SMART REMOTE SENSING WEATHER STATION

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April 2014

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DECLARATION

We do here by declare that the thesis titled "Smart Remote Sensing Weather Station" is submitted to the Department of Electrical and Electronic Engineering of BRAC University in partial fulfillment of the Bachelor of Science in Electrical and Electronics Engineering. This is our original work and was not submitted elsewhere for the award of any other degree or any other publication.

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Acknowledgement

We would like to take this opportunity to express our gratitude to Dr. Md. Khalilur Rhaman for his guidance, and instruction that he has given us from the time we have been doing thesis under his supervision through the completion of our undergraduate program. The skills we have able to learn from him during our Thesis work have benefited us immensely and will continue to do so throughout our future endeavors.

Abstract

In this era of global warming getting the latest weather forecast and take necessary pre -caution has become a big issue all over the world. In the context of carbon emission and Greenhouse effect Bangladesh as a coastal island is always in risk of natural calamities & disasters. With the advancement in modern technology the use of combined weather sensor is essential for Bangladesh, considering the geographical location, climate change issues, agriculture based economy & weather forecast etc. Hence keeping this in mind we have integrated a number of effective sensors in one unit and incorporated them to a combined weather sensor. A cost effective, reliable and efficient combined weather sensor has been developed at BRAC University. The major contribution of this project will be the acquisition of the data's of the sensors altogether, which makes the weather sensing digital rather than manual. Developing a "web- server" that will store all the data's for analysis and prediction to get the accurate data and estimate possible change in overall weather is the future work of the thesis.

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Chapter 1
Introduction

1.1 Objective

The Smart Remote Sensing Weather Station's main objective is to easy integration of the data and to ensure instant data acquisition. The first objective of the system is to automatically take data from the sensors. Sensors have the mechanism to acquire the desired type of data and then send it in the system. The data is acquired and stored to a computer via software synchronization; the data can be recorded with greater efficiency.

Another objective is to automatically update the data of the sensor components. The setting is to plant several sensors on a place of perfection where the requirements of each sensor are fulfilled, and each of them functions best. The software takes the data after each fixed time interval and automatically updates the data sheet. An example would be having temperature sensors in the top of a building that would detect the temperature and we can get the respond to any change by it. For light humidity, there will be sensor that would detect real time atmospheric humidity and that will make us known about the comfort level of weather.

Furthermore our objective is to develop a cost effective, portable weather station. Therefore an easy maintenance of the weather station has been ensured. While the idea to improve the data acquisition of the weather parameters is the priority of this thesis work, importance is made to ensure that this system is affordable to all those who need it. The setup cost may initially lower than the comparative market price ,and at the same time our developed smart remote sensing weather sensor can a role model, and we can set it up in every single village of our country to ensure the coverage of weather.

1.2 Scenario of Bangladesh

At the very beginning of this semester we had an awe-inspiring and accommodating study tour to the National Weather Station in Dhaka with our thesis supervisor. The weather station is facilitated with both the old and modern weather sensors. The tour was began with a very informative and conversation full presentation organized by the experts of the weather station. They shared their valuable experiences with us which were really very much helpful regarding our thesis.

Figure1. 3: Bangladesh Meteorological Department

On that very day we came to know that we have to calibrate our sensors in the testing lab of the weather station before going to any practical application. They will verify and distinguish the accuracy of our sensors. However, they also clued-up that we can’t forecast any news related to weather ourselves.

We can develop a web server to receive and forecast news only for the education purpose.

A huge quantity of weather sensors with different functions is continuously running at the station. Both manual and digital sensors are being used to find out the accurate data’s. All the sensors output directly send to the control room for analysis.

Last of all we went to the field where sensors were planted. There is an automated weather station there which consist almost all the common sensors we planned to put in our combined sensor. Mr. Abul Hossain, experienced weather expert introduced us with all the analog weather sensors and their working mechanism. The national weather station of Bangladesh is facilitated with the following sensors according to the conversation with the officials.

1) An Automated Weather Station (AWS)
2) Sun Shine duration detector.
3) Hygrograph
4) Ordinary Thermometer
5) Rain Collector
6) Soil Tester
7) Anemometer
8) Wind Vane
9) Pyranograph
10) Thermograph
11) Evaporation Graph
12) Tipping Bucket Rain gauge
13) Barometer and etc.
14) Satellite receiver
15) Radar and Radom .etc.

Figure1. 4: Weather Station analog sensors

1.3 Literature Review

We have gone through a number of papers for gaining knowledge about the existing system of Automatic Weather Station (AWS). After researching different papers we have come to a decision that almost all the AWS is quite similar in the area of production cost which is very high, so what we have tried is to minimize the production cost. For that reason we have to think of a technology which is cost effective at the same time reliable and durable. First we will discuss about the temperature and humidity sensor. According to Hendrik Zophel for measuring temperature he used a Platin PT100 temperature probe. Whose basis is a resistance varying according to its temperature, and for humidity it is capacitance varying. The problem of using this is it is very costly and the related circuit connections are also very complex. Jason Eric Box has used Vaisala 50-YC for measuring temperature. This sensor has a great limitation. When the sensor is put out in the direct sunlight, sometimes it gives error. Furthermore, it is thermocouple sensor which is a very old technology. Likewise we have gone through much research for finding the best sensor for measuring temperature in our country condition. First we thought we will go for LM-35 but it is good for laboratory use only so finally we choose HSM-20G. It is the best sensor for AWS. There are many advantages using this sensor. First of all it is cost effective. It gives Voltage analog output for both humidity and temperature. The small size makes it easy to conceal, it is also compatible with all types of microcontrollers and its sensitivity is very high in the air. [1][2]

Bangladesh Meteorological Department (BMD) still use analogue device for measuring barometric pressure. We use a digital sensor BMP085 which is the best low-cost sensing solution for measuring barometric pressure.

Many device is available for measuring wind speed and direction among them Ultra Sonic Anemometer is the latest technology others are Vane Anemometer, Hot-wire Anemometer, Laser Doppler Anemometer, Ping-pong Ball Anemometer, Plate Anemometer, Tube Anemometer. All types of anemometer are accurate in measuring wind speed but there are some disadvantages as well. Like Ultra sonic Anemometer and Vane Anemometer are very costly and the technology is also very complex. Hot-wire Anemometer can be very confusing when temperature is very hot. So our obvious choice is Three Cup Anemometer. We design it especially for outdoor condition. We have use reed switch which not only give accurate output but also very cost efficient. Its simple design with very little starting power is the one of the best design of our AWS sensors.

For Wind Direction sensor we have use eight reed switch to direct eight directions which is very much accurate. The design of this sensor is also very simple and smart.

There are different types of Rain Gauge like Standard Rain Gauge, Weighing Rain Gauge and Tipping Bucket Rain Gauge. Standard and weighing rain gauge are manual. As our AWS is totally digital we choose Tipping Bucket Rain Gauge for measuring precipitation. Using reed switch it convert rainfall into electrical signal which will further process in the processing unit. The construction is very inexpensive and it automatically empties the bucket. There is some error if the rainfall is below the amount of rain for one tip. But for digitalization we have to consider that little error. [1][2][3][4][5]

1.4 Motivation

An effective and efficient weather station is an instrument by which meteorologists are able to be aware about the essential elements of weather so that people can be concerned by getting the right information in the right time. Unfortunately, this does not happen in Bangladesh. The Data acquisition system in our country still lags behind compared to the developed countries. As part of our thesis we visited the only concerned institution for our weather The Meteorological Department of Bangladesh situated in Agargaon. We were really disappointed watching at the old fashion of taking data and with the use of ancient equipments in most of the cases. The only thing that took our attention was the digital station version that has brought here from abroad. The interesting and shocking part is that the maintenance of the station is not so easy, that's why it requires expert technician's to control that. So thinking for a modern version of weather station which will be cost effective , portable structure ,will have digital data acquisition system, very easy maintenance system and affordable in the context of the economic status of our country.

Every year we become the victims of such catastrophic calamities that's why we must consider weather in a serious note in the consequence of global position and risk of affecting by the disaster's in Bangladesh. These calamities cause affect the life of hundreds and thousands of people of our country, which often leads to death and huge loss of infrastructure. So to resolve the burning issues a smart remote sensing weather station has been developed that allows having the digit features to become aware and take pre-cautions to make our life better.

Chapter 2

System Overview/ Architecture

Figure 2. 5: Smart Remote Sensing Weather Station

Smart Remote Sensing Weather Station is the combination of various weather sensors to understand the weather for meteorological analysis. In this project we have developed an automatic weather station and a data acquisition system to store the weather parameters digitally in an interval of every minute. The overall system is indicated in the following flow chart.

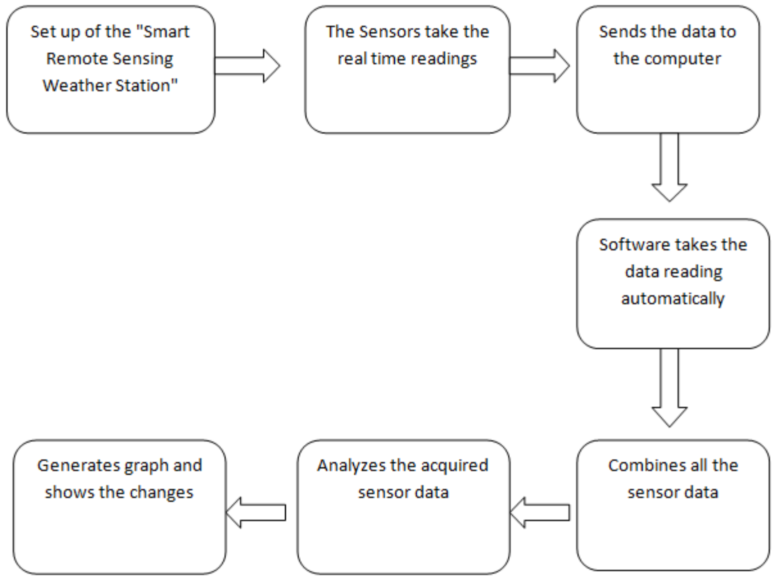


Figure 2. 6: System Flow Chart

The System architecture is divided into two parts. The Hardware part includes the weather sensors and their combination. On the other hand the software part includes the data processing and data acquisition for the computer. All the details are described in details in the next chapters.

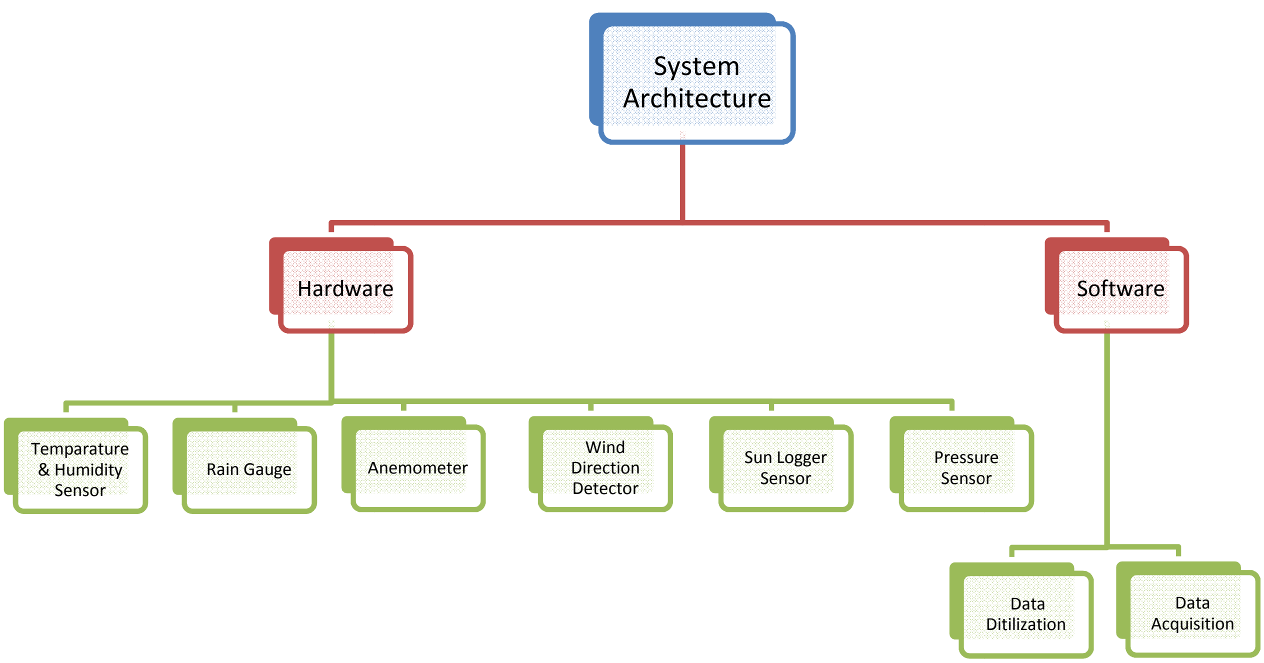


Figure 2. 7: System Architecture

The following functional diagram is the total system overview of our thesis. Arduino mega board is used as the main controller of the system. Received data from the sensors are digitalized in control panel and transfer to the computer using serial communication. Overall system power is achieved using the solar panel.

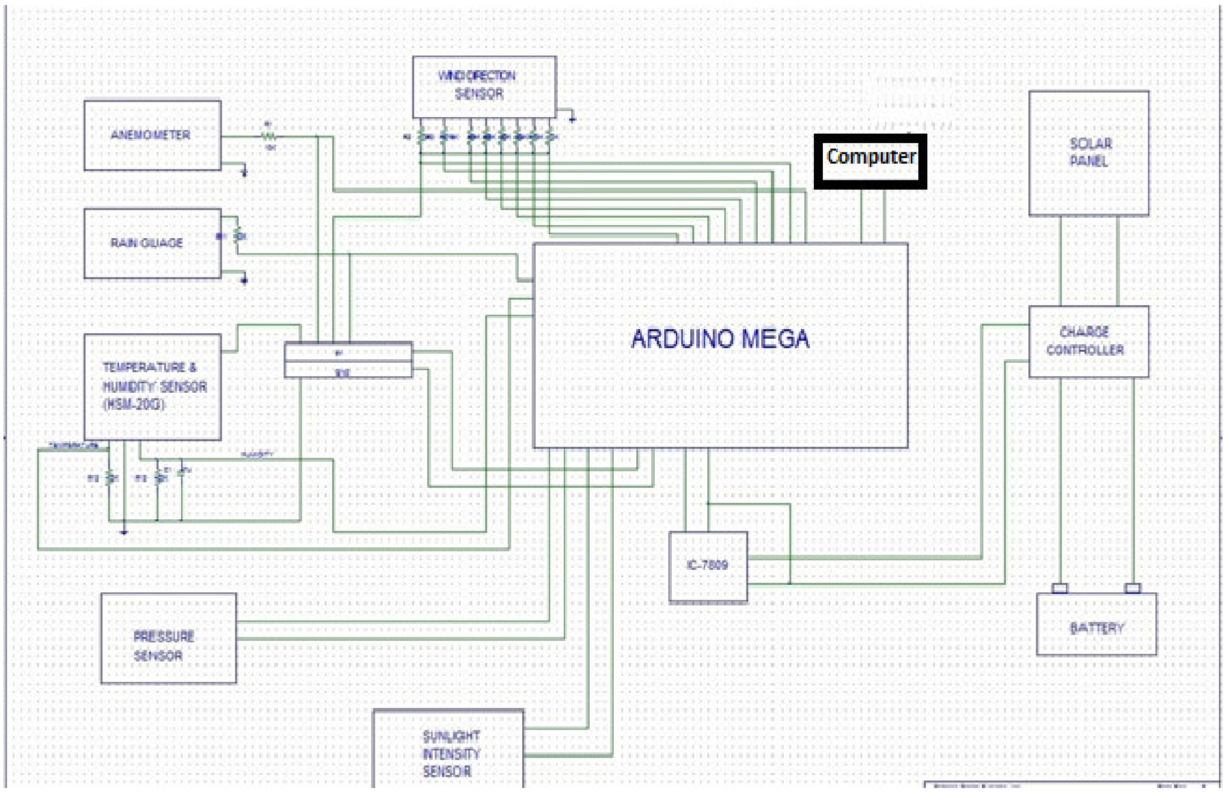


Figure 2. 8: System Functional Diagram

Chapter 3

System Implementation

3.1 List of Definitions

Reed Switch: The reed switch is an electrical switch operated by an applied magnetic field. It consists of a pair of contacts which is normally open. The contacts become close when a magnetic field is applied.

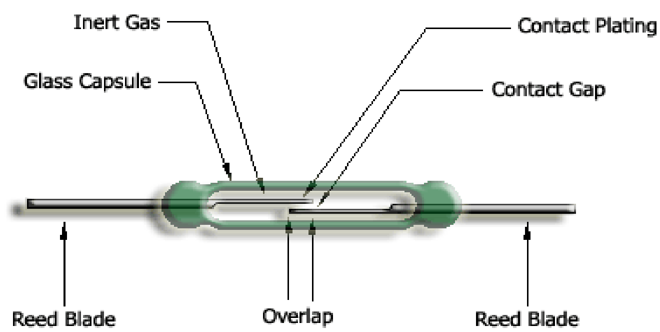


Figure 3. 24: Reed Switch

Pivot and Tipping Bucket:

This is a mechanism used for measuring rainfall. It has two cone shaped buckets being fixed together at their same side and pivoting back and forth about a central axle. Rainfall fills one bucket until it unsettles the balance and tips, causing the empty bucket to face upward. With each tip, a sensor will send pulse indicating one unit of rainfall.

Definition of LUX:

With a bit of math, the TSL2561 can output illumination in lux. Technically, one lux is equal to one lumen per square meter. Practically, lux is a measure of how bright any given illumination will appear to the human eye.

3.2 Humidity / Temperature/ Pressure

Temperature is the result of the motion of particles it is a way to state the notions of hot and cold both Celsius and Kelvin scale are used to measure the temperature.
Humidity is the amount of water vapor in the air Absolute humidity is the mass of water vapor divided by the mass of dry air in a volume of air at a given temperature Relative humidity is the ratio of the current absolute humidity to the highest possible absolute humidity.

We have use HSM-20G sensor for measuring temperature and humidity. BMP085 sensor is used for measuring Barometric pressure. The description of these sensors is given below.

3.2.1 HSM-20G

HSM-20G is an integrated circuit with only four external pin outs for measuring temperature and humidity. The sensor gives temperature and humidity as voltage output that is received by the controller using Analog Input pins. The Atmega controllers used for the Arduino contain an onboard 6 channel analog-to-digital (A/D) converter. The converter has 10 bit resolution, returning integers from 0 to 1023. According to the datasheet of HSM-20G voltage outputs are converted to digital humidity and temperature using few equations which are shown in calculation part.

Humidity sensor is a device consisting of a special plastic material whose electrical characteristics change according to the amount of humidity in the air. Basically it is a sensor that senses the amount of water vapor in air. The module of HSM-20G is essential for those applications where the relative humidity can be converted to standard voltage output.

3.2.1.1 The specifications of humidity sensor

No.	Specification	Humidity Sensor
1.	Input voltage range	DC 5.0±0.2 V
2.	Output voltage range	DC 1.0—3.0 V
3.	Measurement Accuracy	±5% RH
4.	Operating Current (Maximum)	2mA
5.	Storage RH Range	0 to 99% RH
6.	Operating RH Range	20 to 95% (100% RH intermittent)
7.	Transient Condensation	< 3%RH
8.	Temperature Range: - Storage - Operating	 20℃ to 70℃ 0℃ to 50℃
9.	Hysteresis (RH @ 25℃)	MAX 2%RH
10.	Long Term Stability (typical drift per year)	±1.5%
11.	Linearity	Linearity
12.	Time Response (63% step change)	1 min
13.	Dimensions (L*W)	30mm*22mm

3.2.1.2 The Layout Diagram of the sensor

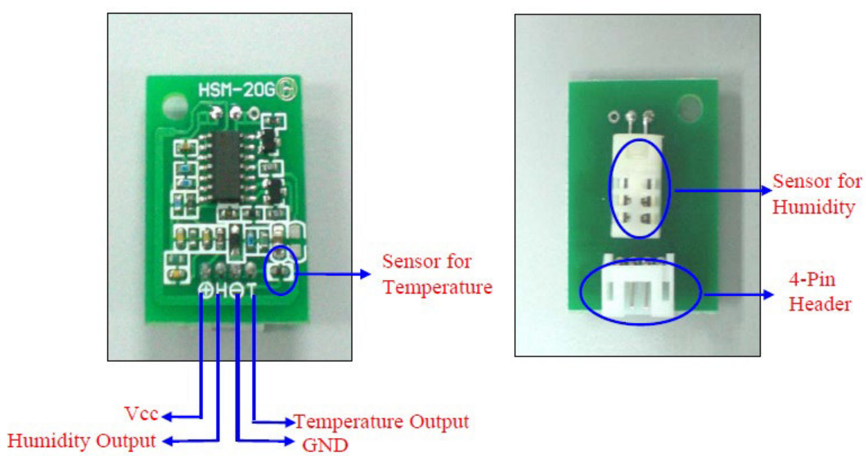


Figure 3. 25: Lay Out Diagram of HSM-20G

3.2.1.3 Circuit Diagram

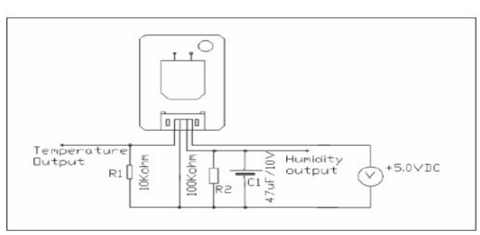
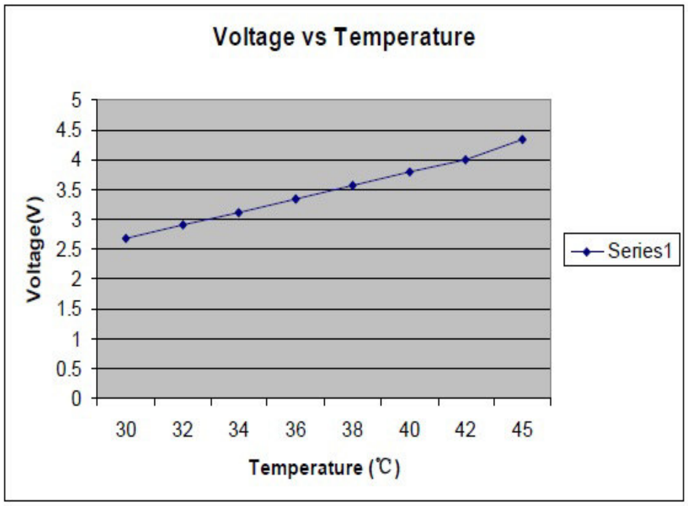


Figure 3. 26: Circuit Diagram of HSM-20G

3.2.1.4 Response Curves of HSM-20G



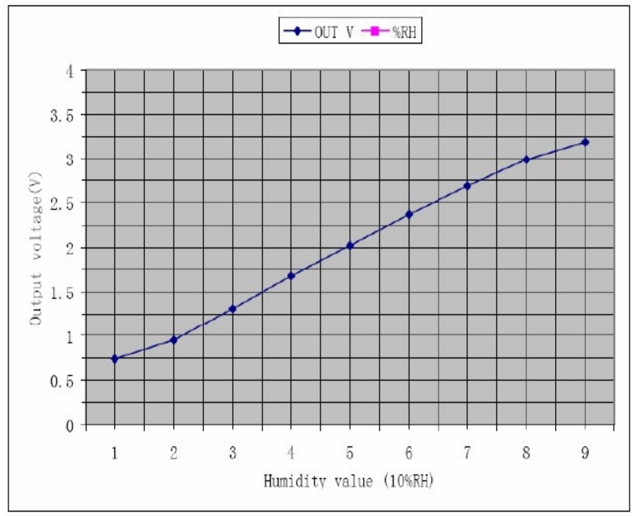


Figure 3. 27: Response Curve of HSM-20G

3.2.2 Calculation of Temperature and Humidity

From the response curves equations are initiated to calculate the relative humidity and temperature.

For Calculating Relative Humidity,

Relative Humidity= ((30.855*(Sensors Analog Value /204.6))-11.504)

For Calculating Temperature,

Temp in C= 281.583*power (1.0230,(1.0/R))*power (R,-0.1227)-150.6614;

Here,

Vt= sensors analog Value*5.0/1023.0;

R= (5.0-Vt)*10.0/Vt;

3.2.3 Calibration

For calibration we used a simple method. We bought a Mercury thermometer. We put the mercury thermometer and our HSM-20G sensor side by side in a similar condition and taking output from the both. The result we got is shown in the graph.

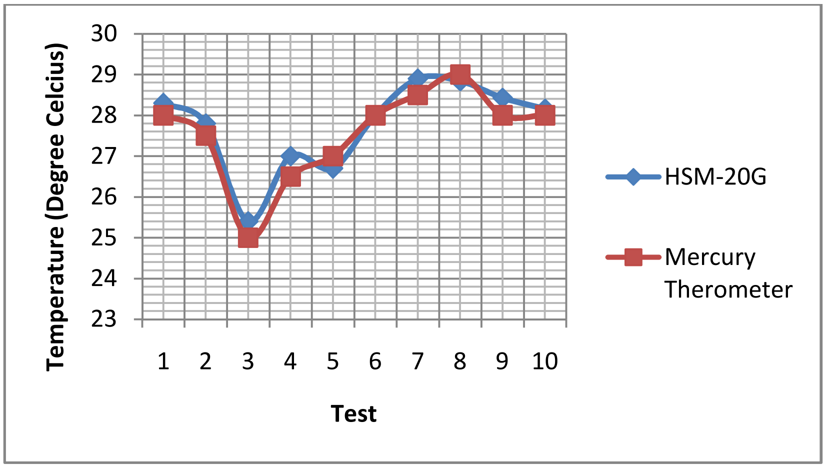


Figure 3. 28: Comparison Curve between HSM-20G and Mercury Thermometer

We can see that there are not much difference between mercury thermometer and HSM-20G output

3.2.4 Dew Point

The dew point is the temperature at which the water vapor in air at constant barometric pressure condenses into liquid water at the same rate at which it evaporates. At temperatures below the dew point, water will leave the air. The condensed water is called dew when it forms on a solid surface.

There is a relationship between Human Body and dew point. As the air surrounding one's body is warmed by body heat, it will rise and be replaced with other air. If air is moved away from one's body with a natural breeze or a fan, sweat will evaporate faster, making perspiration more effective at cooling the body. The more unevaporated perspiration, the greater the discomfort. The given Chart is a relationship between Human comfort and dew point

Dew point		Human perception	Relative humidity at 32 °C (90 °F)
Over 26 °C	Over 80 °F	Severely high. Even deadly for asthma related illnesses	65% and higher
24–26 °C	75–80 °F	Extremely uncomfortable, fairly oppressive	62%
21–24 °C	70–74 °F	Very humid, quite uncomfortable	52–60%
18–21 °C	65–69 °F	Somewhat uncomfortable for most people at upper edge	44–52%
16–18 °C	60–64 °F	OK for most, but all perceive the humidity at upper edge	37–46%
13–16 °C	55–59 °F	Comfortable	38–41%
10–12 °C	50–54 °F	Very comfortable	31–37%
Under 10 °C	Under 50 °F	A bit dry for some	30%

3.2.4.1 Calculation of Dew point

For calculating Dew point we have use a simple formulae, which is given below

Due point = Temperature(C) - (100 - Relative Humidity)/5

According to the specification of this sensor we can see that the sensor unit does not built to take the input from the open environment. So to save this sensor unit from wind speed, dust and from the solar radiation we have to built Stevenson screen which will minimizes the effect of direct solar radiation and yet allow airflow to ensure accurate temperature and humidity readings by the enclosed instruments.

3.2.5 Pressure

Surface Pressure is the force per unit area exerted on a surface in the atmosphere of the earth. On a given plane, low-pressure areas have less atmospheric mass above their location, whereas high-pressure have more atmospheric mass above them.

For measuring Pressure we have use the very latest technology sensor. It is BMP-085.

BMP-085

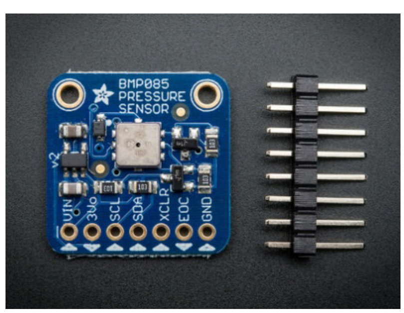


Figure 3. 29: BMP-085 Sensor

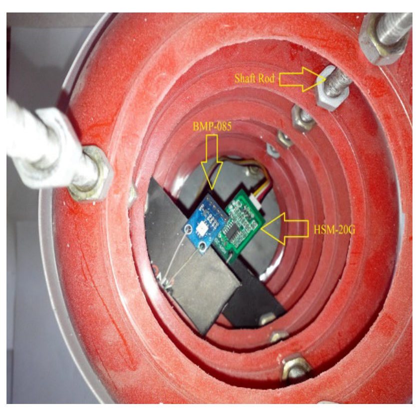
It gives a voltage output. Some of the reasons why we choose this sensor are given below

- Cost effective
- Data analyzing capability
- Compact and simple
- Serial interface for direct connection to PC technology
- Recommended for use in environmental measurements under extreme environmental conditions.
- High efficiency

3.2.6 Construction of Stevenson Screen

This screen is normally constructed with wood but we built it by using a different type of plastic. It is like a number of plastic cups putting one on top of other (Figure 3.7). There were three rod which goes through the entire cup for holding the screen and these rods also used to attach the screen with the base.

This screen is painted with white gloss that reflects from light, keeping the thermometer from heating above the air temperature. Now inside this screen we have installed the sensor unit. For this purpose we attach the sensor to one of the rod which is also used to hold the plastic cup . (Figure 3.7)



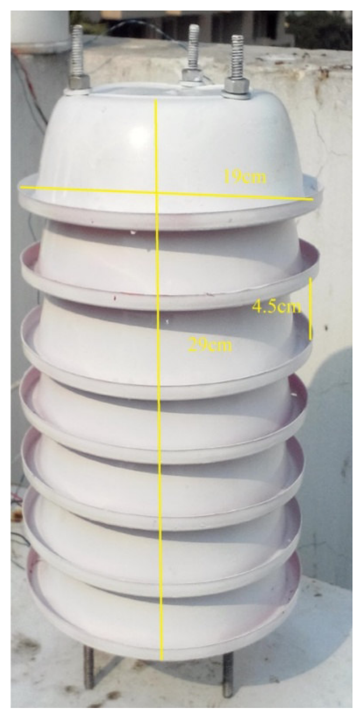


Figure 3. 30: Stevenson Screen

3.3 Rain Gauge

3.3.1 Introduction

Our main goal is to measure rainfall as much accurate as possible. So we have to design a system which is capable of receiving and interpreting a signal from the rain measurement sensor. The next task is to send the data that we got from the rainfall measurement sensor by serial communication. This part of our project activities includes water collection mechanism, signal handling and data interference to the PC. We then design the Hardware and write the code in Arduino that would translate the rainfall measurement sensor output into a form understandable by PC interference. Finally we spent a lot of time in calibrating our Rain Gauge. Calibrating part is very much complicated as the sensors give the digital output. It includes data collection and documentation. We also spent a great deal of time for searching information, coding examples, seeking professional advice and learning about the interference requirements as they related to coding. In future whoever wants to work with this digital rain Gauge will find it very helpful as we referring the sources and information that we have covered.

3.3.2 Construction

The construction of our Digital Rain Gauge can be divided into two parts. One is Hardware and the other is Software. First we will discuss about the hardware description detailed which includes technical drawing, implementation and then about the software part which includes coding.

3.3.2.1 Description of Hardware

For collecting rainfall we have to make a funnel. The upper diameter of the funnel is 8-inch. This is the standard size of the funnel. 8-inch is not fixed; the larger the diameter of the funnel the more rain is concentrated into the tipping bucket mechanism. The funnel is made of 1mm thick aluminum sheet.

For tipping mechanism we have to design a bucket (Figure3.8) which is the main part of designing our digital Rain Gauge. It is also made of 1mm thick aluminum sheet. The detailed is shown in the mechanical diagram

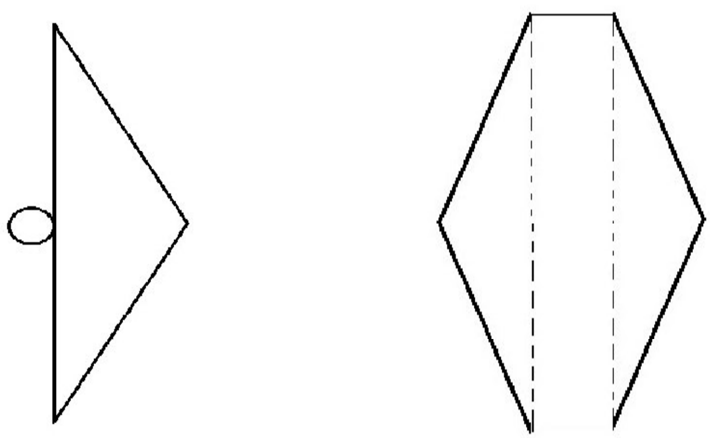


Figure 3. 31: Bucket

Figure 3. 32: Tipping Bucket Rain Gauge

The shape in the diagram (Figure3.8) must be cut from the sheet aluminum and the two triangular flaps folded 90°upward along the dotted lines. In the center of the base of bucket we have to add a divider for making the two similar volume of bucket.

The diagram (Figure3.9) here shows the main body of the sensor unit. It comprised mainly a 6-inch PVC pipe which is used as the outer shield. It is to prevent the damage of the internal mechanism from wind, animals etc. This provides a low cost and very rugged body for the entire unit as well as having the benefit of being easily modified with normal tools.

The base of our Rain gauge is made of steel. It is a circle shape with a diameter of 18cm which is also the diameter of the pipe used for shielding. There are two holes which we drill for the water that was collected by tipping bucket to go out from the main body of the Rain Gauge. For this two pipes of less than 3-inchin height are cut and fixed with adhesive waterproof glue.

Now from the base we have to make a structure to hold the tipping bucket and also the reed switch. So we make a rectangular shape (Figure 3.10) with steel and attached it with the base by screw. From the middle of it we again drill on the both side of the rectangular steel. The hole of the both side must be in same horizontal level so that the shaft which is under the tipping bucket can be attached in the center of the bucket. Now we have to place a smaller funnel

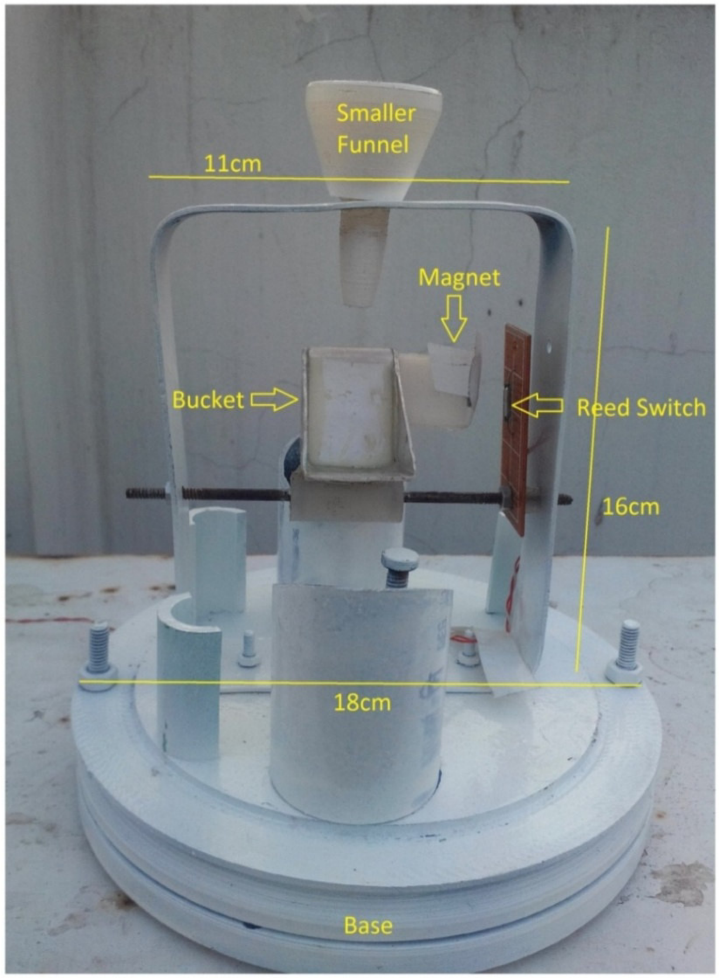


Figure 3. 33: Inner Look of Tipping Bucket Rain Gauge

(Figure3.10) in a way that the rain water goes through it to the tipping bucket. That is why we placed the smaller funnel in the top of the rectangular steel. For tipping

Figure 3. 34: Different Views of Tipping Bucket Rain Gauge

The bucket freely we use bearing which are around the shaft. Bearing are attached under the bucket by using silicon adhesive.

The upper part of our rain gauge is nothing but a funnel made of steel which collects the rainfall. The description of this funnel is given before. This funnel can be called the big funnel from which the rain water will go to the smaller funnel and then to the tipping bucket for tipping.

3.3.2.2 System Mechanism

The digital rain gauge includes the collector, the Arduino for US conversion and software. Within the collector is the magnetic sensor and tipping bucket. These elements provide the basic mechanism for measuring and translating a unit of rainfall into a pulse. The signal then travels to the Arduino where it is translated into a USB signal and sent to the PC. Once in the PC the signal will be read by software and presented to the user in various forms. The data flow from rainfall to the user interface can be seen in (Figure 3.12)

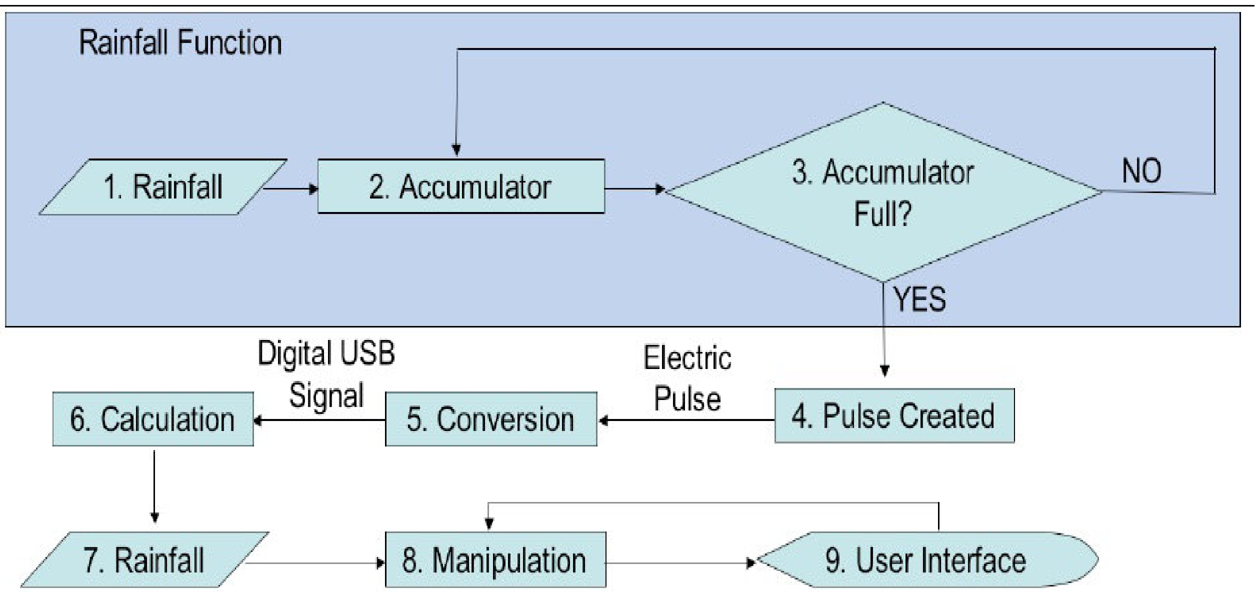


Figure 3. 35: Flow Chart of the System

The main mechanism of this unit is to attach a permanent magnet on one side of the tipping bucket so that whenever it will tip it will make the reed switch on. The bucket will tip from one side to another when a certain amount of water will filled the half of the bucket. This certain amount of water will be constant. In every tipping, the bucket will make a reed switch on. We need to count that how many times the reed switch became on. Suppose the bucket is tip from one side to another when there is 0.1ml of water in it. Now it will make the reed switch on for one time. Again when there will be another 0.1ml of water in the other half of the bucket the reed switch will become on for the second time. So if the switch become on two times there will be 0.2ml of water, for three times there will be 0.3ml,for four times there will be 0.4ml and so on. The work of the Audrain will be to count how many times the reed switch will become on, and measuring the rainfall.

3.3.3 Calculation

1inch= 0.254m

8inch=203.2mm

Base Area= (Diameter)^2 x$\frac{\pi}{4}$

= (203.2)^{2}x$\frac{\pi}{4}$

= 32429.27mm^2

=10000mm

We know, Volume of Cylinder= Area x Height

Therefore, Height= Volume of cylinder/Area

$= \frac{10000}{32429.27} =$ 0.30mm

we got 1 tip= 10ml of water

=10x1000

3.3.4 Calibration

We have to calibrate the software to correctly interpret a pulse and determine the system accuracy.

3.3.4.1 Calibration Process

Step 1) Pre-measure a volume of water

Step 2) Pour the measured water over the collector

Step 3) Read the rainfall accumulation data from the computer

Step 4) Adjust the internal software parameters for bucket volume per pulse

3.3.4.2 Determination of Calibration Accuracy

1) Compare the actual and measured values of collected rain for a fixed volume over much iteration.

2) Accuracy will be calculated as the ratio of average measurement error over the Actual volume.

3.3.5 Limitations

Many of the design specifications are derived from the following listing of limitations. This listing has been modified over the course of the project as more Information was available. In most cases these limitations serve as a boundary for

The possible specification ranges.

•The minimum rainfall rate shall be 0.1mm/hr. The volume required for a bucket Tip will not be able measure smaller rainfall rates.
•The maximum rainfall rate shall be 100mm/hr.
•Placement should allow for a 30-degree angle between the collectors, the height of any surrounding projections and the ground. This placement prevents tall objects from either blocking rainfall or from dropping debris into the collector.
•Rain collector and sensor unit will weigh less than 2.27kg. Minimizing the weight of the actual rain-collecting component will minimize prototyping costs and make the system easier for the end user to install.
•Transmission cable must be flexible enough to allow for routing to the translation module.
•USB provides only 5V supply for the micro-controller and sensor to work with. The micro-controller and sensor were chosen carefully to account for this.

3.3.6 Advantages

- We can place the collector of our rain gauge in any location within the range as the data will send through GSM modem
- Very simple and inexpensive design
- Easily adapted to digital applications
- High accuracy is possible
- Automatically empties the collection unit
- Inexpensive construction
- This sensor is both accurate and inexpensive.
- The switching rate is arbitrarily high. The other technologies considered have deficiencies in these areas

3.3.7 Part sources and cost estimates

These are the updated estimates for component prices. All prices on this list are from the local hardware store.

Equipment	Cost Per Unit	Number of Unit	Total
1.5” PVC Pipe	50	2	100
Funnel	100	1	100
Base(Nylon)	100	1	100
Steel for Bucket	10	1	10
Bearing	10	4	40
Smaller Funnel	20	1	20
Screw and Bolt	10	2	20
Reed Switch	20	1	20
Magnet	5	1	5
Wielding Bill	100	1	100
Total			515

Figure 3. 36: Total Cost Chart of Tipping Bucket Rain Gauge

3.4 Wind Speed

3.4.1 Introduction

Wind speed, or wind velocity, is a fundamental atmospheric rate rate. Wind speed is the rate of the movement of wind in distance per unit of time. In other word it is the rate of movement of air flow. When the air is moving from high pressure to low pressure then the wind speed is occur. It can be reported in a couple of ways: knots or nautical miles per hour, or statute miles per hour.

3.4.2 Importance of wind speed measurement

The measurement of wind speed is one of the most important factors in weather prediction. Wind is the movement of air caused by uneven heating of the earth's surface. It occurs in light breezes that are locally generated due to heating of an immediate landmass, to winds on a grand scale spanning continents caused by solar heating. Besides being used as part of a weather monitoring station there are many other situations where measurement and knowledge of the wind condition helps in decision-making such as pollution control, safety of tall structures, control of wind turbines, studies on the effects of wind on crops, management of ships and aircraft landing systems. Moreover, by using anemometer we able to measure wind speed which is useful to predict when the storms will reach a certain area, what equipment might be necessary for the outdoors and how much preparation an individual might need to take to be safe within their home during inclement weather. Generally, wind speed is measured with an anemometer.

3.4.3 Construction

An anemometer is a simple meteorological device that is used to measure wind speed. Anemometers come in a variety of forms such as cup anemometer, vane anemometer, and wire anemometer and so on. However, the simplest and most usable type is the **cup anemometer**. Using cup anemometer we can measure wind speed by multiplying cups' revolutions per minute by the circumference of the circle the cups create. The product will be a close estimate of the wind's speed per minute.

Figure 3. 37: Cup Anemometer

Cup

anemometer can be constructed by using 3-4 cups. In our system we used 3 cups as there is no difference whether we using three cups or four cups anemometer. The only reason we choose to construct a three cups anemometer is it will be cost effective. Each of the cups mounted with three horizontal arms attached to the top. These horizontal arms are separated by equal angle and mounted on a vertical shaft. When the wind causes the cups to rotate the arms around the central pole, the shaft is also rotate. The cups catch the wind and are propelled around the beam based on the strength of the wind.

The diameter of each cup is 6.5cm whereas the length of each arm where the cups are mounted is 11cm. Moreover, the height of the shaft is 8cm. the diameter and height of the basement is 12.5cm and 9cm respectively. So the total height of the anemometer is about 18cm.

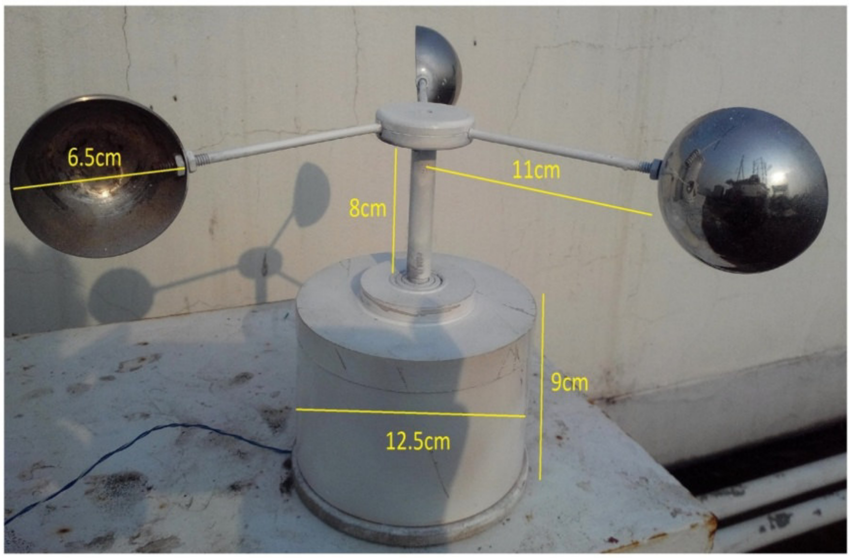


Figure 3. 38: Measurement of the Equipment of Anemometer

3.4.4 Mechanism

The mechanism of our cup anemometer is very simple. We use two plates on the basement of the anemometer. One plate is mounted with the base and has a read switch. Besides, another plate is mounted with the shaft which has a magnet. When the plate that has magnet rotates with the shaft it passes through the read switch and the read switch conducted and send pulse to the control unit whenever the magnet pass through it. By counting the pulses in one minute we can easily measure the wind speed.

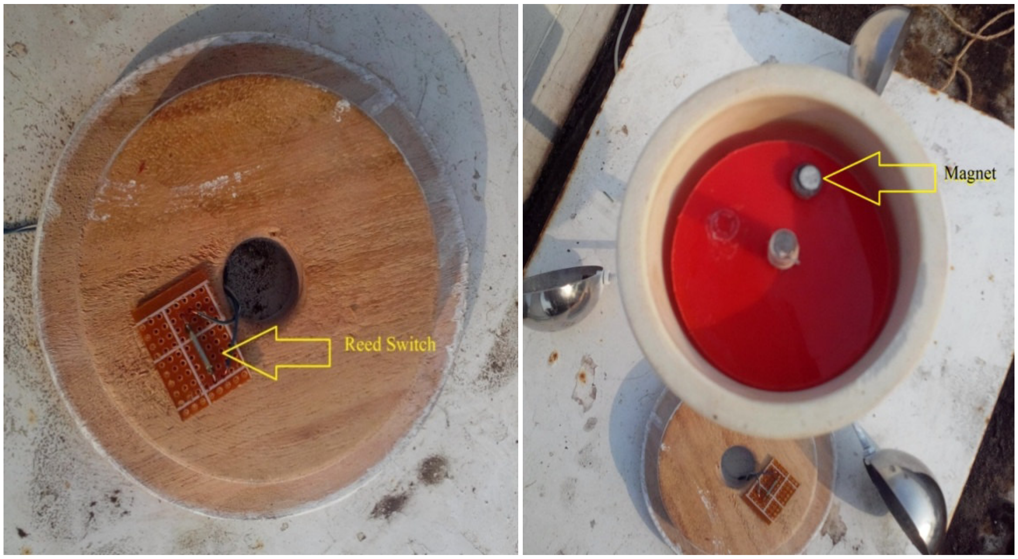


Figure 3. 39: Inner Look of the Basement

3.4.5 Beaufort Chart for Wind Speed

Below a wind chart that is created by Admiral Beaufort. Beaufort arranged the number 0 to 12 to indicate the strength of the wind from calm (force 0) to hurricane (force12). Here's a scale adapted to land:

Beaufort Force	Description	When You See or Feel This Effect	Wind (mph)	Wind (km/h)
0	Calm	Smoke goes straight up	Less than 1	Less than 2
1	Light	Wind direction is shown by smoke drift but not by wind vane	1-3	2-5
2	Light breeze	Wind is felt on the face; leaves result; wind vane moves	4-7	6-11
3	Gentle breeze	Leaves and small twigs move steadily; wind extends small flags straight out	8-12	12-19

4	Moderate breeze	Wind raises dust and loose paper; small branches move	13-18	20-29
5	Fresh freeze	Small trees sway; waves form on lakes	19-24	30-39
6	Strong breeze	Large branches move; wires whistle; umbrellas are difficult to use	25-31	40-50
7	Moderate gale	Whole trees are in motion; walking against the wind is difficult	32-38	51-61
8	Fresh gale	Twigs break from trees; walking against the wind is very difficult	39-46	62-74
9	Strong gale	Buildings suffer minimal damage; roof shingles are removed	47-54	75-87
10	Whole gale	Trees are uprooted	55-63	88-101
11	Violent storm	Widespread damage	64-72	102-116
12	Hurricane	Widespread destruction	73+	117+

3.4.6 Calculation and Calibration

For measuring wind speed the theoretical calculation is describe below.

D= 13.77inches [D= diameter]

Circumference, C=D*pi

=13.77*3.1416

=43.259832inches

$= \frac{43.259832 inches * 1 feet}{12 inches}$

=3.604986feet

Travels in one minute = $\frac{3.604986 \text{feet} * \text{n}}{1 \text{minute}}$ [n=revolution]

Travels per hour = $\frac{3.604986\text{feet}*\text{n}*60\text{minute}}{1\text{hour}}$

=216.29916*n feet/hour

= $\frac{216.29916\text{feet}*\text{n}*1\text{km}}{3280.8\text{feet}}$ [32.80.8 feet=1km, 5280 feet=1mile]

=0.06592879*n km/hour

= $\frac{216.29916\ \text{feet}*\text{n}*1\text{mile}}{5280\text{feet}}$

=0.040965 mile/hour

Due to some technical and mechanical difficulties theoretical calculation is not match with practical calculation. Practically we measure the wind speed with our anemometer by using a motor cycle. By varying the speed of motor cycle we take the reading from the anemometers output unit. Actually here we measure how many times in a minute the read switch send pulses to the control unit. For instance, when the speed of motor cycle was 10 kilometer per hour the average pulses created by the read switch was 27. By this process we get a liner graph of speed Vs pulse from where we get an equation. By solving this equation we can easily find out the wind speed.

Anemometer Speed Test:

Speed(kph)	Test1	Test2	Test3	Avg. Test
10	28	23	30	27
20	45	39	42	42
30	65	71	67	65.666667
40	95	89	97	93.666667
50	129	123	115	122.33333

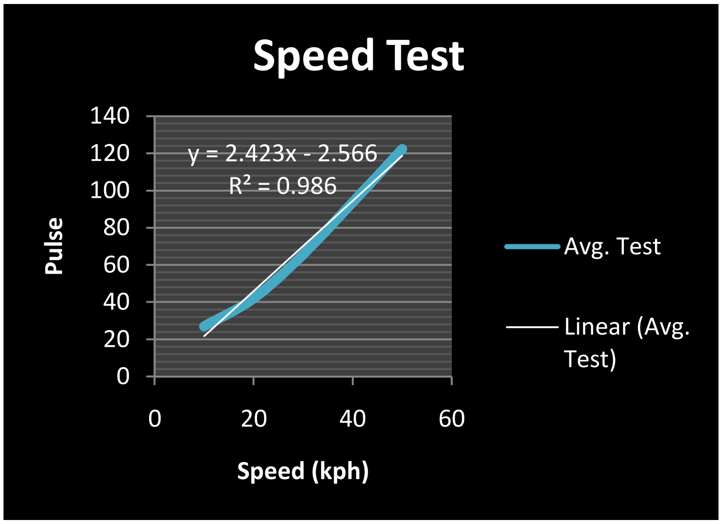


Figure 3. 40: Speed Test Curve

According to the response curve pulses and wind speed can be calculated through the following equation.

Pulse= 2.423*speed (kph)-2.566

Speed= $\frac{Pulse+2.566}{2.423}$

3.5 Wind Direction Detector

3.5.1 Introduction

Wind direction is the direction, measured on the points of a compass, from which wind is coming. For example, a wind that is blowing in a northeasterly direction and coming from the southeast is called a southeast wind. The direction of the wind is extremely important in many ways.

3.5.2 Wind vane

Wind direction is measured by an instrument called a wind vane or weather vane. These have been used for indicating which direction the wind is coming from and allow people to attempt to forecast the weather based on the wind direction.

Figure 3. 41: Wind Vane

It is very important to know the wind direction. This is because, by knowing the direction of the wind we can easily find out the low and high pressure areas. For the prediction of the weather we have to know both the wind direction and wind speed. This is because, there is a slightly relation between wind direction and wind speed in weather prediction. Like, if the wind speed increases, it is an indication of strengthening of pressure systems. It brings cool or hot air from the place of origin or from the places through which they pass. Moreover, the direction of the wind in such cases will be useful in forecasting hot or cold conditions over a place. Monsoon winds constantly blow from a particular direction in a particular part of the year over a particular place. The onset of these monsoons can be predicted in advance by studying the changes in the direction of the winds over these places. In aviation it will be very useful. If the direction of wind is known at the level the aircraft flies,(whether head wind or tail wind),they can decide the amount of fuel they have to carry as taking excess fuel than actually required will increase the weight of the aircraft and will be costlier. Jet streams help the aircrafts to reach a place early if the aircraft flies along the direction of the wind (tail wind) .If it flies against the wind (head wind), the aircraft may take more time to reach a place. If you know about the direction and speed of the jet stream earlier, it will help to inform all the persons concerned the exact time of arrival of the aircraft at a particular place and also to decide about actual fuel consumption. Even for landing and taking off, the aircraft requires wind direction and speed so that it can land safely knowing the exact distance required in the runway to land or take off.

3.5.3 Construction

A wind vane has an aerodynamically shaped detector. Wind vane usually shaped like a jet plane or an arrow that tends to point in the direction the wind is blowing at any given time. We constructed a wind vane which is shaped like an arrow. The arrow points in the direction the wind is blowing and the arrow tails mounted in the opposite side of the arrow point. Arrow point and arrow tail are mounted on a rod. Moreover the rod is mounted with another vertical rod which is freely rotatable.

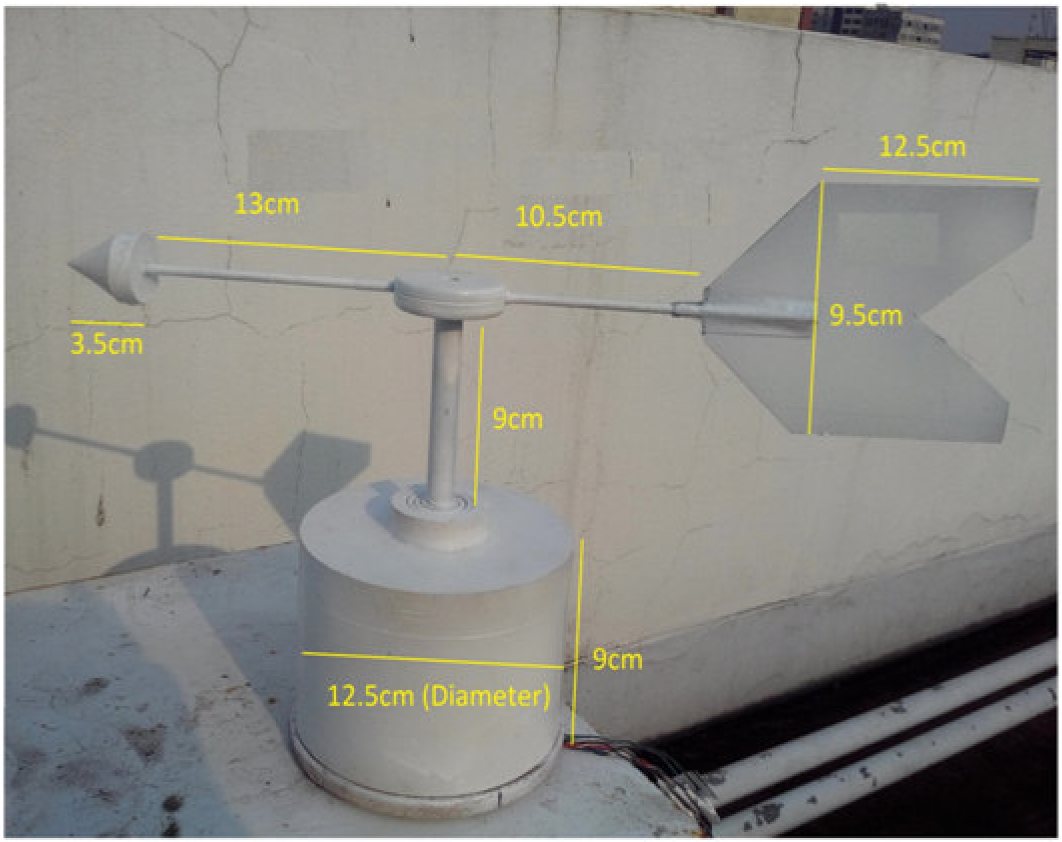


Figure 3. 42: Measurement of the Equipment of Wind Vane

3.5.4 Mechanism

The mechanism of wind vane is almost similar with the anemometer. In the basement of the wind vane we used two plates, one is fixed with the base and has eight read switch for pointing eight directions. On the other hand, another plate is mounted with the rotatable rod and has a magnet. Eight read switches are pointing the directions North (N), Northeast (NE), East (E), Southeast (SE), South (S), Southwest (SW), West (W), and Northwest (NW) respectively. The magnet makes a particular read switch on when it comes to that read switch and makes it on. On that time that read switch send a pulse to the control unit and we can understand that the wind is blowing from that particular direction.

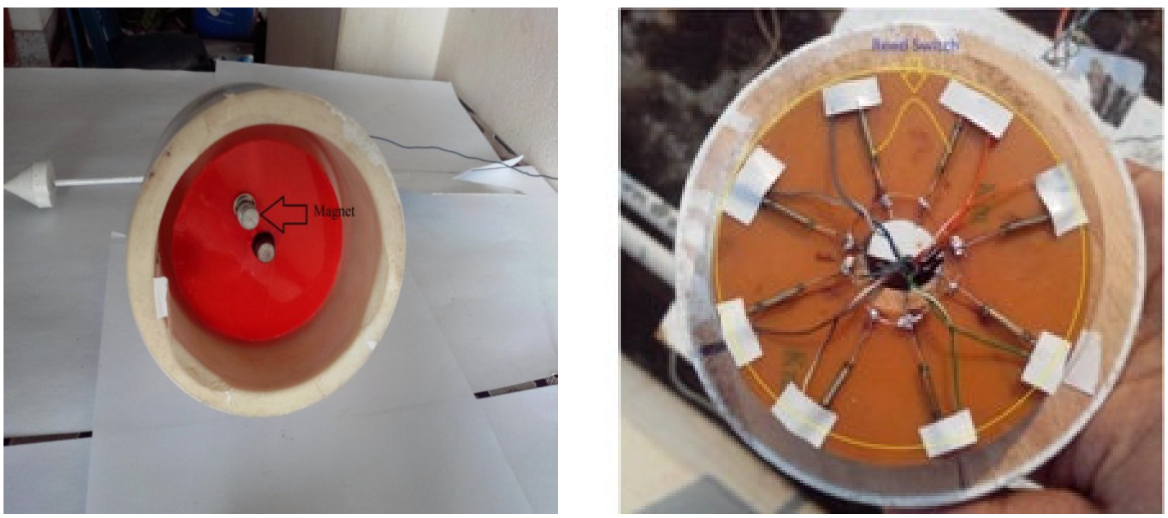


Figure 3. 43: Inner Look of the Basement

3.6 Sun Light Intensity

3.6.1 Introduction

Sunlight is a portion of the electromagnetic radiation given off by the Sun. On Earth, sunlight is filtered through the Earth's atmosphere, and is obvious as daylight when the Sun is above the horizon. When the direct solar radiation is not blocked by clouds, it is experienced as sunshine, a combination of bright light and radiant heat. When it is blocked by the clouds or reflects off other objects, it is experienced as diffused light.

3.6.2 TSL 2561 Luminosity Sensor

We measure sunlight by using the TSL2561 sensor. The TSL2561 luminosity sensor is an advanced digital light sensor, ideal for use in a wide range of light situations. Compared to low cost CdS cells, this sensor is more precise, allowing for exact lux calculations and can be configured for different gain/timing ranges to detect light ranges from up to 0.1 - 40,000+ Lux on the fly. The best part of this sensor is that it contains both infrared and full spectrum diodes! That means you can separately measure infrared, full-spectrum or human-visible light. Most sensors can only detect one or the other, which does not accurately represent what human eyes see (since we cannot perceive the IR light that is detected by most photo diodes)

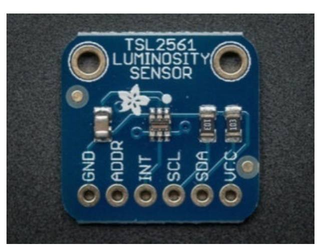


Figure 3. 44: TSL-2561 Sensor

Recommended Operating Conditions for TSL 2561:

	Min	Nor	Max	Unit
Supply Voltage, V_{DD}	2.7	3	3.6	V
Operating Free-Air Temperature, T_A	-30		70	℃
SCL, SDA Input Low Voltage,V_{IL}	-0.5		0.8	V
SCL, SDA Input High Voltage,V_{IH}	2.1		3.6	V

Specifications of TSL2561:

- Approximates Human eye Response
- Precisely Measures Luminance in Diverse Lighting Conditions
- Temperature range: -30 to 80 *C
- Dynamic range (Lux): 0.1 to 40,000 Lux
- Voltage range: 2.7-3.6V
- Interface: I^2C
- This board/chip uses I2C 7-bit addresses 0x39, 0x29, 0x49, selectable with jumpers

3.6.3 Sensor Outdoor Mounting

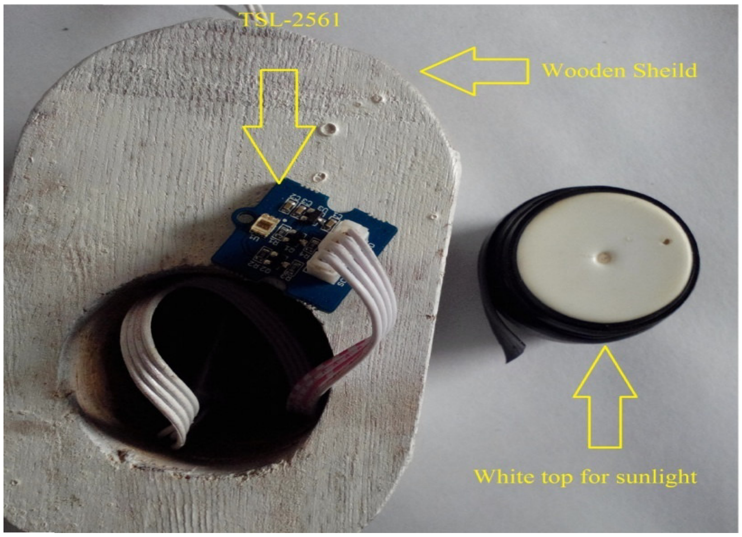


Figure 3. 45: Housing to Keep the TSL-2561 Sensor

As we cannot keep the TSL 1561 sensor in open environment, we had to make a cover to protect the sensor from natural catastrophe like rain, wind, dust etc. We made the cover by using wood as wood is a good heat insulator. That is why the cover cannot make any unwanted impact on the sensor. In the top of the wooden cover we used another plastic cover so that sunlight can easily enter into the wooden cover and the sensor can sense the light. As we use the sensor to measure sunlight intensity we colored the plastic cover white so the heat will reflect back to the environment.

3.6.3.1 Measurement

Here the height of the wooden cover is 7cm while the length and width of the cover is 11cm and 5cm respectively. Moreover the diameter of the plastic cover that we used in the top of the wooden cover is 3cm, whereas the height of the plastic cover is 2.5cm.

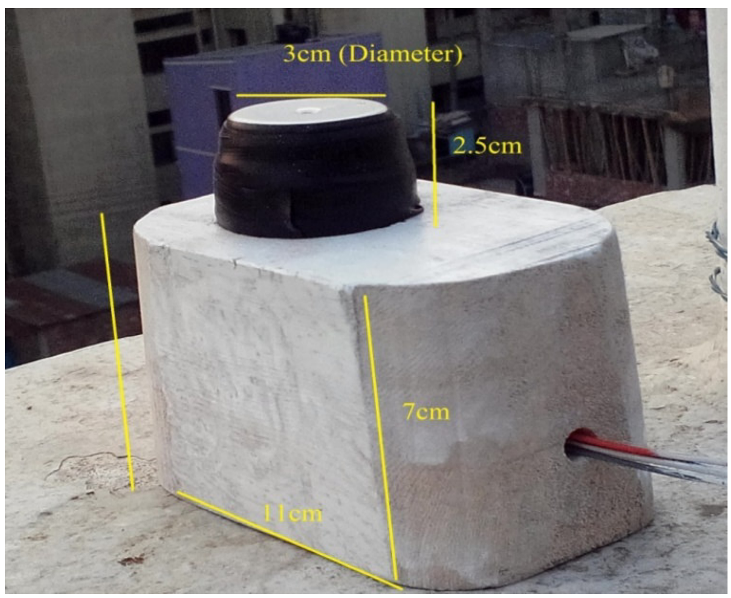


Figure 3. 46: Measurement of the Housing

3.7 Cost Estimation

Sensor	Cost(BDT)
Tipping bucket rain gauge	515/-
Stevenson Screen	1250/-
Anemometer	480/-
Wind vane	350/-
Sun logger	415/-

3.8 Sensor's Combination

Measuring weather data is a scientific system. For making a good automatic weather station at first we have to collect the data very carefully and scientifically. Secondly, location is very important for an automatic weather station. For a weather station we have to choose a location where there is no barriers surround the tower where all the sensors of the station will mount. So it is good to set up the tower in an open place. For example a large lawn, where nearby objects such as buildings, walls and trees won't deflect the entry of wind or wind-blown rain into the tower. The standard recommendation is that the station be positioned at a distance corresponding to two to four times the height of any nearby barriers. Moreover, we have to careful about where we are going to place the sensor in the tower.

The international standard height for measuring weather data for all the sensors from ground level is given below.

Sensors name	Distance from the Ground Level
Temperature Sensor	4 ft
Humidity Sensor	4 ft
Rain Gauge	4 ft
Anemometer	33 ft
Wind Vane	33 ft
Pressure Sensor	4 ft
Sunlight intensity sensor	20 ft

The tower shows that how we set up the sensors in a tower. We set up the Tipping Bucket Rain Gauge, Stevenson Screen where temperature sensor, humidity sensor, pressure sensor are located at a height of 4 feet from the ground level. Besides, the sunlight intensity sensor is installed in the tower at a height of 20 feet from the ground level. However, the anemometer and the Wind Vane are set up at a height of 33 feet from the ground level.

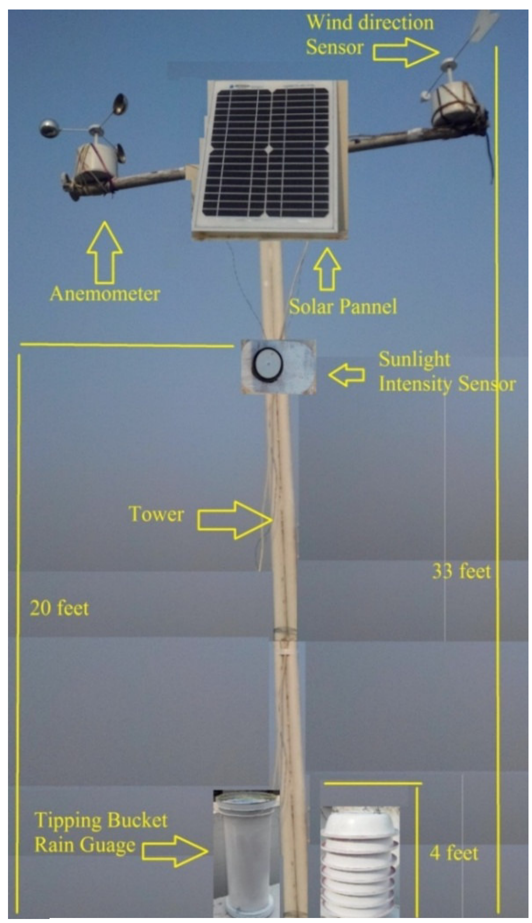


Figure 3. 47: Installation of Sensors in the Tower

Chapter 4
Process Control

4.1 Arduino Mega

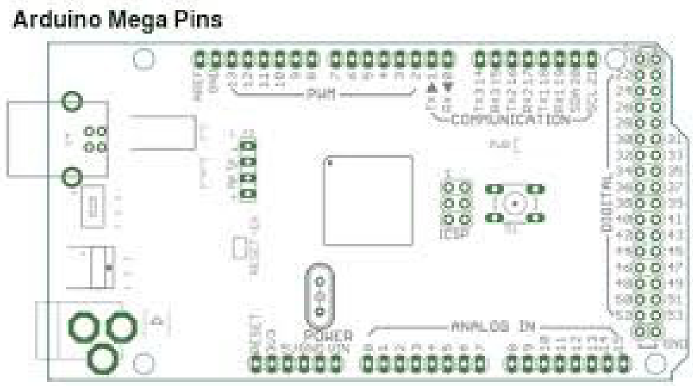


Figure 4. 4: Arduino Mega

The Arduino Mega is a microcontroller board based on the ATmega1280. It has all the pin outs and essential connections to communicate with the microcontroller. It can be powered via the USB connection or with an external power supply. The ATmega1280 provides four hardware UARTs for TTL (5V) serial communication so that it can easily connect to the serial port of the computer. It also supports I2C (TWI) and SPI communication. The Arduino Mega can be programmed with the Arduino software which includes a serial monitor that allows simple textual data to be sent to and from the Arduino board. The ATmega1280 on the Arduino Mega comes preburned with a boot loader that allows uploading new code to it without the use of an external hardware programmer.

4.1.1 I²C Communication

I²C is a multi-master protocol that uses 2 signal lines. The two I²C signals are called ‘serial data’ (SDA) and ‘serial clock’ (SCL). There is no need of chip select (slave select) or arbitration logic. Virtually any number of slaves and any number of masters can be connected onto these 2 signal lines and communicate between each other using a protocol that defines:

- 7-bits slave addresses: each device connected to the bus has got such a unique address;

- data divided into 8-bit bytes
- a few control bits for controlling the communication start, end, direction and for an acknowledgment mechanism.

Physically, the I²C bus consists of the 2 active wires SDA and SCL and a ground connection. The active wires are both bi-directional. The I2C protocol specification states that the IC that initiates a data transfer on the bus is considered the Bus Master. Consequently, at that time, all the other ICs are regarded to be Bus Slaves.

4.1.2 Timer Interrupts

Timer interrupts perform a task at very specifically timed intervals regardless of what else is going on the code. Interrupts can be established for events such as a counter's number, a pin changing state (from low to high or high to low), serial communication receiving of information, or the Analog to Digital having established a conversion. In our system we have used timer interrupt to count the pulses generated from the anemometer and the rain gauge.

4.2 Data Reception and Digitalization Process

All the weather sensors are placed in different positions of a tower. All of them are connected with the controller board where the analog data’s are being processed. Depending on the output modes the sensors are connected to different pins of the controller and hence the programming is being developed. The following figure shows the circuit connections and computer interface of the data acquisition tool.

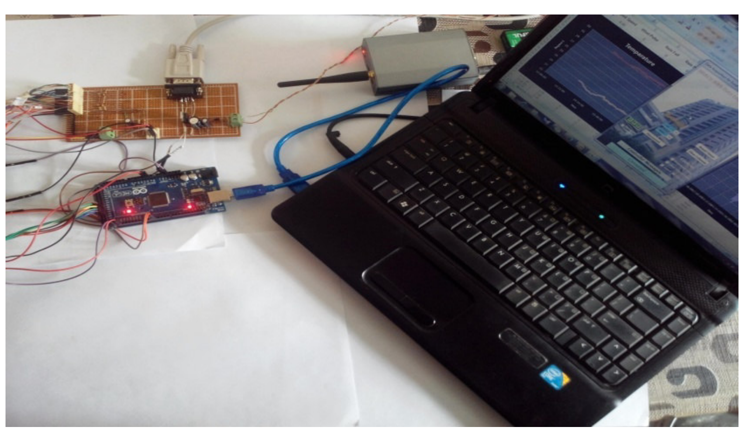


Figure 4. 5: Data Reception and Digitalization Process

4.2.1 Humidity/ Temperature

HSM-20G is an integrated circuit with only four external pin outs for measuring temperature and humidity. The sensor gives temperature and humidity as voltage output that is received by the controller using Analog Input pins. The Atmega controllers used for the Arduino contain an onboard 6 channel analog-to-digital (A/D) converter. The converter has 10 bit resolution, returning integers from 0 to 1023. According to the datasheet of HSM-20G voltage outputs are converted to digital humidity and temperature using few equations.

4.2.2 Anemometer/ Rain Gauge

Anemometer and Rain gauge have almost same electrical configuration and data processing mode. The hardware's are constructed to make the reed switch closed with the flow of the wind or rain drops. In the control unit each reed switch pulses have to be counted for calculating wind speed and rain fall. The outputs of these two sensors are connected to two timer interrupt pins of the Arduino board. A function called millis() in the programming portion sets for one minute to count the low states of the interrupts. Such way pulses of the reed switches are being counted for every minute.

4.2.3 Wind Direction Sensor

There are eight reed switches inside the wind direction sensor for detecting eight different directions. Eight outputs are connected to eight digital pins of the Arduino. With the change of the state of reed switches directions also change. Eight directions that we are considering are 1)South, 2)South West, 3)West, 4)North West, 5)North, 6)North East, 7)East, 8)South East

4.2.4 Sun Light Intensity/ Pressure

Sun Light Intensity and Pressure sensors use I2C communication to send data's to the controller. Both of these sensors has four pin outs, 2 of them are used for the power supply and other two pins SDA and SCL are connected to the SDA and SCL pins of the Arduino board. The sensor provider provides Arduino libraries for programming. All the calculations are processed using the library.

4.3 Power supply

As the system requires a very low power we do not give extra emphasis on the power supply system. We have used a 10w solar panel to charge a 12V battery. A microcontroller based charge controller, that is available in the market is used for controlling the overall power supply process of the system. Arduino requires 9V power supply for operating. In this regards a voltage regulator of 12V to 9V is used. Most of the sensors operate at 5V connection. Arduino has 5V power supply and ground connection that is used for the sensors power up.

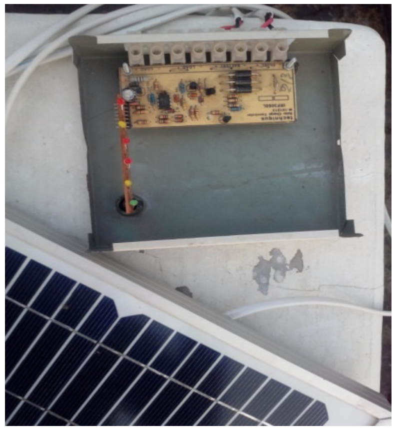


Figure 4. 6: Power Supply Unit

Chapter 5

Data Acquisition and Storage

5.1 Introduction

Unstable behavior of the weather emerges the importance of storing different weather parameters for further meteorological analysis. In this regards data acquisition from the weather station to computer is the most important part of an automated weather station. Sensors readings are stored in the computer using the serial communication between Arduino and data logging software.

5.1.1 Introduction to Serial Communication

In telecommunication and computer science, serial communication is the process of sending data one bit at a time, sequentially, over a communication channel or computer bus. The concept of serial communication is simple. The serial port sends and receives bytes of information one bit at a time. Although this is slower than parallel communication, which allows the transmission of an entire byte at once, it is simpler and can be used over longer distances. Typically, serial is used to transmit ASCII data. Communication is completed using 3 transmission lines: (1) Ground, (2) Transmit, and (3) Receive. Since serial is asynchronous, the port is able to transmit data on one line while receiving data on another. Other lines are available for handshaking, but are not required. The important serial characteristics are baud rate, data bits, stop bits, and parity. For two ports to communicate, these parameters must match. **Baud rate** is a speed measurement for communication. It indicates the number of bit transfers per second. For example, in our system 9600 baud is used that means data's are transmitted 9600 bits per second. When the protocol calls for a 9600 baud rate, then the clock is running at 9600 Hz. This means that the serial port is sampling the data line at 9600 Hz. In Arduino Serial is used for communication between the Arduino board and a computer or other devices. All Arduino boards have at least one serial port (also known as a UART or USART): **Serial**. It communicates on digital pins 0 (RX) and 1 (TX) as well as with the computer via USB.

5.1.2 Parallax Data Acquisition Tool

Parallax Data Acquisition tool (PLX-DAQ) software add-in for Microsoft Excel acquires up to 26 channels of data from any Parallax microcontrollers and drops the numbers into columns as they arrive. PLX-DAQ provides easy spreadsheet analysis of data collected in the field, laboratory analysis of sensors and real-time equipment monitoring. We have developed BRACU-AWS Data Logger by modifying the PLX-DAQ macro to make it work with Arduino. The modification on the macro is authorized for personal use by the Parallax Inc.

5.1.3 BRACU- AWS Data Logger

BRACU-AWS Data logger is a Visual Basic based application macro containing a serial port control that is used in Excel to accept data from the serial port. The computer serial COM ports are used to communicate with the controller. BRACU-AWS Data logger supports Baud rates up to 128,000. When we use a USB device for communications, many of these devices create a virtual COM port which may be accessed as regular COM port. Only COM Port 1 - 15 is supported by this

Figure 5.9: Data Acquisition Tool

software. Data logger can be connected only when port and baud rate are matched with the serial port and the program baud rate. Our system requires receiving data for every minute. Controller message indicates the connection mode and data storing notifications. To open this form in MS excel, macro has to be enabled in that file.

5.2 Communication between Computer and Arduino

Arduino communicates with the computer using the serial ports via USB. A baud rate is defined in the controller program for the serial data transmission. Data in specific formats is sent from the controller to the computer's serial port. A Visual Basic for Applications (VBA) macro containing a serial port control is used in Excel to accept data from the serial port, analyze it, place the data in the spreadsheet or perform other actions. Directives are used to inform BRACU-AWS data logger of what action is to be taken. BRACU-AWS data logger analyzes incoming data strings from the BASIC Stamp for action. Strings begin with a directive informing BRACU-AWS data logger of what action to take. Most all controllers have a means to send serial data to the PC. The data sent must be formatted properly to be understood by BRACU-AWS data logger.

- All directives are in CAPITAL letters, and some are followed by comma-separated data. Each string MUST end in a carriage return (CR).
- Strings not beginning with directives will be ignored.
- Strings containing ASCII characters < 10 or > 200 will not be processed and indicated as an error.

Serial data is transmitted one-bit at a time, including Start and Stop bits. 9600 refers to the ability to send a byte at 9600 bits per second. One byte (or character), plus start and stop bits, is 10 bits long. At 9600 baud this would take 1/9600 * 10 = 1.04 mS or .00104 seconds. We have used a string of approximately 60 characters. For 60 bytes, 1.04 * 60 = 62.4mS or .0624 seconds is needed to transmit the data's serially from Arduino to Computer.

5.3 Data Acquisition for MS Excel

By establishing connection between BRACU- AWS Data logger and Arduino, sensors readings are stored in Excel spreadsheet. Individual levels are used in each column of the excel sheet for placing the readings of different weather parameters. The exact time is also added with the outputs. A response curve is also automatically generated with the frequent changes of the readings. The spread sheet has an auto saving feather that saves the file at a regular interval so that no data will be lost. The outlook of system at the computer end looks like the following.

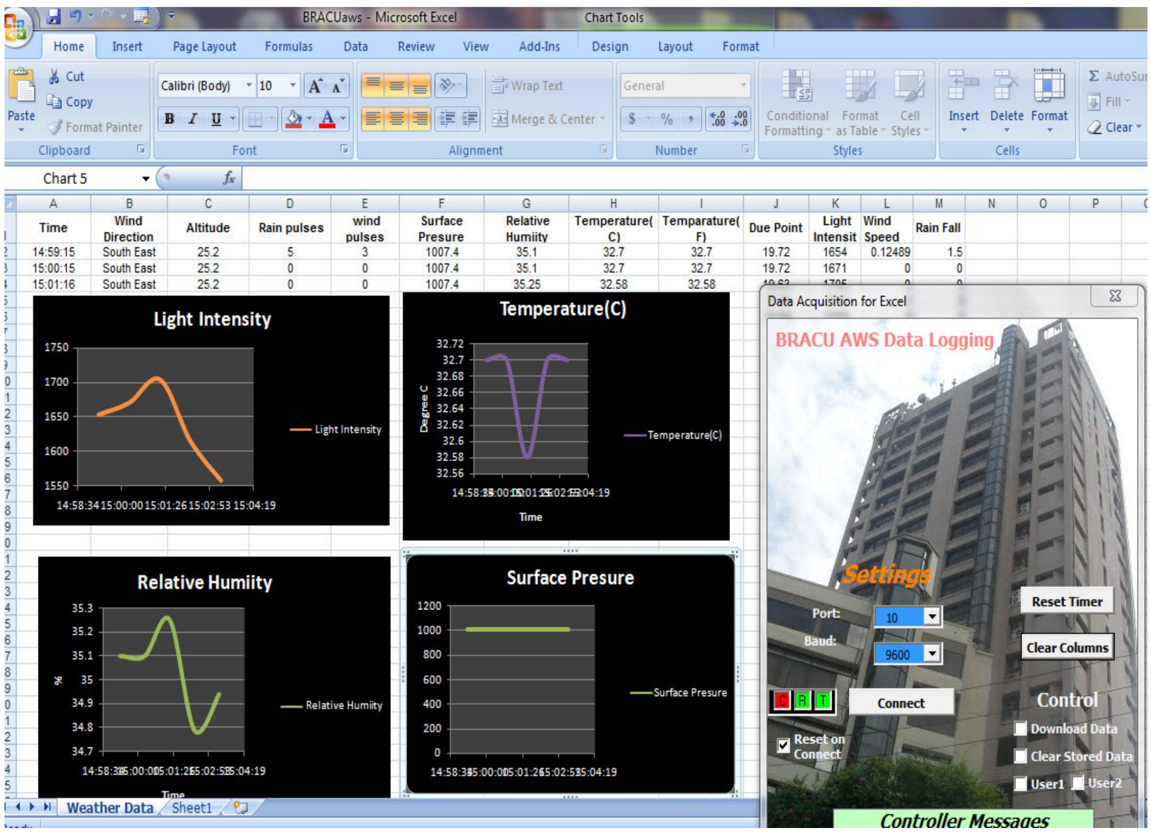


Figure 5. 10: Data Acquisition for MS Excel

5.4 Real Time Data Acquisition

Establishing all the required set ups and connections we have observed the weather for several times. All the readings were satisfactory and almost errorless. The following graphs are generated from these real time data's.

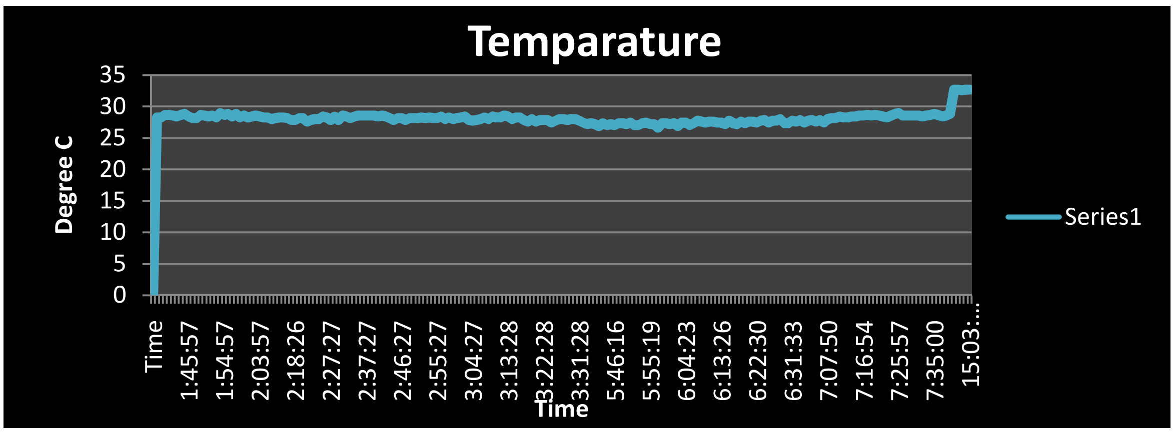


Figure 5. 11: Temperature VS Time Curve

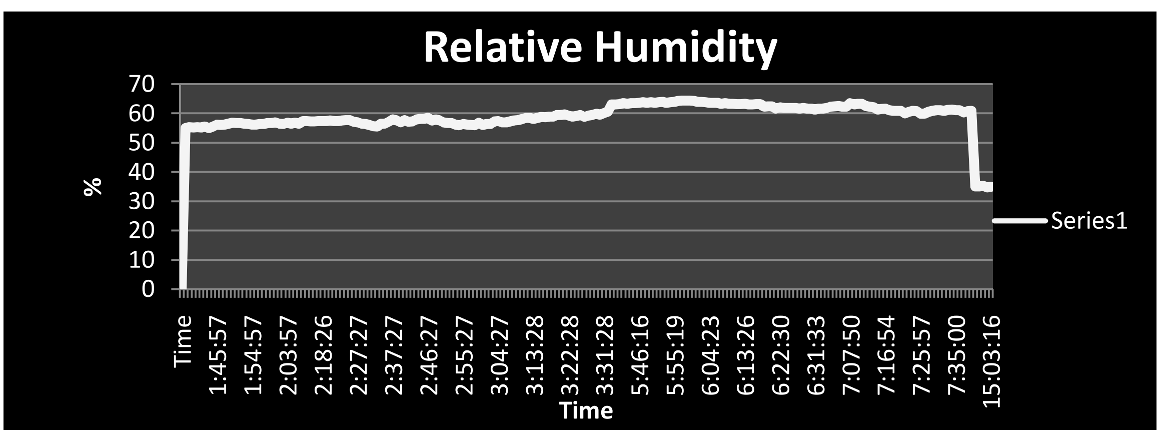


Figure 5-.12: Relative Humidity VS Time Curve

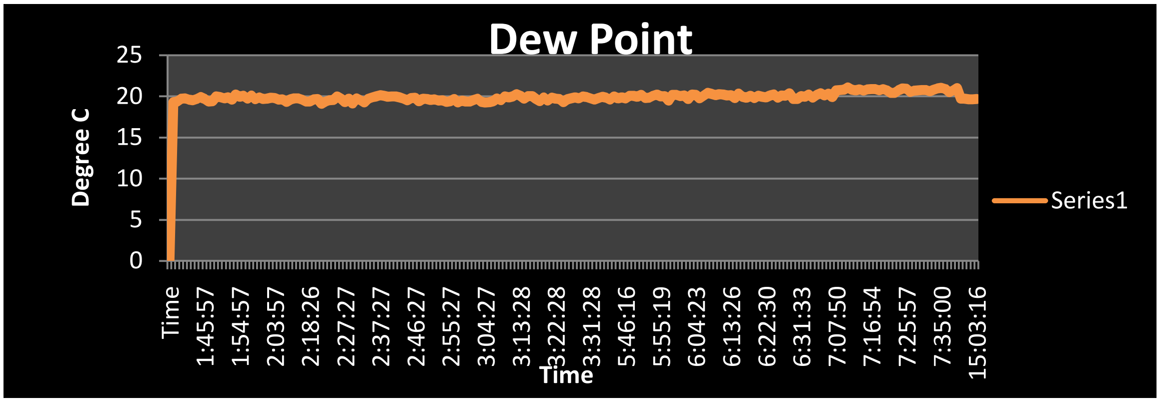


Figure 5. 13: Dew Point VS Time Curve

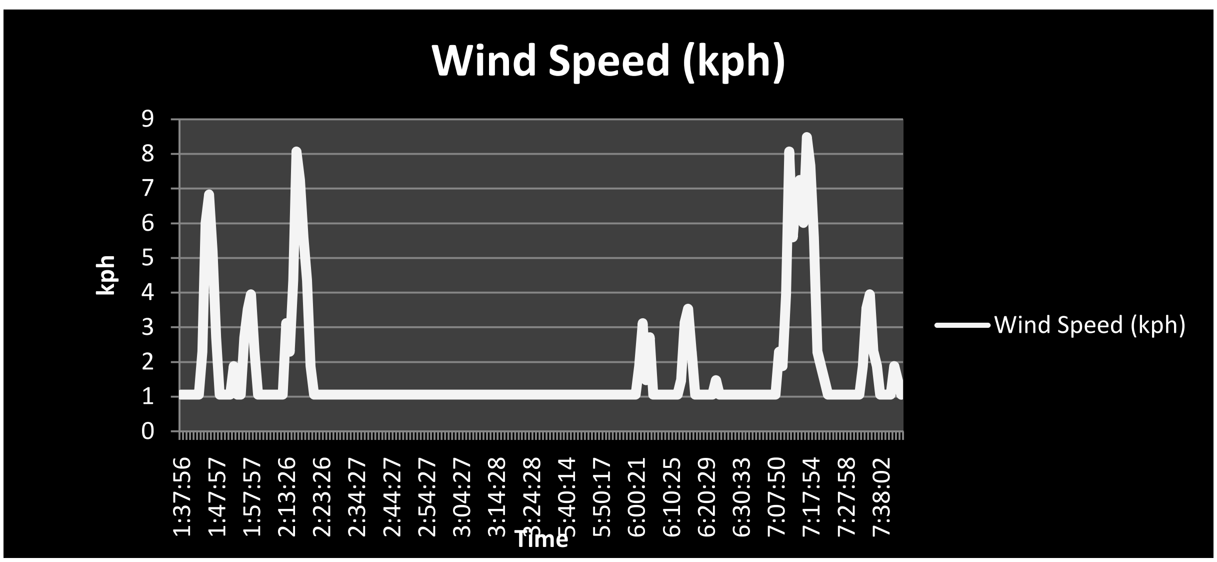


Figure 5. 14: Wind Speed VS Time Curve

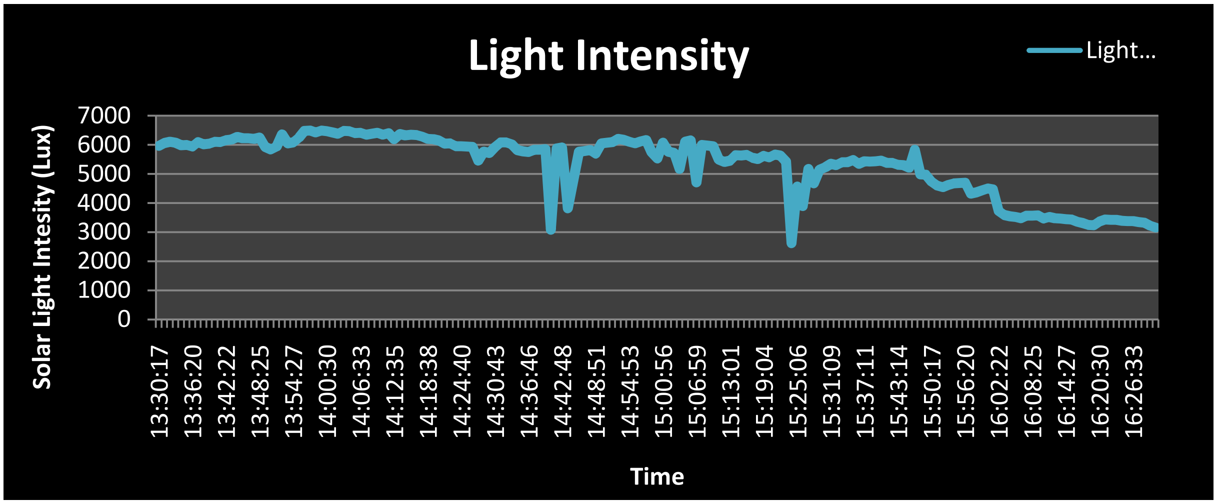


Figure 5. 15: Light Intensity VS Time Curve

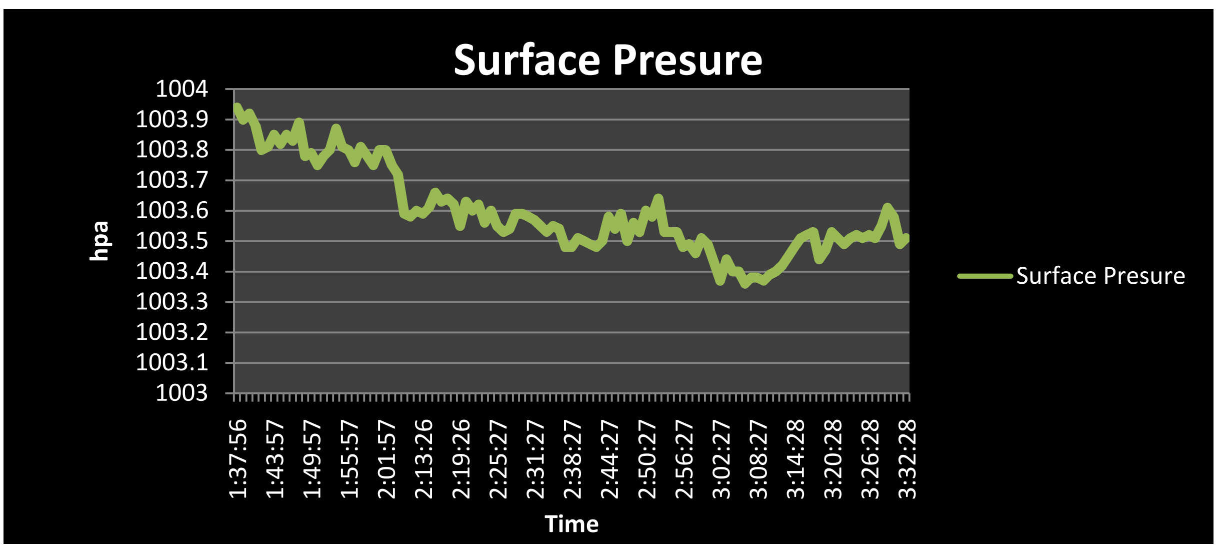


Figure 5. 16: Surface Pressure VS Time Curve

Chapter 6

Discussion

First of all we would like to thank Almighty Allah that we have completed our thesis successfully. From the very beginning to the ending of the thesis there were a number of stories full of success and misery. It's our pleasure that we chose such a topic that has its vast influence in the life of every one.

As part of our thesis work we visited the only concerned institution for weather forecasting in our country, Bangladesh Meteorological Department (BMD). There we had a very effective session about the weather parameters with the scientists and meteorologists of weather station. The officials of the meteorological department gave us the opportunity to explore the technology of the department. As this is the main office in Bangladesh we have watched a number of equipment's which are rare in our country, this was a real unique opportunity for us. It was sunny day with wind when we went there. After the briefing session in the office of meteorological department we went to the technical side of the office. The officials there helped us a lot to understand the basic logics behind the theory.

We started with Microcontroller then later on we switched to Arduino to implement the circuit diagram. It took a lot hassle to work with the PIC of Microcontroller unit. In case of microcontroller we have handle a number of pins in a scattered way, in the other hand Arduino is more organized as easy to integrate the connections. As the Arduino is the latest technical equipment in the circuit industry it has the built in functions in its software and the library is more enriched in Arduino.

To collect the essential equipment's we had gone to the Old Dhaka at Patuatuli to buy the unavailable equipment's. It was really painful when we went there by waiting for long hours in traffic and heard that the sensor is not available. We have bought few things from Techshop Bd; the equipment's were imported from abroad.

While working with the wind vane part we faced problem to fix the sensor in the right place following the greater accuracy. In the bottom of the wind vane we took an approximate measurement of the diameter of the equipment. After making a trial data acquisition we found that the positioning of the sensor was not appropriate. It made us anxious to design the mechanism. Searching in the internet and watching to some video tutorial we got some random examples regarding the positioning of the sensor. Furthermore changing the structure of the set and doing some experiment we got the proper placement of adjustment for the sensor. Wind vane worker properly after the certain adjustment of the place.

To develop the anemometer part we tried our best to implement it as smooth as possible. The round shape half balls were made by the stainless steel. The sticks that are connected with the cups are made of iron bars. The thicknesses of the sticks are made very light so that the measurement is appropriate. We integrated the sticks with the cup of anemometer by welding. The direction of the cup should be proportionate with the exact position of the sticks. A barrel was used to carry the whole stick cup mechanism with the help of a piece of iron stick. The basement of the anemometer was constructed by the thick plastics materials which has type of rubber structure. We used Steveson Screen to get the data reading of the temperature sensor. To make the shape of Stevenson Screen we went to a number of markets in Dhaka city. At last in the local market of Karwan bazaar we got the desired plastic cups then we bought it from the market. Then we placed the plastic cup in a reverse way and we actually needed a base structure to support the weight of the number of plastic plates. Putting the plates and fixing the supporting rods, we were searching for a proper place for the humidity sensor set up. Then we took the middle height of the sensor for setting it up. With the help of small circuit board we made an arrangement that holds the reed switch in the open space in the middle of the Stevenson screen.

In the rain gauge part tipping bucket construction was the main challenge. The mechanism is very simple, but the measurement of the bucket needed to be very accurate so that it can have the balance in both of the sides of the tipping bucket. Tipping bucket is used for the input of the reed switch that were set up for counting the number of left to right or right to left rotation of the bucket. There are two rods in two sides of the bucket so that it can have a balance between the movements of the bucket. As we integrate the sensors the main question that we were looking for was about the calculation of the data. There are a number of formulas for the calculation of the collected data from each of the sensors. It was really difficult to find out the appropriate formulas in consideration of the exact value acquisition. In some cases we tried more than one formula for an individual type of sensor data calculation. The data values varied slightly for the change of specific formula.

As power source is a vital factor for any type electrical project, we tried hard to make the consumption of power for the smart remote sensing weather station. In recent days the use of renewable energy has become so popular that we went for the use of solar energy as well. We have integrated the solar panel with the controller circuit to ensure the proper function of the circuit without power consumption from the national greed. In fact for every project in the electrical and electronic engineering the use of solar is now days ensured to go for the alternative power consumption plan. The software integration of the project was done using the excel data management system. We developed a software system which took the different data from the sensors in real time. In our trial session we took the time interval of one minute for all the sensors. After collecting the sensors the software automatically generates a graph indicating time vs. the sensor data for each of the sensor outputs. We have to a number of schematic works for the smooth execution of the circuit model. The schematics were done in Pspice engineering software.

In the synchronization part the overall integration of all the sensors was a bit tough for us because we were tensed about some of data counter interference of the data's. As the circuit was designed in a simple way so that the connection of the cables and other devices do not create any type of problem for the proper data acquisition. We made a temporary rod tower to set up the anemometer and wind vane in the upper part f the tower. The Stevenson screen was in the lower part of the tower along with the rain gauge sensor. The solar panel was in the middle part of the tower. A wooden box was made to place the sunlight intensity sensor. The sensor was covered inside a plastic cover layer that will protect it from the direct sunlight. If we keep the sensor in direct sunlight it will damage the sunlight intensity sensor.

During our thesis we have to stay in the University electronics laboratory for the construction of the equipments. Furthermore we went to the nearby workshops near BRAC University to complete the other construction works that were not possible in the laboratory.

Chapter 7
Conclusion

7.1 Digest

The project is based on the effective solution of the overall manual weather sensing station towards the digitalization of the weather system. The project has its own great influence over the lifestyle and livelihood of the common people of Bangladesh. Such system can be beneficial for us not in the consideration of cost minimization but it has other excellent features of real time data acquisition, portability of anywhere, an integration of a variety of sensors, easy maintenance system. Modification of the project will make a path towards the starting of industrial production of the weather sensors. If the troubleshoot of the station can be made successfully and we can have the collaboration with the Government, the set up of such weather stations in every Union of our Districts is possible. Later on we can reach to the remotest places of the country with the station, which will ensure the maximum area coverage of the weather. The coverage of the weather station will give us the opportunity to detect a slight change of weather within a very small slot of area, which will make our weather forecasting system more unique and strong.

The project has been build with a sustain feature that in case of power disruption the system will be functioning in full phase by the use of its solar panel. Effective integration technology has been used to ensure the sustainability of the station. The raw materials including which we used are available in the market, the use of highly efficient sensors has been ensured. Versatility in execution of data takes the pride of the effectiveness of the product in different conditions. As time consumption is one of the biggest issues of this project, several tests were implemented where we took the data in a very short time interval, which makes the data validity more reliable. Cost minimization takes the advantage of financial affordability to the mass people. To conclude we must say this thesis work bears the significance towards the digitalization of the weather system of our country and we are really looking forward for the success of the project.

7.2 Future Plan

The future work of the "Smart Remote Sensing Weather Station" will focus on the forecasting system of the station. As per of our work we have completed the sensor part including the data acquisition and automatic storage and the analysis of the outputs. Here in the future work will work with the GSM system. In this part using a GSM module in the user end we will set up an instant network connection to the central data base. Enabling the remotely set up weather station for the instant messaging of data in a fixed time interval will ensure the synchronization of the data collected from different weather stations.

Therefore we will work on the diversification of the station .Include the feature of visibility sensors in our project will measure the visibility of a driver in a risky highway, to warn the drivers of that roads about the speed control of their vehicles to avoid deadly accidents. Another feature will be the set up the station in each of the outdoor stadiums of the country, to know the ground level of the field from the sea level which is taken under consideration in Cricket, Football and other popular games. Alongside this the other sensors will indicate the players about of comfort level, direction of wind flow and possible rain flow etc.

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Appendix:

On Board Controller (Arduino Code):

```
#include <Adafruit_Sensor.h>
#include <Adafruit_BMP085_U.h>
#include <Digital_Light_TSL2561.h>
#include <Wire.h>

//Data Acquisition
        int row=0

//HSM20G
       const byte nsum=10;
       int humidityPin=1;
       int TempPin=2;
       unsigned int sensorValue2 = 0;
       unsigned int sensorValue3 = 0;

//Wind Direction
   int RS1= 30;
   int RS2= 31;
   int RS3= 32;
   int RS4= 33;
   int RS5= 34;
   int RS6= 35;
   int RS7= 36;
   int RS8= 37;
   char* Dir[]={ "South","South West", "West", "North West","North", "North East",
"East",
"South East"};

//Anemometer
      const int buttonPin = 2;
      unsigned long start;
      unsigned int count = 0;

       int buttonState;
       int lastButtonState = LOW;

       long lastDebounceTime = 0;
       long debounceDelay = 1;

//Rain Gauge
      const int buttonPin1 = 3;
      unsigned int countR = 0;
```

```
int buttonState1;
int lastButtonState1 = LOW;

long lastDebounceTime1 = 0;
long debounceDelay1 = 1;

//SetUp
void setup(void)
  {
   Wire.begin();
   Serial.begin(9600);
   Serial.println("CLEARDATA");
Serial.println("LABEL,Time,Wind Direction,Altitude, Rain pulses, Wind pulses,Surface Presure, Relative Humiity,Temperature(C),Temparature(F),Due Point, Light Intensity");

  //Light
     TSL2561.init();

 //Direction
     pinMode(RS1, INPUT);
     pinMode(RS2, INPUT);
     pinMode(RS3, INPUT);
     pinMode(RS4, INPUT);
     pinMode(RS5, INPUT);
     pinMode(RS6, INPUT);
     pinMode(RS7, INPUT);
     pinMode(RS8, INPUT);

 //Anemometer
     pinMode(buttonPin, INPUT);

 //Rain Gauge
     pinMode(buttonPin1, INPUT);

 //Pressure
     Adafruit_BMP085_Unified bmp = Adafruit_BMP085_Unified(10085);
  }

//Main Loop
void loop(void)
 {
   start = millis();
    count = 0;
    countR =0;
     while (millis()-start <60000UL)
```

```
{

  int reading = digitalRead(buttonPin);
  int reading1 = digitalRead(buttonPin1);


//Anemometer

  if (reading != lastButtonState)
    {
     lastDebounceTime = millis();
      }
     if ((millis() - lastDebounceTime) > debounceDelay)
      {
       if (reading != buttonState)
        {
         buttonState = reading;
         if (buttonState == HIGH)
         {
          count++;
}
}
}


//Rain Gauge

  if (reading1 != lastButtonState1)
    {
     lastDebounceTime1 = millis();
      }
     if ((millis() - lastDebounceTime1) > debounceDelay1)
      {
       if (reading1 != buttonState1)
         {
          buttonState1 = reading1;
          if (buttonState1 == HIGH)
          {
           countR++;
}
}
}
}


//Temp & Humidity
```

```
  for (byte i=0;i<nsum;i++)
    {
     sensorValue2 += analogRead(humidityPin);
     sensorValue3 += analogRead(TempPin);
    }

    int sensorValue2Avg=sensorValue2/nsum;
    float RH= ((30.855*(sensorValue2Avg/204.6))-11.504);

   int sensorValue3Avg=sensorValue3/nsum;
   float Vt=(float) sensorValue3Avg*5.0/1023.0;
   float R=(5.0-Vt)*10.0/Vt;
   float TinC=281.583*pow(1.0230,(1.0/R))*pow(R,-0.1227)-150.6614;
   float TinF=TinC*(9.0/5.0)+32;

   sensorValue2=0;
   sensorValue3=0;

//Due Point
  float duepoint= TinC- (100-RH)/5;

//Light
  unsigned long  Lux;
  TSL2561.getLux();

//Pressure
 sensors_event_t event;
 bmp.getEvent(&event);
 if (event.pressure)
  {

    Serial.print("DATA,TIME,");

  if ( digitalRead(RS1)==LOW){Serial.print(Dir[0]);}
  else if ( digitalRead(RS2)==LOW){Serial.print(Dir[1]);}
  else if ( digitalRead(RS3)==LOW){Serial.print(Dir[2]);}
  else if ( digitalRead(RS4)==LOW){Serial.print(Dir[3]);}
  else if ( digitalRead(RS5)==LOW){Serial.print(Dir[4]);}
  else if ( digitalRead(RS6)==LOW){Serial.print(Dir[5]);}
  else if ( digitalRead(RS7)==LOW){Serial.print(Dir[6]);}
  else if ( digitalRead(RS8)==LOW){Serial.print(Dir[7]);}
  Serial.print(",");

  Serial.print(bmp.pressureToAltitude(seaLevelPressure,
  event.pressure,
  temperature)); Serial.print(",");
```

```
      Serial.print(count); Serial.print(",");
      Serial.print(countR);Serial.print(",");
      Serial.print(event.pressure); Serial.print(",");
      Serial.print(RH);Serial.print(",");
      Serial.print(TinC);Serial.print(",");
      Serial.print(TinF);Serial.print(",");
      Serial.print(duepoint);Serial.print(",");
      Serial.println(TSL2561.calculateLux(0,0,1));
     }

   row++;

   }
```

__Data Acquisition for Excel (VBA Code):__

```
Dim Row
Dim FlagConnect As Boolean
Dim TimeStart
Dim TimeLast
Dim TimeAdd
Dim cc

Private Sub cboBAUD_Change()
    Stamp.Disconnect
    cmdConnect.Caption = "Connect"
    FlagConnect = False
    Stamp.Baud = cboBAUD
End Sub

Private Sub cboPort_Click()
   Stamp.Disconnect
   cmdConnect.Caption = "Connect"
   FlagConnect = False
   Stamp.Port = cboPort
End Sub



Private Sub chkReset_Click()
```

```
    Beep
End Sub

Private Sub ChkUser1_Click()
   Beep
End Sub

Private Sub ChkUser2_Click()
   Beep
End Sub

Private Sub cmdClear_Click()
    Beep
    Call clearSheet

End Sub

Private Sub cmdConnect_Click()
If FlagConnect = False Then
  On Error GoTo ConnectErr
  Stamp.DTREnabled = CBool(chkDTR)
  Stamp.Connect
  Stamp.Disconnect
  Stamp.Connect
  cmdConnect.Caption = "Disconnect"
  FlagConnect = True
  txtStatus2 = "Connected"
  Call SaveSetting("plx-daq", "app", "port", cboPort.Text)
  Call SaveSetting("plx-daq", "app", "baud", cboBAUD.Text)
Else
  Stamp.Disconnect
  cmdConnect.Caption = "Connect"
  FlagConnect = False
  txtStatus2 = "Disconnected"
End If

Exit Sub

ConnectErr:
```

```
Call MsgBox("StampDAQ could not connect." & vbCrLf & "Please check port settings",
vbExclamation)
End Sub

Private Sub chkDump_Click()
   Beep
End Sub

Private Sub cmdResetTimer_Click()
   TimeStart = Timer
   TimeLast = Timer
   TimeAdd = 0
End Sub

Private Sub Label4_Click()

End Sub

Private Sub stamp_CommError()
' On comm error beep and display

Beep
MsgBox ("Data or Communications error")
  txtStatus2 = "Data or Comm Error"
End Sub

Private Sub stamp_DataError()
  txtStatus2 = "Error: Data < ASCII 10 or > ASCII 200"
End Sub

Private Sub stamp_DataReady()

On Error GoTo Data_Error
Dim DataVal() As String
Dim data As String


While Stamp.gotData = True
  data = Stamp.GetData
```

```
If data <> "" Then
 DataVal = Split(data, ",")

 Select Case DataVal(0)
 Case "CMD?"
    txtStatus2 = "Stamp requesting instruction..."
    If chkDump.Value = True Then
       Stamp.SendData ("11")
       Exit Sub
    End If

    If chkReset = True Then
       Stamp.SendData ("22")
       Exit Sub
    End If


 Case "CLEARDATA"
    Beep
    txtStatus2 = "Clearing sheet"
    Call clearSheet
    Row = 1

 Case "RESETTIMER"
    TimeStart = Timer
    TimeLast = Timer
    TimeAdd = 0
    txtStatus2 = "Timer Reset"

 Case "LABEL"
    cc = countChar(data, ",")
    txtStatus2 = "Setting labels"
    For x = 1 To cc Mod 27
     Worksheets(1).Range(Chr(64 + x) & CStr(1)).Value = ReplaceData(DataVal(x))
    Next

    Row = 1

 Case "DATA"
    cc = countChar(data, ",")
```

```
        Row = Row + 1
        txtStatus2 = "Accepting data for Row " & (Row - 1)
        If Row < 65000 Then
          For x = 1 To cc Mod 27
            Worksheets(1).Range(Chr(64 + x) & CStr(Row)).Value =
ReplaceData(DataVal(x))
          Next
        End If

      Case "DUMPING"
        txtStatus2 = "Download starting..."
        Call clearSheet
        Row = 1

      Case "RESET"
          Beep
          txtStatus2 = "Data cleared!"
          chkReset.Value = False

      Case "DONE"
         Stamp.ClearBuffer
         chkDump.Value = False
         Beep
         txtStatus2 = "Operation Complete!"

      Case "MSG"
          txtStatus1 = DataVal(1)

      Case "CELL"
        Select Case DataVal(1)
        Case "GET"
            Stamp.SendData (Worksheets(1).Range(DataVal(2)).Value)
            txtStatus2 = "Getting Cell " & DataVal(2)

        Case "SET"
            Worksheets(1).Range(DataVal(2)).Value = ReplaceData(DataVal(3))
            txtStatus2 = "Setting Cell " & DataVal(3)
        End Select

      Case "USER1"
```

```
    Select Case DataVal(1)
    Case "SET"
      ChkUser1.Value = CBool(Val(DataVal(2)))
      txtStatus2 = "Setting " & ChkUser1.Caption
    Case "GET"
       Stamp.SendData CStr(Abs(CInt(ChkUser1.Value)))
       txtStatus2 = "Getting " & ChkUser1.Caption
    Case "LABEL"
       ChkUser1.Caption = DataVal(2)
    End Select

Case "USER2"
    Select Case DataVal(1)
    Case "SET"
      ChkUser2.Value = CBool(Val(DataVal(2)))
      txtStatus2 = "Setting " & ChkUser2.Caption
    Case "GET"
       Stamp.SendData CStr(Abs(CInt(ChkUser2.Value)))
       txtStatus2 = "Getting " & ChkUser2.Caption
    Case "LABEL"
       ChkUser2.Caption = DataVal(2)
    End Select

Case "DOWNLOAD"
    Select Case DataVal(1)
    Case "SET"
      chkDump.Value = CBool(Val(DataVal(2)))
      txtStatus2 = "Setting " & chkDump.Caption
    Case "GET"
       Stamp.SendData CStr(Abs(CInt(chkDump.Value)))
       txtStatus2 = "Getting " & chkDump.Caption
    Case "LABEL"
       chkDump.Caption = DataVal(2)
    End Select

Case "STORED"
    Select Case DataVal(1)
    Case "SET"
      chkReset.Value = CBool(Val(DataVal(2)))
      txtStatus2 = "Setting " & chkReset.Caption
```

```
        Case "GET"
          Stamp.SendData CStr(Abs(CInt(chkReset.Value)))
          txtStatus2 = "Getting " & chkReset.Caption
        Case "LABEL"
          chkReset.Caption = DataVal(2)
        End Select

     Case "ROW"
        Select Case DataVal(1)
        Case "SET"
         Row = Val(DataVal(2)) - 1
         txtStatus2 = "Setting Row"
        Case "GET"
          Stamp.SendData CStr(Row)
        End Select

   End Select
End If
Wend
Exit Sub

Data_Error:
End Sub
Private Sub clearSheet()
       If Row < 5000 Then Row = 5000
       Worksheets(1).Range("A2:" & Chr(64 + (cc Mod 27)) & CStr(Row + 10)).Value =
Null
       txtStatus2.Caption = "Cells cleared"
       Row = 1
End Sub
Private Function countChar(stringIn As String, stringChar As String)
For x = 1 To Len(stringIn)
   If Mid(stringIn, x, 1) = stringChar Then
       countChar = countChar + 1
   End If
Next
End Function
Private Function ReplaceData(strData)

If Timer < TimeLast Then
```

```
    If TimeAdd = 0 Then
        TimeAdd = (86400# - TimeStart)
    Else
        TimeAdd = TimeAdd + 86400#
    End If
    TimeStart = 0
End If

TimeLast = Timer
        strData = Replace(strData, "TIMER", Str(Timer - TimeStart + TimeAdd))
        strData = Replace(strData, "TIME", Time)
        strData = Replace(strData, "DATE", Date)
        ReplaceData = strData
End Function

Private Sub userform_Initialize()
cboPort.AddItem "1"
cboPort.AddItem "2"
cboPort.AddItem "3"
cboPort.AddItem "4"
cboPort.AddItem "5"
cboPort.AddItem "6"
cboPort.AddItem "7"
cboPort.AddItem "8"
cboPort.AddItem "9"
cboPort.AddItem "10"
cboPort.AddItem "11"
cboPort.AddItem "12"
cboPort.AddItem "13"
cboPort.AddItem "14"
cboPort.AddItem "15"
cboPort.Text = GetSetting("plx-daq", "app", "port", "1")

cboBAUD.AddItem ("300")
cboBAUD.AddItem ("600")
cboBAUD.AddItem ("1200")
cboBAUD.AddItem ("2400")
cboBAUD.AddItem ("4800")
cboBAUD.AddItem ("9600")
cboBAUD.AddItem ("14400")
```

```
cboBAUD.AddItem ("19200")
cboBAUD.AddItem ("28800")
cboBAUD.AddItem ("38400")
cboBAUD.AddItem ("56000")
cboBAUD.AddItem ("128000")
cboBAUD.Text = GetSetting("plx-daq", "app", "baud", "9600")
Row = 1
cc = 10
End Sub
```