detecting a wide range of gases, including NH3, NOx, alcohol, benzene, smoke and CO2. It is ideal to use in office or factory with simple drive and monitoring circuit.

3.5.5MQ4CH4 Gas Sensor

Fig. 3.11. MQ4 CH4 Gas sensor module [18].

The Fig. 3.10 showsMQ4 CH4 Gas sensor module.This methane gas sensor detects the concentration of methane gas in the air and ouputs its reading as an analog voltage. The concentration sensing range of 300 ppm to 10,000 ppm is suitable for leak detection. For example, the sensor could detect if someone left a gas stove on but not lit. The sensor can operate at temperatures from -10 to 50°C and consumes less than 150 mA at 5 V.

3.5.5 MQ6LPG Gas Sensor

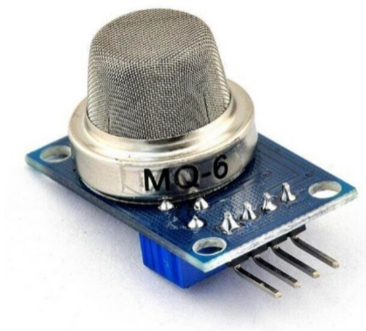

Fig. 3.12. MQ6LPG Gas sensor module [19].

The Fig. 3.10 showsMQ6 LPG Gas sensor module.The MQ-6 Gas sensor can detect or measure gases like LPG and butane. The MQ-6 sensor module comes with a Digital Pin which makes this sensor to operate even without a microcontroller and that comes in handy when you are only trying to detect one particular gas. When it comes to measuring the gas in ppm the analog pin has to be used, the analog pin also TTL driven and works on 5V and hence can be used with most common microcontrollers.

3.6 Software Requirements

1. IDE
2. THINGSPEAK website

3.7 Summary

We have discussed our system device which was built by us, in this section. The circuit diagram and block diagram were shown in this section. We also introduced our formula which was used to detect gas percentage and gas concentration and described briefly.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter is all about our devices experiment and its results. We put our device in different situations to get data as much as possible.

4.2 Dataset Description

To measure and compare the performance of our device, we have used the US Embassy of Bangladesh dataset. This dataset consists of 2500 records and corresponding AQI scores. We have collected these datasets from their website. Data was taken in every hour of a day, every day of the month and every month of years.

1.2.1 Displaying data in LCD Display

Fig. 4.1(a), Fig. 4.1(b), Fig. 4.1(c), Fig. 4.1(d), and Fig. 4.1(e) show the output of air quality, CO, temperature and humidity, CH4, & LPGin LCD Display respectively.

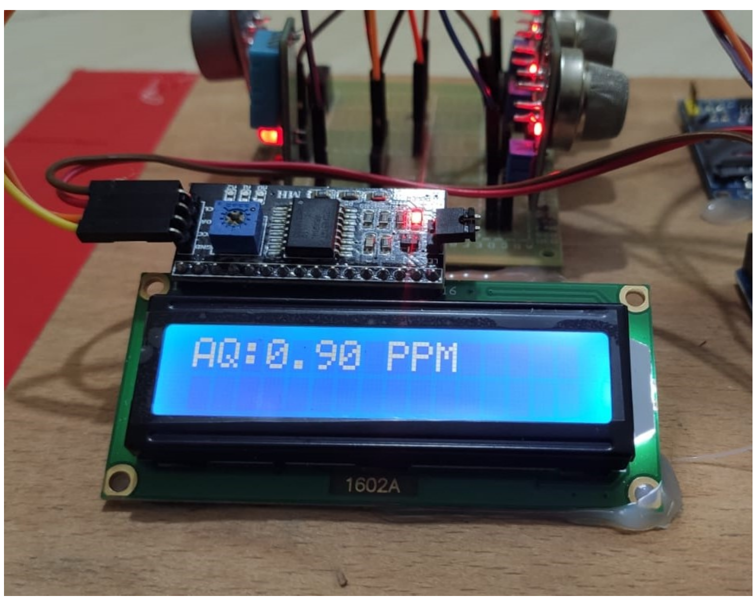

Fig. 4.1(a). LCD Display View (Air Quality)

Fig. 4.1(b). LCD Display View (CO)

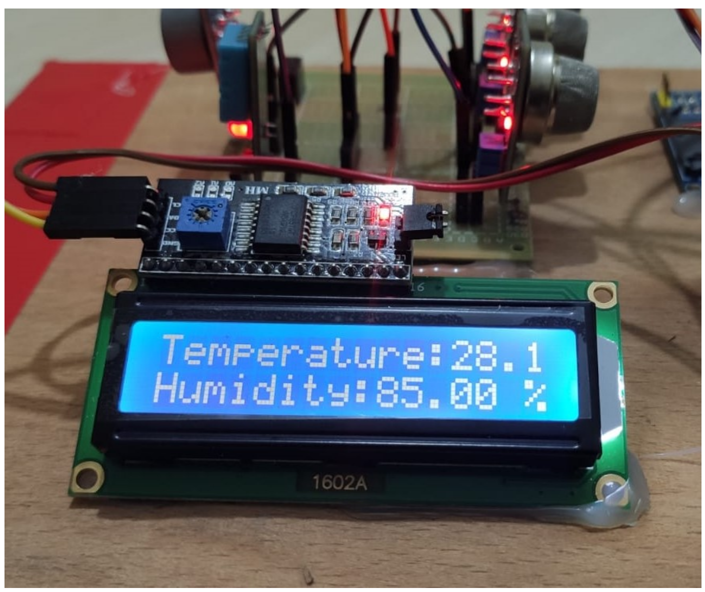

Fig. 4.1(c). LCD Display View (Temperature & Humidity)

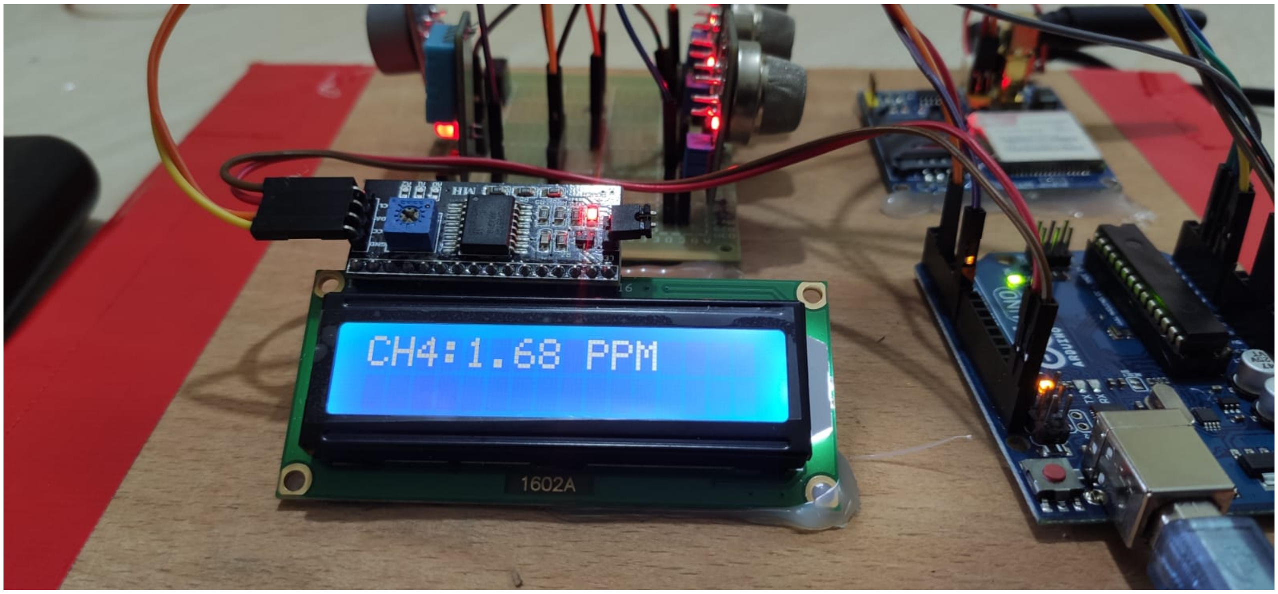

Fig. 4.1(d). LCD Display View (CH_4)

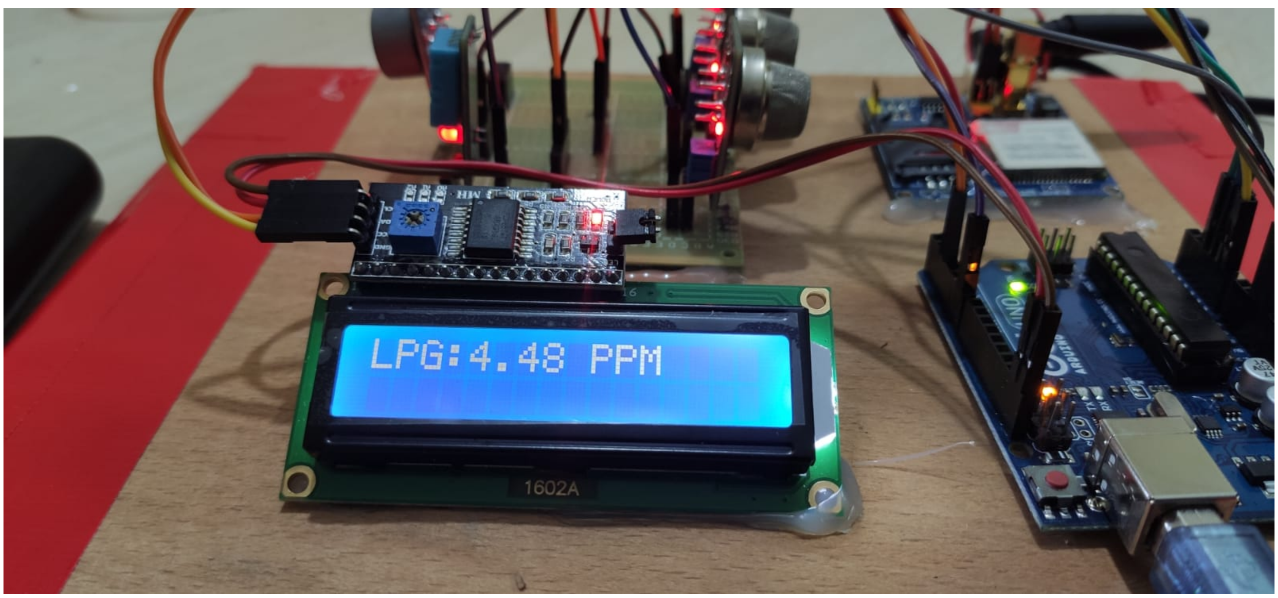

Fig. 4.1(e). LCD Display View (LPG)

4.2.2 Sending data to the cloud platform:

We have selected 5 data to send over to the cloud platform. The server takes 1 input from the Arduino every 10 seconds. We took 5 variables to store the data and send it to 5 different fields of the cloud channel. Fig. 4.2 shows the Mobile Application view of the system.Fig. 4.2(a), Fig. 4.2(b), Fig. 4.2(c),Fig. 4.2(d),Fig. 4.2(e),Fig. 4.2(f),and Fig. 4.2(g) show the output of air quality, CO, temperature and humidity CH4, LPG, warning inthe cloud platform respectively.

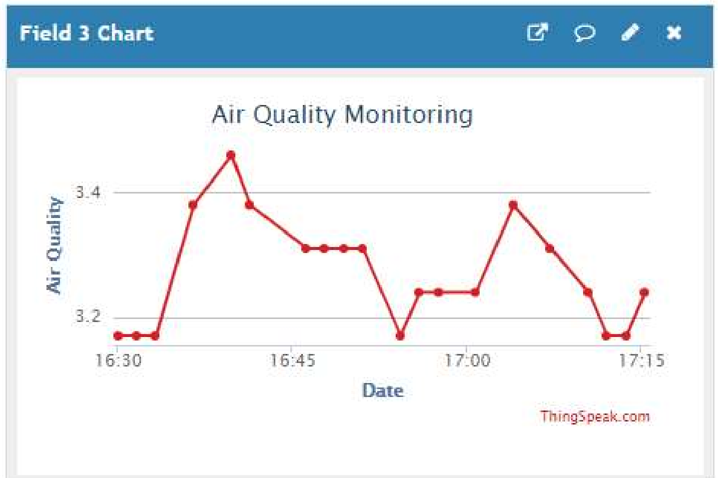

Fig. 4.2(a). Output of the device in the cloud platform (Air Quality)

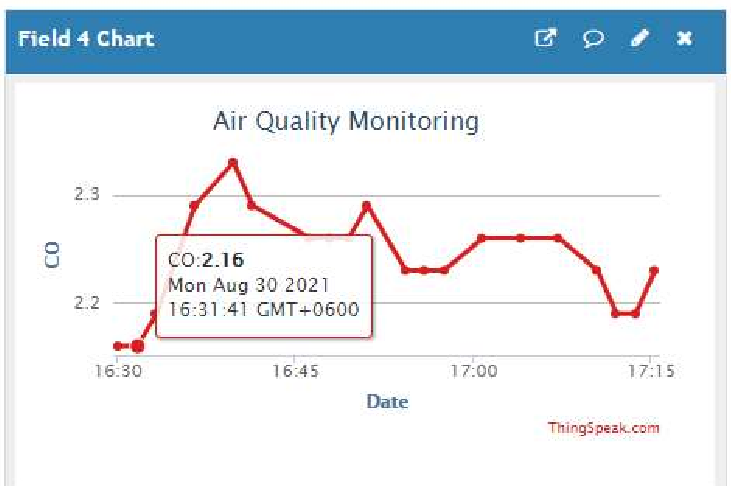

Fig. 4.2(b). Output of the device in the cloud platform (Carbon Monoxide)

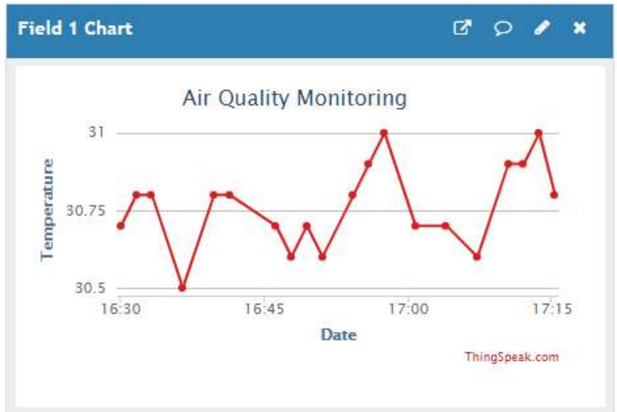

Fig. 4.2(c). Output of the device in the cloud platform (Temperature)

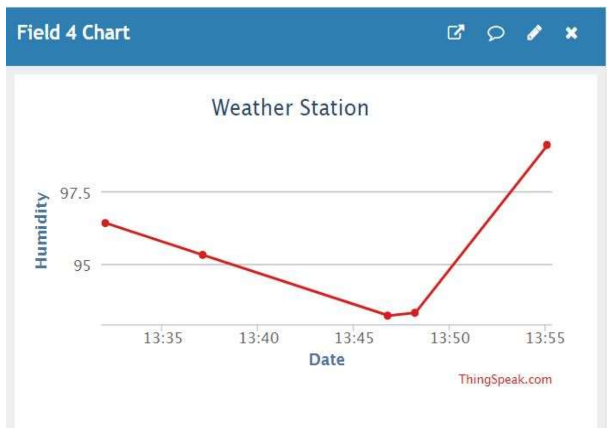

Fig. 4.2(d). Output of the device in the cloud platform (Humidity)

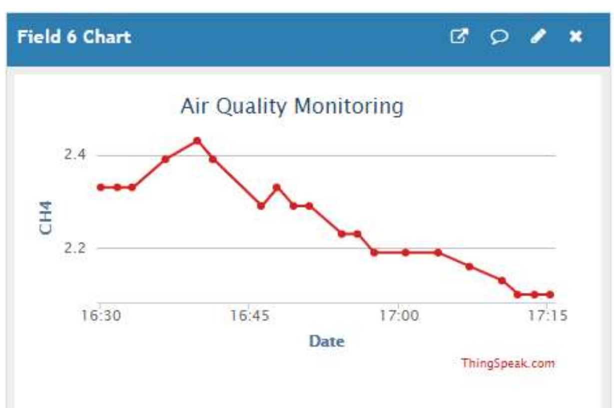

Fig. 4.2(e). Output of the device in the cloud platform (CH_4)

Fig. 4.2(f). Output of the device in the cloud platform (LPG)

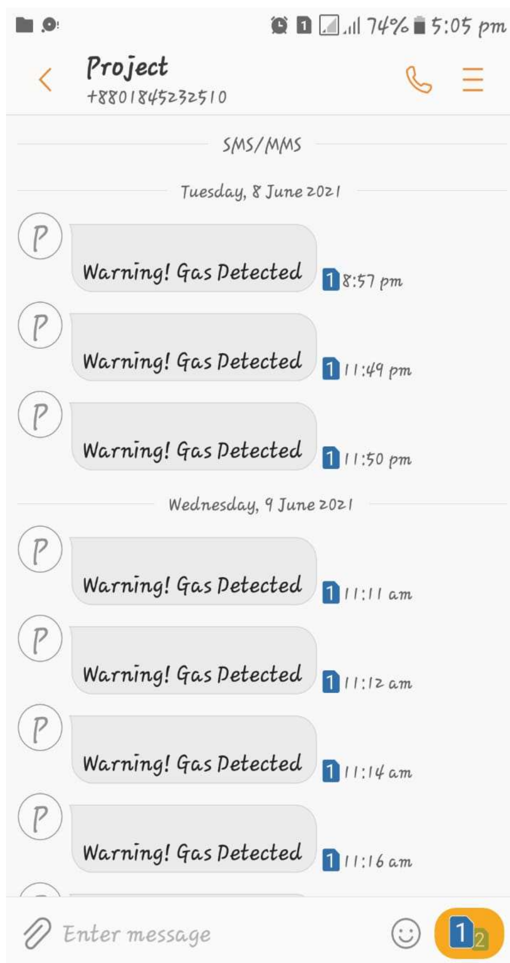

Fig. 4.2(g). Over Gas Detection Warning Via SMS

4.3 Result

Humans are very sensitive to humidity, as the skin relies on the air to get rid of moisture. If the air temperature is 24 C and the relative humidity is 100 percent, its feel like it's 27 C. At room temperature of 28.5 C, the humidity rate we get is slightly higher than due point. The standard rate of CO in air is 0 to 5 ppm. We have found 2.78 ppm. After the comparison, we found that our dataset has a higher accuracy.

1.3 Cost Analysis

Table: 4.1 shows thecost analysis of the project.

Table: 4.1: Cost Analysis of the Project

Equipment name	**Quantity**	**Price (BDT)**
Arduino UNO	1	450
GSM module	1	1450
MQ-135	1	280
MQ-7	1	180
MQ-4	1	180
MQ-6	1	180
DHT-11	1	180
LCD Display	1	160
I2C	1	160
PCB Board	1	50
	Total	**3270**

CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 Conclusion:

An air pollution monitoring system was designed, implemented and tested. The proposed system shows better reliability because it is based on GPRS system. GPRS network is easily available and consume less bandwidth as compare to other networks. In this proposed system use Sim900A model that is contain low cost as compare to other 3G and 4G hardware. The proposed system provides high accuracy as compare to other previous method due to its low bit error rate.

5.2 Future work:

In this project model, we didn't use any dust sensors and alarming devices to alert in danger. We will do that in future. In our model, we didn't make this for bigger houses like offices, schools. In that case we had to use wireless sensor network. But we had a lack of budget to build such devices. In future we will work along with radiation detection and machine learning algorithms for better future air quality detection.

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APPENDIX

Microcontroller Code of the proposed model:

```
#include <Wire.h>
#include <LCD.h>
//#include <dht.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 2, 1, 0, 4, 5, 6, 7, 3, POSITIVE);
#include <SoftwareSerial.h>
SoftwareSerialgprsSerial(2,3);
SoftwareSerial SIM900(2, 3); // gsm module connected here
String textForSMS;

#include <String.h>
#include <DHT.h>
#define DHTPIN 7
DHT dht(DHTPIN, DHT11);

intgas_sensor = A0; //Sensor pin... mq 135
float m = -0.3376; //Slope
float b = 0.7165; //Y-Intercept
float R0 = 15.52; //Sensor Resistance in fresh air from previous code

intCO_sensor = A1; //Sensor pin... mq 7
float m1 = -0.6527; //Slope
float b1 = 1.30; //Y-Intercept
float R01 = 6.42; //Sensor Resistance

intLPG_sensor = A2; //Sensor pin ... mq 6
float m2 = -0.6527; //Slope
float b2 = 1.30; //Y-Intercept
float R02 = 6.42; //Sensor Resistance

int ch4 = A3; //Sensor pin ... mq 4
float m3 = -0.6527; //Slope
float b3 = 1.30; //Y-Intercept
float R03 = 6.42; //Sensor Resistance


void setup() {

    // PC to Arduino Serial Monitor
//  Serial.begin(115200);   // Arduino to ESP01 Communication
lcd.begin(16, 2);
lcd.backlight();
lcd.setCursor(0, 0);
lcd.print("  Air Quality & ");
```

```
lcd.setCursor(0, 1);
lcd.print("Weather  Station");
delay(2000);
lcd.clear();

pinMode(gas_sensor, INPUT);
pinMode(CO_sensor,INPUT);
pinMode(LPG_sensor,INPUT);
pinMode(ch4,INPUT);

gprsSerial.begin(9600);              // the GPRS baud rate
Serial.begin(9600);    // the GPRS baud rate
dht.begin();
delay(1000);
randomSeed(analogRead(0));
 SIM900.begin(9600); // for sim900D 19200. while enter 9600 for sim900A
 }

void loop() {
  // put your main code here, to run repeatedly:
  float sensor_volt; //Define variable for sensor voltage
  float RS_gas; //Define variable for sensor resistance
  float ratio; //Define variable for ratio
  float sensorValue = analogRead(gas_sensor); //Read analog values of sensor
sensor_volt = sensorValue*(5.0/1023.0); //Convert analog values to voltage
RS_gas = ((5.0*10.0)/sensor_volt)-10.0; //Get value of RS in a gas
ratio = RS_gas/R0;  // Get ratio RS_gas/RS_air
  double ppm_log = (log10(ratio)-b)/m; //Get ppm value in linear scale according to the the ratio value
double ppm = pow(10, ppm_log); //Convert ppm value to log scale
Serial.print("Air Quality = ");
Serial.println(ppm);
lcd.clear();
lcd.setCursor(0,0);
lcd.print("AQ:");
lcd.print(ppm);
lcd.print(" PPM ");
delay(2000);
lcd.clear();

  float sensor_volt1; //Define variable for sensor voltage
  float RS_gas1; //Define variable for sensor resistance
  float ratio1; //Define variable for ratio
float sensorValue1 = analogRead(CO_sensor); //Read analog values of sensor
  sensor_volt1 = sensorValue1*(5.0/1023.0); //Convert analog values to voltage
  RS_gas1 = ((5.0*10.0)/sensor_volt1)-10.0; //Get value of RS in a gas
  ratio1 = RS_gas1/R01;  // Get ratio RS_gas/RS_air
  double ppm_log1 = (log10(ratio1)-b1)/m1; //Get ppm value in linear scale according to the the ratio value
double ppm1 = pow(10, ppm_log1); //Convert ppm value to log scale
Serial.print("CO PPM = ");
```

```
Serial.println(ppm1);

lcd.clear();
lcd.setCursor(0,0);
lcd.print("CO:");
lcd.print(ppm1);
lcd.print(" PPM ");
delay(2000);
lcd.clear();

  float sensor_volt2; //Define variable for sensor voltage
  float RS_gas2; //Define variable for sensor resistance
  float ratio2; //Define variable for ratio
float sensorValue2 = analogRead(LPG_sensor); //Read analog values of sensor
  sensor_volt2 = sensorValue2*(5.0/1023.0); //Convert analog values to voltage
  RS_gas2 = ((5.0*10.0)/sensor_volt2)-10.0; //Get value of RS in a gas
  ratio2 = RS_gas2/R02;  // Get ratio RS_gas/RS_air
  double ppm_log2 = (log10(ratio2)-b2)/m2; //Get ppm value in linear scale according to the the ratio value
double ppm2 = pow(10, ppm_log2); //Convert ppm value to log scale
Serial.print("LPG PPM = ");
Serial.println(ppm2);

lcd.clear();
lcd.setCursor(0,0);
lcd.print("LPG:");
lcd.print(ppm2);
lcd.print(" PPM ");
delay(2000);
lcd.clear();

  float sensor_volt3; //Define variable for sensor voltage
  float RS_gas3; //Define variable for sensor resistance
  float ratio3; //Define variable for ratio
  float sensorValue3 = analogRead(ch4); //Read analog values of sensor
  sensor_volt3 = sensorValue3*(5.0/1023.0); //Convert analog values to voltage
  RS_gas3 = ((5.0*10.0)/sensor_volt3)-10.0; //Get value of RS in a gas
  ratio3 = RS_gas3/R03;  // Get ratio RS_gas/RS_air
  double ppm_log3 = (log10(ratio3)-b3)/m3; //Get ppm value in linear scale according to the the ratio value
double ppm3 = pow(10, ppm_log3); //Convert ppm value to log scale
Serial.print("CH4 = ");
Serial.println(ppm3);

lcd.clear();
lcd.setCursor(0,0);
lcd.print("CH4:");
lcd.print(ppm3);
lcd.print(" PPM ");
delay(2000);
lcd.clear();
```

```
float h = dht.readHumidity();
float t = dht.readTemperature();
delay(100);

Serial.print("Temperature = ");
Serial.print(t);
Serial.println(" °C");
Serial.print("Humidity = ");
Serial.print(h);
Serial.println(" %");

lcd.setCursor(0,0);
lcd.print("Temperature:");
lcd.print(t);
lcd.print(" Celcius ");
lcd.setCursor(0,1);
lcd.print("Humidity:");
lcd.print(h);
lcd.print(" % ");
delay(1000);
lcd.clear();


 if (gprsSerial.available())
Serial.write(gprsSerial.read());

gprsSerial.println("AT");
delay(1000);

gprsSerial.println("AT+CPIN?");
delay(1000);

gprsSerial.println("AT+CREG?");
delay(1000);

gprsSerial.println("AT+CGATT?");
delay(1000);

gprsSerial.println("AT+CIPSHUT");
delay(1000);

gprsSerial.println("AT+CIPSTATUS");
delay(2000);

gprsSerial.println("AT+CIPMUX=0");
delay(2000);

ShowSerialData();
```

```
gprsSerial.println("AT+CSTT=\"robigprs.com\"");//start task and setting the APN,
delay(1000);

ShowSerialData();

gprsSerial.println("AT+CIICR");//bring up wireless connection
delay(3000);

ShowSerialData();

gprsSerial.println("AT+CIFSR");//get local IP adress
delay(2000);

ShowSerialData();

gprsSerial.println("AT+CIPSPRT=0");
delay(3000);

ShowSerialData();

gprsSerial.println("AT+CIPSTART=\"TCP\",\"api.thingspeak.com\",\"80\"");//start up the connection
delay(6000);

ShowSerialData();

gprsSerial.println("AT+CIPSEND");//begin send data to remote server
delay(4000);
ShowSerialData();

  String str="GET https://api.thingspeak.com/update?api_key=ZBH8TUM52HDGIQ51&field1=" + String(t)
+"&field2="+String(h)+"&field3="+String(ppm)+"&field4="+String(ppm1)+"&field5="+String(ppm2)+"&f
ield6="+String(ppm3);
Serial.println(str);
gprsSerial.println(str);//begin send data to remote server

delay(4000);
ShowSerialData();

gprsSerial.println((char)26);//sending
delay(5000);//waitting for reply, important! the time is base on the condition of internet
gprsSerial.println();

ShowSerialData();

gprsSerial.println("AT+CIPSHUT");//close the connection
delay(100);
ShowSerialData();
```

```
if (( ppm > 8)||( ppm1 > 2)||( ppm2 > 5)||( ppm3 > 6)||( t > 30)||( h > 50))
  {
textForSMS =  "\nWarning! Gas Detected";
sendSMS(textForSMS);
Serial.println(textForSMS);
Serial.println("message sent.");
delay(5000);
//while(1)
//{
//
//}
  }
}

voidShowSerialData()
{
while(gprsSerial.available()!=0)
Serial.write(gprsSerial.read());
delay(5000);
  }
voidsendSMS(String message)
{
SIM900.print("AT+CMGF=1\r");                    // AT command to send SMS message
delay(1000);
SIM900.println("AT + CMGS = \"+8801839689600\"");  // recipient's mobile number, in international
forma8t

delay(1000);
SIM900.println(message);                       // message to send
delay(1000);
SIM900.println((char)26);                      // End AT command with a ^Z, ASCII code 26
delay(1000);
  SIM900.println();
delay(100);                                    // give module time to send SMS
 // SIM900power();                             // turn off module
}
```