TECHNOLOGICAL UNIVERSITY (MEIKTILA)
DEPARTMENT OF ELECTRONIC ENGINEERING

DESIGN AND IMPLEMENTATION OF ARDUINO BASED WEATHER MONITORING SYSTEM

BY
MA PHYU PHYU AYE

GRADUATION THESIS

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A THESIS
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We certify that we have examined, and recommend to the University Steering Committee for acceptance of the graduation thesis entitled: **"DESIGN AND IMPLEMENTATION OF ARDUINO BASED WEATHER MONITORING SYSTEM"** submitted by **Ma Phyu Phyu Aye, Roll No. VI.EC-1 (December, 2017)** to the Department of Electronic Engineering in partial fulfilment of the requirements for the Degree of Bachelor of Engineering (Electronics).

Board of Examiners:

1. Dr. Khine Myint Mon
B.E.(EC), MTU; M.E.(EC), YTU;
Ph.D.(EC), MTU
Professor and Head
Department of Electronic Engineering ……………………………………
Technological University (Meiktila) (Chairman)

2. Daw Ni Ni San Hlaing
B.E.(EC), TU (Kyaukse); M.E.(EC), MTU
Lecturer
Department of Electronic Engineering ……………………………………
Technological University (Meiktila) (Supervisor)

3. Daw Yu Yu Swe
B.E.(EC), TU (Kyaukse)
Lecturer
Department of Electronic Engineering ……………………………………
Technological University (Meiktila) (Co-Supervisor)

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ABSTRACT

Nowadays, the weather monitoring system is very useful in many places such as homes, schools, colleges, universities, etc. The monitoring of weather is really helpful in various applications like in critical scientific systems or for simulation purposes. Weather sensing is one of the major functions in aerospace applications to check suited weather environments of other planets too. The main objective of this thesis is to devise a simple low cost, portable Arduino based weather monitoring system using wireless technology which fetches different weather conditions using various sensors like temperature and humidity… etc., displays it on LCD. In this thesis, Arduino Mega, DHT11 temperature and humidity sensor, soil moisture sensor, rain drop sensor and LCD are used. This system is very useful for anyone who wishes to monitor the weather condition of a location without being physically present there.

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LIST OF ABBREVIATIONS

Abbreviations	Description
AD converter	Analog to Digital Converter
ARM	Advance RISC Machine
CRT	Cathode Ray Tube
DCOMP	District Completion Rate
DEM	Digital Elevation Models
DVD	Digital Versatile Disk
EEPROM	Erasable Programmable Read-Only Memory
GUI	Graphical User Interface
ICSP	Interagency Committee on Standards Policy
IDE	Integrated Development Environment
IoT	Internet of Things
JTAG	Jtag Technology
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCU	Multipoint Control Unit
MDL	Meteorological Development Laboratory
MODIS	Moderate Resolution Imaging Spectroradiometer
NCEP	National Centers for Environmental Prediction
NDBC	Nation Data Buoy Center
NTC	Negative Temperature Coefficient
NWS	National Weather Service
OTP	One Time Password
PWM	Pulse Width Modulation
Rpi	Raspberry Pi
RTOS	Real-Time Operating System
SD Card	Secure Digital Card
SRAM	Static Random Access Memory

TFT	Thin Film Transistor
UARTs	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
WSN	Wireless Sensor Networks

CHAPTER 1
INTRODUCTION

1.1. Introduction to Arduino Based Weather Monitoring System

There are many ways to monitor the weather like satellites, radars, microcontrollers and many other simple instruments.Weather conditions are also monitored by using Zigbee, Resberry pi, IoT and Arduino, etc. This thesis is mainly designed by using Arduino microcontroller. On the basis of these weather forecasting patterns people take precautions on even harsh weather conditions. The Arduino based weather monitoring system has a capability of working on low power.

The monitoring of weather is really helpful in various applications like in critical scientific systems or for simulation purposes and many other fields like agriculture, disaster management and medical suited environments. Weather sensing is also one of the major functions in aerospace applications. Weather affects a wide range of man's activities, including agriculture, transportation and leisure time. Weather involves the main role in the development of a country such as in agricultural development and plays an important role in human life such as today is sunny day or rainy day.In any industry during certain hazards it is very important to monitor weather.

A weather monitoring station is a collection of different instruments and apparatus used to measure many different weather variables like temperature, humidity, wind speed, rainfall, atmospheric pressure and many others. Weather monitoring system is a system that measures and records the parameters from sensors and displays the result of the measurements on the LCD.This thesis is made by using Arduino and LCD and many sensors. This system contains many sensors like temperature, humidity, soil moisture and rain sensor are monitored on LCD and Arduino microcontroller. The data from the sensors are collected by the Arduino microcontroller and the Arduino microcontroller sends the data of the sensor into the LCD. The main objective of this thesis is to develop a low cost weather monitoring system to receive the weather conditions quickly and correctly.

1.2. Block Diagram of Arduino Based Weather Monitoring System

In the block diagram of Arduino based weather monitoring system, Arduino Mega, LCD display, DHT11 temperature and humidity sensor, rain drop sensor and soil moisture sensor are used to monitor the weather conditions on LCD. Arduino Mega is supplied from 5V power bank. Each sensor is connected to Arduino Mega and the data of each sensor is collected by Arduino microcontroller and displays the data of each sensor on the LCD.

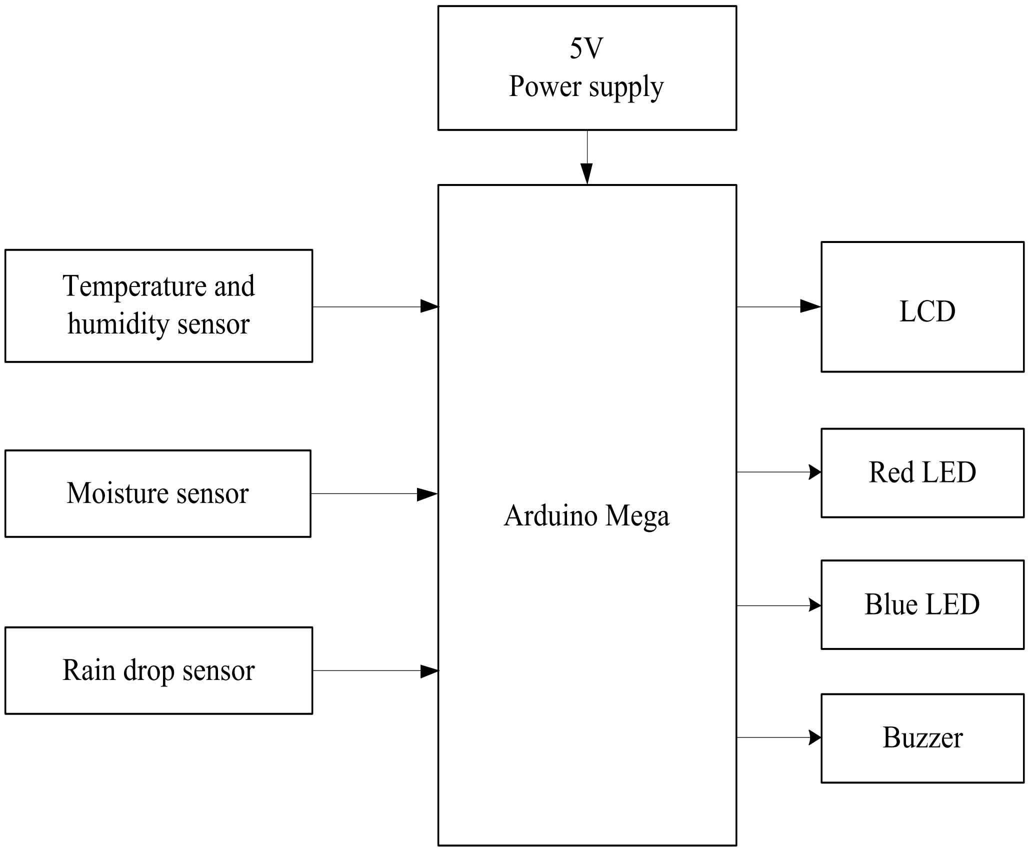

Figure 1.1. Block Diagram of Arduino Based Weather Monitoring System

1.3. Aim and Objectives

The main aim and objectives of the Arduino based weather monitoring system are as follow;

- To design a low cost weather monitoring system
- To understand the working principle of LCD display
- To know the connection between the sensors and LCD display
- To use this weather monitoring system in many places
- To know the weather conditions easily and quickly

1.4. Scope of Thesis

The goal of this thesis is to design a low cost weather monitoring system using Arduino microcontroller, many sensors and LCD display. In this thesis, temperature and humidity sensor, moisture sensor and rain drop sensor are used. This thesis is divided into two categories; to connect the sensors and Arduino and records the data of the sensors and to display the data of the sensors on the LCD display.

1.5. Implementation Programs

This thesis was implemented according to the following program.

- ❖ Knowing the use of temperature and humidity sensor, moisture sensor, rain drop sensor and pressure sensor
- ❖ Simulating the data of the sensors
- ❖ Working principle of LCD display

1.6. Outline of Thesis

In chapter one, introduction to Arduino based weather monitoring system, system block diagram, aim and objectives of the thesis, scopes of thesis, implementation programs and outline of thesis are mentioned. Background theory of weather monitoring system is described in chapter two. Chapter three includes the components of the system. Operation and software implementation of Arduino based weather monitoring system is mentioned in chapter four. In chapter five, test and results of the system is well described. Finally, discussions and conclusion and further extension are mentioned.

CHAPTER 2
BACKGROUND THEORY OF WEATHER MONITORING SYSTEM

2.1. Literature Review

Weather and climate are among the foremost factors which determine the development of a society in geographical region. Weather usually describes the particular event or condition for the short period of time such as hours or days whereas climate refers to the behavior of the atmosphere to a place over many years. On the other hand, weather includes current atmospheric conditions such as the temperature, precipitation, humidity and the wind while climate describes the general weather conditions of a certain area over a long period of time.

Weather data are important in our daily life. The data collected such as rainfall and temperature can be used to serve as a precautionary measure to against natural calamity or disaster such as flood and drought. Besides that, it is important for others to plan the works. For example, in the construction industry, the weather data is important for a thesis manager to plan their schedule so that the thesis will complete on time. The weather data collected for a long period are used to predict the climate change in future trends. The weather data collected for the past decade can be used to analysis in order to identify the pattern of climate change.

Weather monitoring system is one of the devices to collect the weather data. The weather data such as precipitation, humidity, temperature, and wind speed can be collected by using this device. The usage of weather station is increasing popularity among the nation.

Weather monitoring system is a system that can update the weather data in a more quickly and frequent way. It can collect the data in minute or hourly based on the setting mode. The user can change the setting mode according to the purpose of the project respectively. Weather station has now been increasingly accepted as the technology that facilities faster and more up to date monitoring of the earth atmosphere system. In particular, it is becoming increasingly important in the study of hydrology pattern.

Through weather monitoring system the information about humidity and temperature can be collected and according to current and previous data the results can be produced in graphical manner in the system. After reviewing many articles, there are presently no researches that mention monitoring the combination of temperature, lighting and humidity in one integrated system and have actuators to modify these settings. In addition to this, there is one research that has discussed monitoring these three environmental conditions; however, there has been no mention about having actuators to modify. So the main idea was to coin a system that can sense the main components that formulates the weather and can be able to forecast the weather without human error.

Ancient weather forecasting methods usually relied on observed patterns of events, also termed pattern recognition. For example, it might be observed that if the sunset was particularly red, the following day often brought fair weather. This experience accumulated over the generations to produce weather lore. However, not all of these predictions prove reliable and many of them have since been found not to stand up to rigorous statistical testing. The simplest method of forecasting the weather, persistence, relies upon today's conditions to forecast the conditions tomorrow. This can be a valid way of forecasting the weather when it is in a steady state, such as during the summer season in the tropics. This method of forecasting strongly depends upon the presence of a stagnant weather pattern. It can be useful in both short range forecasts and long range forecasts. Measurements of barometric pressure and the pressure tendency (the change of pressure over time) have been used in forecasting since the late 19th century [16Mad].

Weather monitoring systems are classified based on technology used as

- ❖ Wireless sensor network based system
- ❖ Satellite based system
- ❖ Microcontroller based system
- ❖ Arduino based system
- ❖ GSM based system
- ❖ Zigbee based system
- ❖ Prediction based system
- ❖ Sensor based system
- ❖ Camera based system
- ❖ Internet of Things based system

- ❖ Raspberry Pi based system
- ❖ Cloud based system

2.2. Wireless Sensor Network Based System

Wireless Sensor Networks (WSNs) includes various sensors distributed spatially with the capacity of communication, processing and computing. The data is sensed and transmitted to the base station regularly. Here, in real time manner, data is processed and managed. One proposed framework conquers the above restriction by organization of WSN base for different climate advance utilizing virtual sensor and overlay idea. Checking climate information and givingsoftware as a service and interpersonal organization cataclysm cautions in light of choice ID3 system and give cloud validation utilizing secure shell. Similar work gives a conditional summary on WSN with Internet of bothers based on parasense plan. A good arrangement is made for sending continuous applications and for conveying it.

2.3. Satellite Based System

Satellite information is progressively being utilized as a part of conjunction with routine meteorological perceptions in the concise investigation and traditional climate gauge to concentrate data.Satellite data are increasingly being used in conjunction with conventional meteorological observation in the synoptic analysis and conventional weather forecast to extract information of relevance for agriculture. Particular emphasis is laid on identification of large scale convective precipitation systems such as monsoon depressions and tropical cyclones. In this study, the climate satellite is a kind of satellite that is basically used to screen the climate and atmosphere of the earth. Weather satellite pictures are always helpful in checking the volcanic powder cloud.

2.4. Microcontroller Based System

The basic point of a work based on microcontroller is to manufacture an implanted framework to plan an air checking framework which empowers the saw of climate parameters in an industry. This type of work includes different sensors like Gas sensors, temperature sensors and dampness sensors which were observed with the use of ARM9, LPC1768 microcontrollers. The following framework utilizes a complex circuit developed with ARM 9 processor. Embedded C programming is used. Scheduling is done with the use of Jtag Technology (JTAG) in association with ARM 9 processor.

2.5. Arduino Based System

Through a specific framework, it can naturally gather the data about stickiness and temperature. Through this framework authors can naturally gather the data about stickiness and temperature. The points of interest are put away in a database and as per present and past information authors can deliver the outcomes in graphical way in the framework. The circuit diagram describes the interdependent functionality of the components and their output.

2.6. GSM Based System

In GSM based systems, a gadget for ongoing climate observing is displayed to screen the constant temperature, environmental weight, relative dampness and air's dew point temperature through such system which is utilizing simple and advanced parts. In the following system, digital signals are obtained from analog signals and database is altered according to the program designed for displaying userfriendly outcomes in terms of pressure on a display [16Mad].

2.7. ZIGBEE Based System

To create sensor networking and weather station monitoring system without human mediation, utilizing Wireless ZigBee Technology. Zigbee is the most recent remote climate checking method. The previous checking frameworks of weather monitoring system are manual that time.

2.8. Prediction Based Systems

A prediction based system proposed a methodology for monitoring transient climate conditions based on semantic and geospatial coherent cross disciplinary. In this, demonstration of individuals driven detecting system is given to improve the accuracy of the system and the legitimacy of information collected using regular sensor is affirmed.The wave soul range, which all Nation Data Buoy Center (NDBC) climates floats routinely report hourly. It contains a lot of data with respect to the starting point, quality and term of sea tempests. Such estimations are delivered from basic accelerometers originating from an adult, settled innovation. Swap is another one method which will execute as an operational sun based observing instrument for space climate forecasting. The Lyra information will make profitable sun powered checking data, for agent space climate now throwing and testing. Similarly in another prediction based system, the control outfit figure with starting condition instability, is handy yet under dispersive. To enhance the unwavering quality of the outfit gauges, the control group is supplemented with annoyed side perspective limit conditions; or, representation blunder representation utilizing either stochastic active soul backscatter or stochastically bothered parameterization propensities. Multi physics and a stochastic active fundamental backscatter arrangement are utilized in a similar system to speak to model instability in a mesoscale troupe conjecture framework utilizing the weather investigation and forecasting model.

The computation of environment forecast rightness has dependably been a troublesome subject to address for some reasons. In a novel study, a simple semi target strategy is utilized to look at the exactness of zone prediction. Zone forecasts were picked in light of the fact that these expectations are ordinarily get either straightforwardly or in a roundabout way from various media outlets. The Meteorological Development Laboratory (MDL) is a novel approach which has been developed and implemented a frame work based on flight environment gauge in recent work.It is executed by each hour and collected the data for about 25hours for validating the requirements of the National Weather Service (NWS).Based on the temperature field and wind fields, the land dispersion of the expectation sways at 500hpa and10m stature is arranged in a novel prediction system. This work demonstrates the enhancement of the National Centers for Environmental Prediction (NCEP) wind and temperature by acclimatizing the surface wind recoveries with the use of wind sat satellite.

2.9. Sensor Based System

In a recent work, a company planed to distinguish the topographical ranges for sun based and wind vitality eras with ease. There framework depends on remotely worked framework with sensors, which accumulates climate data and transmits measured qualities to the ground. The framework is worked by battery and is required to keep running with an expanded life period. Static sensor hubs and submerged sensor web are connected in ecological verification in a novel study. By consolidating adding a sensor system and a technique of distributed computing, the submerged sensor bid can be improved. The climate station is designed recently which has a gathering of sensors for measuring wind pace and bearing, air temperature, relative dampness and precipitation. A snowfall connector can be continuing the precipitation gage that permits estimation of the water fulfilled of snow amid winter months. District Completion Rate (DCOMP) is a novel system having a set up to keep running on sensors with comparative channel settings and has been effectively practiced on most current meteorological imagers. This standard makesespecially profitable for air research. Correlations with the Moderate Resolution Imaging Spectroradiometer (MODIS) gathering 5 dataset are utilized to figuring the execution of DCOMP. During 2016, in a recent work, wind sensor, wind direction sensor, humidity and temperature sensor are used for sending the real time data on thing speak cloud which can be easily observed and analyzed to authorized person or may be publically open. It uses Raspberry Pi development board used earlier by many authors for user friendly works. ARM7 is an efficient processor which is generally used for real time operation in many applications [16Mad].

2.10. Camera Based System

With a unique sort of camera and computerized multi-image photogrammetric framework, it's currently conceivable to takeout Digital Elevation Models (DEM) with capturing an image by the camera.Using such strategy; the plane is may not be limited to flight way straightly. And it may go straightforwardly along objective region. That postulation presented the work hypothesis of computerized photographic visibility framework, edge of framework, structure of equipment and programming stream, at last correspondence amongst host and open air cell.

2.11. Internet of Things Based System

The system proposed is 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. The system deals with monitoring and controlling the environmental conditions like temperature, relative humidity, light intensity and carbon dioxide 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.

2.12. Raspberry Pi Based System

Raspberry Pi is acting as data logger process the converted output of sensors from analog to digital. The logged data can then be transferred to a desktop or any other monitor has GUI for further analysis. By using easily obtained components and less complicated circuitry powerful weather station can be built. Nowaday's various weather factors like wind and many other cause great impact on humans day to day life.

In Raspberry Pi based weather monitoring system which depends on combination of several sensors to be integrated has been proposed. Raspberry Pi will receive readings from various sensors and then process the data and then data will be available on cloud server for viewing of user at remote location weather monitoring can be done in either wireless or wired manner. The Raspberry is cheap, small and rugged which make it perfect for real world projects. For agricultural development and industrial management, the proposed system is useful.

Raspberry Pi is the latest wireless technology. Proposed system will visualize and store various weather parameters as given above with the help of sensors interfaced to Raspberry will get all data, SD card on Pi stores the collected data as like memory card. Then at the output side LCD is to be connected for showing the result and on off relays for server access.To know the current weather status at remote location, the user can to log in on web browser by entering username and password given for particular server by the user. Web application opens after entering password and with the output graphical representation also obtain. Raspberry Pi processed data will update continuously on cloud server and user will get to know the stored data on hourly and daily basis.

2.13. Cloud Based System

Cloud data can be secured and easy and fast for accessing. Any continuous varying data can be logged into cloud. Software and hardware support logging into cloud are the two different processes. Software based logging indicates logging with personal computer. Hardware based support indicates logging with hardware systems with specific processor. Hardware based support system may be dedicated to particular application and can be designed with RTOS with embedded processor. In hardware support logging process, choosing processor is the main task. Fast and error less sensor network handling and processing having internet accessing service is the main requirement in hardware based logging system. It is also required to enter real time varying data with specific intervals. The hardware system is designed so that it will direct the real time temperature, humidity, wind speed and wind direction's details to Google cloud. The logged data can be monitored to cloud from Internet. ARM 11 Raspberry Pi board can be used for designing committed embedded system. Internet access and sensing system interface can be efficiently achieved with ARM 11 board so specifically used. Python coding can be used for programming with Raspberry Pi. The service of the Google cloud is taken for logging into their cloud. Excel sheet like content can be monitored from mass through Internet. Humidity, temperature, wind speed and wind direction for any application can be logged into mass so that any one (authenticated person) from any location can observe the specific data. In case of any calamity like fire, heavy rain, heavy wind, temperature or humidity inner side and or outside may be uncontrollable and different due to heavy rain or heavy wind. In these cases the immediate information can be conveyed throughout the world using mass to the authenticated persons so that action can be taken as early as possible with emergency help. This will be very much helpful in calamity management.System requires hardware like ARM 11 processor, humidity, temperature, wind direction and wind speed sensor circuitries, Internet connection through LAN or wifi. Far terminal requires the Internet connection (for demo Internet can be used through LAN access). Raspberry Pi Arm 11 panel is essential to be loaded with boot loader for proper operation. Raspberry Pi desktop monitoring is essential to grow the Python coding. Raspberry Pi (Rpi) board's desktop can be accessed on Laptop and PC using LAN connection with Rpi board. Once Rpi board is set after initial loading, it can be pinged from the using Laptop and PC. Putty and Xming software are used to entry the desktop of Rpi on laptop. One can develop the Python using desktop of Rpi easily. Tools for Python editing, behead, debugging are already available in desktop of Rpi. So, Python dummy can be easily developed using those tools. Open origin Python coding can be used for Rpi obtainable on internet for developing the codes for hardware. Rpi system desktop is like a window desktop through which we can entry the Internet, LAN, wifi devices bluetooth devices through ARM 11 processor. The keyboard and mouse can be used on desktop of Rpi like PC.

It works on linux operating system. Rpi panel can be act as real time dedicated system by loading the code on root. Features like easy to interface, easy to operate and easy to get information on Internet lead us to use this ARM 11 board for this purpose [16Ano].

CHAPTER 3
COMPONENTS OF ARDUINO BASED WEATHER MONITORING SYSTEM

3.1. DHT11 Temperature and Humidity Sensor

DHT11 temperature and humidity sensor feature a temperature and humidity sensor complex with a calibrated digital signal output. By using the exclusive digital signal acquisition technique and temperature and humidity sensing technology, it ensures high reliability and excellent long term stability. This sensor includes a resistive type humidity measurement component and an Negative Temperature Coefficient (NTC) temperature measurement component and connects to a high performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost effectiveness.

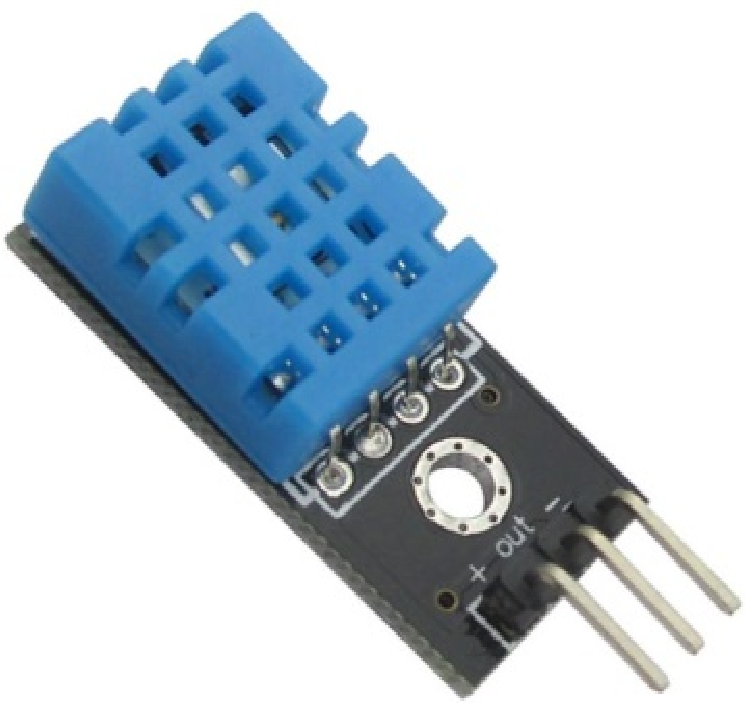

Figure 3.1. DHT11 Temperature and Humidity Sensor

Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programs in the OTP memory, which are used by the sensor's internal signal detecting process. The single wire serial interface makes system integration quick and easy. Its small size, low power consumption and up to 20m signal transmission making it the best choice for various applications, including those most demanding ones. The component is 3 pin single row pin package. It is convenient to connect and special packages can be provided according to user's request [11Ano].

Table 3.1. Detailed Specifications of DHT11 Temperature and Humidity Sensor

Parameters	Conditions	Minimum	Typical	Maximum
Humidity				
Resolution		1%RH	1%RH	1%RH
Repeatability			±1%RH	
Accuracy	25°C		±4%RH	
	0-50°C			±5%RH
Interchangeability	Fully Interchangeabillity			
Measurement Range	0	30%RH		90%RH
	25	20%RH		90%RH
	50	20%RH		90%RH
Response Time (Seconds)		6s	10s	15s
Hysteresis			±1%RH	
Long-Term Stability	Typical		±1%RH/year	
Temperature				
Resolution		1	1	1

Repeatability			±1	
Accuracy		±1		±2
Measurement Range		0		50
Response Time(Seconds)		6s		30s

3.1.1. Features of DHT11 Temperature and Humidity Sensor

- Good precision
- Resistive type
- Full range temperature compensated
- Relative humidity and temperature measurement
- Calibrated digital signal
- Outstanding long term stability
- Long transmission distance, up to 100m
- Low power consumption
- 3 pins packaged and fully interchangeable

3.1.2. Differences Between DHT11 Sensor and Module

The DHT11 sensor can either be purchased as a sensor or as a module. Either way, the performance of the sensor is same. The sensor will come as a 3 pin package out of which only three pins will be used whereas the module will come with three pins as shown above.

The only difference between the sensor and module is that the module will have a filtering capacitor and pull up resistor inbuilt and for the sensor, if required both the sensor and module can be used externally [11Ano].

3.1.3. Applications of DHT11 Temperature and Humidity Sensor

The DHT11 is a commonly used temperature and humidity sensor. The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers.

The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%. So this measurement range is wanted, then this sensor might be the right choice for everyone.

- Measure temperature and humidity
- Local weather station
- Automatic climate control
- Environment monitoring

3.2. Soil Moisture Sensor

This soil moisture sensor can be used to detect moisture. This is a simple and easy moisture sensor can be used for testing the moisture in the soil, when the soil water shortage, the simulation values of sensor output will decrease, instead will increase. When the soil is dry, the sensor's output analog value will decrease, while moist soil will result in an increased analog value output.

A key application for this sensor is for an automatic watering device. The sensor can sense whether the plant is thirsty or not, preventing over or under watering. The sensor's surface is made from metal to extend its life. Insert it into the soil, then read it using an AD converter. One commonly known issue with soil moisture sensor is their short lifespan when exposed to a moist environment [16Ano].

Figure 3.2. Moisture Sensor

3.2.1. Working Principle of Soil Moisture Sensor

Soil moisture sensors measure the water content in soil. A soil moisture probe is made up of multiple soil moisture sensors. One common type of soil moisture sensors in commercial use is a frequency domain sensor such as a capacitance sensor. Another sensor, the neutron moisture gauge, utilize the moderator properties of water for neutrons.

Soil moisture content may be determined via its effect on dielectric constant by measuring the capacitance between two electrodes implanted in the soil. Where soil moisture is predominantly in the form of free water (example, in sandy soils), the dielectric constant is directly proportional to the moisture content.

The probe is normally given a frequency excitation to permit measurement of the dielectric constant. The readout from the probe is not linear with water content and is influenced by soil type and soil temperature. Therefore, careful calibration is required and long term stability of the calibration is questionable.

3.2.2. Specifications of Soil Moisture Sensor

- ❖ Supply voltage 3.3 - 5VDC
- ❖ Operating current less than 20mA
- ❖ Output voltage 0-2.3V (2.3V is completely immersed in water)
- ❖ Sensor type Analog Output
- ❖ Packaging Static bag sealed
- ❖ Interface definition DATA GND VCC
- ❖ Module dimensions 20mm x 60mm

3.2.3. Features of Soil Moisture Sensor

- ❖ Sense whether soil is wet or dry
- ❖ Can be used to build an automatic watering machine
- ❖ Metal sensor surface for durability
- ❖ Easy to use

3.2.4. Applications of Soil Moisture Sensor

- ❖ Agriculture
- ❖ Landscape irrigation
- ❖ Research

3.3. Rain Drop Sensor

The rain sensor module is an easy tool for rain detection. It can be used as a switch when raindrop falls through the raining board and also for measuring rainfall intensity. The module features, a rain board and the control board that is separate for more convenience, power indicator LED and an adjustable sensitivity though a potentiometer.

The analog output is used in detection of drops in the amount of rainfall. Connected to 5V power supply, the LED will turn ON when induction board has no rain drop, and D0 output is HIGH. When dropping a little amount water, D0 output is LOW, the switch indicator will turn ON. Brush OFF the water droplets, and when restored to the initial state, outputs HIGH level [07Ano].

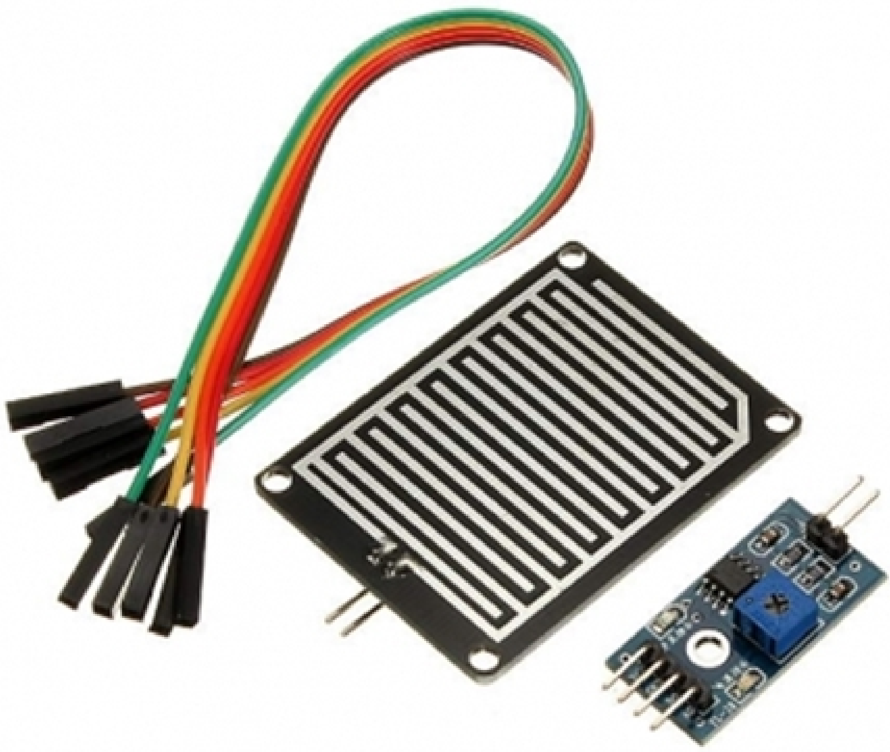

Figure 3.3. Rain Drop Sensor Module

3.3.1. The Working Principle of Rain Drop Sensor

When power supply is given to the module, the LED turns ON. When there is no raindrop, the digital output remains HIGH. When water is detected, digital output becomes LOW and the switch indicator turns ON. Rain sensor board acts like a variable resistor which changes from 100k while being wet to 2M while being dry.

When the board is wet, more current gets conducted. Rain Sensor plate has two PCB tracks. These tracks are not connected. When water falls on the plate or board, the resistance between tracks changes. This resistance is measured by the opamp. When there is more water (lower resistance), the analog voltage output is LOW. While, if the amount of water is less (more resistance), the analog output voltage is MORE. A dry rain board gives an analog output of 5V [08Ano].

3.3.2. Specifications of Rain Drop Sensor

- ❖ Adopts high quality of RF-04 double sided material
- ❖ Area: 5cm x 4cm nickel plate on side
- ❖ Anti-oxidation, anti-conductivity, with long use time
- ❖ Comparator output signal clean waveform is good, driving ability, over 15mA;
- ❖ Potentiometer adjust the sensitivity
- ❖ Working voltage 5V
- ❖ Output format: Digital switching output (0 and 1) and analog voltage output A0
- ❖ With bolt holes for easy installation
- ❖ Small board PCB size: 3.2cm x 1.4cm
- ❖ Uses a wide voltage LM393 comparator

3.3.3. Features of Rain Drop Sensor

- ❖ Operating voltage : 5V
- ❖ Provide both digital and analog output
- ❖ Adjustable sensitivity
- ❖ Output LED indicator
- ❖ Compatible with Arduino
- ❖ TTL compatible
- ❖ Bolt holes for easy installation
- ❖ Jumper wires included

3.3.4. Applications of Rain Drop Sensor

- ❖ Rain detection
- ❖ Rainfall intensity monitoring
- ❖ Irrigation control

3.4. Liquid Crystal Display (LCD)

A Liquid Crystal Display (LCD) is a flat panel display or other electronically modulated optical device that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome. LCDs are available to display arbitrary images (as in a general purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and seven-segment displays, as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements.

LCDs are used in a wide range of applications including LCD televisions, computer monitors, instrument panels, aircraft cockpit displays and indoor and outdoor signage. Small LCD screens are common in portable consumer devices such as digital cameras, watches, calculators and mobile telephones, including smartphones. LCD screens are also used on consumer electronics products such as DVD players, video game devices and clocks. LCD screens have replaced heavy, bulky Cathode Ray Tube (CRT) displays in nearly all applications. LCD screens are available in a wider range of screen sizes than CRT and plasma displays, with LCD screens available in sizes ranging from tiny digital watches to very large television receivers [10Ano].

Since LCD screens do not use phosphors, they do not suffer image burn in when a static image is displayed on a screen for a long time, e.g., the table frame for an airline flight schedule on an indoor sign. LCDs are, however, susceptible to image persistence. The LCD screen is more energy efficient and can be disposed of more safely than a CRT can. Its low electrical power consumption enables it to be used in battery-powered electronic equipment more efficiently than CRTs can be. By 2008, annual sales of televisions with LCD screens exceeded sales of CRT units worldwide, and the CRT became obsolete for most purposes.

LCD is the technology used for displays in notebook and other smaller computers. Like LED and gas plasma technologies, LCDs allow displays to be much thinner than CRT technology. LCDs consume much less power than LED and gas display displays because they work on the principle of blocking light rather than emitting it.

An LCD is made with either a passive matrix or an active matrix display grid. The active matrix LCD is also known as a TFT display. The passive matrix LCD has a grid of conductors with pixels located at each intersection in the grid. A current is sent across two conductors on the grid to control the light for any pixel. An active matrix has a transistor located at each pixel intersection, requiring less current to control the luminance of a pixel. For this reason, the current in an active matrix display can be switched on and off more frequently, improving the screen refresh time.

Some passive matrix LCD's have dual scanning, meaning that they scan the grid twice with current in the same time that it took for one scan in the original technology. However, active matrix is still a superior technology [05Ano].

3.4.1. Basic Structure of an LCD

The liquid crystal display has the distinct advantage of having a lower power consumption than the LED. It is typically of the order of microwatts for the display in comparison to the some order of milliwatts for LED. A liquid crystal cell consists of a thin layer (about 10 um) of a liquid crystal sandwiched between two glass sheets with transparent electrodes deposited on their inside faces. With both glass sheets transparent, the cell is known as transmittive type cell. When one glass is transparent and the other has a reflective coating, the cell is called reflective type. The LCD does not produce any illumination of its own. It, in fact, depends entirely on illumination falling on it from an external source for its visual effect.

3.4.2. Types of Liquid Crystal Displays (LCD)

Two common types of LCD are transmissive LCD and reflective LCD. The transmissive LCD is illuminated from one side and viewed from the opposite side. Activated cells appear dark and inactive cells appear bright. One disadvantage of transmissive LCD is that lamp used to illuminate the LCD consumes more power than consumed by the LCD itself.

Reflective LCD is commonly used in pocket calculators and digital watches. It is viewed by ambient light reflected in a mirror behind the display. They have lower contrast than the transmissive type, because the ambient light passes twice through the display before reaching the viewer. The advantage is that there is no lamp to consume power, so the battery life is long.

3.5. 20x4 LCD

LCD is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. The liquid-crystal display has the distinct advantage of having a low power consumption than the LED. It is typically of the order of microwatts for the display in comparison to the some order of milliwatts for LEDs.

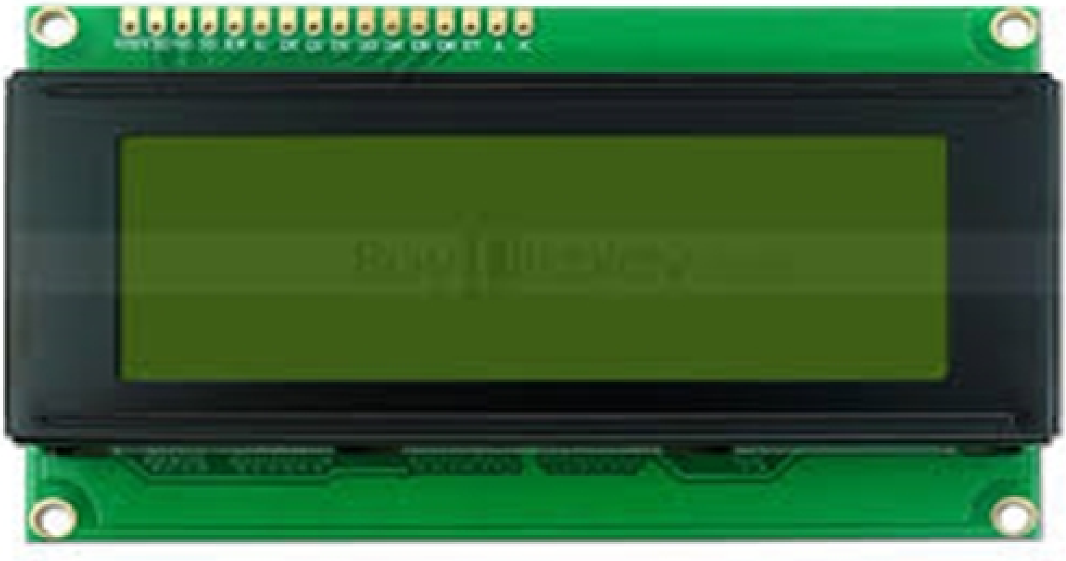

Figure 3.4. 20x4 LCD

Low power consumption requirement has made it compatible with integrated logic circuit. Its other advantages are its low cost and good contrast. The main drawbacks of LCDs are additional requirement of light source, a limited temperature range of operation (between 0 and 60°C), low reliability, short operating life, poor visibility in low ambient lighting, slow speed and the need for an AC drive.

20x4 means that 20 characters can be displayed in each of the 4 rows of the 20x4 LCD, thus a total of 80 characters can be displayed at any instance of time.

Table 3.2 Pinout Connections of 20x4 LCD

Pin No.	Symbol	Level	Description
1.	VSS	0V	Ground

2.	VDD	5V	Supply Voltage for logic
3.	VO	(Variable)	Operating voltage for LCD
4.	RS	H/L	H: DATA, L: Instruction code
5.	R/W	H/L	Chip enable signal
6.	E	H,H->L	Data bus line
7.	D0	H/L	Data bus line
8.	D1	H/L	Data bus line
9.	D2	H/L	Data bus line
10.	D3	H/LH/L	Data bus line
11.	D4	H/L	Data bus line
12.	D5	H/L	Data bus line
13.	D6	H/L	Data bus line
14.	D7	H/L	Data bus line
15.	A	5V	LED +
16.	K	0V	LED -

3.6. Introduction to Arduino Mega 2560

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input and output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC to DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila. The Arduino Mega it can have high memory space compared to the Arduino UNO [13Ano].

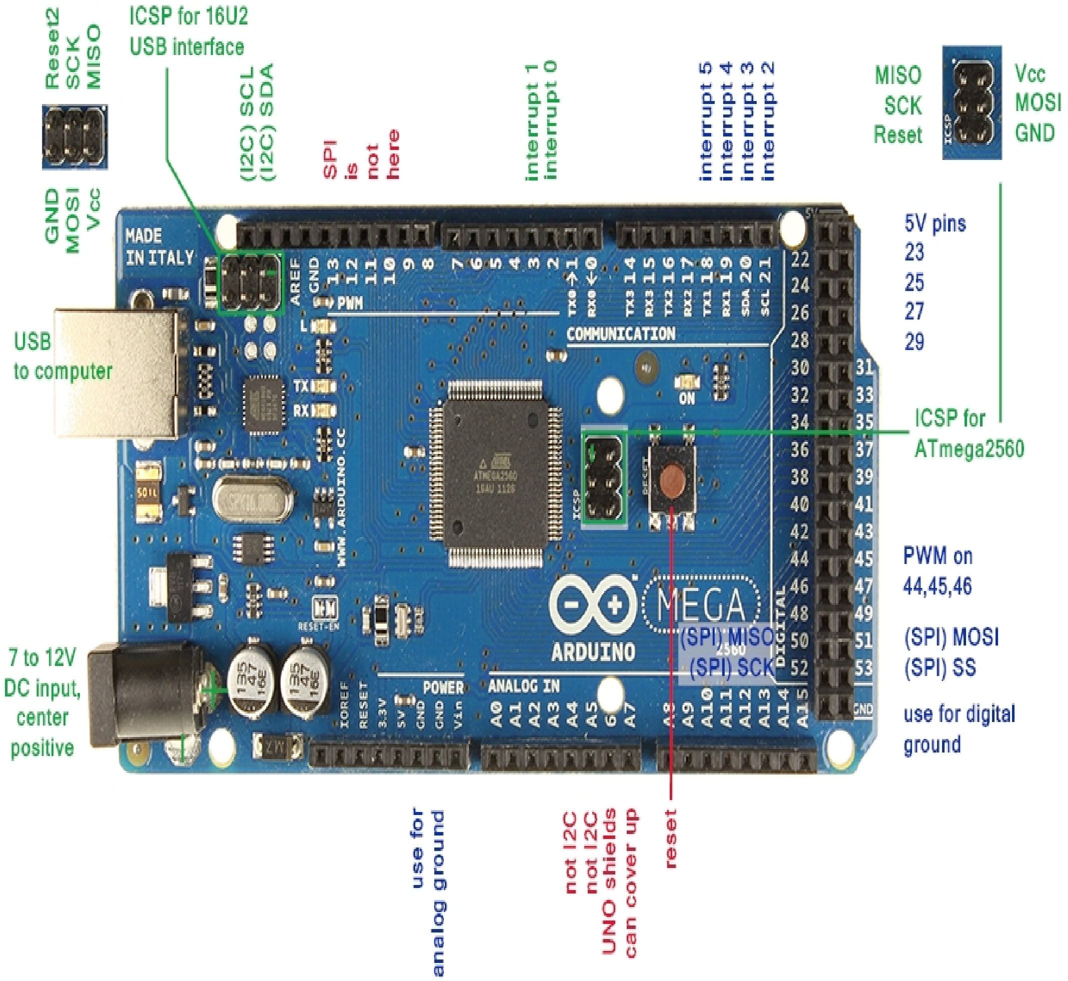

Figure 3.5. Arduino Mega2560

3.6.1. Components in Arduino Mega2560

- 16MHZ crystal oscillator
- USB cable port
- Reset button
- Power jack
- ICSP header

3.6.2. Power Pins of Arduino Mega2560

The Arduino Mega can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC to DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center positive plug into the board's power jack. Leads from a battery can be inserted in the GND and VIN pin headers of the power connector.

The board can operate on an external supply of 6 to 20V. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12V.

The Mega2560 differs from all preceding boards in that it does not use the FTDI USB to serial driver chip. Instead, it features the ATmega8U2 programmed as a USB to serial converter.

The Mega2560 can have the power supply of 3.3V and the 5V.

- ❖ 3.3V: A voltage supply generated by the on-board regulator. The maximum current can pass the 50mA.
- ❖ 5V: The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator or be supplied by USB or another regulated 5V supply.
- ❖ VIN: The input voltage to the Arduino board when it's using an external power source (as opposed to 5V from the USB connection or other regulated power source). Voltage can be supplied voltage through this pin if supplying voltage via the power jack, access it through this pin.
- ❖ Gnd:It can be connected to the gnd to gnd of the connection [13Ano].

3.6.3. Memory of Arduino Mega2560

The Arduino Mega2560 can have the memory of 256kB of the storing codes.

- ❖ SRAM = 8kB
- ❖ EEPROM = 4kB

3.6.4. Features of Arduio Mega2560

❖ Microcontroller	ATmega2560
❖ Operating voltage	5V

❖ Input voltage (recommended)	7V to 12V
❖ Input voltage (limits)	6V to 20V
❖ Digital I/O pins	54 (of which 14 provide PWM output)
❖ Analog input pins	16
❖ DC current per I/O pin	40mA
❖ DC current for 3.3V pin	50mA
❖ Flash memory	256kB (8kB is used by bootloader)
❖ SRAM	8kB
❖ EEPROM	4kB
❖ Clock speed	16MHz

3.7. C Programming for Arduino

Technology is constantly changing. New microcontrollers become available every year. The one thing that has stayed the same is the C programming language used to program these microcontrollers. Arduino is the hardware platform used to teach the C programming language as Arduino boards are available worldwide and contain the popular AVR microcontrollers from Atmel.

C is a powerful general purpose programming language used for wide range of applications from operating systems like Windows and iOS to software that is used for creating 3D movies. It is fast, portable and available in all platforms. Standard C programs are portable. The source code written in one system works in another operating system without any change.

The development cycle of an Arduino program is divided into 4 phases:

Edit → Compile → Upload → Run

Figure 3.6. Development Cycle of an Arduino Program

- ❖ Compile: Compile means to translate the sketch into machine language, also known as object code.
- ❖ Run: Arduino sketch is executed as soon as terminates the step of uploading on the board.

CHAPTER 4
OPERATION AND SOFTWARE IMPLEMENTATION OF ARDUINO BASED WEATHER MONITORING SYSTEM

4.1. Operation of Arduino Based Weather Monitoring System

This system works by taking readings from various sensors at different pins in Arduino microcontroller. For this purpose, Arduino Mega is used. The various sensors, DHT11 temperature and humidity sensor, soil moisture sensor and rain drop sensor are attached to the Arduino Mega microcontroller each of them taking 5V input from Arduino. All the sensors are connected using a breadboard.

In this thesis, DHT11 temperature and humidity sensor is used to get the temperature and humidity readings by connecting to analog pin A0 on Arduino Mega board for input signals. It gives us continuous reading of surrounding environment in the range of two to three seconds and shows this temperature and humidity data of this sensor on LCD. If the temperature value is less than 30°C, blue LED is ON and if the temperature value is greater than 30°C, red LED is ON.

One more sensor attached which is soil moisture sensor module, connected to analog pin A1 on Arduino Mega board for input signal, which when dipped within a humid wet or dry soil fluctuates accordingly. It detects how much moisture is present in the soil. For quick representation purpose it could be checked with moistening the board by dropping some water. It consists of two tongs like rod for sensing the moisture so that it is added within the soil and takes readings. Arduino Mega stores this data of soil moisture sensor and sends this data to LCD.

A raindrop sensor module is also attached from analog pin A2 on Arduino to take input signals from the sensor. The sensor detects either there is any rain or not in terms of values. The raindrop sensor module comes with a potentiometer attached to it. For simulation purpose, by putting some water droplets on the board can check there is no rain or rain and can see the readings fluctuating and shows this rain or no rain on LCD. If the data of rain drop sensor is greater than 800, LCD shows "No Rain" and the buzzer does not work and the data of rain drop sensor is less than 800, LCD shows "Raining" and the buzzer starts working.

The other part of the system is 20x4 LCD display. This LCD is connected to the Arduino Mega to show the data of all above the sensors. The data of temperature and humidity, soil moisture and rain drop sensor are showed on this 20x4 LCD display.

4.2. Flowchart ofArduino Based Weather Monitoring System

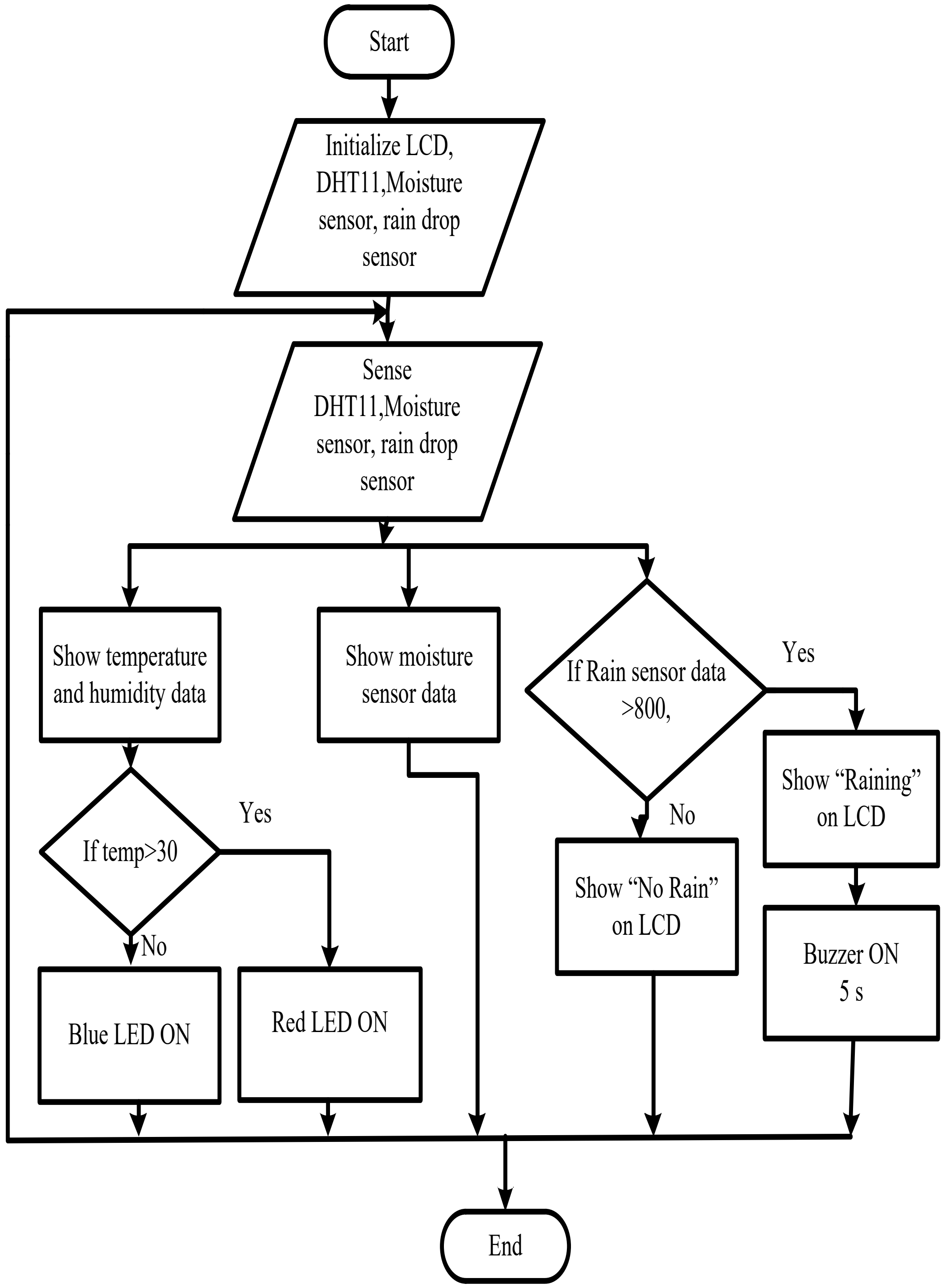

Figure 4.1. Flowchart of Arduino Based Weather Monitoring System

4.3. Circuit Diagram of Arduino Based Weather Monitoring System

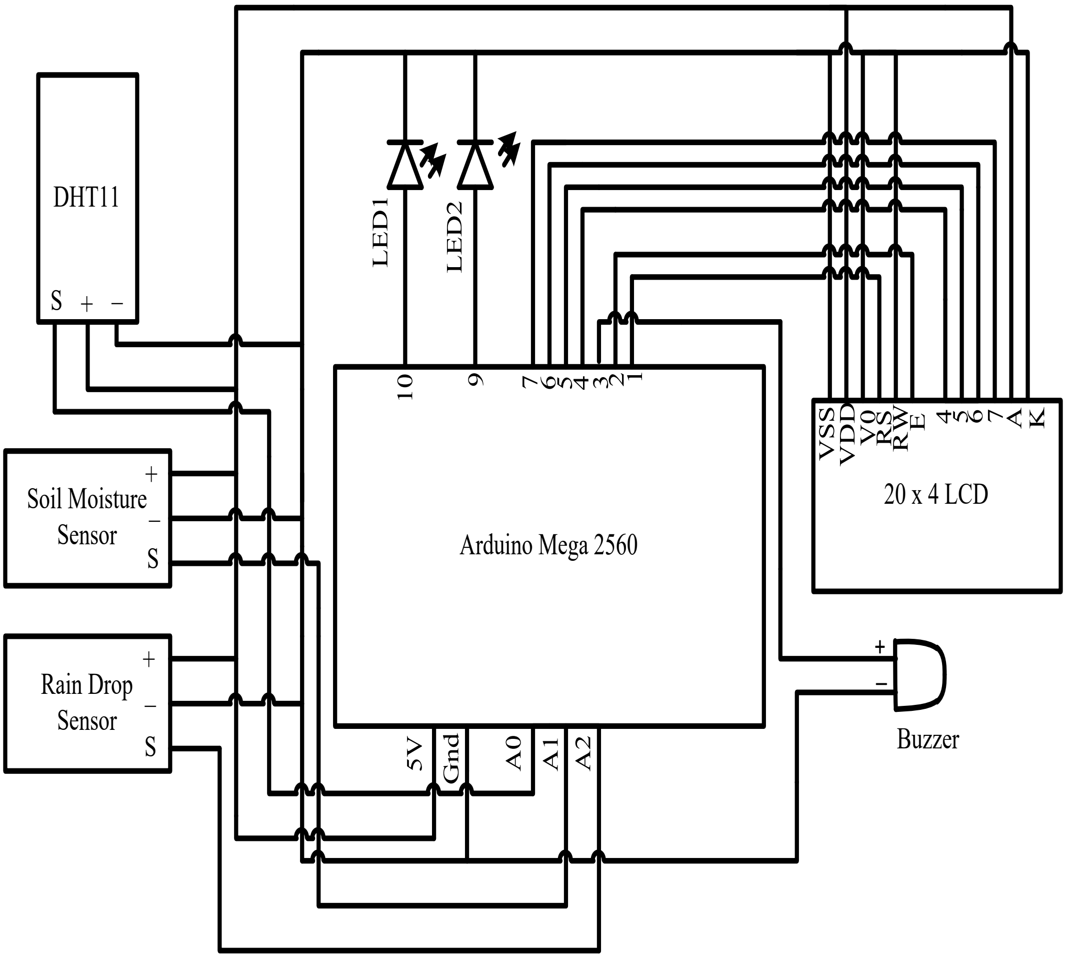

Figure 4.2.Circuit Diagram of Arduino Based Weather Monitoring System

4.4. Software Implementation of Arduino Based Weather Monitoring System

In this thesis, DHT11 temperature and humidity sensor, soil moisture sensor, and rain drop sensor are connected to Arduino Mega using Arduino IDE software and C programming. Firstly, as 20x4 LCD is used to display all the data of sensors, LCD must declare at the beginning of the program with the use of LCD pins as follow;

#include <LiquidCrystal.h>

LiquidCrystallcd(1, 2, 4, 5, 6 , 7);

And the each data pin of the sensors that use in this program connected to Arduino Mega is firstly declared in program as follow;

#include <Adafruit_Sensor.h>

#include <DHT.h>

#define DHTPIN   A0

```
intsoil_sensor = A1 ;
intsensorValue = 0;
intrainSen_pin = A2;
```

And then write the character that wants to show on LCD. In this program, temperature with a unit of degree Celsius and humidity with a unit of percentage want to show on LCD so,

```
lcd.setCursor(0,0);
lcd.print("Temp=");
lcd.print(event.temperature);
lcd.print("°C,");
lcd.setCursor(11,0);
dht.humidity().getEvent(&event);
lcd.print("Humidity=");
lcd.print(event.relative_humidity);
lcd.print("%");
```

For soil moisture sensor, the data value of sensor want to display with a unit of percentage on the LCD, so

```
sensorValue = analogRead (soil_sensor);
lcd.setCursor(14,1);
lcd.print(sensorValue);
delay (1000);
lcd.print("  ");
```

Finally, the conditions of rain drop sensor show on LCD. For rain drop sensor, if-else statement must be used because the data value of rain sensor is greater than 800, it shows “No Rain” and the data is less than 800, it shows “Rain” on LCD.

```
intRainSenReading = analogRead(rainSen_pin);
 if (RainSenReading<=800)
  {
lcd.setCursor(0, 2);
lcd.print("Raining");
  }
else
  {
lcd.setCursor(0, 2);
```

```
lcd.print("No Rain");
  }
```

4.5. Working Principle DHT11 Sensor

The DHT11 sensor comes in a single row 3 pin package and operates from 3.5 to 5.5V power supply. It can measure temperature from 0 to 50°C with an accuracy of ±2°C and relative humidity ranging from 20 to 95% with an accuracy of ±5%. The sensor provides fully calibrated digital outputs for the two measurements. It has got its own proprietary 1 wire protocol, and therefore, the communication between the sensor and a microcontroller is not possible through a direct interface with any of its peripherals. The protocol must be implemented in the firmware of the MCU with precise timing required by the sensor.

The following timing diagrams describe the data transfer protocol between a MCU and the DHT11 sensor. The MCU initiates data transmission by issuing a Start signal. The MCU pin must be configured as output for this purpose. The MCU first pulls the data line low for at least 18ms and then pulls it high for next 20 to 40s before it releases it. Next, the sensor responds to the MCU Start signal by pulling the line low for 80s followed by a logic high signal that also lasts for 80s. Remember that the MCU pin must be configured to input after finishing the Startsignal. Once detecting the response signal from the sensor, the MCU is ready to receive data from the sensor. The sensor then sends 40bits (5bytes) of data continuously in the data line. Note that while transmitting bytes, the sensor sends the most significant bit first.

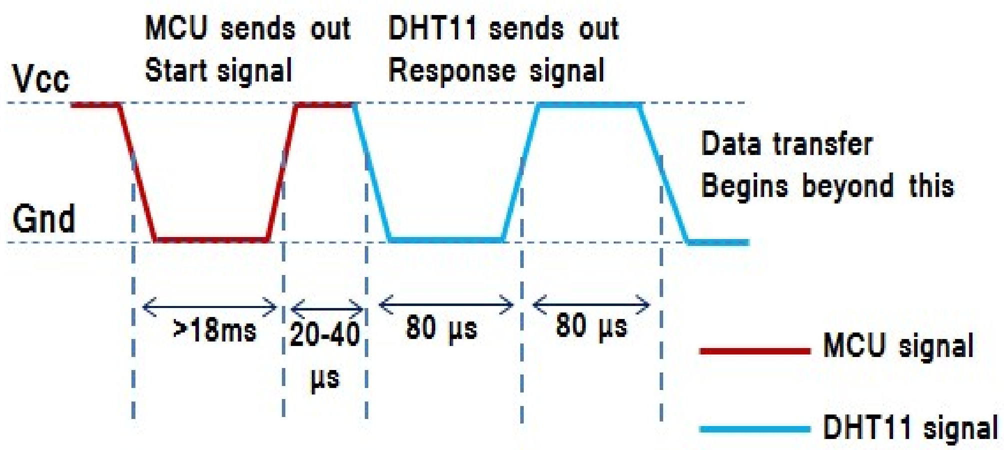

Figure 4.3. DHT11 Start and Response Signals

The 40-bit data from the sensor has the following structure.

Data (40-bit) = Integer Byte of RH + Decimal Byte of RH + Integer Byte of Temp. + Decimal Byte of Temp. + Checksum Byte Equation (4.1)

For DHT11 sensor, the decimal bytes of temperature and humidity measurements are always zero. Therefore, the first and third bytes of received data actually give the numeric values of the measured relative humidity (%) and temperature (°C). The last byte is the checksum byte which is used to make sure that the data transfer has happened without any error. If all the five bytes are transferred successfully then the checksum byte must be equal to the last 8bits of the sum of the first four bytes, i.e.,

Checksum = Last 8 bits of (Integer Byte of RH + Decimal Byte of RH + Integer Byte of Temp. + Decimal Byte of Temp.) Equation (4.2)

Now lets talk about the most important thing, which is signaling for transmitting 0 and 1. In order to send a bit of data, the sensor first pulls the line low for 50s. Then it raises the line to high for 26 to 28s if it has to send 0, or for 70s if the bit to be transmitted is 1. So it is the width of the positive pulse that carries information about 1 and 0.

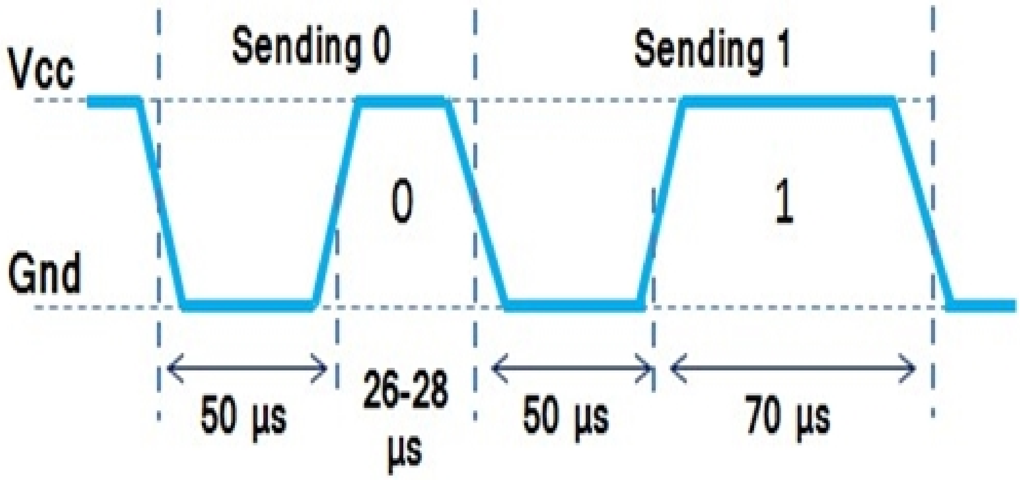

Figure 4.4. Timing Difference for Transmitting "1s" and "0s"

Start, Response and Data signals in sequence. At the end of the last transmitted bit, the sensor pulls the data line low for 50s and then releases it. The DHT11 sensor requires an external pull up resistor to be connected between its VCC and the data line so that under idle condition, the data line is always pulled high. After finishing the data transmission and releasing the data line, the DHT11 sensor goes to the low-power consumption mode until a new “Start” signal arrives from the MCU.

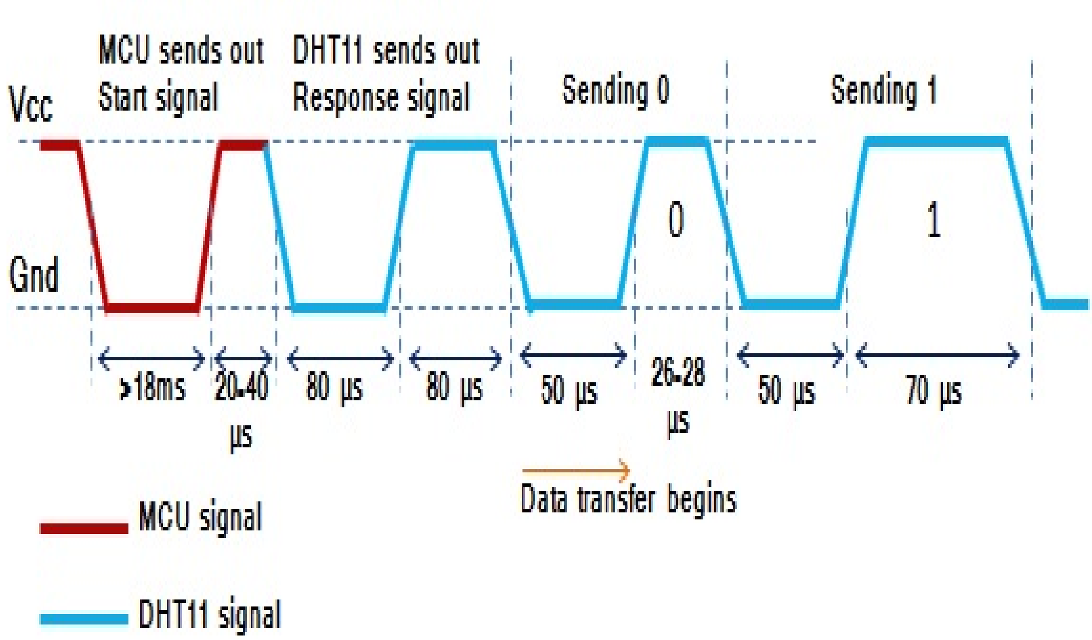

Figure 4.5. Data Transferring of DHT11

The formula to calculate the relative humidity is

RH = (ρw/ρs) x 100 % Equation (4.3)

where,

ρw = Density of water vapour

ρs = Density of water vapour at saturation

At 100 % RH, condensation occurs.

At 0% RH, the air is completely dry.

4.6. Working Principle of Soil Moisture Sensor

This sensor uses capacitance to measure the dielectric permittivity of the soil by calculation of change in frequency. The volume of water in the total volume of soil most heavily influences the dielectric permittivity of the soil because the dielectric of water is much greater than the other constituents of the soil like mineral soil 4, organic matter 4, air 1. When the amount of water is changed in the soil, it also affects the capacitance (from the change in dielectric permittivity).

The sample (moisture contained soil) for testing is placed between two test plates that form a capacitor connected into an LC oscillating circuit. The dielectric permittivity of the soil is measured by calculating the change in frequency originated by the oscillator before and after the sample is placed. Frequency is affected by soil moisture. The greater the soil moisture content, the smaller the frequency.

The best way to reduce variations attributes to environmental conditions, such as temperature and room humidity, is the use of a differential technique. That is frequency shift,

Change in frequency (delta f), w = f0 - f1 Equation (4.4)

where,

f0 = frequency produced by empty container

f1 = frequency produced with the sampled material

4.7. Working Principle of Rain Drop Sensor

- Wet: the resistance increases, and the output voltage decreases
- Dry: the resistance is lower, and the output voltage is higher

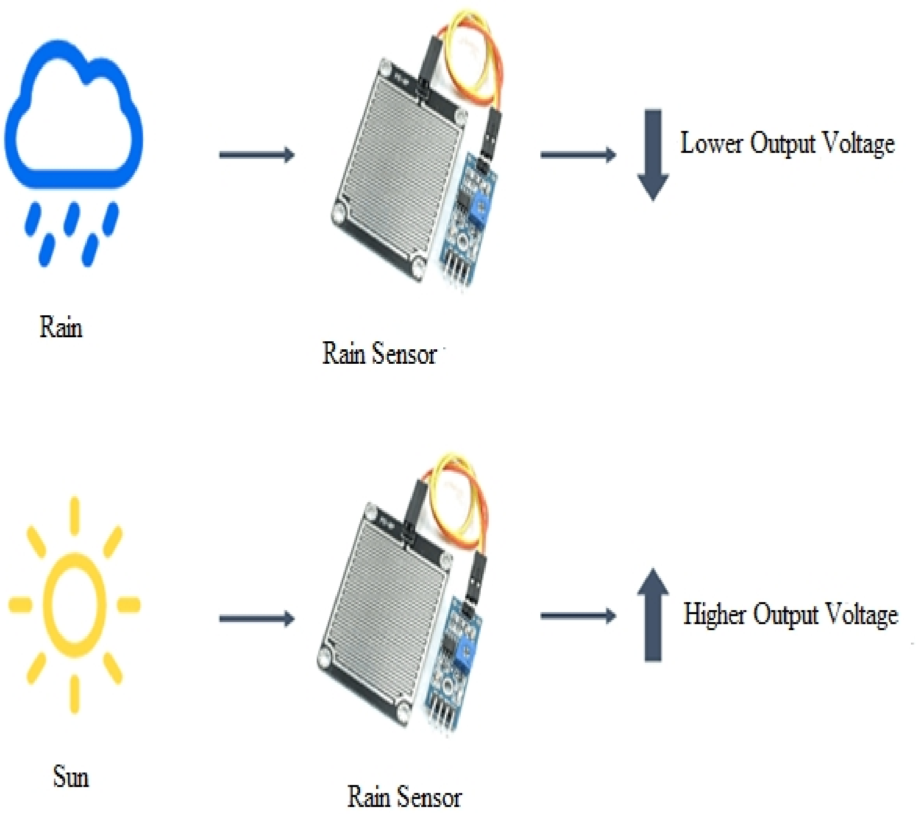

Figure 4.6. Working Principle of Rain Drop Sensor

Table 4.1. List of Components

Component	Number
Arduino Mega	1
DHT11 temperature and humidity sensor	1
Soil Moisture Sensor	1
Rain drop sensor	1
20 x 4 LCD	1
LED	2
Buzzer	1

CHAPTER 5
TEST AND RESULTS OF ARDUINO BASED WEATHER MONITORING SYSTEM

5.1. Test and Results

Arduino based weather monitoring system depends on many sensors such as DHT11 temperature and humidity sensor, soil moisture sensor and rain drop sensor. These sensors are connected to Arduino Mega and shows the data of these sensors on LCD.

5.1.1. Testing DHT11 Temperature and Humidity Sensor

DHT11 temperature and humidity sensor is used to know the temperature and humidity data using Arduino IDE software by running the program code.

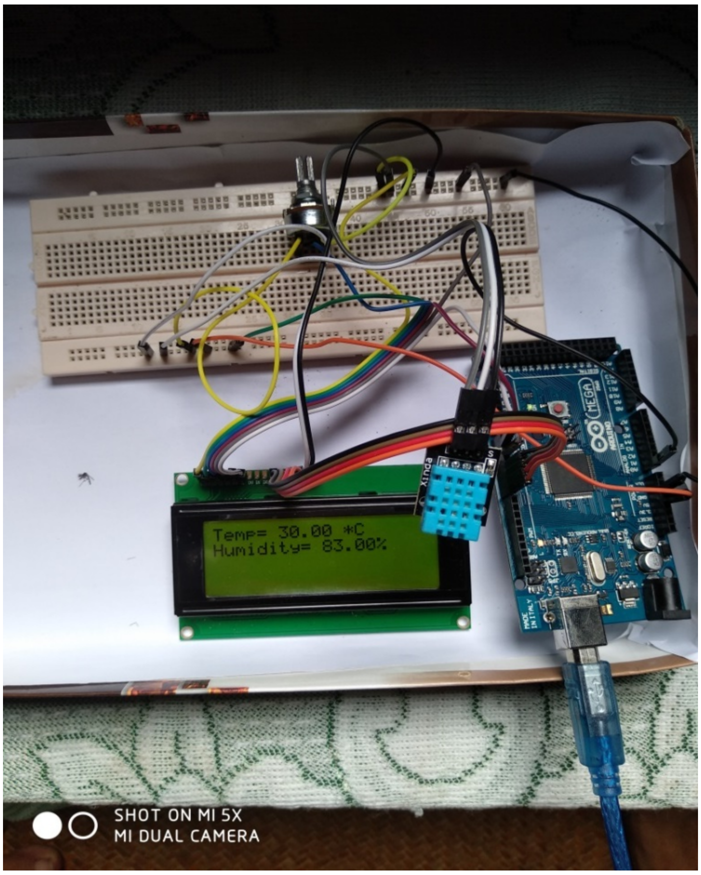

Figure 5.1. Testing DHT11 Temperature and Humidity Sensor

5.1.2. Testing Soil Moisture Sensor

The soil moisture sensor is used to know the water content in soil. By using Arduino IDE software, the moisture sensor is tested as shown in Figure 5.2.

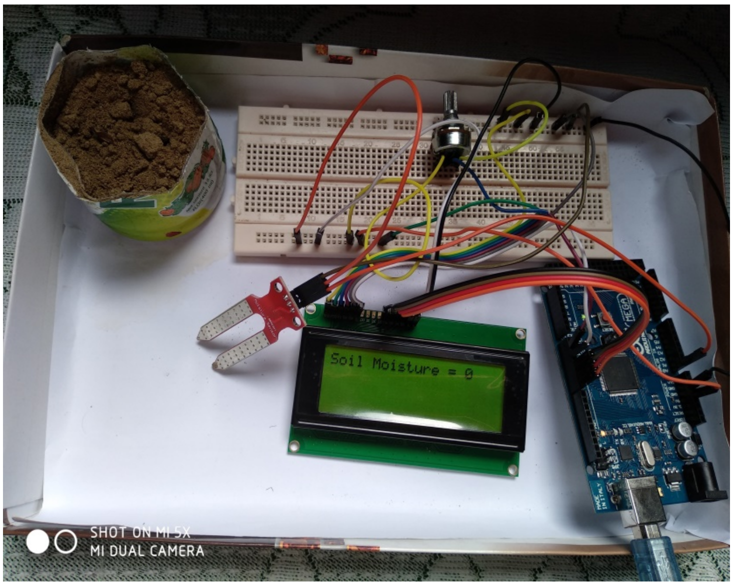

Figure 5.2. Testing Soil Moisture Sensor

5.1.3. Testing Rain Drop Sensor

Rain drop sensor is used to know there is no rain or rain. This sensor is tested by using Arduio IDE software. Figure 5.3 shows the result of rain drop sensor when there is no rain and when there is raining.

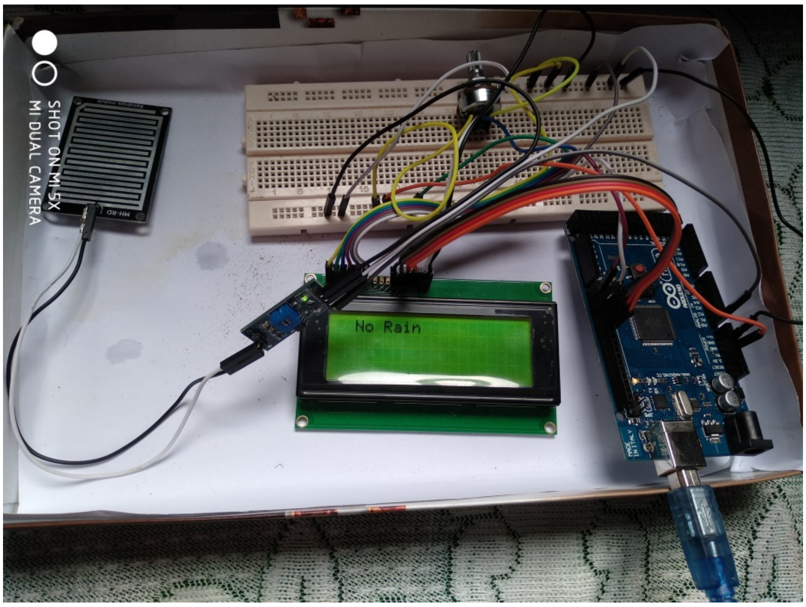

Figure 5.3. (a) Testing Rain Drop Sensor When There is No Rain

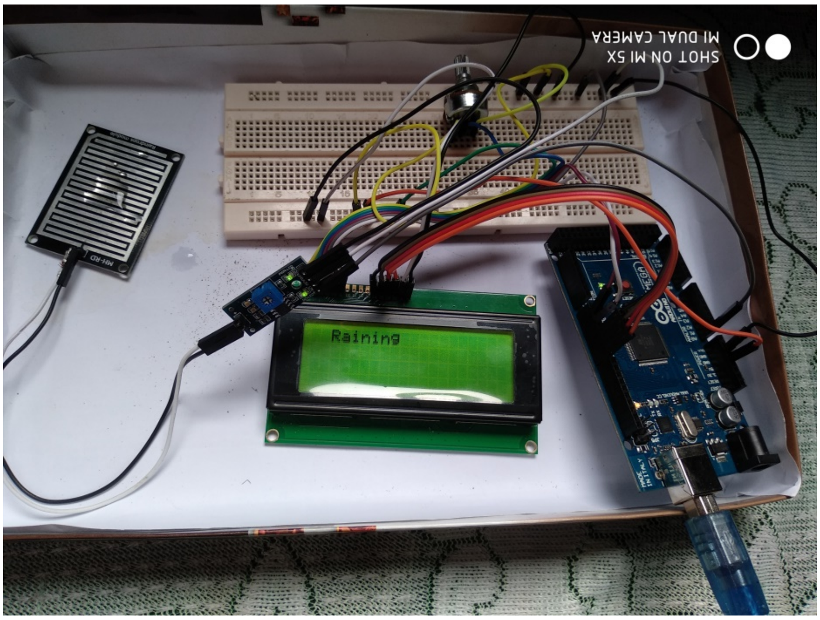

Figure 5.3. (b) Testing Rain Drop Sensor When There is Raining

5.1.4. Testing the Weather Monitoring System

By using DHT11 temperature and humidity sensor, soil moisture sensor and rain drop sensor, the weather monitoring system is built. This weather monitoring system is tested by using Arduino IDE software as shown in Figure 5.4.

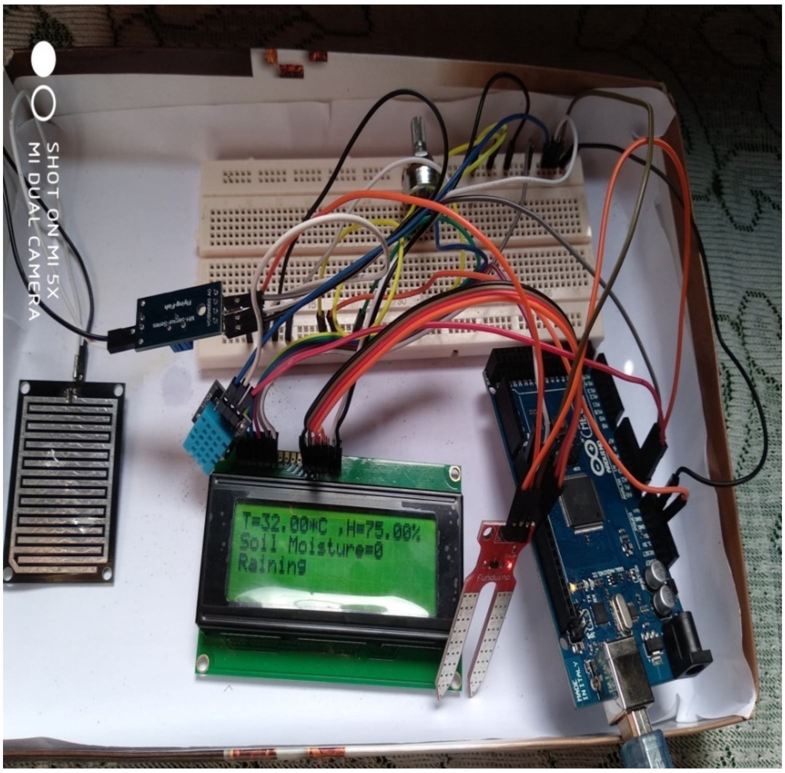

Figure 5.4. Testing the Weather Monitoring System

5.1.5. Result of Weather Monitoring System

The overall result of Arduino based weather monitoring system is shown in Figure 5.5.

Figure 5.5. Result of Weather Monitoring System

CHAPTER 6
DISCUSSIONS AND CONCLUSION

6.1. Discussions and Conclusion

The prime concern for this thesis was to construct an inexpensive mini weather monitoring system which provides data of different weather variables including temperature, humidity, soil moisture and rain. The special feature to be included as an idea in this device is that it is used for any critical environments or local area rather than expensive weather stations capable of performing over a large scale. These work on small scale too on public wireless LANs.

Weather monitoring system built by using various methods such as IoT, microcontroller, prediction, camera, Zigbee, cloud and many others, This Arduino based weather monitoring system is simple to construct, portable, cost efficient, less power consuming and reliable and easily installed in both urban and rural backdrop; able to withstand weather adversity to a certain extent. In conclusion, the weather monitoring system is very useful in many places such as homes, universities, schools, etc., but as the internet network does not use, the data transmission is not very high. In conclusion, Arduino based weather monitoring system is low cost and very useful in many places but this system does not use the internet network, the data transmission is not very high.

6.2. Further Extension

In this thesis, the power is supplied from the power bank. Solar power supply is also used to supply the Arduino microcontroller, other sensors and LCD. If solar power supply is used, the circuit is applied the power in the day and at the night, power bank is used to supply the circuit instead of solar power.

Different other sensors as altitude sensor, light intensity sensor, barometric pressure sensor, soil PH sensor, carbon dioxide, oxygen sensor and gas sensor are also added to this weather monitoring system to get the weather conditions very quickly and exactly and a wide range of measurements. Automatic irrigation control is also implemented using moisture sensor to fetch data regarding water presence in the farm and do turn ON or turn OFF water pump accordingly. The data can be uploaded to web server continuously. And if IoT system is also added to this thesis, smart home automation system also built such as if temperature is greater than 30°C, the fan opens and if there is raining, the door closes and if the moisture data is less than 300, the plants is watered.

REFERENCES

[16Ano] Anonymous: "*Moisture Sensor*", May, (2016)

[16Mad] Madhuri, P.P., S.R.P., J.P.C., K.P.R., "*Study of Recent Literature on Weather Monitoring System"*, November, (2016)

[15Mad] Madhuri, P.P., K.P.R., "*Literature Review of Weather Monitoring System*", (2015)

[13Jul] Julien Bayle: "*Arduino Mega 2560 Rev3*", December, (2013)

[11Ano] Anonymous: "*DHT11 Temperature and Humidity Sensor*", September, (2011)

[10Ano] Anonymous: "*Rain Sensor Module*", April, (2008)

[10Cas] Casellano, J.S.: "*Liquid Crystal Displays*", June, (2005)

[08Ano] Anonymous: "*Rain detector*", April, (2008)

[07Ano] Anonymous: "*Rain Drop Sensor Arduino Detector*", March, (2007)

[06Ano] Anonymous: "*Raindrop Sensor*", July, (2006)

[05Ano] Anonymous: "*Definition of Liquid Crystal Display*", October, (2005)

APPENDIX

APPENDIX

Source Code of Arduino Based Weather Monitoring System

```
#include <LiquidCrystal.h>
#include <Adafruit_Sensor.h>
#include <DHT.h>
#include <DHT_U.h>
#define DHTPIN           A0
#define DHTTYPE          DHT11
DHT_Unified dht(DHTPIN, DHTTYPE);

int soil_sensor = A1 ;
int sensor_value =0;
int sensor_value_threshold = 60;
int rainSen_pin = A2;
int outputpin1 = 10;
int outputpin2 = 9;
int outputpin3 = 3;   //setting the output pin

void setup()
{
lcd.begin(20,4);
LiquidCrystal lcd (1, 2, 4, 5, 6 , 7);
dht.begin();
sensor_t sensor;
dht.temperature().getSensor(&sensor);
pinMode(rainSen_pin, INPUT);
pinMode(outputpin1, OUTPUT); // sets the digital pin as output
pinMode(outputpin2, OUTPUT); // sets the digital pin as output
pinMode(outputpin3,OUTPUT);
}
```

```
void loop()
{
sensors_event_t event;
dht.temperature().getEvent(&event);

lcd.setCursor(0,0);
lcd.print("Temp=");
lcd.print(event.temperature);
lcd.print("*C ");
lcd.setCursor(0,1);
dht.humidity().getEvent(&event);
lcd.print("Hum=");
lcd.print(event.relative_humidity);
lcd.print("%");

if (event.temperature < 30)
{
digitalWrite(outputpin1, HIGH); // sets the Red LED on
digitalWrite(outputpin2, LOW); // sets the Red LED on
}

else
{
digitalWrite(outputpin1, LOW); // sets the Red LED off
digitalWrite(outputpin2, HIGH); // sets the Red LED on
}

lcd.setCursor (0,2);
lcd.print ("Soil Moisture=");
sensor_value = analogRead (soil_sensor);
sensor_value = map(sensor_value,550,0,0,100);
lcd.setCursor(14,2);
lcd.print(sensor_value);
lcd.print("%");
```

```
delay (1000);

int RainSenReading = analogRead(rainSen_pin);

 if (RainSenReading <=800)
  {
    lcd.setCursor(0, 3);
    lcd.print("Raining");
    digitalWrite(3,HIGH);
  }

else
  {
    lcd.setCursor(0, 3);
    lcd.print("No Rain");
    digitalWrite(3,LOW);
  }

}
```