Portable Environmental Monitoring System

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A thesis submitted to the Department of Electrical & Electronic Engineering in partial fulfillment of the requirements for the degree of
Bachelor of Science

Electrical & Electronic Engineering
BRAC UNIVERSITY
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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at BRAC University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.
5. A Research Paper of this thesis project got **accepted by WTS2019 and Published** in Poster Paper Category.

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Ethics Statement

We, hereby, declare that this thesis is based on results we found ourselves. The materials of work conducted by other researchers are mentioned in References. This is to affirm that this thesis report is submitted by the authors listed for the degree of Bachelor of Science in Electrical and Electronic Engineering to the Department of Electrical and Electronic Engineering under the School of Engineering and Computer Science, BRAC University. We, hereby, declare that the research work is based on the results found by us and no other. The materials of work found by other researchers have been properly acknowledged. This thesis, neither in whole nor in part, has been previously submitted elsewhere for assessment.

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Abstract

In this modern world of 21st century, the development of new technologies is rapid than in the past. People are more concerned about new industries and businesses. As a result, environment has become less important to human beings all over the world. Due to increasing number of factory and industries, the pollution of environment has increased from past days at a significant rate. There are various types of environment pollution caused by human beings, for example, air pollution, sound pollution, radioactive pollution, water pollution, soil pollution etc. Now if we analyses some of the survey data on environment pollution of Bangladesh, we can see that the rate of air and water pollution is too high. There are a lot of reasons behind this situation of pollution. One of the major reasons is there are no such way for the general people to know about the current data of any environmental units. General people cannot generate ideas about different environmental values of air, water or soil which may help them to understand the current situation of environment. Now if they have a modular device which can collect data from the environment and one that analyses those data, then people can easily understand the situation of any particular environment. To solve this issue, we approached to building a portable environmental monitoring system which can collect data from the environment automatically using distinct sensors and can store those data on a web server. The main features of this system are light weight and portable and it can also be accessed by any authorized person from anywhere in the world. There are several sensors integrated into a tiny PCB board to minimize the size and increased portability. The on field experimental data helps us to verify the system practically and measure the efficiency of each sensor and subsystem.

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Chapter 1: Introduction

1.1. Introduction:

Now a days in this era of modernization, environment is a major issue. The existence of our planet earth is mostly related with the term environment. The existence of humans is also depended on the environment. However, many people give little or no importance to this issue which is why the rate of diseases has increased among humans, animals and plants in a significant manner. If we take Bangladesh as an example and analyze the environmental survey, then we can see that according to World Health Organization, 37,000 of people from Bangladesh die annually because of environmental pollution [1]. Moreover, it states that Bangladesh is in 4^{th} position for worst air quality among 92 countries [2]. So, we can understand from those data that environment is at great threat in the present time. The main reason for this problem is that people are not aware about the pollution. Sometimes they cannot understand what harm pollution can cause to the environment. As general people do not have any way or source from where they can get continuous data about the environment, they are indifferent about the environment pollution issue. Now with a vision of offering a way to the general people for access to the different environmental data, we have developed a portable environment monitoring system. By using our system anyone from anywhere of the world can easily get data and information related to any specific place. As our system is portable, user-friendly and can be accessed through web and internet. Using our system people can instantly monitor the air, sound, light and many other data of environment from where they can find decide whether the weather quality is good or bad. Depending on the result, people can control their activities to ensure a healthy environment.

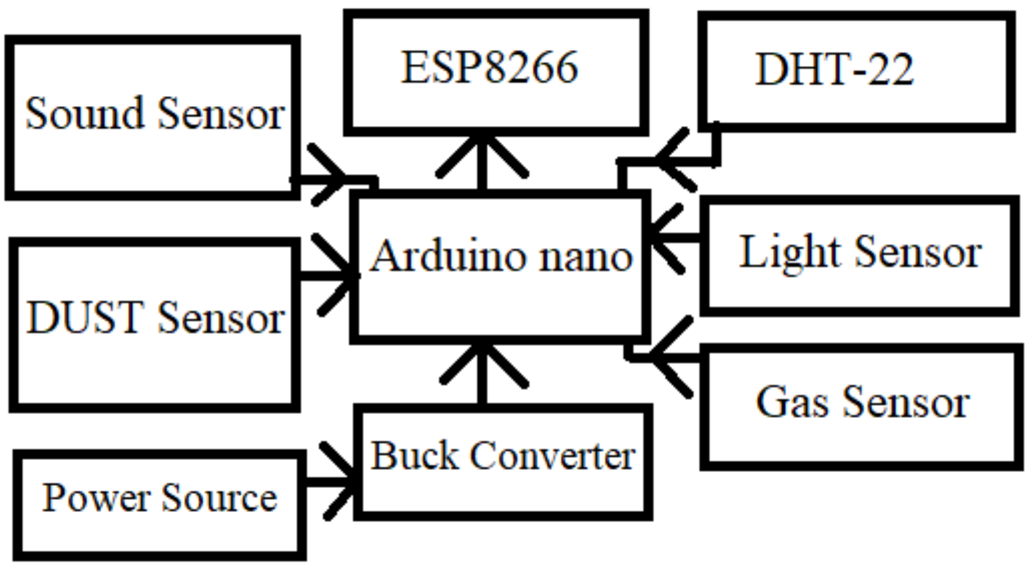

Figure: 1.1: System Block Diagram

1.2. Motivation

With the increasing amount of environmental pollution, the rate of diseases has also increased. If we take air pollution as an example, we see that several deaths occur yearly due to this single pollution. According to World Health Organization, air pollution causes 2.4 million deaths every year [3]. Most people who accept death due to environmental pollution are below poverty line. As there are no such way for the poor people to have knowledge about the detrimental situation, most of the face early death. If we take any leather factory or any other factory of Bangladesh for example, then we can see that almost no factory has a good standard for a healthy working environment. Most of them are polluted with dangerous chemicals which harm the environment as well as human beings. As the people below poverty line need to earn money, they compromise with their surroundings. Moreover, in those factories there are no such system from where workers can gather knowledge about the factory environment. Hence, after a brief analysis of those facts we were further motivated to help the environment and also the helpless and ignorant people through our portable environment monitoring system. We were also motivated from our duty towards nature. That's why we chose to build such a system which will help people to analyze the environment and save their life as well as the world.

1.3. Literature Review

Previously, a couple of work related to environment monitoring system had been developed. When we studied the related work for our research, we found quite a good number of indoor environment monitoring systems. One of them was a web based indoor environment monitoring system which was developed in 2013 [4]. The system was implemented using light and temperature sensors. The light and temperature data values were measured from an indoor area. The communication system of this project was web based. So, anyone can access the system from long distance. Another system named indoor environment intelligent monitoring system was developed in early 2018 [5]. In this system, temperature and humidity sensor were integrated into a compact PCB. They had developed a mobile phone application for accessing the data units. This system could send notification about the environment and suggest some ideas to the user which is why it was named intelligent.

Figure: 1.3.1: Indoor environment intelligent monitoring system

Another system named indoor environment monitoring system based on LinkIt one and Yeelink platform was developed in 2016 [6]. In this system, the researchers had used three different types of sensor namely temperature & humidity sensor, dust sensor and light sensor. It had a mobile application via which users can extract data acquire from the sensors.

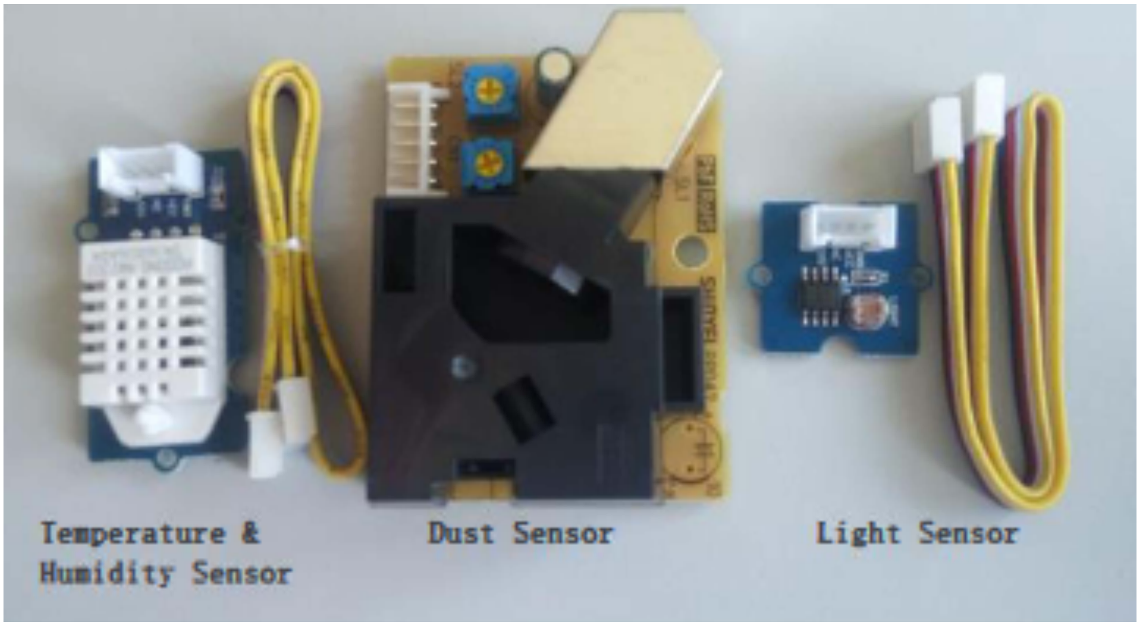

Figure: 1.3.2: indoor environment monitoring system based on LinkIt one and Yeelink platform

After analyzing couple of related work, we understood that maximum work has been indoor based. The maximum number of sensors used in a single system was three. The communication range with mobile applications was a big issue. On the other hand, our system has 5 different sensors via which we can extract 6 different types of values. The communication range of our system is also maximum as we are using web-based system.

Chapter 2: System Design

2.1. System Architecture Review

In order to ensure a compact design with lower weight materials, our developed system is portable as well as light weight. To maximize the efficiency and ensure the quality of each section of the system, we have divided the total system into several subsystem. As our system consists of couple of sensors, a subsystem is dedicated for sensor fusion. In this section, each and every sensor was tested individually to finding problems and expected solution. In order to ensure a compact device, organizing the sensor was a major issue. That's why we have designed custom PCB to organize all the sensor in an efficient manner. In this PCB, all the sensors are fixed which reduces the wire connections and ensures a plug and play system. For equal distribution of power, there are two subsystems in the main system. The main system can be powered up by a 12V adaptor. It can also be powered up by a 12V battery. One of the major issues for our system is communication. As we are offering universal communication, we have followed a secure way to ensure a strong communication system by which people can easily access our system. The system will be connected to the Wi-Fi with the onboard Wi-Fi module. The data collected from the sensor are processed and sent to the web server. Afterwards, those data can be accessed if we log in to the designated website. In this way, IOT feature has been offered by our system. We also tried Bluetooth communication for our system but as Bluetooth has short wavelength, we switched to web based Wi- Fi communication.

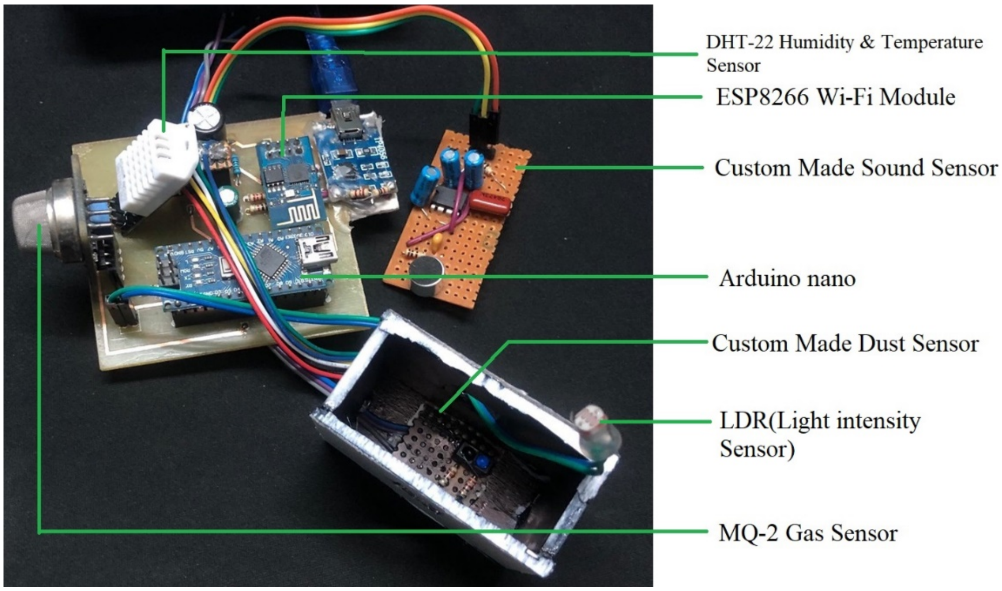

Figure: 2.1: Developed System

2.2. Sensor Fusion:

One of the main motives of our system is to collect different data from the environmental data. So, for that we have integrated different types of sensors into our system. We went through brief analysis of each sensor to integrate it with the main system. For maximize the amount of data, we have added five different types of sensors into our system. The sensors are as follows:

Sound level sensor: One of the major pollutions in our country is sound pollution. The increasing number of vehicles and industries maximizes the pollution occurred by sound. For detecting the sound level, we have developed our custom-made sound level sensor. There are a lot of sound level detect sensors available in the market now a days. However, as a contribution to our thesis we have developed our own designed sound level sensor. For developing the sensor, we followed step by step process to gain maximum amount of efficiency. Our sensor consists of different types of components. The components are as follows: LM386 audio amplifier, resistors and capacitors, microphone and variable potentiometer. Firstly, for verifying our design we made a schematic design of the circuit using Proteus software.

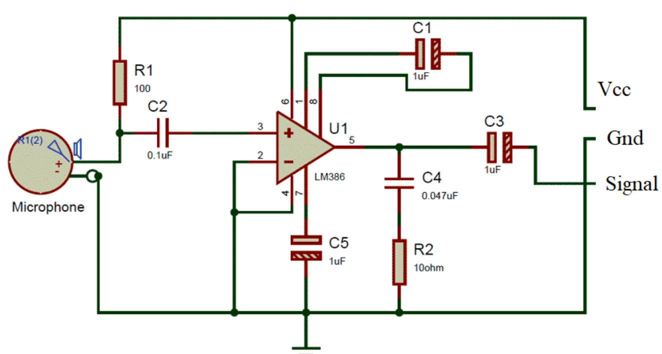

Figure: 2.2.1: Sound Sensor Schematic

In the following circuit LM386 audio amplifier has been used to amplify the signals from the microphone and supply it to the analog port of microcontroller unit. For measuring the gain of this op-amp, pin 1 and 8 have been used. For measuring the maximum gain, we have used 10uF capacitor which is denoted by C1 between pin 1 and 8 of the op-amp. When the microphone senses sound, the sound waves convert to AC signal. For converting it into DC signal capacitor C2 has been used. After amplification one more capacitor denoted by C3 has been used for filtering the DC noise. There are three pins available in this diagram one is for 5v power, one is for ground connection and last one is dedicated for signal. Now, for checking that the microphones ADC value are valid or not we converted those values into dB. After converting the ADC value through microcontroller programming, we acquired the dB values. For increasing the accuracy, we have designed another amplifier circuit with LM358 amplifier circuit. One low pass filter consisting of R5 and C2 and one high pass filter C1 and R2 has been incorporated into the design for filtering anything below 8Hz and above 15 KHz.

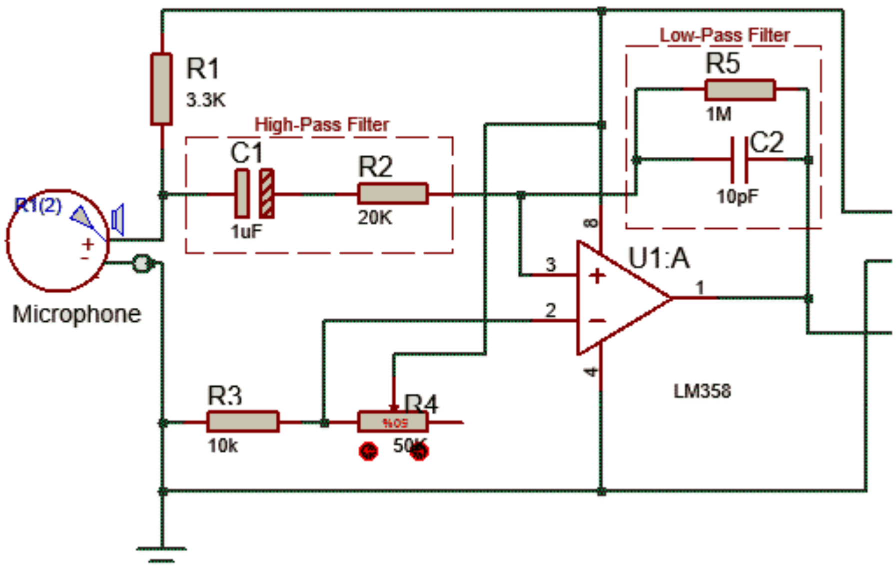

Figure: 2.2.2: Noise decreasing amplifier

The developed circuit can work Omni directionally. The operating voltage of the following circuit is 5Vdc. It can work between 100 to 10,000 Hz frequency ranges. The operating temperature for this circuit is -20º C to +60ºC.

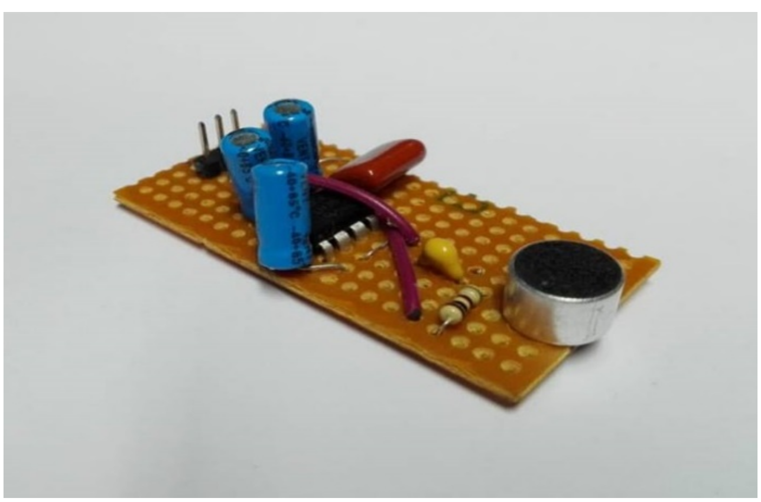

Figure: 2.2.3: Developed Sound Sensor

Humidity & Temperature sensor: One of the important data about any specific place's environment is humidity and temperature. Depending on the pollution these two data tend to vary a lot. For collecting both data, we have integrated one single sensor into our system. The sensor is named DHT22. This single sensor can read both temperature and humidity values from environment. In this sensor there are four pins available for voltage, ground and signal. The temperature range for this sensor is -40ºC to 80ºC. It can measure humidity between 0-100% range. The accuracy resolution is 0.1 for this particular sensor.

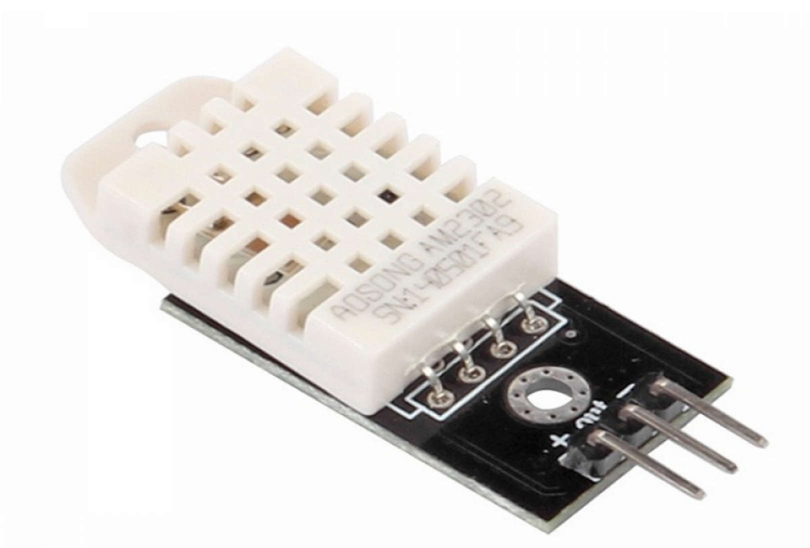

Figure: 2.2.4: DHT22 Sensor

Light sensitive sensor: For detecting the presence of light, we have used LDR which is a light sensitive resistor. From our study, we found that there are two types of LDR available. One is LDR photo resistor and another one is LDR light sensitive resistor. We used the latter into our system as it is more accurate. This LDR can work between the temperatures -30° C to 70° C. The bright resistance is 20-30 K-ohms and the dark resistance is 2 M-ohms for this model. The response time for this sensor is between 20-30 ms which is considerably fast.

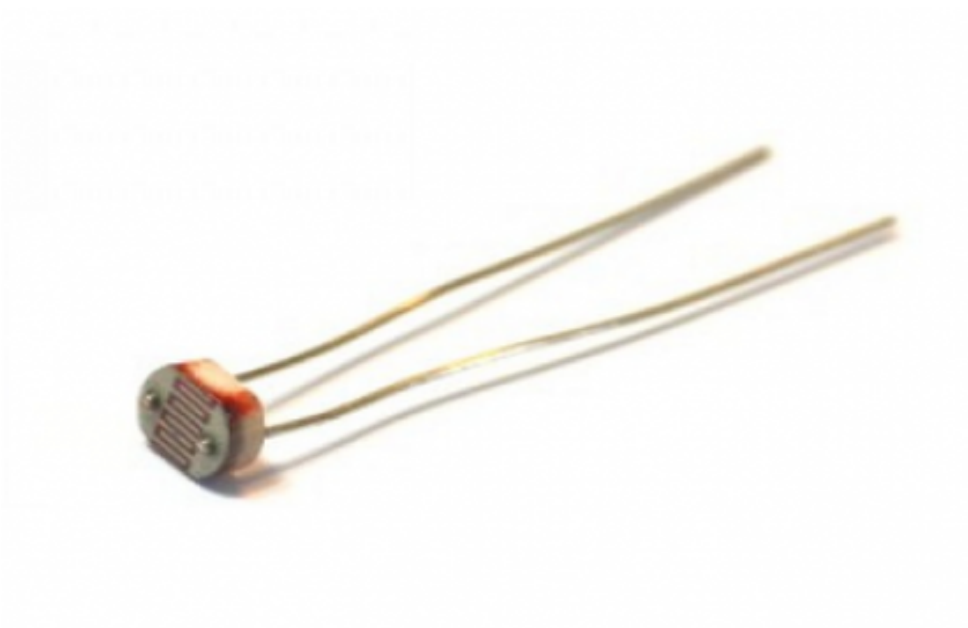

Figure: 2.2.5: Light Sensitive Sensor

Gas Sensor: When the pollution level goes upward, the amount of harmful gases increases into the environment. For detecting the amount of CO_2 and CH_4, we have integrated a gas detection sensor named MQ-2. By using this sensor couple of gases can be detected, but we have implemented it for only two harmful gases. The following sensor gives the gas values in PPM unit.

Figure: 2.2.6: MQ-2 Gas Sensor

Dust Sensor: If the pollution rises too much then there might be dust everywhere. So, detection of dust was an important part for our research. Consequently, we integrated an optical dust sensor into our system. This sensor has the ability to distinguish between smoke and dust. This dust amount detection sensor has been developed by us. In this sensor, we used LM358 IC, along with which we used photodiode and IR LED to help us detect and measure the quantity of air particle. In this sensor, we made a hole to enter the air particle into a box so that any other element cannot contaminate. Using those IR LED, we too values from a constant field, thus further helping us to get the accurate data.

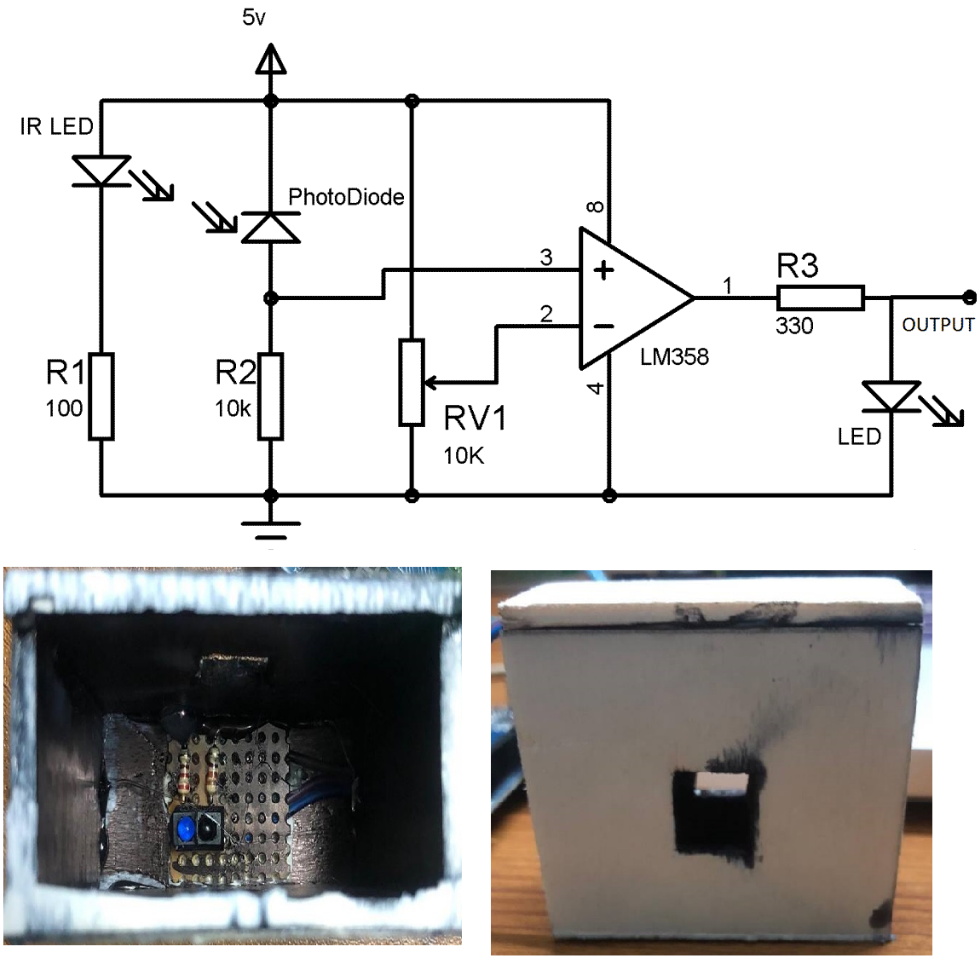

Figure: 2.2.7: Developed Dust Sensor

2.3: Electrical Design

Circuit: For any embedded system project. The circuit is the main part. If the connection between the components are not strong enough then the circuit will not work efficiently. We designed the total circuit system and simulated it in Proteus software. The main section of the circuit is the microcontroller unit. In our system, Arduino Nano with Atmega328p chip has been used as our main microcontroller unit. As portability is one of the main features of our system, we selected Arduino Nano due to its tiny size, which is o.73 inches in width and 1.70 inches in width. This microcontroller unit has 14 digital I/O pins and 8 analog input pins. It has a flash memory of 32KB and clock speed of 16 MHz. For connecting the total system with the web server, we used Wi-Fi as our protocol. For ensuring Wi-Fi facilities on the device, we used a chip named ESP8266. The chip has 64 Kbytes of instruction RAM and 96 Kbytes of data RAM, 64 Kbytes of boot ROM with 1M external flash chip. This chip can make smooth connection with internet using Wi-Fi. For sending data to the web server through this chip, we implemented AT command in the programming section. Now as we need to ensure a compact system, we designed our custom PCB using Proteus to integrate all the sensors into a small board which minimizes the size of the system. With the help of this PCB design, we have successfully reduced the wire connections which ensures a minimum system loss. This custom-made PCB also helps us to ensure a plug and play connection system using so we can easily replace our components in no time.

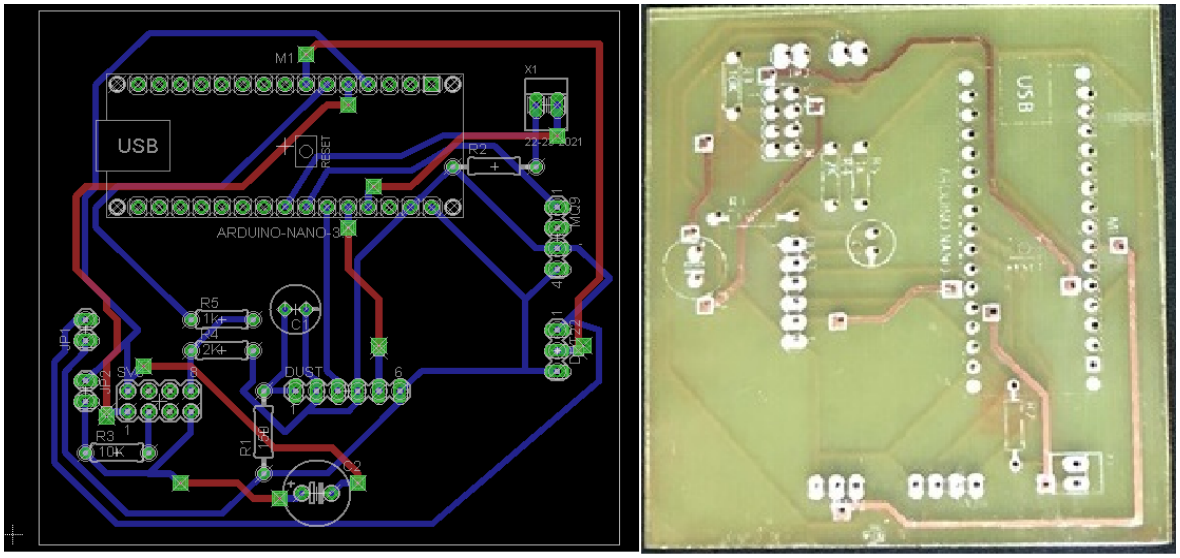

Figure: 2.3: Custom Designed PCB

2.4: Power Distribution:

For powering up the device we have two different types of source. One of them is a 12V 2A DC adaptor and another is a 12V 2200 mah lithium polymer battery. If we place the device near to any AC power source, we can use the DC adaptor as our power source. If we place the device in a remote area where the electricity is not available then we may use that battery pack as our power source. By hands on experiment, we have measured the ampere rating that has been drawn by the components of our system. Several individual circuit modules have been integrated into our system. The microcontroller unit needs 5V to power up itself.

It draws 0.2 A. The Wi-Fi module named ESP8266 consume 3.3V and 200 mA. Now moving on to the sensors, the temperature and humidity sensor DHT22 require 3.3V to operate and it consumes 0.2A. The sound sensor consumes 5V and 1mA to operate. Gas detection sensor MQ2 requires 5V and a 20mA for any operation. The light sensitivity sensor LDR consumes 5V and 0.3mA of current for working. Lastly, the dust sensor draws 20mA and requires 3V-7V for operation. If we observe the ratings, we see that maximum voltage we need to operate the system is 5V and each component draws current within 0.5A. So, as we are using power sources with 12V and 2A rating, it is enough for powering up the system with equal distribution. For converting the voltage from 12V to 5V, we used DC – DC buck converter.

2.5 Communication:

For accessing device data, we need to communicate with the system. In our case we have selected the Bluetooth communication as our communication protocol. We have developed a mobile application which can be connected with the system through a Bluetooth device which is integrated into the device. We have selected this protocol as Bluetooth is cheap and easily available. But when we started operating this device we faced couple of problems. One of them was Bluetooth having a very low range for communication and it also gets disconnected when any obstacle comes between the device and the mobile. As we want to build a device which can be accessed from anywhere of the world, we have switched our communication protocol from Bluetooth to web based protocol.

Chapter 3: IOT Features

IoT Features Block Diagram:

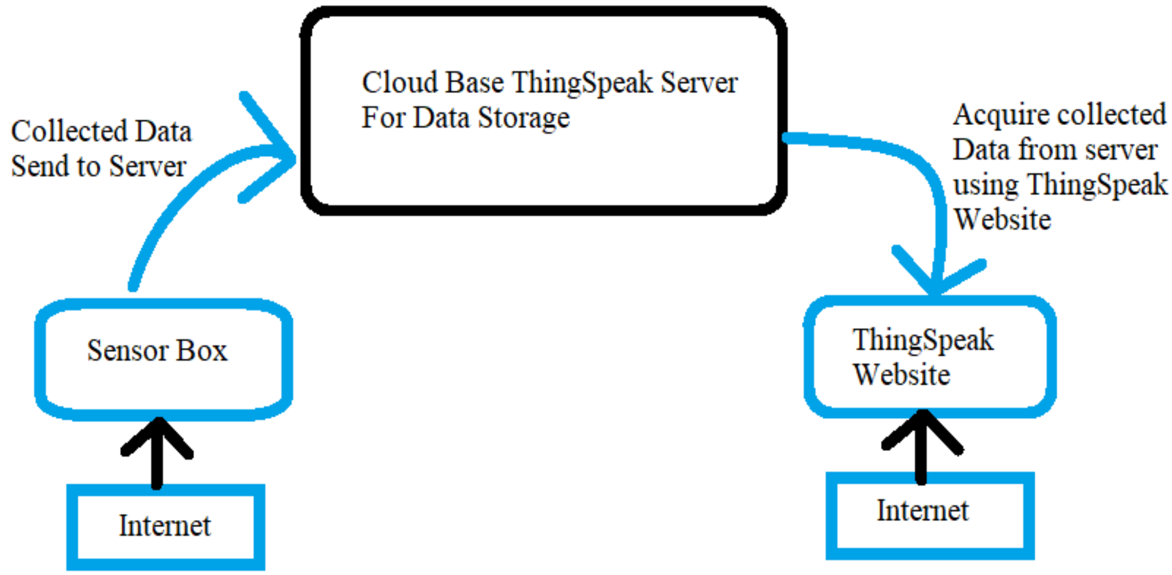

Figure: 3.1: IoT Communication system of the developed system.

3.1 Universal Communication: As we have discussed earlier that we have switched our communication protocol from Bluetooth to web-based communication, it helped us to build a universal communication system. In our system, a Wi-Fi module is integrated into the device. This module can send data to web server if there is internet connectivity available to the device. So, after collection of the data through the sensors, the device automatically sends all the data to the designated web server. This sending procedure was guided by the AT commands of ESP8266 Wi-Fi module. After sending the data, the server stores it in an organized manner. Now if anyone wants to access the data then he/she needs to go to that designated website and log on to it. The website shows all the data through graphical representation. In this way, internet of things or IOT has been served by our developed system which makes it a universal communication system.

3.2 Server system: For ensuring IOT features, server system is a must needed component. As we are offering universal communication system through our IOT feature, we also included a server system into our main system. So, after collecting the data through sensors the device sends those data to a web server using the ESP8266 Wi-Fi module. The sending process is done by AT command of ESP module. In the programming section of the microcontroller, we have written the AT command which works for sending the data to the web server.

```
void setup() {
  Serial.begin(9600);
  esp8266.begin(9600);
  sendCommand("AT",15,"OK");
  delay(4000);
  sendCommand("AT+CWMODE=1",5,"OK");
  delay(2000);
  sendCommand("AT+CWJAP=\""+ AP +"\",\""+ PASS +"\"",20,"OK");
  Serial.println("DHTxx test!");
  pinMode(ledPower,OUTPUT);

  dht.begin();
}
```

Figure: 3.2: AT command code

Now if we see at the above code which is short part of our main code then we can see that it is for DHT22 sensor which is known as temperature and humidity sensor. In the code we have used AT command which helps us to send a string to a destination. AT command means AT tension. Every command line starts with AT or at. When data collection for DHT22 is finished then AT command sends those data as string to the server. In the string two different data are sent in a delay of 4000 ms and 2000 ms.

3.3 Data Acquiring: So, after sending the data to the server, the expected work of the device is done. Now the server system starts working to organize the data. In our system we have used a free IOT based server named ThinkSpeak [10]. If we open an account in this server, we get a dedicated slot automatically where we can store data. There is a useful graphical user interface available in the website where we can plot the data into designated graph. There are both public and private access available in one single account. For users, we can open private access where they can only see the data and the analysis. We can also simulate and visualize our data in MATLAB through ThinkSpeak. As this system is accessed through internet, people can easily log on and know the data from any part of the world. In this way, we have ensured IOT features and universal communication system for our device.

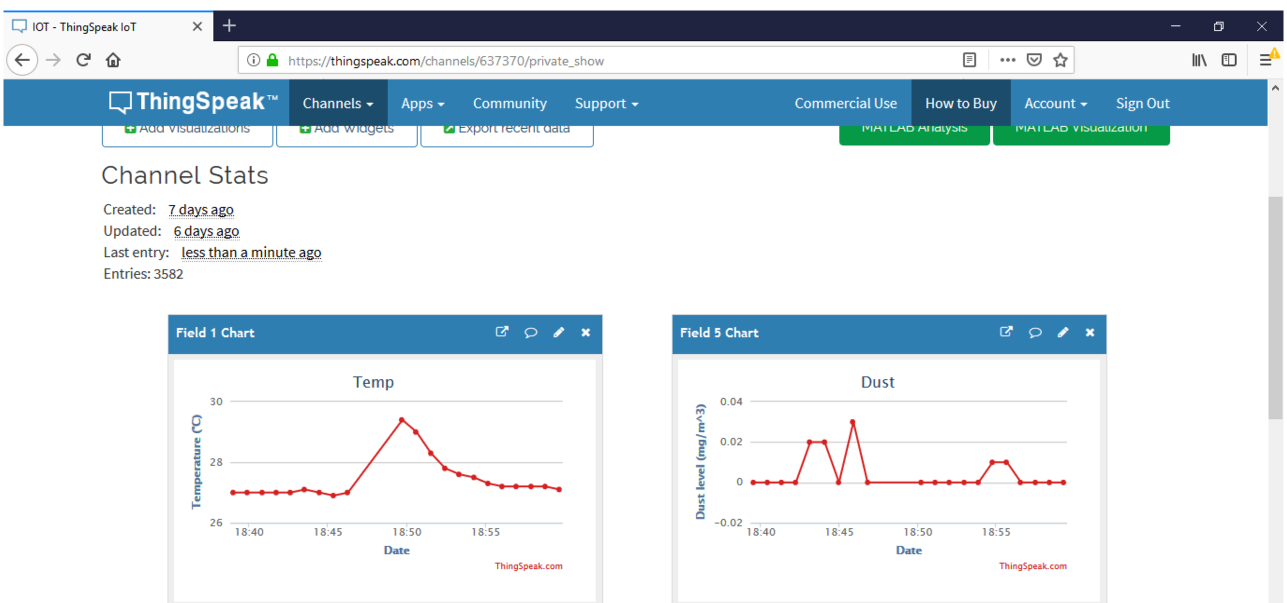

Figure: 3.3: GUI of Server

Chapter 4: Programming & Automation

Programming

For controlling the sensor individually, we have to program the microcontroller in a structured manner. The total codding part is divided into three part. The part are as follows

Part: 01

```
void setup() {
  Serial.begin(9600);
  esp8266.begin(9600);
  sendCommand("AT",15,"OK");
  delay(4000);
  sendCommand("AT+CWMODE=1",5,"OK");
  delay(2000);
  sendCommand("AT+CWJAP=\""+ AP +"\",\""+ PASS +"\"",20,"OK");
  Serial.println("DHTxx test!");
  pinMode(ledPower,OUTPUT);

  dht.begin();
}
```

Figure: 4.1: Program part -1 (Void setup)

This part is called the void setup. In this part the gathered values from the sensors will be send to the server for storage. If we look at the commands then we can understand that there are baud rate given for the 9600 per second information transfer. In the specific portion of that program shows that values from DHT22 sensor are being send to the server through serial.println command.

```
void loop(){
  gas();
  dht_d();
  for(x=0; x<5 ; x++){
  dust2();
  delay(1000);
  }
  lumen();
  sound();

  send_data_temp();
  delay(4000);
  send_data_hum() ;
  delay(4000);
  send_data_lpg();
  delay(4000);
  send_data_light();
  delay(4000);
  send_data_dust();
  delay(4000);
  send_data_sound();
  delay(4000);
```

Figure: 4.2: Program part -2 (Void loop)

In this portion of the program a loop has been set for continues data transfer from the sensor. Some variable values are set and a delay 0f 4000ms also set for smooth data transfer to the server.

```
void dust2(){
  digitalWrite(ledPower,LOW);
  delayMicroseconds(samplingTime);

  voMeasured = analogRead(measurePin);

  delayMicroseconds(deltaTime);
  digitalWrite(ledPower,HIGH);
  delayMicroseconds(sleepTime);
  voMeasured = analogRead(measurePin);

  calcVoltage = voMeasured*(5.0/1024.00);
  dustDensity = 0.17*calcVoltage-0.1;
  if ( dustDensity < 0)
  {
    dustDensity = 0.00;
  }


  Serial.print(voMeasured);
  Serial.println("Dust Density:");
  Serial.println(dustDensity);
```

Figure: 4.3: Program part -3 (Sensor working procedure)

In this portion of the program how a sensor collect data from the environment and how to calculate the exact value it shown. This specific portion is working for the collection and calculation of dust values from the environment. Firstly the sensor will collect the raw analog values from the environment regarding dust. After that using some equations the actual amount of dust has been calculated by the program itself. In this way for each sensor individual part has been written into the program.

Home Automation

After completing the total system, we have integrated the sensor modules with some of the home appliances. For example, we have integrated the DHT22 temperature sensor with the ceiling fan used in the home. In temperature goes up from a certain value then the fan will automatically turn on and if the temperature goes down then the fan will turn off automatically. Based on the temperature sensors value the fan will be operating. In this way we have also integrated LDR or light sensor with the energy bulb that we are using in our home. If the light sensor values go down then the bulb will automatically turn on itself and if the light sensor value goes up then the light will be turn off. Based on the values of light sensor the bulb will be controlled.

For integrating this automation part with our system and home we have designed some circuit.

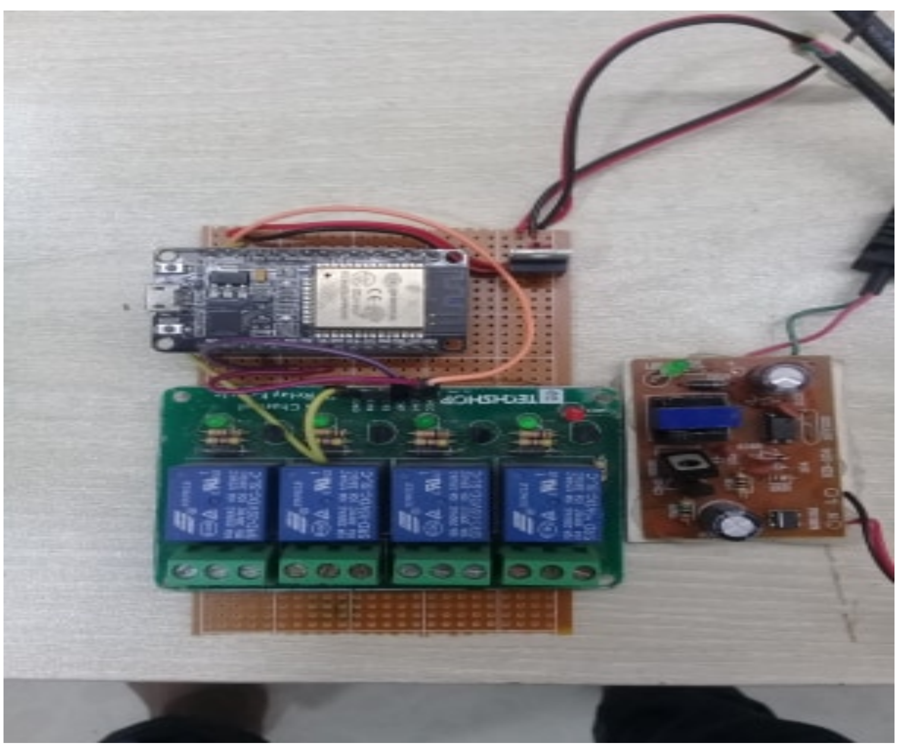

Figure: 4.4: Home Automation Circuit

The above shown circuit is consist of Node MCU Wi – Fi module, four channel relay module and a 12v & 5v voltage regulator. Using the Node MCU module a temporary server has been created. When the sensor box and the automation circuit get connected into same router through Node MCU Wi – Fi module then an IP address has been created automatically. The IP address will look like this 192.168.0.106/H. If we go to that IP address then we can see the on / off commands for light and fan. When the sensor receives values more than a certain value for example temperature sensor receives value 30^{o} C then a http request will be sent to the IP address for turn of the fan. This http protocol works through gate method. After the request the IP will look like this 192.168.0.106/G it means the automation circuit will turn on the fan through relay. In this way 192.168.0.106/g, 192.168.0.106/H, 192.168.0.106/h this IP's will work for fan off, light on and light off respectively.

Chapter: 5: Experiment and Analysis

Practical Dataset Collection:

For finding the efficiency and testing the feasibility of a system, there is no better way than real life experiment. For our developed system, we have also conducted few tests in practical scenario. We picked three different places from the capital city of Bangladesh, Dhaka. The places are Mirpur 10, Greenroad and Gulshan. We set our device in different places on those designated areas and collected the data directly from our web server. We conducted our experiment from 8 AM to 10 PM that is, a collection 14 hours of continues data.

The data set we have collected from those three places were directly sent to our web server from those particular areas. Later, we extracted those datasets from our server site. We organized those data sets according to the specified areas. The dataset we have collected are as follows:

Time	Dust(mg/m3)	Time	Sound(dB)	Time	Light(cd)
8	3.05	8	60	8	200
9	3.1	9	63	9	220
10	3.28	10	67	10	232
11	3.5	11	68	11	250
12	3.68	12	70	12	260
1	3.75	1	73	1	274
2	3.81	2	74	2	282
3	3.89	3	73	3	271
4	3.94	4	76	4	260
5	3.96	5	80	5	180
6	3.82	6	82	6	170
7	3.73	7	82	7	150
8	3.62	8	84	8	142
9	3.51	9	78	9	135
10	3.47	10	72	10	129

Time	Temp	Time	Humidity	Time	Co2
8	18	8	68	8	360
9	19.6	9	65	9	362.6
10	21.5	10	62	10	350
11	22	11	59	11	348.3
12	24	12	57	12	344
1	27	1	55	1	340
2	26.5	2	56	2	332.5
3	25	3	58	3	328
4	23	4	62	4	325
5	21.6	5	65	5	322
6	20	6	68	6	330
7	19.2	7	71	7	338
8	18	8	74	8	342.4
9	17.1	9	78	9	346
10	16	10	81	10	351

Figure: 5.1: Collected Data from Mirpur-10

Time	Dust(mg/m3)
8	2.94
9	2.96
10	2.97
11	3.1
12	3.25
1	3.3
2	3.41
3	3.49
4	3.53
5	3.62
6	3.71
7	3.68
8	3.62
9	3.51
10	3.47

Time	Sound(dB)
8	58
9	60
10	62
11	65
12	68
1	70
2	71
3	73
4	75
5	79
6	80
7	81
8	81
9	75
10	73

Time	Light(cd)
8	200
9	220
10	232
11	250
12	260
1	274
2	282
3	271
4	260
5	180
6	170
7	150
8	142
9	135
10	129

Time	Temperature
8	20
9	20.6
10	21.5
11	22.9
12	23.6
1	26
2	26.5
3	25.3
4	24
5	22.9
6	21.2
7	20.4
8	19
9	18
10	16

Time	Humidity
8	67
9	65
10	62
11	58
12	57
1	55
2	56
3	58
4	60
5	62
6	67
7	71
8	74
9	78
10	84

Time	Co2
8	320
9	332
10	342.6
11	348.3
12	350
1	354
2	356
3	358
4	362
5	365
6	367
7	369
8	374
9	368
10	361

Figure: 5.2: Collected Data from GreenRoad

Time	Dust(mg/m3)
8	2.1
9	2.16
10	2.2
11	2.28
12	2.39
1	2.45
2	2.48
3	2.54
4	2.59
5	2.63
6	2.67
7	2.71
8	2.75
9	2.6
10	2.54

Time	Sound(dB)
8	50
9	51
10	53
11	54
12	57
1	60
2	62
3	65
4	66
5	69
6	70
7	72
8	74
9	75
10	73

Time	Light(cd)
8	200
9	220
10	232
11	250
12	260
1	274
2	282
3	271
4	260
5	180
6	170
7	150
8	142
9	135
10	129

Time	Temperature
8	19
9	20
10	20.8
11	21.4
12	22
1	23
2	23.6
3	25
4	24.2
5	23.1
6	21.2
7	20.4
8	19
9	18
10	18

Time	Humidity
8	62
9	60
10	59
11	58
12	57
1	55
2	56
3	58
4	61
5	62
6	67
7	69
8	72
9	75
10	80

Time	Co2
8	300
9	304
10	307
11	311
12	315
1	320
2	327
3	330
4	334
5	339
6	340
7	344
8	350
9	357
10	360

Figure: 5.3: Collected Data from Gulshan

We plotted all the collected data in designated graph to visualize the actual situation practically using MATLAB. The graphs are as follows

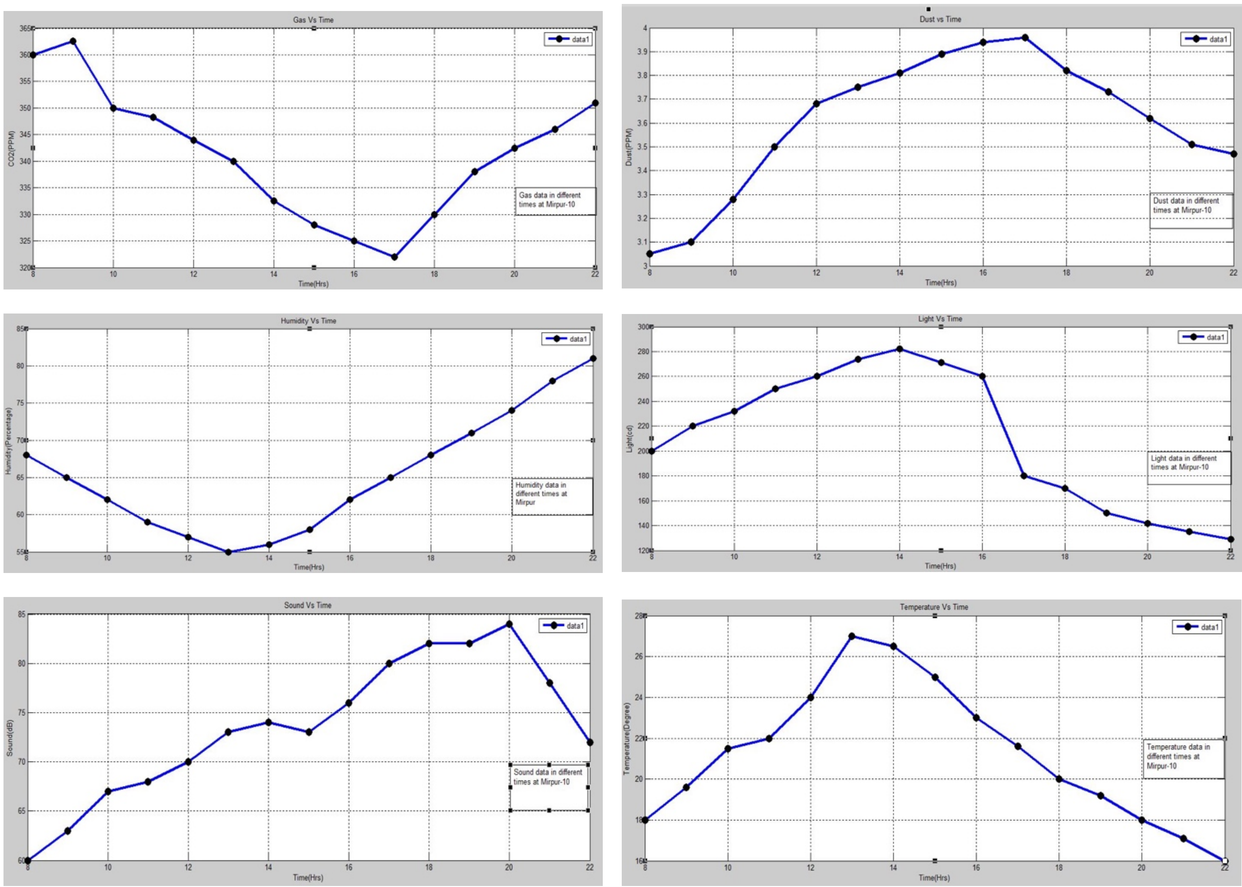

Figure: 5.4: Data set from Mirpur-10

In the above graph, we have arranged the values we collected from Mirpur- 10 area Dhaka, Bangladesh. In the graphs there are six curves stating temperature, humidity and Co2(Gas Data), Dust, Light, Sound. Now if we see at the values then we can relate that the temperature is increasing with respect to time. When time is between 4-5 PM then the temperature goes downwards. As currently winter season is knocking at the door so the average temperature we have calculated is around 22°C at Mirpur. For winter season humidity is also increasing with respect to time. The average humidity we have achieved is around 70%. Now the Co2 level is too much high at Mirpur according to our data set. With respect to time the value of Co2 is gone upward direction. The average value of Co2 at Mirpur is around 340 ppm. The minimum value of need to be under 200 ppm to ensure a good quality of environment [7]. But in Mirpur we have found the average value at 340 ppm so it states that the air quality is polluted. The average sound level at Mirpur is around 72dB. From our study we have found that above 70dB sound level is generally made from heavy traffic jam [8]. So according to our data set we can state that the noise level is too much in Mirpur which causes sound pollution. Now moving to the dust level curve in second graph we see that the average value for dust level at Mirpur is around 3.50 mg/m3 in the air. With respect to time the value is increasing. The minimum dust that human being can tolerate is below 1.5 mg/m3 [9]. So according to our data set the dust level is too much high at Mirpur which is around 3.50 mg/m3. So, we can state that the air quality is also affected by the dust pollution at Mirpur. Now coming to the light sensor, we found the value at pick daylight is around 282 cd. With respect to time it goes downwards. At night time the value we found is around 129 cd.

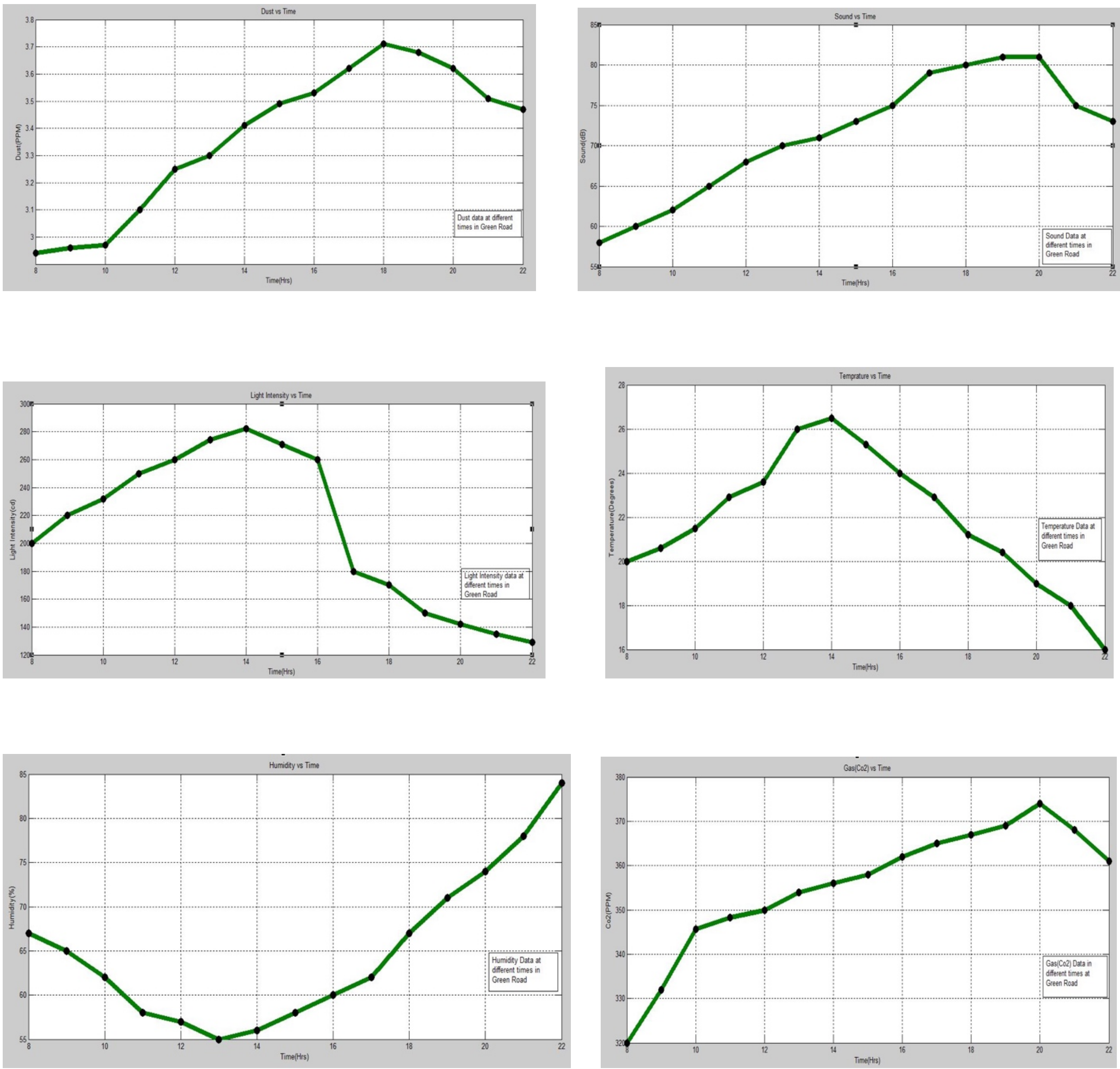

Figure: 5.5: Dataset from Green Road

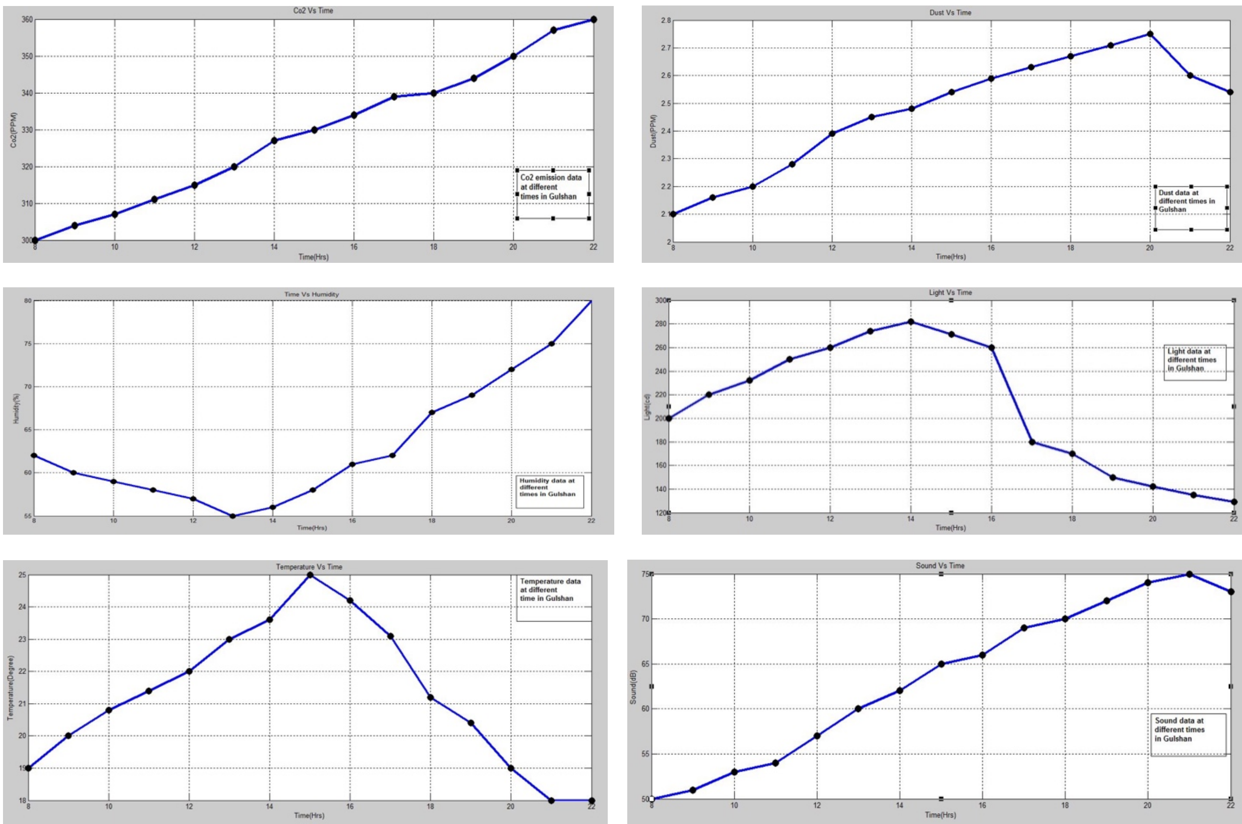

Figure: 5.6: Dataset for Gulshan

We have also collected similar type of data from two more places in Dhaka. One is from GreenRoad and another is from Gulshan. After having 3 type of dataset we can now easily find the environment condition of different places in Dhaka city. For example, from the Dust sensor value we see that the average amount of dust in Mirpur is 3.50 mg/m3 and the average amount of dust in Gulshan is 2.42 mm/m3. From those two values we can understand that the air quality of Gulshan is quite good comparing to Mirpur. In this way we can find the comparison from other values as well. We have also plot comparison graph to visualize the difference of the environment in Mirpur, Greenroad and Gulshan. We put all the temperature, sound and dust data into three separate graph and create three different curves in one graph.

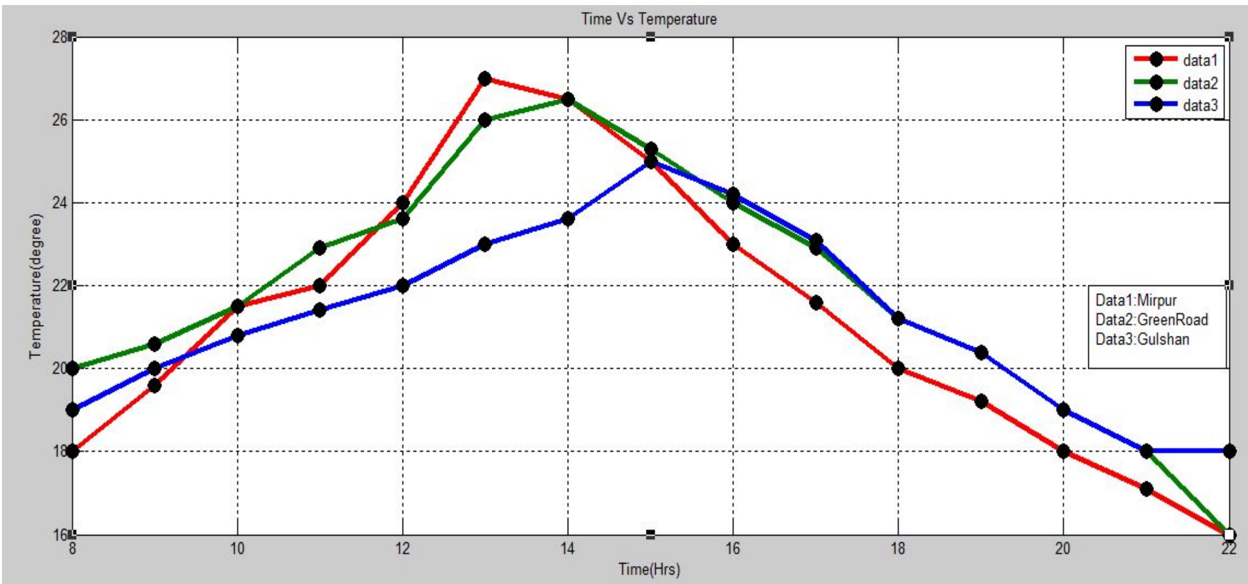

Figure: 5.7: Comparison Graph for Temperature

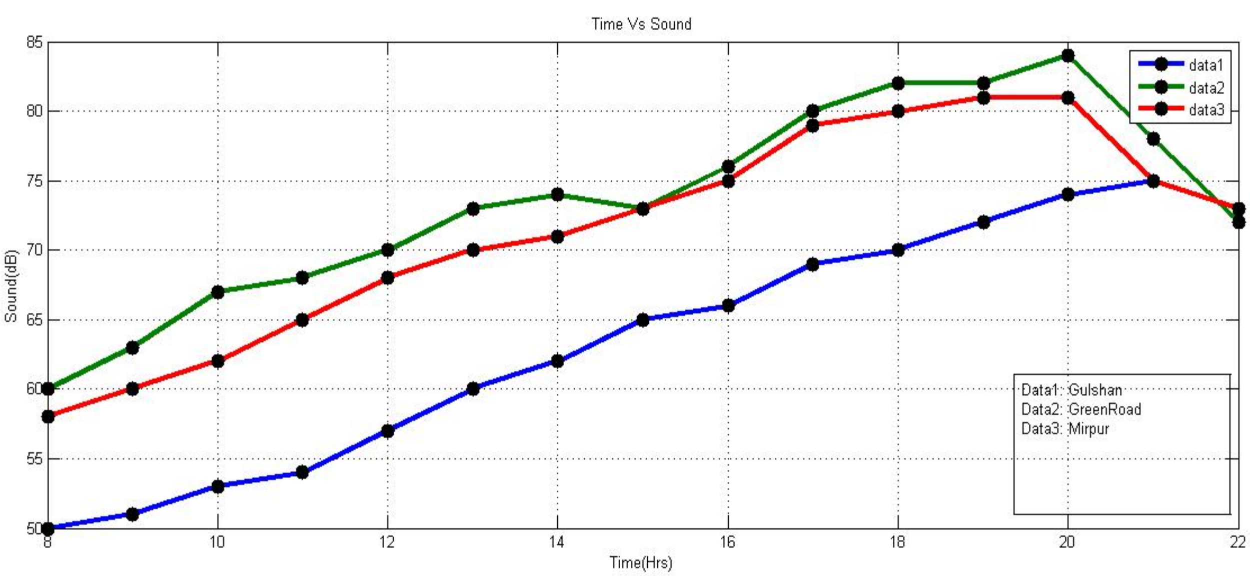

Figure: 5.8: Comparison Graph for Sound

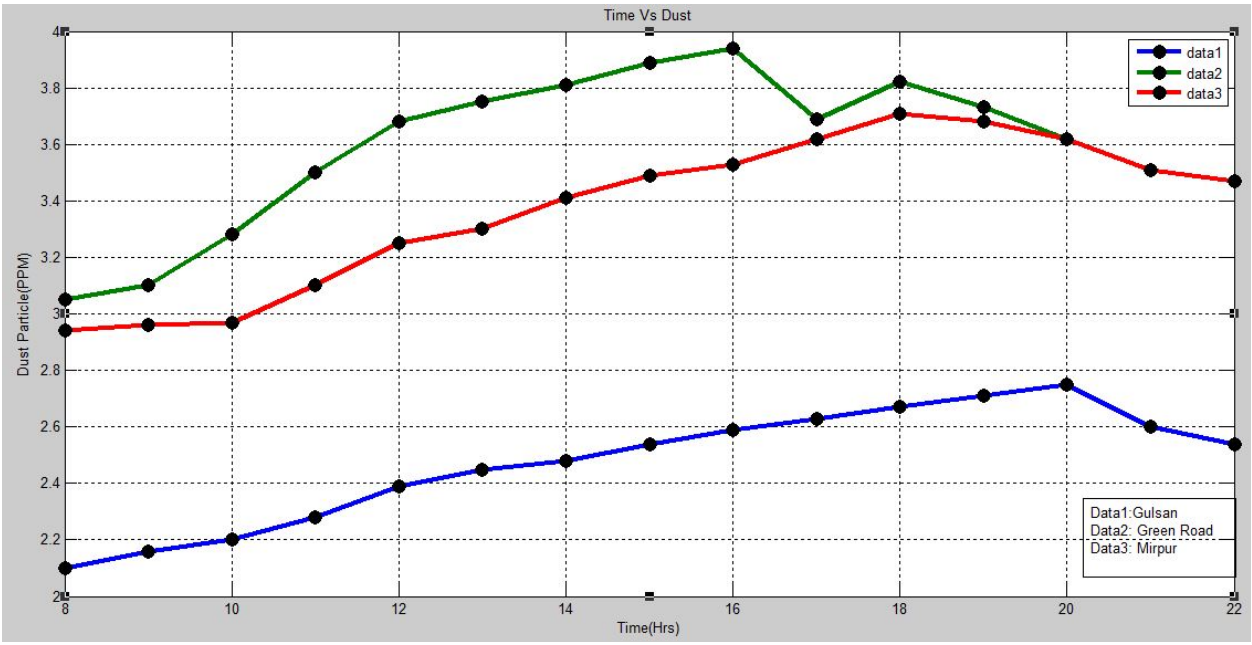

Figure: 5.9: Comparison graph for Dust

If we observe the above graphs then we can easily understand about the environmental difference in these places. For example, if we look at the Dust amount curve then we can see that the dust curve of Mirpur shows higher values than Gulshan. From that we can understand that the Gulshan area's air quality is healthier than Mirpur-10 area. In this way we can find the comparison between different areas.

Now if we have mentioned earlier that we developed two sensors by our self. Those are sound sensor and dust sensor. Now we have calculated the efficiency of our custom-made sensors comparing with the readymade sensors.

Accuracy of custom-made Sound sensor:

We have collected data from same place Mirpur-10 using both readymade sound sensor and our custom-made sound sensor. The data are as follows:

Readymade sound sensors value at 11 AM - : 83dB

Custom made sound sensor value at 11 AM -: 68dB

Accuracy = $\frac{68 X 100}{83}$ = 81.93%

Accuracy of custom-made Dust sensor:

We have collected data from same place Gulshan using both readymade DUST sensor and our custom-made DUST sensor. The data are as follows:

Readymade DUST sensors value at 3 PM - : 2.73 mg/m3

Custom made DUST sensor value at 3 PM -: 2.54 mg/m3

Accuracy = $\frac{2.54 X 100}{2.73}$ = 93.04%

Chapter 6: Results and Implementation Challenges

6.1: Result Analysis:

As we have mentioned earlier that we have practically operated our device in different scenario. We selected three different places in Dhaka city which are Mirpur-10, GreenRoad and Gulshan. We have collected data through our system from 8 AM to 10 PM of a certain day. Now if we observe the data quality then we can see that the values from the readymade sensors are quite accurate and to be more specific the sensors give us almost 100% accurate values. Now moving on to our own built sensor, we have built sound and dust sensor by our self. Therefore, when we collect the data from those two sensor then we see that it gives us 93% for DUST and 81.93% for sound accurate data comparing with the readymade sensor modules. Now after our findings we see that readymade sensor module uses high quality SMD electronics component like resistor, capacitor and diodes. But we are using conventional resistors, capacitors so there occur the data loss. That's why we receive little bit lower amount of accuracy comparing with the readymade sensors.

6.2. Limitations during Implementation and Solutions:

When we are developing the system, we have faced couple of problems with some sensor module. During the development process of sound sensor, we used LM386 audio amplifier with capacitors, which sends the values from microphone to ADC. Now firstly when use the sensor we see that it was working properly but the noise amount of the sensor was too much high that's why the values were scattered.

Now if we use this sensor in this way then we may not get a higher amount of accuracy. As a solution of this problem we have designed a new amplifier circuit with LM358 audio amplifier. Now in this circuit we have implemented one high pass filter and one low pass filter. Using those filter the module can eliminate the noise under or above a certain frequency range. In this way we have solved the noise related problem.

Chapter 7: Conclusion and Future Development Scopes

In this modern era of robotics and new technologies we have almost forgot about our one of the most important elements of the earth which is environment. Now a days we do not care about to harm the environment in different ways. Like we use to through waste materials on roads and pollute our rivers with industrial waste. So, for finding the solution of the environment pollution and introducing a new idea we have developed the system named portable environmental monitoring system. In our system we have integrated different types of sensors with a microcontroller unit and a Wi-Fi module. The sensors are capable of collecting six different types of environmental data. Those data are also can be accessed using a website from anywhere of the world. If people use our sensor then they can easily realize the current environment situation. Base on that people can take necessary steps to improve the environment. Moreover, in near future we will developed a custom mobile application only for this device which will do communication using internet and server system. As mobile applications are getting popular day by day so we can do this. We can also use single sensor module to fulfil any single agenda. For example, if we take light sensor and fixed it with the road side lamp post with microcontroller unit then we can automatically control the lamp post operation using the light sensor data. Moreover, if we use the gas sensor in our kitchen then we can detect gas leakage and protect our self and also can save the natural resource. So, for ensuring a safe and healthy weather we have to be more cautious about our action towards environment. In this process of reconstructing our environment devices like portable environment monitoring system can play vital role to achieve required goals.

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