DESIGN AND IMPLEMENTATION OF AN ARDUINO BASED SOLAR POWERED WEATHER STATION

by

FAHIM ASHBAB SAHEEL

MOHAMMAD SAIFUL ISLAM

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

Department of Electrical & Electronic Engineering

INTERNATIONAL ISLAMIC UNIVERSITY CHITTAGONG

AUGUST 2017

DESIGN AND IMPLEMENTATION OF AN ARDUINO BASED SOLAR POWERED WEATHER STATION

by

FAHIM ASHBAB SAHEEL

MOHAMMAD SAIFUL ISLAM

An Undergraduate Project

Submitted as partial fulfillment of the requirement for the degree of

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

Department of Electrical & Electronic Engineering

INTERNATIONAL ISLAMIC UNIVERSITY CHITTAGONG

AUGUST 2017

CERTIFICATE OF APPROVAL

This undergraduate project entitled as **"Design & Implementation of An Arduino Based Solar Powered Weather Station"** submitted by **Fahim Ashab Saheel (ET – 131060**) and **Mohammad Saiful Islam (ET-133004) of** session **Spring 2017**, to the Department of Electrical & Electronics Engineering, International Islamic University Chittagong has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science in Engineering (Electrical & Electronics Engineering) and approved as to its style and contents for the examination for 18 August, 2017.

Supervisor
Engr. Md. Ahsanul Haque
Assistant Professor
Department of Electrical and Electronics Engineering
International Islamic University Chittagong.

DECLARATION

We hereby declare the project "Design & Implementation of An Arduino Based Solar Powered Weather Station" under the supervision of Engr. Ahsanul Haque, Assistant Professor of the Department of Electrical and Electronics Engineering, International Islamic University Chittagong is based on practical result found by ourselves. Any part or whole part of this project has not been previously submitted for any degree. Theoretical materials have been properly cited as per IIUC academic report writing format.

Fahim Ashab Saheel

Mohammad Saiful Islam

ACKNOELEDGEMENT

With the great mercy and bless by Almighty Allah (SWT) this project has come to an end. It would not be possible without Him.

We are highly thankful to our honorable supervisor Engr. Md. Ahsanul Hoque for his guidance and constant supervision as well as providing necessary information regarding this project. We would like to also express our gratitude to our beloved parents for their co-operation and support which help us in completing this project.

Authors

ABSTRACT

Weather is the state of the atmosphere and is a very essential part of human life. Important things like living in a place or scientific experiments depends on weather of that particular area or state or room. For these, people need atmospheric measurements of temperature, humidity, pressure etc. and these information is providing by weather stations. This paper describes the approach to set up a weather station based on Arduino. The main attributes of this weather station is to measure the surrounding atmospheric readings of weather. These readings will be collected by some sensors which are temperature and humidity sensor (THD), barometric pressure sensor. A wifi module is also used in this weather station to maintain a connection to the internet to get more informations like sunrise, sunset, rainfall and wind speed . All these readings will be displayed on a LCD display and every steps of this station is directed by an arduino mega microcontroller. A matrix keypad is used in here to help the users to view the readings of current weather update, predictions of today and tomorrow easily. Also this weather station is powered by solar panel.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Introduction :

From the ancient time human beings depend on weather. Many activities of human life depends directly on weather. To live in a place, people needs to observe first about the weather forecast around there. Weather forecast combines humidity, temperature, atmospheric pressure, rainfall etc. Now a days, many facilities are there to observe weather by the wonder of science and technologies. In weather monitoring systems, different parameters like time and date, temperature, relative humidity, dew point, wind direction and speed, rainfall amount, and weather forecast are all shown on the LCD display. Temperature and humidity are indicated for both indoor and outdoor locations. Modern technology has allowed the combination of several sensors into one integrated weather station that can be permanently located at one site, or transported to a site where localized weather is needed. This project is to design and implement a weather station which can observe the air pressure, humidity and temperature with various sensors and displaying the readings on the LCD display.

An Arduino mega microcontroller is the controller of this whole system. A DTH22 temperature and humidity sensor is used to give the readings of temperature and humidity around the area. To measure the atmospheric pressure, a barometric pressure sensor has been used. A Solar panel has been used to provide the power supply of this “Arduino Based Solar Powered Weather Station”. Also this weather station can show some important readings like sunset, sunrise, rainfall, wind speed etc by using internet via ESP 8266 wifi module. All the readings will be shown on a 20x4 LCD Display.

1.2 Motivation :

After researching various papers we acknowledged that a complete weather station must needs various kinds of features related to forecast. Although some readings are always important and we are focusing on this point to work on these readings. Also we want to implement this station by using Arduino and solar panel, because Arduino is a very useful microcontroller to do project and we intended to use solar panel so that the station could use renewable energy to provide power supply.

1.3 Objectives :

Objectives of this project are given below

1. To design a weather station.
2. To implement this station to observe air atmosphere by using sensors.
3. To show the readings of weather by a LCD display.

1.4 Methodology :

The main goal of this project is to design a cost-effective and simple weather station by using solar panel as the power supply. The controller of this project is Arduino Mega 2560, all the operations will be operated by it as prototype. Prototype of this is written via Arduino IDE software which is the specially made for Arduino programmable board. Though two different sensors have been used in this station to get the present readings of air, a wifi module is also used to provide some important informations like sunrise, sunset, rainfall, wind speed due to cost efficiency. A small keypad also has been attached to the Arduino to make a section where user can easily access the weather station. The whole system gets its operated power from solar panel, which directly connected to Arduino Mega 2560. A backup battery has also been attached to serve power in the bad weather, also this battery conserves energy from solar panel.

1.5 Report Outline :

Chapter 1 : Introductions of this project, objectives of this project, motivation and this outline methodology of this project.

Chapter 2 : History of the weather forecasting and literature reviews, system of this project, different technologies around the world about this system.

Chapter 3 : Design methodology and hardware implementation of this project.

Chapter 4 : System designs and analysis.

Chapter 5 : Results, system testing and discussion of performance of this device and system.

Chapter 6 : Conclusions of this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction :

All the theory concepts related to this project will be discussed in this chapter . The history and background of weather stations , the purpose of weather monitoring system will be derived briefly in this literature review . Also , here will be shown the benefits of weather monitoring system and different technologies about weather monitoring system across the world.

2.2 History of Weather Station :

For centuries peoples are directly depending on agriculture. From then till now farmers and agricultural departments of every states and country use different technologies to get a of glimps of weather update which is beneficial for the agriculture. Also, weather update is necessary for living, scientific experiments etc. At the beginning of scientific revolution, heavy instrument are used to get the atmospheric readings of weather. People can get the news of daily weather or future prediction in the newspaper or television which was delivered by the national weather station. Now a days, it is very easy to know the news of weather by the help of internet. Every smartphone has different kinds of weather oriented application [1].

2.3 Weather monitoring System :

A weather station is a facility, either on land or sea, with instruments and equipment for measuring atmospheric conditions to provide information for weather forecasts and to study the weather and climate. The measurements taken include temperature, atmospheric pressure, humidity, wind speed, wind direction. Wind measurements are taken with as few other obstructions as possible, while temperature and humidity measurements are kept free from direct solar radiation, or insolation. Manual observations are taken at least once daily, while automated measurements are taken at least once an hour [1].

A personal weather station is a set of weather measuring instruments operated by a private individual, club, association, or even business (where obtaining and distributing weather data is not a part of the entity's business operation). The quality, number of instruments, and placement of personal weather stations can vary widely, making the determination of which stations collect accurate, meaningful, and comparable data difficult. A variety of land-based weather station networks have been set up globally. Some of these are basic to analyzing weather fronts and

pressure systems, such as the synoptic observation network, while others are more regional in nature, known as mesonets [2].

2.4 Benefits of Weather Station :

Many farmers rely on weather stations to provide them with accurate weather information. From family owned farms and vineyards to the agricultural industry at large, being able to take accurate and reliable environmental measurements is a must as their livelihood depends on having precise and up-to-date weather information around the clock. Many other industries and businesses such as construction companies, utilities and more depend on knowing current and future weather conditions and find weather stations to be indispensable in their line of work.

2.5 Previous Works :

Many works have been done about weather station in various universities around the world. Some of them are described below :

2.5.1 Design of Weather Monitoring System Using Arduino Based Database Implementation:

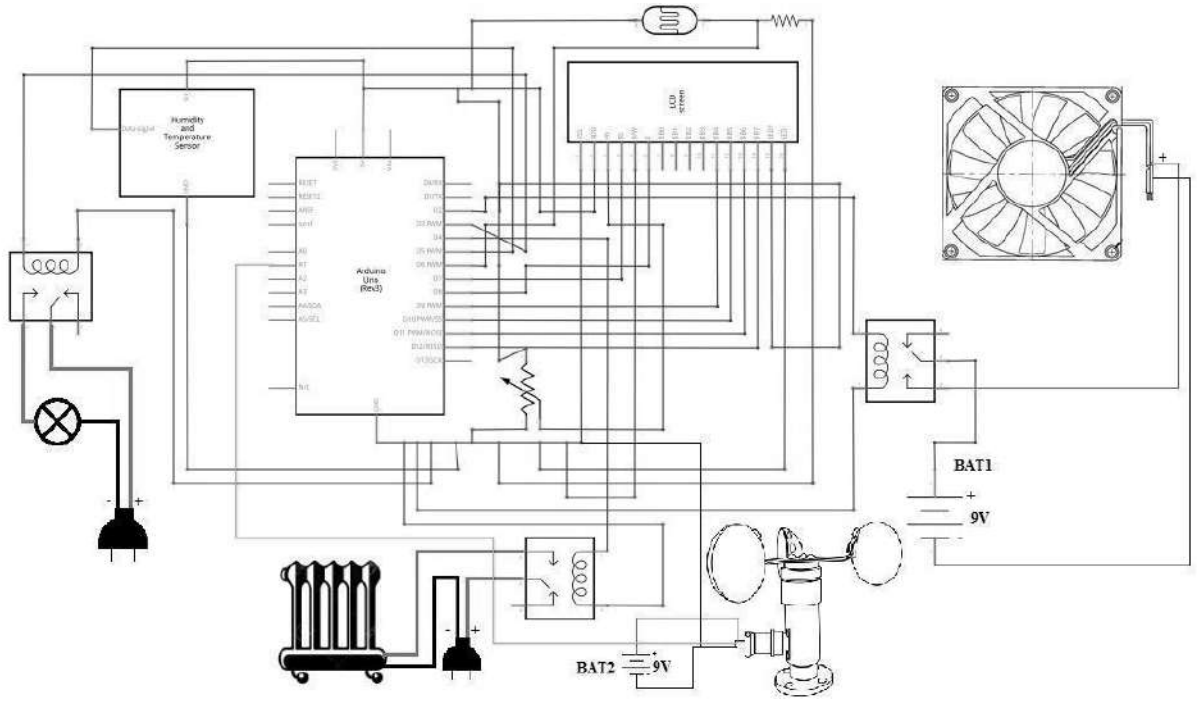

Fig 2.1 Circuit diagram of database based weather monitoring system using Arduino [3]. This project had been done by Sarmad Nozad Mahmood and Forat Falih Hasan of Al- Kitab University College. Circuit diagram of this Arduino based weather monitoring system is shown in "**Fig. 2.1**". Their work is basically build an combination of two study fields based on control system and data acquisition technique. They created a database system including with some

sensors to generate the presented data. The main attributes of their work have been chosen based on the sensors used to build the system in order to create an effective weather station project. The proposed sensors used to measure and store Temperature, Humidity, and Wind speed data [3].

2.5.2 Wireless Remote Weather Monitoring System Based on MEMS Technologies :

Rong-Hua Ma of Department of Mechanical Engineering in Chinese Military Academy, Yu-Hsiang Wang of Department of Mechanical and Automation Engineering and Chia-Yen Lee of Department of Materials Engineering proposed a wireless remote weather monitoring system based on Micro-Electro-Mechanical Systems (MEMS) and wireless sensor network (WSN) technologies comprising sensors for the measurement of temperature, humidity, pressure, wind speed and direction, integrated on a single chip. The passage of air across the surface of the flow sensors prompts variations in temperature among each of the sensing resistors. Evaluating these variations in resistance caused by the temperature change enables the measurement of wind direction [4].

2.5.3 Internet of Things (IoT) Based Weather Monitoring system :

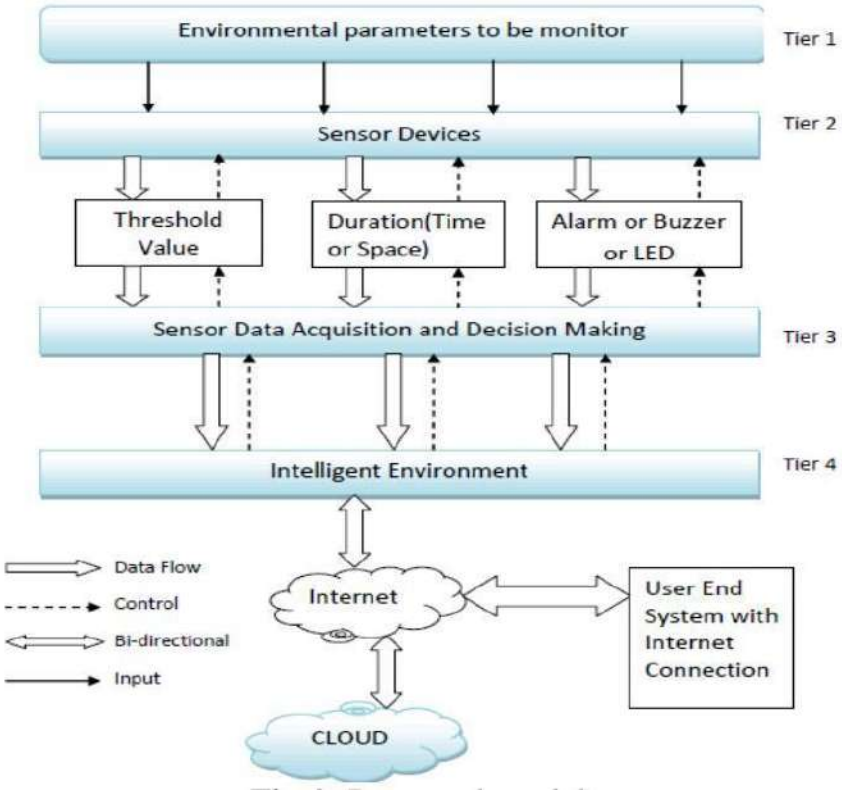

Fig 2.2 Functional Diagram of IoT based weather station [5].

Bulipe Srinivas Rao, Prof. Dr. K. Srinivasa Rao of TRR College of Engineering at Hyderabad and Mr. N. Ome of GRIET at Hyderabad in India proposed this weather system based on IoT. Functional Diagram of IoT based weather station is shown in " **Fig. 2.2**". Their system proposed an advanced solution for monitoring the weather conditions at a particular place and make the information visible anywhere in the world. The technology behind this is Internet of Things (IoT), which is an advanced and efficient solution for connecting the things to the internet and to connect the entire world of things in a network. Here things might be whatever like electronic gadgets, sensors and automotive electronic equipment. This system deals with monitoring and controlling the environmental conditions like temperature, relative humidity, light intensity and CO level with sensors and sends the information to the web page and then plot the sensor data as graphical statistics. The data updated from the implemented system can be accessible in the internet from anywhere in the world [5].

2.5.4 Design of wireless weather Monitoring System :

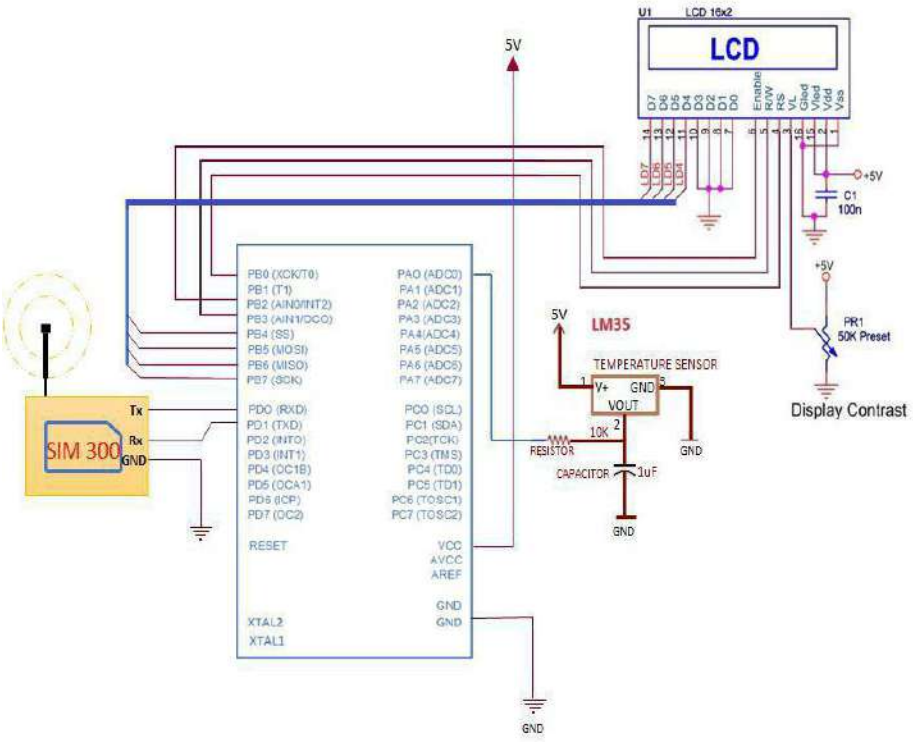

Fig 2.3 Circuit diagram of microcontroller based wireless weather monitoring system [6].

Keshav Kumar Singh and S. Styline Chirmaxo of the Department of Electronics & Communication Engineering at National Institute of Technology in Rourkela had done this project. Circuit diagram of microcontroller based wireless weather monitoring system is shown in "**Fig. 2.3**". The main objective of their project is to devise a simple low cost microcontroller based weather monitoring system using wireless technology which fetches weather conditions using various sensors like temp, humidity etc , displays it on LCD and forwards it to remote user by SMS [6].

2.5.5 Arduino Based Weather Monitoring System :

Karthik Krishnamurthi, Suraj Thapa, Lokesh Kothari and Arun Prakash are in the department of Computer Science in Christ University at Bangalore. Circuit Diagram of Arduino Uno Based Weather Monitoring System is shown in "**Fig. 2.4**". They have worked on weather monitoring system based on arduino microcontroller. Their work is on to develop an automated system which monitors the weather condition. Through this system operator can automatically collect the information about humidity and temperature. The details are stored in a database and according to current and previous data the results can be produced in graphical manner in this system. The objective of their project is to formulate the weather and be able to forecast the weather without human error [7].

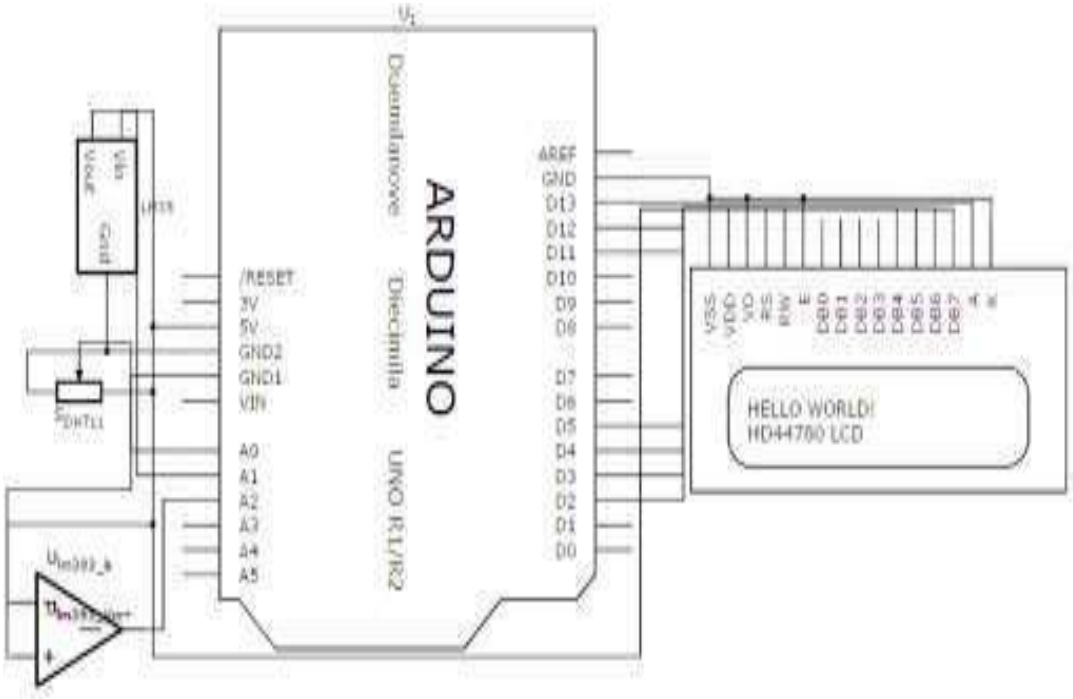

Fig 2.4 Circuit Diagram of Arduino Uno Based Weather Monitoring System [7].

2.5.6 Design and Implementation of Weather Monitoring and Controlling System :

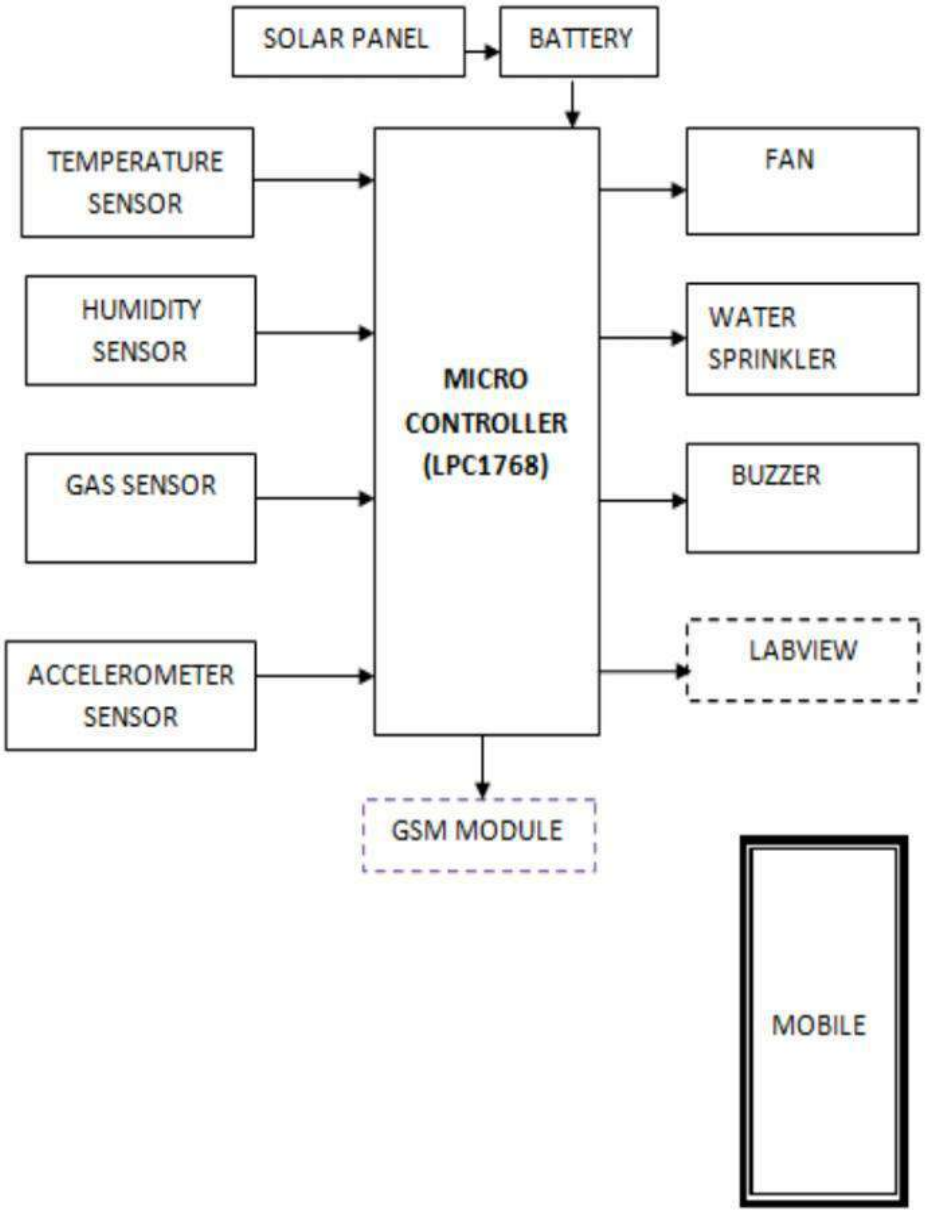

Fig 2.5 Block digram of LPC1768 microcontroller based station [8].

This project had been done by a student named P. Susmitha and an assistant professor named G.Sowmyabala of Dept. of ECM at K L UNIVERSITY in Guntur (Dt). Block digram of LPC1768 microcontroller based station is shown in "**Fig. 2.5**". The fundamental aim of their project is to develop an embedded system to design a weather monitoring system which enables the monitoring of weather parameters in an industry [8].

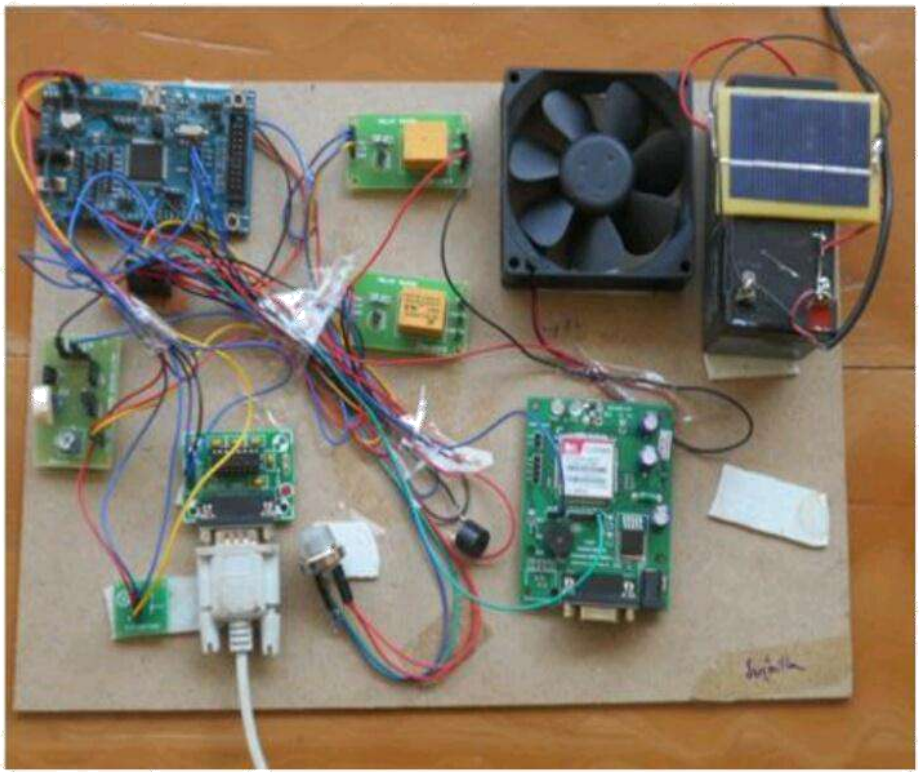

Fig 2.6 Hardware screen shot of LPC1768 microcontroller based station [8].

Hardware screen shot of LPC1768 microcontroller based station is shown in "**Fig. 2.6**". The data from the sensors are collected by the microcontroller and also microcontroller sends the sensors data in to the LABVIEW by using the Serial Communication and this module will keep the data in excel page & also users can get the SMS in the mobile with the help of GSM module. Their system uses a compact circuitry built around LPC1768 (ARM9) microcontroller Programs are developed in Embedded C using the IDE Keiluvision4. JTAG is used for loading programs into Microcontroller [8].

CHAPTER 3

METHODOLOGY

3.1 Introduction

The main goal of this project is to design a costless and simple weather station by using solar panel as the power supply. In this section, hardware components used for the project are discussed in details. The controller of the project is Arduino Mega 2560. Though two different sensors have been used in this station to get the present readings of air, a wifi module is also used to provide some important informations like sunrise, sunset, rainfall, wind speed due to cost efficiency. A small keypad also has been attached to the Arduino to make a section where user can easily access the weather station. All stages of this project is also discussed in this chapter. Also the methods that have been used to make this weather station is also discussed in this section.

3.2 Stages of this Project

There are 4 stages in prototyping development methodology which are planning, analysis, design, implementation of the final system. Every stage is discussed in detailed in this section.

3.2.1 Planning

Any kind of project always needs good research and planning in the first stage. Planning has been done in the first stage of this work. After discussion with project supervisor, the name for proposed project "Design & Implementation of An Arduino Based Solar Powered Weather Station" is produced. After confirmation of project title, studies on existing system are performed. Based on studies performed on previous works on this field, we didn't find any related work between solar power and weather station and this is the section we intend to work on.

3.2.2 Analysis

In this stage we had been researched on both theory and practical works on weather station projects. We had found similar type of work sometimes with different techniques. To measure temperature, humidity or pressure researchers of previous works heavily relied on sensors and some of them attached many sensors to get various readings. Then we have decided to implement most necessary readings related to daily life and those are temperature, humidity and pressure which will be measured by sensors. On the other hand other readings of weather is also important, so we also intended to attach a wifi module to get those readings. Though we could have been

done our project all by wifi communication with internet, but we didn't because in many places around the country don't have network coverage. So, we think DTH22 and barometric sensor will be enough for any user to access the station and could be placed anywhere around the country. We didn't apply any tough technologies to make it more user friendly.

3.2.3 System Design

We designed this weather station in the simplest way. We used Arduino mega 2560 as the brain of this project. This is the best microcontroller to do any electronics project. Also two sensors and a wifi module is attached with the Arduino and two small solar panels will provide the power to run the station.

3.2.4 Implementation

After the design is developed, final testing will be performed. Go through the final testing, the final system is ready to deploy and implement into real operating environment. The whole processes of development must be documented so that the system can be easily maintained in future.

3.3 Components

Required components of this project are listed below :

3.3.1 Arduino Mega 2560

3.3.2 20x4 Liquid Crystal Display (LCD)

3.3.3 DTH22 Temperature and Humidity Sensor

3.3.4 ESP8266 Wifi Module

3.3.5 Barometric Pressure Sensor

3.3.6 Solar Panel

3.3.7 4x4 Matrix Keypad (#27899)

Descriptions of these components are discussed

below ***3.3.1 Arduino Mega 2560 :***

Arduino is an open source platform used for building electronics projects. The Arduino Mega 2560 is a microcontroller board based on the ATmega2560.

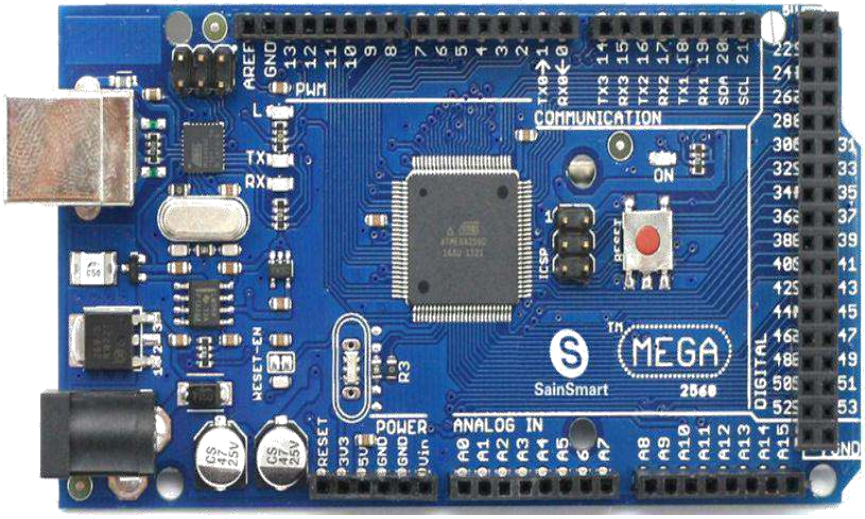

Fig 3.1 Arduino Mega 2560 [9] .

The Arduino Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila. "**Fig. 3.1**" shows the Arduino mega programmable board. It has 54 digital input/output pins (of which 14 can be used as PWM outputs),16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button [9].

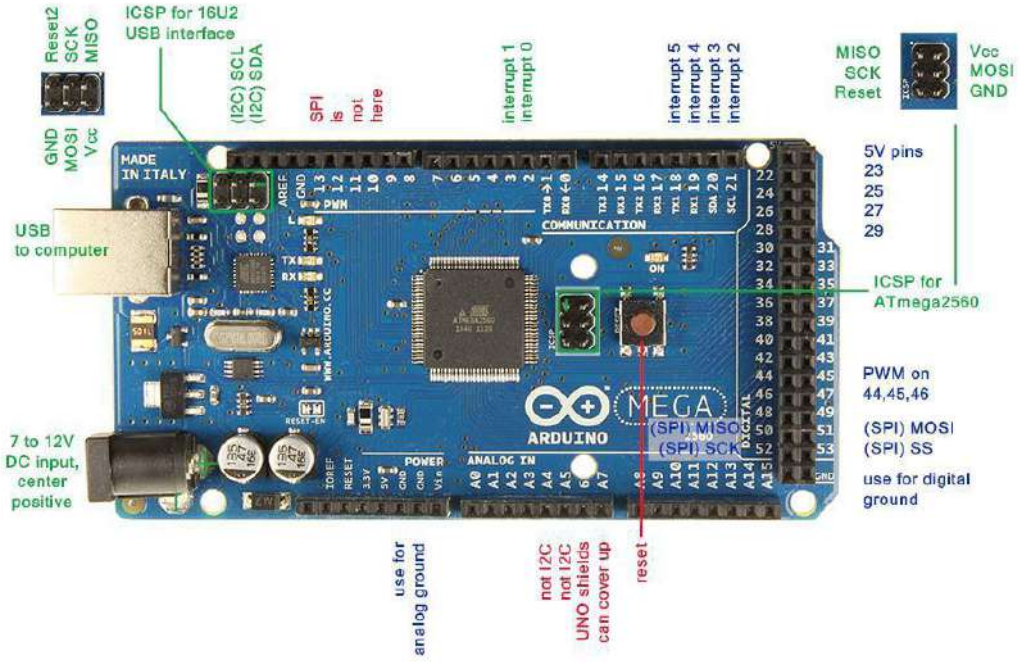

Fig 3.2 Arduino Mega 2560 (pin out) [9].

In "**Fig. 3.2**", the pin out diagram of Arduino Mega is shown elaborately. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. It has two parts, physical programmable circuit board and IDE (Integrated Development Environment) software to write a program. The Arduino programming language is a simplified version of C/C++ [9].

3.3.2 20x4 Liquid Crystal Display (LCD):

A 20x4 character LCD display with white text on a vivid blue backlit LCD. The pictures don't do justice to the bright blue background with clear white text of this display. It can shows 4 lines of 20 characters. Standard Hitachi HD44780 compatible interface for easy connection to microcontrollers. It needs +5V power supply , also variable for +3V [10].

Fig 3.3 20x4 LCD Display [10].

3.3.3 Temperature and Humidity Sensor (DHT)

Temperature / Humidity sensor (DHT) shown in **Fig. 3.4**, that measures the values of temperature and humidity of weather periodically based on the update period with adjusted digital signal output. The sensor is considered reliable and stable due to the exclusive digital signal and data realization based Temperature / Humidity sensing module. DHT sensor is constructed of resistive type element that reads Humidity and negative temperature e coefficient NTC element that reads

temperature [11]. "**Fig. 3.4**" shows the internal connection and description of DHT22 Temperature and Humidity sensor.

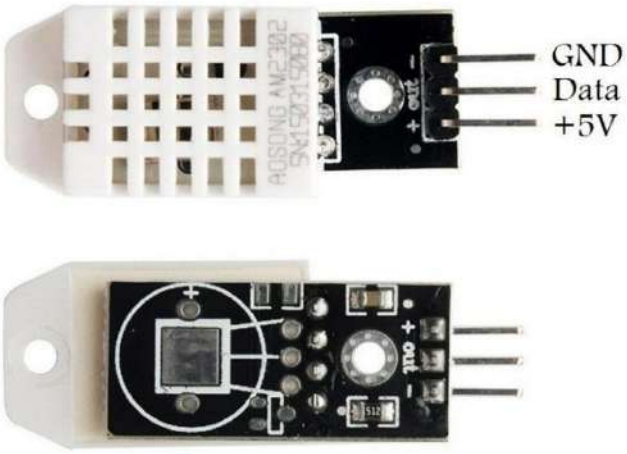

Fig.3.4 DHT22 Sensor Module [11].

The sensor deals with 8 – bit microcontroller which demonstrate reliability, sensitivity, stability, high response, no interference, and finally can be found in a low cost. The employed Temperature / Humidity sensor (DHT) is given by 3 pins identified as VCC connected to the 5V of Arduino, GND connected to Arduino GND, and DATA pin connected to the digital pin of Arduino board [11].

3.3.4 Wi-Fi Module :

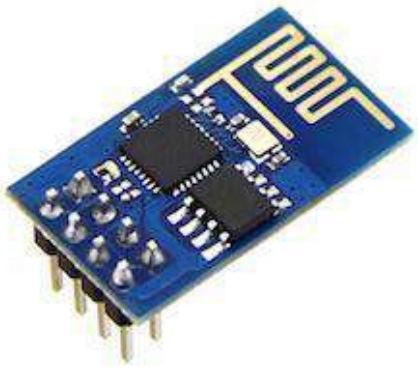

Fig 3.5 ESP 8266 Wifi Module [12] .

Here we used ESP8266 Wi-Fi module which is having TCP/IP protocol stack integrated on chip. So that it can provide any microcontroller to get connected with Wi-Fi network. ESP8266 is a preprogrammed SOC and any microcontroller has to communicate with it through UART interface. It works with a supply voltage of 3.3v. The module is configured with AT commands

and the microcontroller should be programmed to send the AT commands in a required sequence to configure the module in client mode. The module can be used in both client and server modes [12].

3.3.5 Barometric Pressure Sensor MPL1115A1 :

Fig 3.6 MPL1115A1 Barometric Pressure Sensor [13].

The MPL115A1 is an absolute pressure sensor with digital output for low cost applications. Low current consumptions of 5 μA during Active mode and 1 μA during Shutdown (Sleep) mode target battery and other low-power applications. A wide operating temperature range from -40°C to +105°C fits demanding environmental requirements. MPL115A1 employs a MEMS pressure sensor with a conditioning IC to provide accurate pressure measurement from 50 to 115 kPa. An integrated ADC provides digitized temperature and pressure sensor outputs via a SPI port.Calibration Data is stored in internal ROM. Utilizing raw sensor output, the host microcontroller executes a compensation algorithm to render Compensated Absolute Pressurewith 1 kPa accuracy. The MPL115A1 pressure sensor's small form factor, low power capability, precision, and digital output optimize it for barometric measurement applications [13].

3.3.6 Solar Panel :

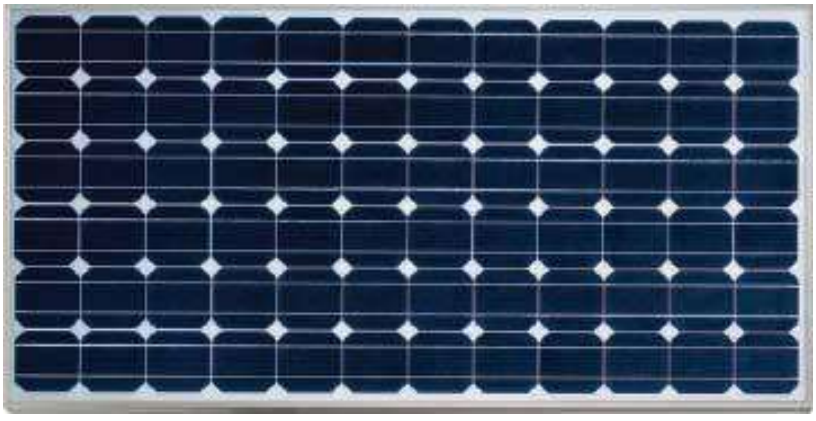

Fig 3.7 Solar Panel [14].

Solar panel is the best option to use as a renewable energy. It absorbs the sunlight which is the biggest source of energy to generate heat or electricity. A photovoltaic module is a packaged, connect assembly to typically 6x10 photovoltaic solar cells. Each module is rated by its DC output power under standard test conditions (STC) and typically ranges from 100 to 365W (Watts). The efficiency of a module given the same rated output – an 8% efficient 230W module will have twice the area of a 16% efficient 230W module. Very few commercial solar modules exceeds efficiency of 22%. A single solar module can produce only a limited amount of power, for that a panel needs multiple modules to produce sufficient power [14].

3.3.7 4x4 Matrix Keypad (#27899) :

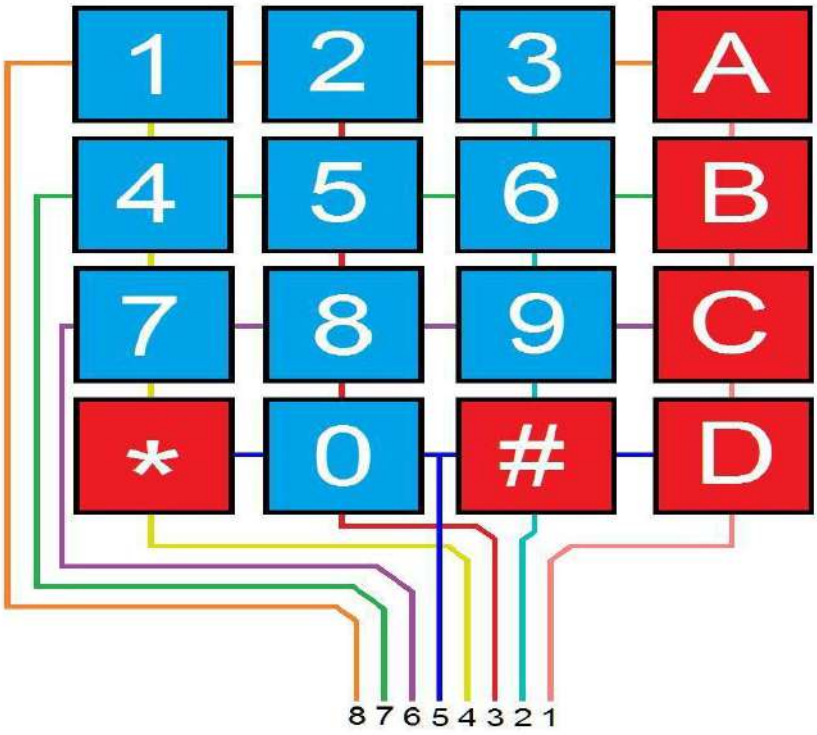

Fig 3.8 Matrix Keypad Connections [15].

This 16-button keypad provides a useful human interface component for microcontroller projects. "**Fig. 3.8**" shown the internal connection diagram of the keypad. Matrix keypads use a combination of four rows and four columns to provide button states to the host device, typically a microcontroller. Underneath each key is a pushbutton, with one end connected to one row, and the other end connected to one column. These connections are shown in Figure 3.8. In order for the microcontroller to determine which button is pressed, it first needs to pull each of the four columns

(pins 1-4) either low or high one at a time, and then poll the states of the four rows (pins 5-8). Depending on the states of the columns, the microcontroller can tell which button is pressed [15].

3.4 Method Followed

In this project we follow the method of Arduino IDE to write the program or prototype of this system.

3.4.1 Arduino IDE

This software is specially decorated for Arduino programmable board. To write a program in this software we need to have knowledge about various programming language to ensure communication between the microcontroller and the modules that have been implemented in the board. Arduino IDE software is open source software and C programming language has been used in here to write a prototype of any system. This coding has two different parts, one is void setup () and void loop (). First part is known as preparation of a program and second part is known as execution of a program. We also need to declare library files of different modules to run the program of the system [16].

CHAPTER 4

SYSTEM DESIGN AND ANALYSIS

4.1 Designing Interface

This undergraduate project of solar powered weather station is made up with Arduino mega 2560, DTH22 temperature and humidity sensor and MPL1115A1 barometric pressure sensor including an ESP8266 wifi module. This station also needs Arduino IDE to run the program according to prototype. A pair of 9V solar panels is connected in here to generate power. This station is very lightly designed to move and carry. A 16x4 display will be display all the readings recorded both by the sensors and web with the communication with the wifi module.

4.2 Block Diagram

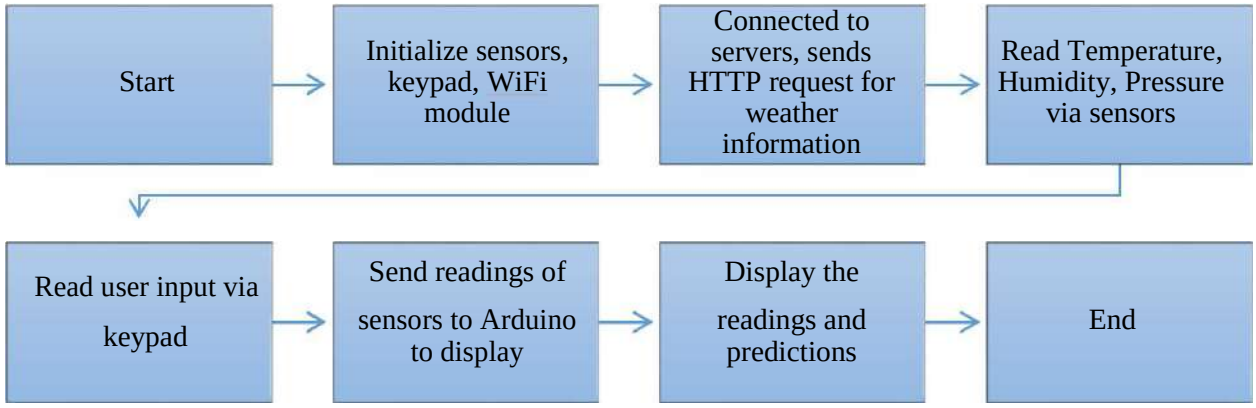

Fig. 4.1 Block diagram of the weather station.

The functional block diagram of this project is shown in "**Fig. 4.1"**. This weather station always runs with the power of Solar Panel. When the station is started to run, both sensors and wifi module initialize. The wifi module then trying to connect with the server by sending HTTP requests for weather information and within 1 minute it will be connected. At the same time, sensors are also working to get the readings of temperature, humidity and pressure. To see the readings user must input instruction via keypad and according to instruction, LCD display will show the readings. Wifi module is used in here to show the predictions of tomorrow.

4.3 Circuit Diagram

"Fig 4.2" shows the circuit diagram of this weather station. All the connection of the modules those have been used in this station with the Arduino board is shown clearly in this diagram. The VCC and GND connection of DTH22, BMP, ESP8266, LCD has been connected with the GND

and VCC Connection of the Arduino mega. The R/W (Read / Write) and E (Chip Enable) pin of the LCD Display is connected with the Arduino digital pins 5 and 6 respectively. Data bus lines D4, D5, D6 and D7 of the LCD Display 1 is connected with the Arduino digital pins 22,24,26 and 28 respectively. TXD, RXD pin of ESP8266 are connected with 10, 11 pin and SDN, CSN, SDO, SDI, SCK pin of BMP are connected with 12, 53, 50, 51, 52 pins of Arduino respectively. Signal pin of DTH22 is connected with pin no. 2 and all the 8 pins of keypad are connected with 31, 33, 35, 37, 39, 41, 43, 45 pins of the microcontroller respectively.

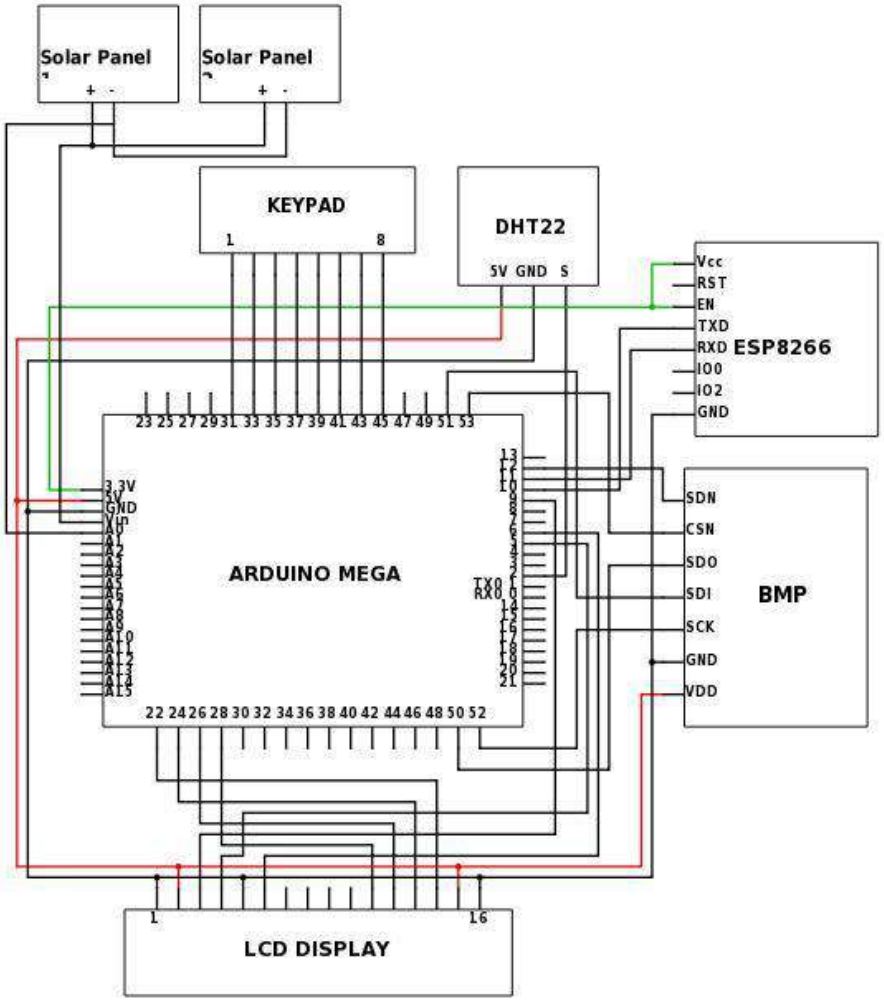

Fig. 4.2 Circuit Diagram of Solar powered Arduino Mega based Weather Station.

4.4 Algorithm

"Fig 4.3" is showing the algorithm of this project. When the power is delivered to the Arduino board it starts its processes. At first , all the sensors will be initialized and following on they will

be showing the readings immediately. At the same time, wifi module will be trying to connect with the internet. If the connection is set, Arduino will send HTTP request for weather information and after that the display will show the readings of other parameters. This operation will be going on until power is cut off.

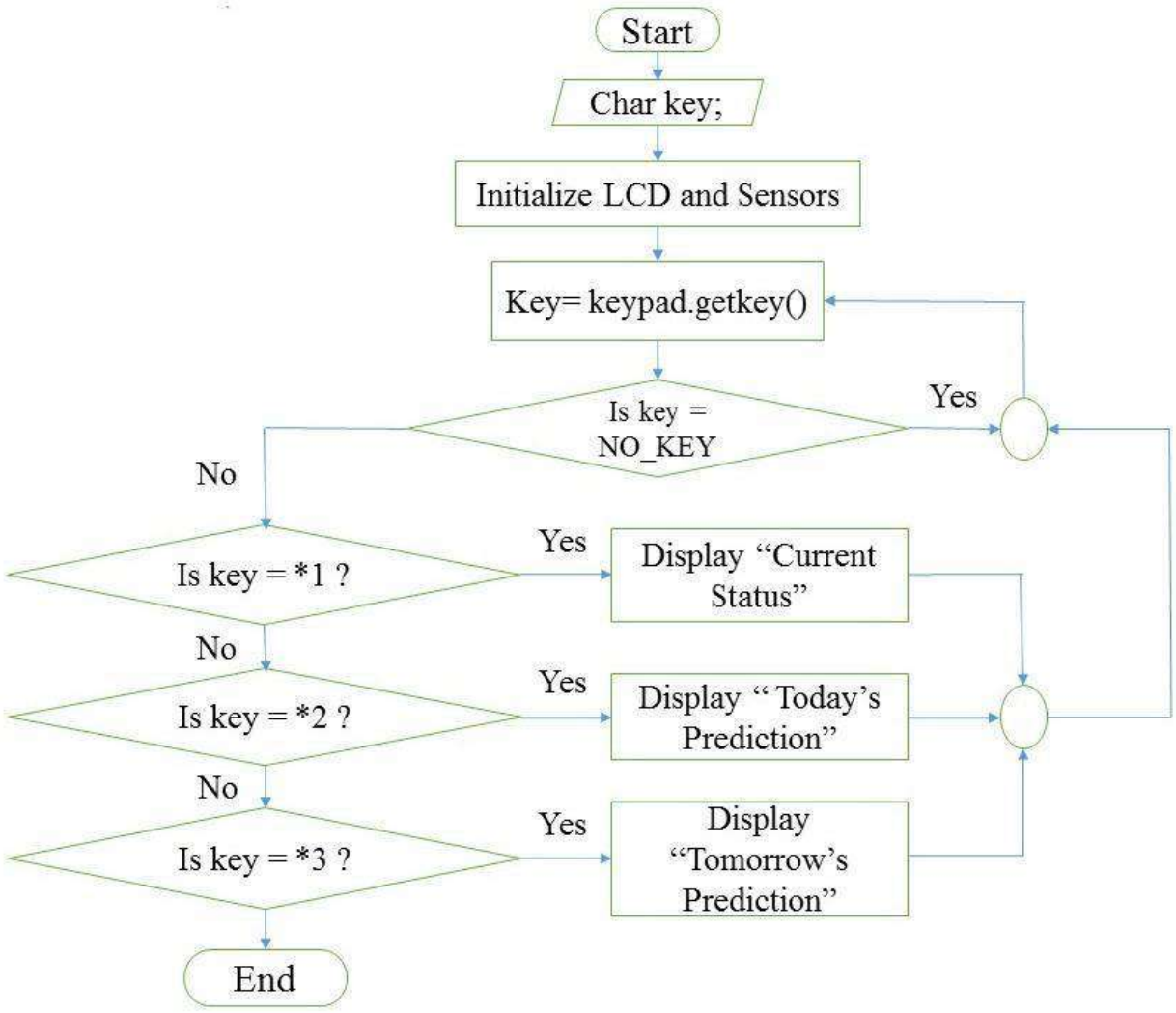

Fig 4.3 Algorithm of proposed Weather Station.

4.4 Working of The System :

When the Arduino will be connected with the solar panel it will run the whole station. Since the 2 sensors are attached with the Arduino, so the readings with those will be recorded and ready to display at first. This station has the option to access the forecast of present, whole day and tomorrow. The future prediction of whole day and day after today is basically collected by wifi

connection with internet. This internet connection through wifi module will be stablished by setting IP which is already coded in Arduino IDE. So this connection could be set by mobile or computer or any medium which has wifi facility. All these readings will be then showing on the display. To see this user needs to press the mentioned button to watch desired readings.

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 System Testing

Implementation of this weather station has been done and system testing will be performed to testing on system performance. We need to taste the results in three parts. Test case 1 is present reading of temperature ,humidity and pressure which will be measured by applied sensors. Test case 2 is future prediction of today's forecast and test case 3 is future prediction of tomorrow.

5.1.1 Test Case 1 :

After starting the process of the program of this station, a welcome note is appearing on the screen as it is instructed by the prototype of this system. Following that an instruction like "**Fig. 5.1"** appears on the display.

Fig. 5.1 Instruction to continue process.

A keypad is attached in the system to enter instruction. After pressing 1, current readings by the sensors is displaying on the display like "**Fig. 5.2".**

Fig. 5.2 Current status of weather.

5.1.2 Test Case 2 :

In case 2 , we test the other readings of the present day such as sunrise, sunset, rain prediction. To get these readings, we pressed 2 on the keypad and readings of sunrise, sunset appears on the screen of the display. This readings have been taken from internet by using API.

Fig 5.3 Today's forecast.

5.1.3 Test Case 3 :

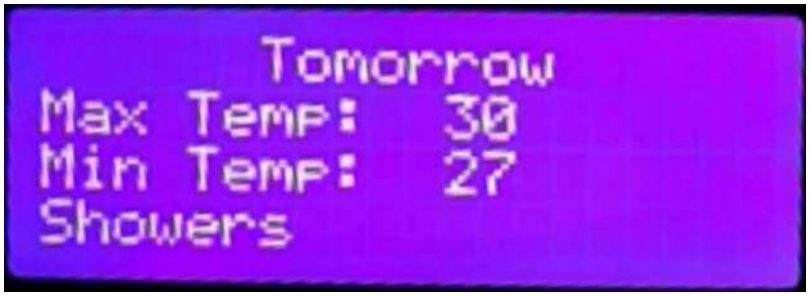

Fig 5.4 Prediction of temperature of tomorrow.

After pressing this displays shows the reading as "**Fig. 5.4"**. Also after this displays shows humidity, wind speed, pressure predictions. So, all the cases has been tasted successfully.

5.2 Discussions

In this project, we implement a weather station by using various sensors. All the steps and operation of this project is directed by Arduino Mega 2560. This microcontroller board is based on ATmega2560 and it has an excellent facilities of more pins which makes easy for us to use different modules. By designing and implementing this weather station, it had been a great way to learn the basics of Arduino IDE which is also beneficiary for us to learn to write prototype of a system.

As we mentioned our objectives in the first chapter of this project, we have successfully able to done it. It was not easy to design the hardware part of this project. We faced some problems to enrich this weather station but we could managed it as we wanted. After all the hardwork this project has ended nicely.

5.3 Cost Analysis

We made this weather station as an effective one also as a costless one. Since temperature, humidity and pressure is very much required readings among the atmospheric readings in daily life. The whole station costs approximately 9,100 BDT. Inspite of using more sensors we use wifi

module via which user can get future predictions through the internet. Other weather stations use different methodologies and more functional apparatus which costs approximately 20,000 BDT, whereas we focus on the important functional apparatus and make an easy and effective station for which our cost is too differ from their costs. **Table 5.1** shows the costings of this Weather Station.

Table 5.1 Cost of Proposed Weather Station.

Apparatus	**Cost (BDT)**
Arduino Mega	1,400 /=
DHT22 Temperature and Humidity sensor	1,400 /=
Barometric pressure Sensor	1,400 /=
ESP8266 WiFi Module	800 /=
20x4 LCD Display	500 /=
2 Solar Panels (9V- 200mA)	2,000 /=
4x4 Keypad	100 /=
Other machinery and tools	1,500 /=
Total	= 9,100 /=

CHAPTER 6

CONCLUSION

6.1 Conclusions

A solar powered weather station has been implemented by using Arduino mega and two sensors. To make it user friendly to access we provide a keypad to send request to the system by pressing buttons to show the atmospheric readings whether it is current readings or future prediction. This feature will save time of a user. Also in this weather station a wifi module is used in the purpose to notify other atmospheric readings and future predictions by using internet.

6.2 Limitations

Basically a complete weather station needs more features than we used in here. In this system we have not used too many sensors to detect the present data, which is our main limitation. Instead of this, we use a wifi module to get notified with other measurements. But we can't find internet everywhere around the country, so this is an another limitation of our project. Also, we here use a very limited powered solar panel to provide power which may cause a problem in rainy season or in a cloudy weather.

6.3 Future Scopes

This weather station provides major weather readings like temperature, humidity and pressure. But this station could be developed by implementing more sensors , so that the station does not need to rely on internet to show other readings. Also, providing big solar panel with back up batteries could be a future work t be done , where the back up batteries could store energy of sunlight which is not using fully by solar panel so that it could serve power at night.

REFERRENCES

[1] Weather Station, July 11, 2017, www.wikipedia/weatherstation.

[2] Verbelen, Yannick (2016)."WeatherStation 3". Circuit Maker*;* Retrieved 16 April 2017.

[3] Sarmad Nozad Mahmood Forat Falih Hasan, Al- Kitab University College Al- Kitab University College; "Design of Weather Monitoring System Using Arduino Based Database Implementation", *Journal of Multidisciplinary Engineering Science and Technology (JMEST);* ISSN: 2458-9403; Vol. 4 Issue 4, April – 2017.

[4] Rong-Hua Ma, Yu-Hsiang Wang and Chia-Yen Lee, "Wireless Remote Weather Monitoring System Based on MEMS Technologies", Sensors 2011, 11, 2715-2727; doi:10.3390/s110302715, sensors , ISSN 1424-8220.Article.

[5] Bulipe Srinivas Rao, Prof. Dr. K. Srinivasa Rao, Mr. N. Ome, "Internet of Things (IoT) Based Weather Monitoring system", *International Journal of Advanced Research in Computer and Communication Engineering*, IJARCCE ISSN (Online) 2278-1021.

[6] Keshav Kumar Singh, S. Styline Chirmaxo, Prof. S. Hiremath, Department of Electrical and Communication Engineering, National Institute of Technology, "Design of Wireless Weather Monitoring System", ISSN: 2341-587529, Vol. 2, Issue 2, May 2013.

[7] Karthik Krishnamurthi, Suraj Thapa, Lokesh Kothari, Arun Prakash, "Arduino Based Weather Monitoring System", *International Journal of Engineering Research and General Science* , ISSN 2091-2730452, Volume 3, Issue 2, March-April, 2015.

[8] P.Susmitha , Dept. of ECM K L UNIVERSITY Guntur (Dt), India, G.Sowmyabala, Assistant Professor Dept. of ECM K L University, India, "Design and Implementation of Weather Monitoring and controlling System", *International Journal of Computer Applications* (0975 – 8887) Volume 97– No.3, July 2014.

[9] *Arduino Mega 2560 Datasheet.*

[10] *"LCD-016M002B, 20 x 4 Character LCD user manual"* by Vishay.

[11] DTH22 Sensors, 11 July 2017, http://howtomechatronics.com/tutorials/arduino/dht11-dth22-sensors-temperature-and-humidity-tutorials-using-arduino/.

[12] ESP8266, 11 July 2017, http://howtomechatronics.com/tutorials/arduino/ESP-8266-wifi-module-tutorials-using-arduino/.

[13] MPL1115A1 Barometric Pressure Sensors, 11 July 2017, http://howtomechatronics.com/tutorials/arduino/MPL1115A1-barometric-pressure-sensors-tutorials-using-arduino/.

[14] Solar Panel 9V, 11 July 2017, http://forum.allaboutcircuits.com/threads/9v-solar-panel.105600/.

[15] Parallax Inc. 4x4 Matrix Membrane Keypad (#27899) , v1.2 , 16 December 2011.

[16] Arduino IDE , 11 July 2017, http://developer.android.com/guide/topics/sensors/index.html.

APPENDIX A

```
#include <Adafruit_Sensor.h>
#include <DHT.h>
#include <DHT_U.h>
#include <SoftwareSerial.h>
#include <LiquidCrystal.h>

LiquidCrystal lcd(8, 7, 47, 49, 51, 53);

#define ESP8266_rxPin 10
#define ESP8266_txPin 11
#define DHTPIN 2
#define DHTTYPE DHT22
DHT dht(DHTPIN, DHTTYPE);

//SSID + KEY
const char SSID_ESP[] = "1212";
const char SSID_KEY[] = "123581321";

// URLs
const char URL_date[] = "GET
https://api.thingspeak.com/apps/thinghttp/send_request?api_key=A07V348LJ4N8PMHJ HTTP/1.0\r\n\r\n";
const char URL_current_temp[] = "GET
https://api.thingspeak.com/apps/thinghttp/send_request?api_key=14JUNOGXD8ZTZG7H
HTTP/1.0\r\n\r\n"; // tomorrow forecast
const char URL_sunrise[] = "GET
https://api.thingspeak.com/apps/thinghttp/send_request?api_key=SQGDW1DTG2OZ012D
HTTP/1.0\r\n\r\n";
const char URL_sunset[] = "GET
https://api.thingspeak.com/apps/thinghttp/send_request?api_key=QXXK2JUS83MXWOLZ
HTTP/1.0\r\n\r\n";
const char URL_tomorrowMax_temp[] = "GET
https://api.thingspeak.com/apps/thinghttp/send_request?api_key=CS9ARLQOHM7I0C59
HTTP/1.0\r\n\r\n";
const char URL_tomorrowMin_temp[] = "GET
https://api.thingspeak.com/apps/thinghttp/send_request?api_key=0GAQ2449EFQQGB9S HTTP/1.0\r\n\r\n";
const char URL_todayforecast[] = "GET
https://api.thingspeak.com/apps/thinghttp/send_request?api_key=TCI8EX5SZKD9Z9NO HTTP/1.0\r\n\r\n";
const char URL_wind[] = "GET
https://api.thingspeak.com/apps/thinghttp/send_request?api_key=G2FBY9FLM0FX34QO
HTTP/1.0\r\n\r\n";

//MODES
const char CWMODE = '1';//CWMODE 1=STATION, 2=APMODE, 3=BOTH
const char CIPMUX = '1';//CWMODE 0=Single Connection, 1=Multiple Connections

SoftwareSerial ESP8266(ESP8266_rxPin, ESP8266_txPin);// rx tx
```

```
//DEFINE ALL FUNCTIONS HERE
boolean setup_ESP();
boolean read_until_ESP(const char keyword1[], int key_size, int timeout_val, byte
mode); void timeout_start();
boolean timeout_check(int timeout_ms);
void serial_dump_ESP();
boolean connect_ESP();
void get_youtube();
void get_current_temp();
void get_hilo_temp();
void get_tomorrowMax();
void get_todayforecast();

//DEFINE ALL GLOBAL VAARIABLES HERE
unsigned long timeout_start_val;
char scratch_data_from_ESP[20];//first byte is the length of
bytes char payload[150];
byte payload_size=0, counter=0;
char ip_address[16];
char youtube_subs[10];
char youtube_views[13];
char current_temp[15];
char sun_rise[9];
char sun_set[9];
char hi_temp[5];
char lo_temp[5];
char tomorrowMax_temp[9];
char tomorrowMin_temp[9];
char today_forecast[15];
char wind[5];

//DEFINE KEYWORDS HERE
const char keyword_OK[] = "OK";
const char keyword_Ready[] = "Ready";
const char keyword_no_change[] = "no change";
const char keyword_blank[] = "#&";
const char keyword_ip[] = "192.";
const char keyword_rn[] = "\r\n";
const char keyword_quote[] = "\"";
const char keyword_carrot[] = ">";
const char keyword_sendok[] = "SEND OK";
const char keyword_linkdisc[] = "Unlink";


//keywords for youtube
const char keyword_html_start_b[] = "\">";
const char keyword_html_end_b[] = "</";

//keywords for current temp
```

```
const char keyword_html_start_temp[] = ">";
const char keyword_html_end_temp[] = "<";

//keywords for sunrise
const char keyword_html_start_rise[] = ">";
const char keyword_html_end_rise[] = "<";

//keywords for tomorrow Temp
const char keyword_html_start_tomorrowMax_temp[] = "\">";
const char keyword_html_end_tomorrowMax_temp[] = "<";

void setup(){//       SETUP     START
  //Pin Modes for ESP TX/RX
  pinMode(9, OUTPUT);
  analogWrite(9, 50);
  lcd.begin(20, 4);
  dht.begin();

  pinMode(ESP8266_rxPin, INPUT);
  pinMode(ESP8266_txPin, OUTPUT);

  ESP8266.begin(9600);
  ESP8266.listen();
  Serial.begin(115200);
  lcd.setCursor(5, 0);
  lcd.print("Welcome To");
  lcd.setCursor(2, 1);
  lcd.print("Weather Station");
  delay(10000);
  setup_ESP();//go setup the ESP
  get_date();
  delay(15000);
  get_sunrise();
  delay(15000);
  get_sunset();
  delay(15000);
  get_todayforecast();
  delay(15000);
  get_tomorrowMax();
  delay(15000);
  get_tomorrowMin();
  delay(15000);
  get_tomorrow_forecast();
  delay(15000); // Tomorrow Forecast
  //get_wind();
  //delay(15000);
}//                SETUP      END

void loop(){//         LOOP     START
```

```
// Display Date &
Time lcd.clear();
lcd.setCursor(13, 0);
for(int i=1; i<=youtube_subs[0];
  i++) lcd.print(youtube_subs[i]);
lcd.setCursor(0, 0);
for(int i=1; i<=youtube_views[0];
  i++) lcd.print(youtube_views[i]);

delay(5000);

// Display Sunrise
lcd.setCursor(0, 1);
lcd.print("Sunrise :");
lcd.setCursor(10, 1);
lcd.print("0");
lcd.setCursor(11, 1);
for(int i=1; i<=sun_rise[0];
    i++) lcd.print(sun_rise[i]);

 // Display Sunset
lcd.setCursor(0, 2);
lcd.print("Sunset :");
lcd.setCursor(10, 2);

for(int i=1; i<=sun_set[0]; i++)
    lcd.print(sun_set[i]);

 // Display Tody Forecast

lcd.setCursor(0, 3);
int m = today_forecast[0];
if(m<16){
for(int i=1; i<=today_forecast[0]; i++)
    lcd.print(today_forecast[i]);
}
else
  lcd.print("Thunderstorms");
 // Tomorrow
delay(10000);
lcd.clear();
lcd.print(" Tomorrow");
lcd.setCursor(0, 1);
lcd.print("Max Temp: ");
lcd.setCursor(11, 1);
for(int i=1; i<=tomorrowMax_temp[0];
    i++) lcd.print(tomorrowMax_temp[i]);
```

```
 lcd.setCursor(0, 2);
 lcd.print("Min Temp: ");
 lcd.setCursor(11, 2);
 for(int i=1; i<=tomorrowMin_temp[0]; i++)
    lcd.print(tomorrowMin_temp[i]);
 lcd.setCursor(0, 3);
 int k = current_temp[0];
 if(k<16){
 for(int i=1; i<=current_temp[0]; i++)
    lcd.print(current_temp[i]);
 }
 else
  lcd.print("Thenderstromes");
 delay(7000);
  // Print Current Temperature & Humidity

 for(int n=1; n<20; n++){
  float h = dht.readHumidity();
  float t = dht.readTemperature();
  float f = dht.readTemperature(true);

 if (isnan(h) || isnan(t) || isnan(f)) {
  lcd.clear();
  lcd.print("Failed to Read Sensor!");
  return;
 }

 lcd.clear();
 lcd.print("    Current");
 lcd.setCursor(0, 1);
 lcd.print("Humidity: ");
 lcd.setCursor(11, 1);
 lcd.print(h);
 lcd.setCursor(17, 1);
 lcd.print(" %");
 lcd.setCursor(0, 2);
 lcd.print("Temperature: ");
 lcd.setCursor(13, 2);
 lcd.print(t);
 lcd.setCursor(18, 2);
 lcd.print(" C");
 delay(2000);
 }

}//
```

APENDIX B

IDE	Integrated Development Environment
HTTP	Hypertext Transfer Protocol
DHT	Digital Humidity and Temperature sensor
LCD	Liquid Crystal Display
IoT	Internet of Things
BMP	Barometric Pressure
GND	Ground
MEMS	Micro-Electro-Mechanical Systems
WSN	Wireless Sensor Network
SMS	Short Message Service