DESIGN AND IMPLEMENTATION OF A GSM BASED WEATHER STATION.

by

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ABSTRACT

A wireless remote weather station is an ideal solution for knowing the weather conditions at a specific remote location. Weather forecasts are informative, but they are only a forecast. With a Remote Weather Station, one would always know the exact weather conditions from where ever the Remote Weather Station is located. This project seeks to devise a simple low cost micro-controller based remote weather station that measure weather conditions using sensors to measure temperature, humidity, atmospheric pressure, rainfall received, and light intensity, displays it on LCD and forwards it to a remote user by SMS. This project is developed by using Arduino uno, SIM900 GPRS/GSM shield, LCD display, temperature, humidity, atmospheric pressure and light intensity sensors. The advantage of using GSM based technology is that GSM based communication network is widespread in Zimbabwe and have almost reached every corner of the country. GSM technology also provides users with high quality signal and channels, giving them access to high quality digital communication at very affordable rates. This microcontroller based weather station can be useful to anyone who wishes to monitor the weather conditions of a location without being physically there.

DECLARATION

I, **Raphael Muchovo**, hereby declare that I am the sole author of this thesis. I authorize the Midlands State University to lend this thesis to other institutions or individuals for the purpose of scholarly research.

Signature ___________________________________ Date ______________________________

APPROVAL

This dissertation/thesis entitled **DESIGN AND IMPLEMENTATION OF A GSM BASED WEATHER STATION** by **RAPHAEL MUCHOVO** meets the regulations governing the award of the degree of **BSC TELECOMMUNICATIONS HONOURS** of the **Midlands State University**, and is approved for its contribution to knowledge and literal presentation.

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ABBREVIATIONS

GSM – Global system for mobile communication

SMS – Short message service

AWS – automatic wireless system

GPRS – general packet radio system

IDE – intergrated development envir

RTC – real time clock

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Weather monitoring is of great importance because if affects many human activities. In Zimbabwe weather monitoring and forecasting is very important to farmers so that they know when to plant, weed or harvest their crops. The agriculture sector is of key importance in bankrolling the economy of Zimbabwe, since it contributes 15 to 19 percent of the country's Gross Domestic Product. This shows that the agriculture sector contributes a large income and plays a vital role in the economy of the country. In order to produce quality crops farmers rely on correct weather prediction and monitoring. Failure to correctly predict weather conditions leads to reduced expected yield and hunger.

The Zimbabwe metrological services provide weather forecasting information throughout the country. The weather monitoring and forecasting system in our country is outdated compared to developed countries. Weather forecasting information provided by the Zimbabwe metrological services is recorded by weather stations located in the nearby cities or towns and not necessarily the conditions at a farm located hundreds of kilometers away. The use of a remote weather station can help farmers to monitor the weather conditions at their farms, hence the need to design a low cost, automated and portable weather station. Weather monitoring allows farmers to keep a track record of weather parameters including temperature, humidity, atmospheric pressure, light intensity rainfall, wind speed and wind direction.

The study of day-to-day weather requires a connection of a couple of instruments together to form a weather station. A weather station is an observation post where weather conditions and meteorological data are observed and recorded. Weather stations provide weather forecasting information to aviation, agriculture, construction, or shipping [1]. Weather forecasting and monitoring is the application of science in predicting the atmospheric conditions of any given place. Weather forecasting is done through collection of quantitative and qualitative data of the prevailing state of the atmosphere at a given place. Weather prediction and forecasting is based on understanding various scientific atmospheric processes in predicting how the weather will change [1].

Modern weather stations are automated remote weather stations which are updated versions of the common weather stations which have been in existence for centuries. The automated remote weather station uses a sensor network to measure different atmospheric parameters. A sensor network is a network of microcontroller integrated with spatially distributed smart devices and sensors. A sensor is used for monitoring a real world physical condition or variable such as barometric pressure, wind speed, humidity, wind speed, temperature, wind direction, and precipitation amount [2]. An automated remote weather station is used minimise human effort, and to enable measurement of weather parameters from remote areas that are not easily accessible to human beings. The disadvantage of the manual weather station is that it requires human effort, skills, power and energy to get its results.

This project will design and implement a GSM based remote weather station using an embedded system to monitor the weather parameters at a remote location through sensors. GSM technology is widespread cheapest wireless technology in Zimbabwe that is convenient to use since almost everyone owns a mobile phone. To check the status of the weather, the user will send a Short Message Service (SMS) text to the remote weather station and get a reply about the status of the weather conditions where the remote weather station is located. The wireless remote weather station will be designed using basic and cheap components such as GPRS/GSM shield.

1.2 PROBLEM STATEMENT

Traditional weather stations lack self-sustainability, autonomous logging capabilities and the ability to transmit data wirelessly. Furthermore, professional weather stations are too expensive for the average consumer and they have got a limited range of transmission. Although it is not possible to monitor the weather parameters of all the places as some places are not easily accessible, the advancement of science and technology can provide us a way to get information of such places by the use of wireless devices. With the use of GSM based remote weather station, we can monitor the weather conditions of desired remote places. The data from the remote location is made available to the user by sending an SMS text containing values of measured weather conditions, using the GSM network. At any time the user is able to send an SMS to the remote weather station and get a reply about the status of temperature, humidity and rainfall. The proposed system will use wireless communication technology to provide real time access to weather conditions at a remote place.

1.3 AIM

The main aim of this research is to design and implement a wireless remote weather station. The weather station will measure weather conditions using various sensors that measure temperature, light intensity, relative humidity and atmospheric pressure. A central micro-controller will be used to collect all the data from the sensors and send it to a remote user using a GSM network.

1.4 OBJECTIVES

The objectives of this research are:

- To design a micro-controller based system that automatically measures weather parameters using sensors.
- To develop a cheap, portable remote weather station.

1.5 JUSTIFICATION

- The wireless remote weather station will be beneficial to agriculture, industry, and mining and tourism sectors of the economy. The system will help these sectors in weather monitoring and forecasting, thus enabling proper planning on various activities to be carried out.
- The system will allow monitoring of weather conditions of any desired remote place from anywhere in the world using the widespread GSM network.
- The design of a cost effective , portable , easy to maintain and affordable weather station will help to give warning of catastrophic weather conditions such as elnino that impact weather patterns causing drought. Zimbabwe is often a victim of such calamities, causing hunger, starvation and untold suffering
- This project can be used by University students studying mateorology to carry out research on weather.

1.6 SCOPE

- The immediate scope of this project is to monitor the weather conditions of a remote place using GSM technology.

- This weather station measures five parameters, which are temperature, humidity, atmospheric pressure and light intensity. These parameters are measured and monitored through sensors.

1.7 MOTIVATION

The primary motivation behind taking up this project is the large utility of the wireless weather monitoring in varied areas ranging from agricultural growth and development to industrial development. The weather conditions of a field can be monitored from a distant place by farmers and won't require them to be physically present there in order to know the climatic behavior at the location by using wireless communication. I

REFERENCE

[1] A Guide to the Siting, Exposure and Calibration of Automatic Weather Stations for Synoptic and Climatological Observations, By Andrew K. Overton.

[2] http://www.mstarlabs.com/; Temperature Measurements using Data Acquisition Processors

[3] Zhang Hong, Zhang Jie. Wireless sensor network technology based on coal mine safety monitoring system [J]. Microcontroller and Embedded Systems, 2009

[4] “Data sheet, ICATmega328, Arduino Uno, LDR, BMP180, Zigbee”,

[5] https://www.arduino.cc/en/Guide/HomePage

CHAPTER 2: THEORATICAL ASPECTS

2.1 INTRODUCTION

The researcher carried out extensive literature review related to the design and implementation of a remote weather station in order to find out previous work carried out by other researchers. In previous studies most of the researchers have used both wired and wireless technologies to transmit measured weather parameters to a remote user. P.Susmitha has developed a weather forecasting and monitoring that enables monitoring of weather conditions in industries [1]. The system has, a microcontroller, Gas and humidity sensors. The microcontroller acquires the data from sensors and sends it to a computer through the Serial port. There are many systems for remote weather stations, designed as commercial products or experimental research platforms using various techniques. The techniques used in some of these researches were quite expensive and were not global. However my proposal is to design and implement a remote weather station using open source hardware and software. The system will use modern digital sensors which are more compact, robust and efficient. At the heart of the system will be an arduino microcontroller that will send the measured parameters to a GSM module which transmits the data wireless to the user. The advantage of using GSM technology is that it is widespread in Zimbabwe. Using wireless technology also offers the ability to measure weather data during disasters when human beings cannot be physically there. The hardware and software components used in the design and implementation of this project will be discussed and show that they are a suitable choice to reach the objectives set for this project.

2.2 LITERATURE REVIEW

2.2.1 WEATHER MONITORING BY USING SIMPLE INSTRUMENTS

For many years simple instruments and techniques have been used in order to measure weather changes. Basic weather measuring instruments like cup anemometer and wind vane had been used to measure wind speed and direction. These instruments are still widely used in most common weather monitoring technologies today. Barometers, thermometers, rain gauges and hygrometers, are the vital tools for weather monitoring, from which more advanced technologies used in weather monitoring are developed [2]. However measuring weather data using this traditional way has the disadvantage that the system requires constant intervention of the human being to record the data manually. Furthermore it is difficult to monitor the weather station remotely as it cannot be easily integrated with modern technologies.

2.2.2 AUTOMATIC WEATHER STATION (AWS)

Automatic weather station (AWS) is a system that enables the collection of meteorological observations automatically. An AWS comprises a number of sensors, a data logger (housed in a waterproof enclosure) and a power supply. Typically, an AWS has got sensors that measure various weather parameters like rainfall, atmospheric temperature, wind speed, humidity, pressure, and direction [3]. The advantage of AWS over a traditional manual weather station is that it is far less labour-intensive. Provided an AWS is regularly checked to ensure that it is functioning properly, it does not need to be physically attended so that results can be manually recorded. Professional AWS such as the one depicted in the fig below are available online. However, the capital-intensive nature of AWS often means that it is too expensive to set up a large number of stations. Consequently, data-hungry forecasting models, which operate best when fed with a vast quantity of observations from a very dense network of AWS, cannot operate to their full capacity. In addition professional AWS are not available on the local market.

Fig 2.1: Professional AWS

2.2.3 DIGITAL WEATHER STATION

This journal proposed to build a weather station with a digital display. This weather station is powered by a power supply. The analog signal from sensors is converted to a digital signal. This weather station provides reading parameters for pressure, rainfall, temperature, humidity, wind direction and wind speed and could only display one parameter from the weather station at one time [2]. The limitations of this system are that it cannot be monitored remotely and requires the physical presence of the human being to take readings. Moreover the system lacks autonomous data logging capability which is crucial for future weather forecasting and prediction

2.2.4 MONITORING SYSTEM OF A WEATHER STATION VIA IP

From this journal, a monitoring system for weather station was developed. They converted analog signal from sensor to digital signal to be read by computer via data acquisition card usb-6009 and using LabView as application software to interface the data from weather station [1]. This method is limited by availability of internet connection to access the remote weather station. This system cannot be used in rural areas since internet access is limited and some areas are not covered at all.

2.3 HARDWARE COMPONENTS

The following hardware components will be required to successfully accomplish the objectives of this project.

- Liquid crystal display
- Arduino uno Microcontroller
- Arduino GPRS/GSM shield
- Barometric pressure sensor
- Temperature and humidity sensor
- Rain detection module sensor
- Light Intensity sensor

2.3.1 LIQUID CRYSTAL DISPLAY (LCD)

A liquid-crystal display is a flat electronic display panels that use light modulation property of liquid crystals. Liquid crystal display does not emit light directly. The principle of LCD depends on two sheets of polarized material with a liquid crystal solution. If an electrical current is passed through, the crystals to align so that light is blocked and does not pass through [10]. Each crystal is like a shutter, which either blocks the light or allows it to pass through. LCD s has got temperature range of -10℃ to 60℃ for them to function properly and has a lifetime of more than 50000 hours (without direct irradiation of sunlight). Fig 1 below shows a typical 16x2 display.

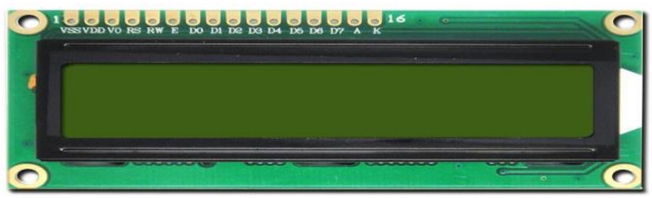

Fig 2.2: Liquid crystal display

2.3.2 ARDUINO UNO

Arduino is based on open-source computing platform that has got a very simple input/output board and implements Processing/Wiring language as a development environment. The Arduino platform provides an integrated development environment (IDE) which has got support for C and C++ programming languages. Arduino boards may either consist of an Atmel 8-, 16- or 32-bit and AVR microcontroller that facilitates programming and can be incorporation into other circuits easily. The Arduino Uno i microcontroller board architecture is based on ATmega328 AVR microcontroller. Arduino has got 14 digital input/output pins (six pins are used as PWM outputs), six analog inputs, an ICSP header a 16 MHz ceramic resonator, a power jack, a USB connection, and a reset button. The arduino board has got everything that is needed to supports microcontroller. It can either be powered through a USB connection or through an external power adapter. The source of power automatically selected. The 14 digital pins can be used either input or output pins [5].

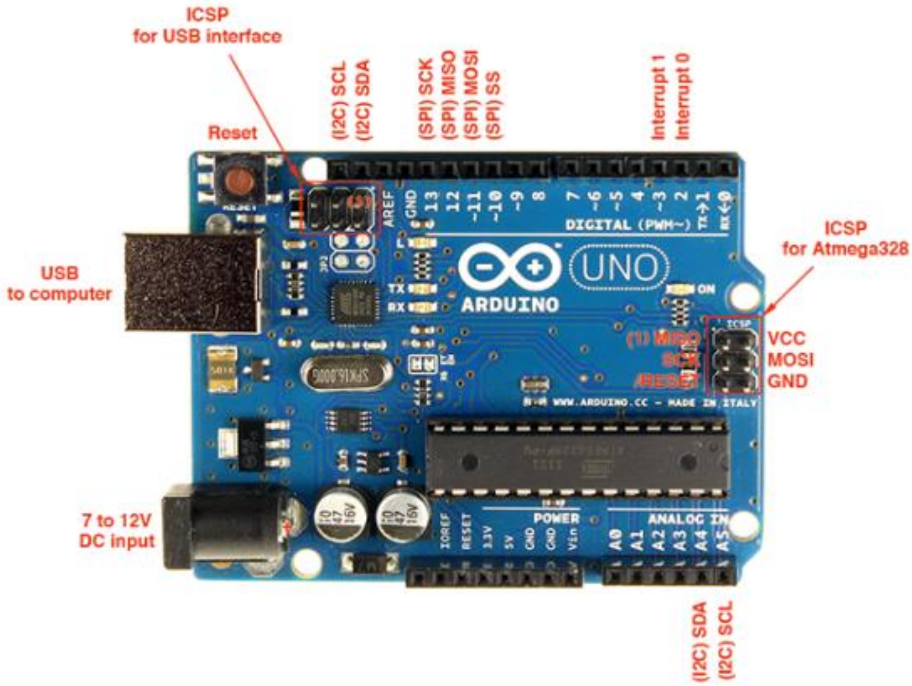

Fig 2.3: Arduino micro-controller board

2.3.3 ARDUINO SIM900 GPRS/GSM SHIELD

The SIM900 GSM/GPRS Shield uses the GSM cellular network to receive and transmit data to the user. The SIM900 GSM/GPRS shield is a complete Quad-band GSM/GPRS module that has got a single powerful chip processor. The SIM900 delivers GSM/GPRS 850/900/1800/1900MHz services for SMS, voice, Fax, Data, and has got very low power consumption.

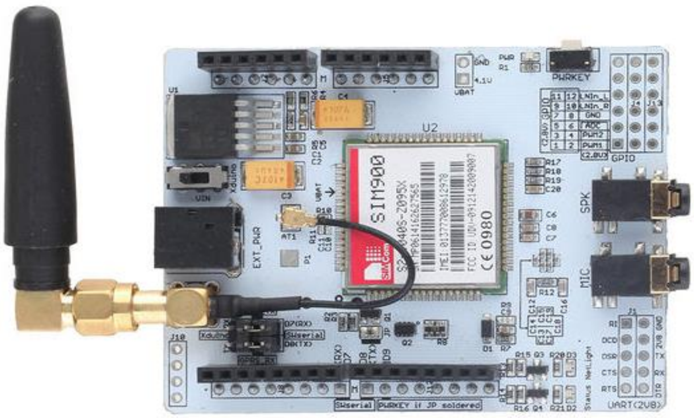

Fig 2.4: Arduino sim900 gprs/gsm shield

2.3.4 DHT11 TEMPERATURE AND HUMIDITY SENSOR

The DHT11 sensor is used for measuring air temperature and relative humidity of the atmosphere. DHT11 Temperature & Humidity digital sensor has got three pins and is characterized by very low power consumption. The temperature ranges from –40°C to 123.8°C, and range for relative humidity is from 0–100%. The DHT11 Sensor has got a temperature and humidity sensor that has got a precisely calibrated digital output signal. The DHT11 has got a super long term stability and high reliability. The sensor uses exclusive digital-signal-acquisition technique to measure temperature and humidity based on sensing technology. This sensor incorporates NTC temperature measurement component and a resistive-type humidity component. The DHT11 sensor can be connected to high performance 8-bit microcontroller, giving excellent quality, fast response, and anti-interference ability and is very cost-effective. The DHT11 is a basic, low-cost digital temperature and humidity sensor. The sensor is very simple to use, however it requires very accurate timing to acquire data. The only disadvantage of this sensor is that new data is only acquired after a two seconds delay.

Fig 2.5:DHT11 humidity and temperature sensor

2.3.5 BMEP280 PRESSURE SENSOR

The BMEP280 pressure sensor is used to measure the atmospheric pressure. The BMEP280 is a highly accurate reliable digital pressure sensor that is used for consumer applications. The BMEP280 uses very low power, low-voltage and it is optimized for being used in GPS navigation devices. The sensor has got very low altitude noise of about 0.25 m at fast conversion time, offering superior performance. The BMEP280 I2C interface allows very easy system integration with a microcontroller. BMEP280 is entirely based on piezo-resistive technique for electromagnetic interference immunity, linearity, long-term stability and high accuracy. Fig 2.5 below shows the BMEP280 digital barometric sensor

Fig 2.6: BMP180 digital barometric pressure sensor

2.3.7 RAINDROP MODULE SENSOR

The rain sensor module used for rain detection. The sensor can easily be used as a switch when raindrop falls on its surface and can also be used for determining rainfall intensity. This module has got a rain board and a control board with power indicator LED and an adjustable potentiometer changing the sensitivity of the module.

Fig 2.7: raindrop detection sensor

2.3.7.1 SPECIFICATIONS

- Adopts high quality of RF-04 double sided material.
- nickel plated on the sides side Area: 5cm x 4cm.
- Anti-conductivity, Anti-oxidation, over long use time.
- Comparator output signal clean waveform is good, driving ability, over 15mA.
- Potentiometer to adjust the sensitivity.
- Works on voltage 5V
- Output data format: Digital output (0 and 1) and analog voltage output AO.
- bolt holes for installation.
- Smaller sized PCB board measuring: 3.2cm x 1.4cm.
- wide voltage range LM393 comparator

2.3.8 BH1750 DIGITAL LIGHT INTENSITY SENSOR

The BH1750 sensor measures incident light intensity and converts it to a 16-bit digital number. It measures incident light intensity in the range from 0 - 65535 Lux. The Lux is the standard international unit for measuring luminance and it is equivalent to one lumen per square meter. The BH1750 sensor gives output directly in Lux. The BH1750 spectral response function is approximately similar to that of human eyes. The output from the sensor is accessed through the I2C interface. The 7-bit address of the I2C is 0x23 when ADDR pin is grounded, or conversely it is 0x5C when the ADDR pin is connected to VCC.

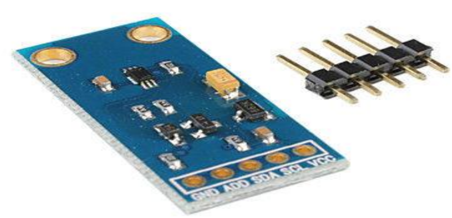

Fig 2.8 : BH1750 digital light sensor

Power suply	2.4 – 3.6v
current	1 – 7 mA
Output signal	Digital
Range of operation	Fig 1: Professional AWS
Accuracy	2 lux
Resolution	1 lux

Table 1: BH1750 digital sensor specifications

2.4 SOFTWARE

The software used to design and implement this project is:

- Arduino Software(IDE)
- Proteus 8 Professional Software

2.4.1 ARDUINO SOFTWARE

Arduino is an integrated software development environment (IDE) which is cross-platform and it is written in Java. Arduino uses Software programs, called *sketches* that are created on a computer using the Arduino IDE. The IDE is used to write and edit programs and convert these programs into HEX files that Arduino hardware understands. The IDE is also used to upload these instructions to the Arduino board.

2.4.2 ARDUINO SKETCH

The basic format of the Arduino language is very simple and has got at least two parts. These two required parts or functions enclose block of statements

```
Void setup ()
  {
     Statements;
  }

Void loop ()
  {
     Statements;
  }
```

Where setup () is only run once during program execution, loop () function is the main function of arduino and runs infinitely. Both functions are required for the program to work.

setup ()

The setup ( ) is called only once when a program starts. It is used to initialize communication ports and setting pinMode. Setup must be included in every program even if there are no statements to run.

Loop ()

After calling the setup () function, the loop () function loops consecutively allowing program to change, respond and control the Arduino board.

2.4.3 PROTEUS PCB DESIGN AND SIMULATION SOFTWARE

The simulation of the project will be done using Proteus 8 Professional Software and the Arduino compiler. The Proteus simulation and design software was developed by **Labcenter Electronics.** Proteus 8 Professional software can draw schematics and simulate circuits in real time. A unique feature of proteus 8 professional is 3D viewing of the designed PCB and components.

Features

- IT has a library with wide range of components
- It has got analysis tool like oscilloscope, ammeter and voltmeters and other components like signal generators and sources.
- Has got the capability for monitoring of parameters in real time. Proteus can monitors switches, capacitors, microcontrollers, processors, loads like motors and lamps.

2.4.4 MICRO-CONTROLLER SIMULATION

The Arduino and several other micro-controller models can be simulated in Proteus 8 professional. Proteus micro-controller simulation uses either a hex file or a debug file. The file is then co-simulated with any digital and analog components wired to it. This means that proteus has got a broad spectrum of applications in project prototyping. It can be used in areas like temperature control, motor control and designing of user interfaces.

REFERENCES

[1]Design and implementation of a programmable remote controlled and monitored irrigation system
Tajedinn abdelgawi Baker , Abdelrasoul jabar kizar alzubaidi, *Bahri University, Sudan,2014*

[2]Development of a Remote Automatic Weather Station with a PC-based Data Logger Roneel V.
Sharan,*School of Engineering and Physics, University of the South Pacific, Su*

[3] Chen Chao; MengKeqilao; GaoMuyu;, "The Remote Wireless Monitoring System Based on GPRS for Off-Grid Wind Turbine," *New Trends in Information and Service Science, 2009. NISS '09. International Conference on* , pp.1150-1153, June 30 2009July 2 2009.

[4] T. Murugan, Azha.Periasamy, S. Muruganand, "Embedded based Industrial Temperature Monitoring System using GSM," *International Journal of Computer Applications,* vol. 58, p. 0975 – 8887, 2012.

[5] *ATmega32 Datasheet,* Atmel Corp., 2006.

[6] Subhani Sk., Sateesh, Chaitanya and Prakash Babu , "Implementation of GSM Based Heart Rate and Temperature Monitoring System," *Research Journal of Engineering Sciences,* vol. 2, pp. 43-45, april 2013.

[7] "Hitachi HD44780 LCD controller," Hitachi, 1998. [Online]. Available: en.wikipedia.org/wiki/Hitachi HD44780 LCD controller.

[8] "JHD162A datasheet," [Online]. Available: www.egochina.net.cn/eBay/Download/JHD162A.pdf.

[9] "SIM900 datasheet," [Online]. Available: probots.co.in/Manuals/SIM900.pdf.

[10] "Microcontroller to sensor interfacing techniques," BiPOM Electronics INC., [Online]. Available: www.bipom.com.

[11] Theophilus Wellem, Department of Information Systems, Bhudi Setiawan, Department of Informatics,Satya Wacana Christian University Salatiga, Indonesia., "A Microcontroller- based Room Temperature Monitoring System," *International Journal of Computer Applications,* vol. 53, no. 1, 2012.

[12] Jifeng Ding, Jiyin Zhao,Biao Ma, College of Electromechanical & Information

Engineering,Dalian Nationalities University Dalian, China, "Remote monitoring system of temperature and humidity based on GSM," in *2nd International Congress onImage and Signal Processing*, 2009.

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

This chapter discusses all the hardware and software designs combined to come about with the final model. The hardware components of the system model consist of Humidity and Temperature Sensor, atmospheric pressure sensor, raindrop detection sensor, light detection sensor, arduino uno development board and an LCD. A description and analysis of the prototype is given. The author uses illustrations such as block diagram, system flowchart diagram, and a schematic diagram to aid the description of the proposed system

3.2 SYSTEM DESIGN

The objectives of this project stipulate that a portable prototype of the proposed system has to be built. The system will interface with sensors to measure and transmit and receive data through the GSM. To attain these objectives different design approaches have been verified. The proposed system has been designed to consist of an ATMEGA microcontroller reading data from temperature, humidity, light intensity and pressure. The system is interfaced to a Sim900 GSM/GPRS shield for transmitting and receiving data through wireless communication.

The system block diagram for the weather station is illustrated in figure 1below

3.3 BLOCK DIAGRAM OF THE SYSTEM

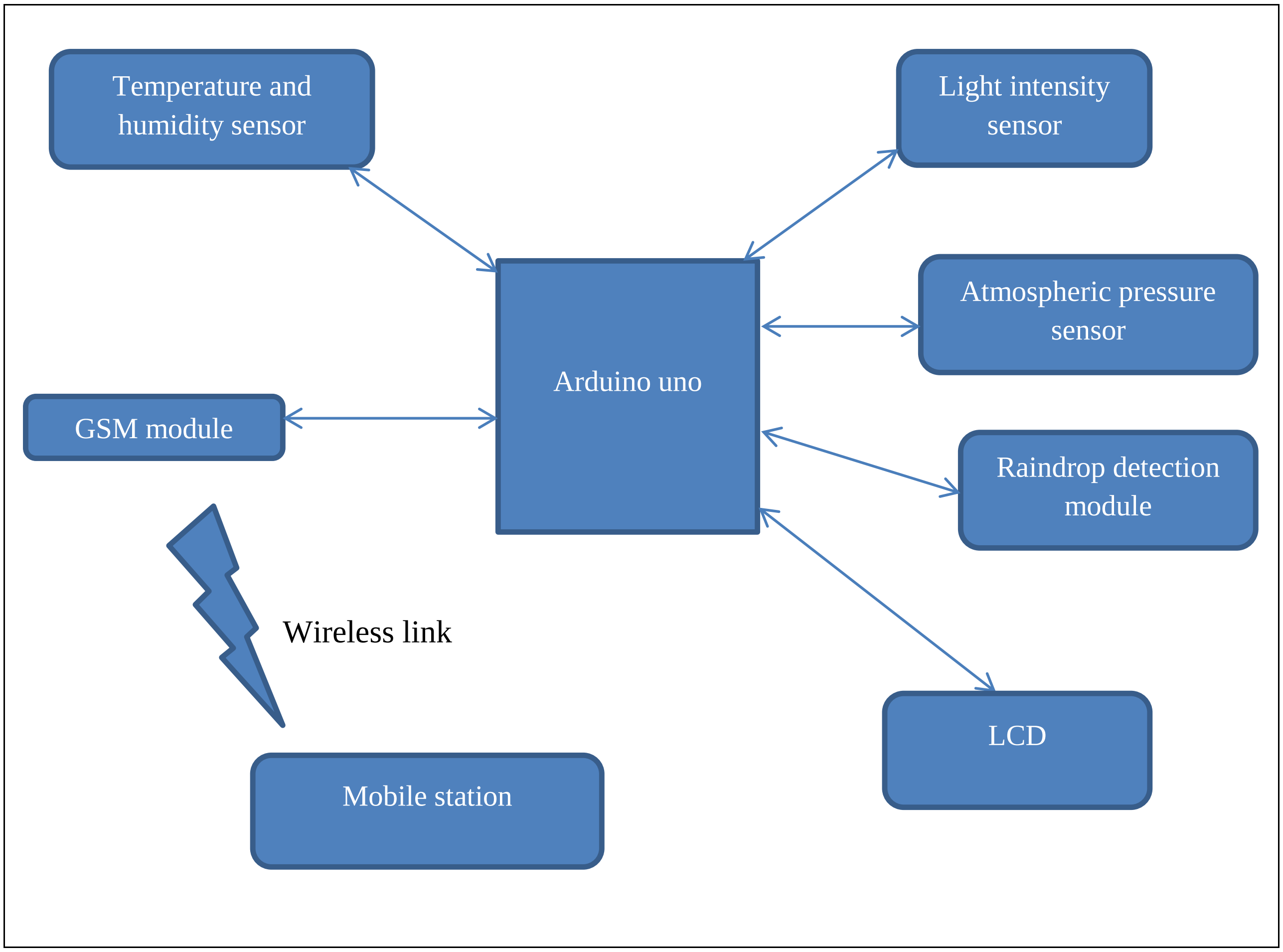

Fig 3.1: system block diagram

3.4 HARDWARE CONNECTIONS

3.4.1 ARDUINO UNO

Arduino uno microcontroller is the heart of the weather station system. Arduino provides enough processing power and memory to run the software required and it can read multiple sensors simultaneously. To add network connectivity to the project, a SIM900 GSM shield is plugged on top of the arduino board. SIM900 GSM shield enables the system to transmit SMS messages containing measured weather parameters to the user. The SIM900 GSM module also receives user's requests for desired weather parameters in form of text messages. The SMS received is passed to the arduino microcontroller for processing

3.4.2 TEMPERATURE AND HUMIDITY SENSOR

The combined humidity and temperature sensor measures the ambient temperature and humidity of the environment. The DHT11 is used for measuring air temperature and relative humidity. The DHT11 digital sensor is wired to arduino uno board as follows:

- connect VCC pin to Arduino's 5V output
- connect GND pin to Arduino's GND and
- connected the DATA pin to Arduino's digital pin D7

The figure 3.2 below shows the pin configuration of DHT11 sensor and how it is connected to arduino.

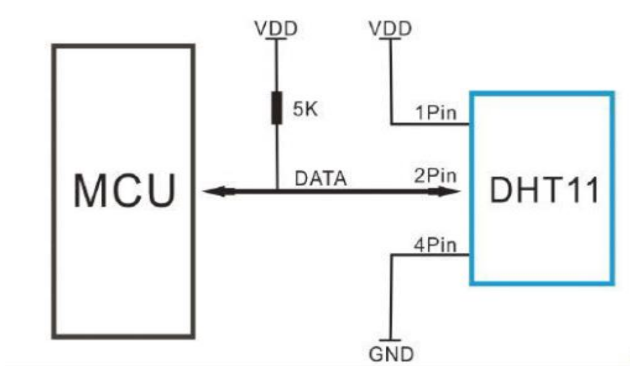

Fig 3.2: DHT11 pin configuration

3.4.3 ATMOSPHERIC PRESSURE SENSOR

The BMEP280 digital sensor uses the I2C interface. Since pressure varies with altitude it can be used to measure altitude too. It has 4 pins SDA, SCL, GND and Vin, the pins are connected to arduino as follows.

- connect VCC to Arduino’s 3.3V output
- connect the GND pin to Arduino’s GND
- connect SDA (Serial Data Line) pin to Arduino’s analog pin A4
- connect SCL (Serial Clock Line) pin to Arduino’s analog pin A5

Figure 3.3 below shows BMEP280 connection with arduino

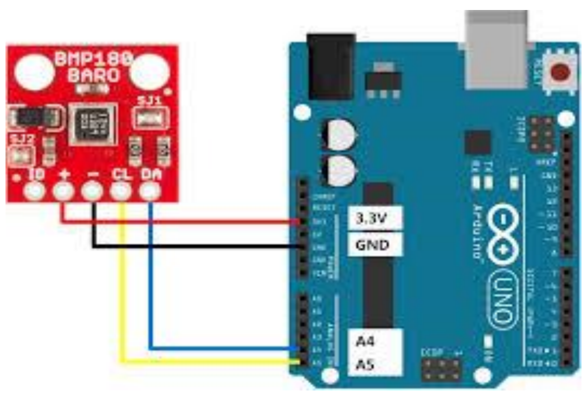

Fig 3.3: BMEP280 connection with arduino

3.4.4 RAIN DETECTION SENSOR

The rain drop sensor module is used to detect whether there is any rain or presence of rain weather near the surroundings. It is a tool for rain detection. The module consists of a rain board on which droplets can be detected, and a potentiometer is attached to adjust its sensitivity and a LED to show the power indication. It gives only analog output. The raindrop detection module is connected to arduino as follows.

- Connect the VCC pin to Arduino’s 5V output
- Connect the GND pin to Arduino’s GND
- connected Analog Data to Arduino's analog pin A0

Figure 3.3 below shows raindrop sensor connection with arduino

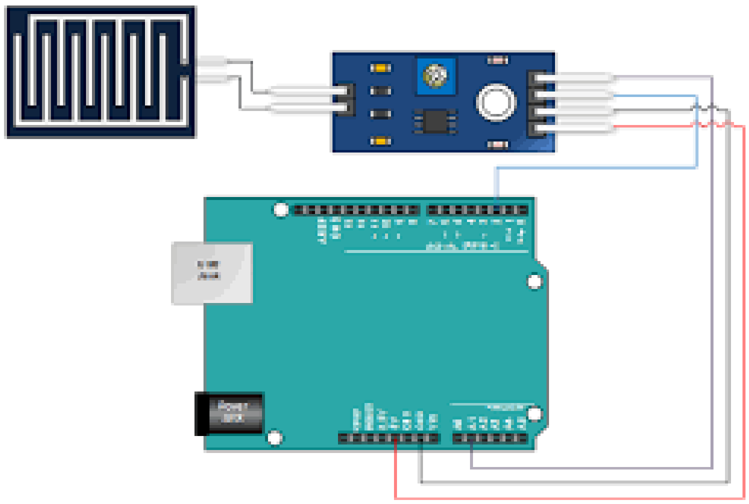

Figure 3.4: rain sensor module to arduino connection

3.4.5 ARDUINO GSM SHIELD

A GSM Module is basically a GSM Modem. To interface arduino with the GSM module I selected two PWM enabled pins of arduino and connected them to receive and transmit pins of the GSM module. Connected the GSM module to arduino as follows:

- connect the transmit(TX pin) of the GSM module arduino's to receive pin (D9)
- the receive pin of the GSM module is connected to the transmit pin of arduino(D10)

Fig 3.5 below shows how to connect the GSM shield to arduino.

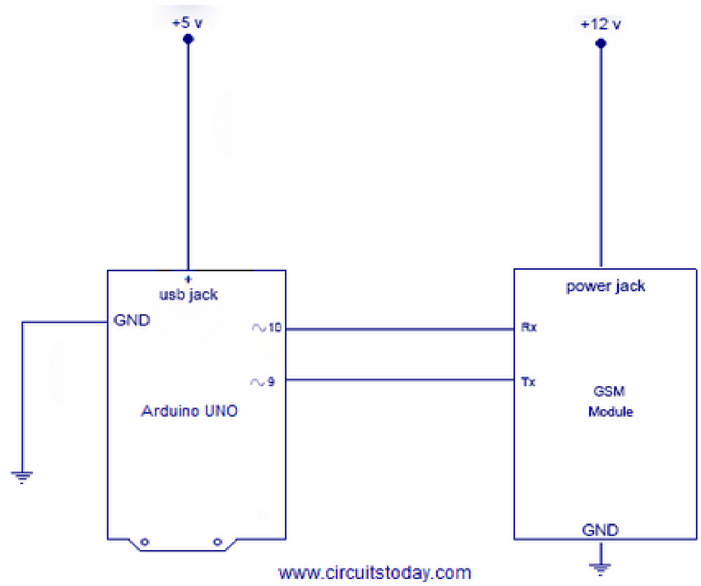

Figure 3.5: Gsm shield to arduino connection

3.4.6 LIGHT INTENSITY SENSOR

The BH1750 digital light sensor measures ambient incident light intensity. The measured light intensity will give an indication of cloud cover in the sky at any particular time. Figure 3.6 below shows BH1750 connection with arduino

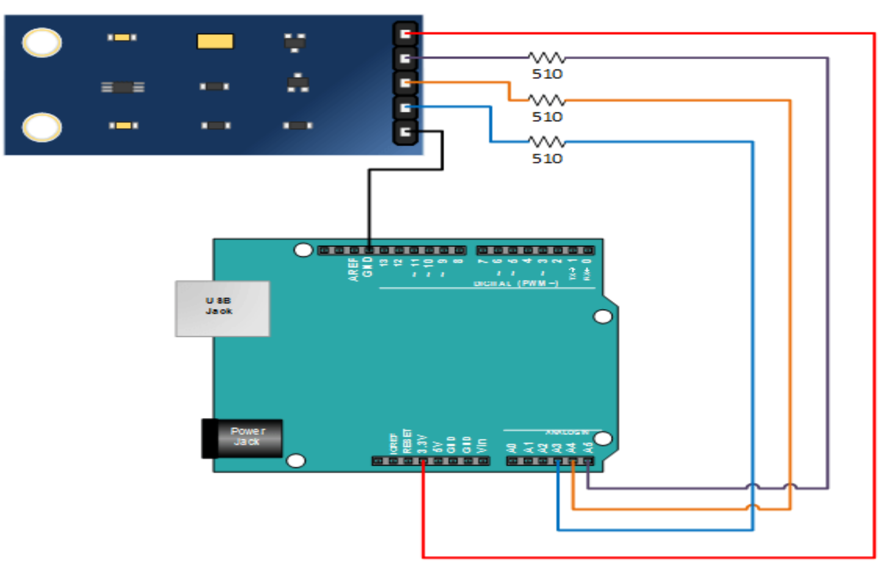

Fig 3.6: BH1750 connection with arduino

3.4.7 LIQUID CRYSTAL DISPLAY (LCD)

The liquid crystal display provides a human interface to take weather parameter readings on the weather station locally. The LCD is connected in 4-bit mode as shown in figure 3.7 below

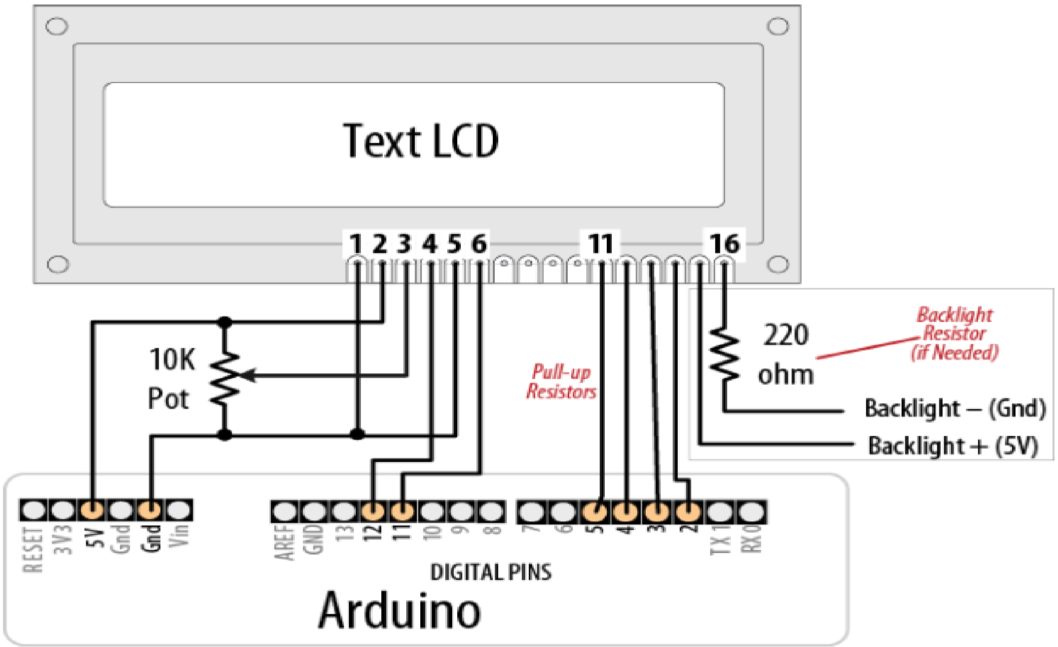

Fig 3.7 : connections for LCD

3.4.8 SOFTWARE

In Arduino programming there are two main functions. Main functions are setup() and loop(). Setup() function is only operated once when device is booted up, it is mostly used to setup initiation settings. Loop() is ran after the setup() function has finished, loop() function will run repeatedly until power off or reset button is pushed . Arduino programming is supported by wide amount of libraries. The system software was written, compiled and uploaded to arduino board using arduino's IDE. Figure 3.8 below shows a flowchart of the system's software.

3.4.9 FLOWCHART FOR SYSTEM SOFTWARE

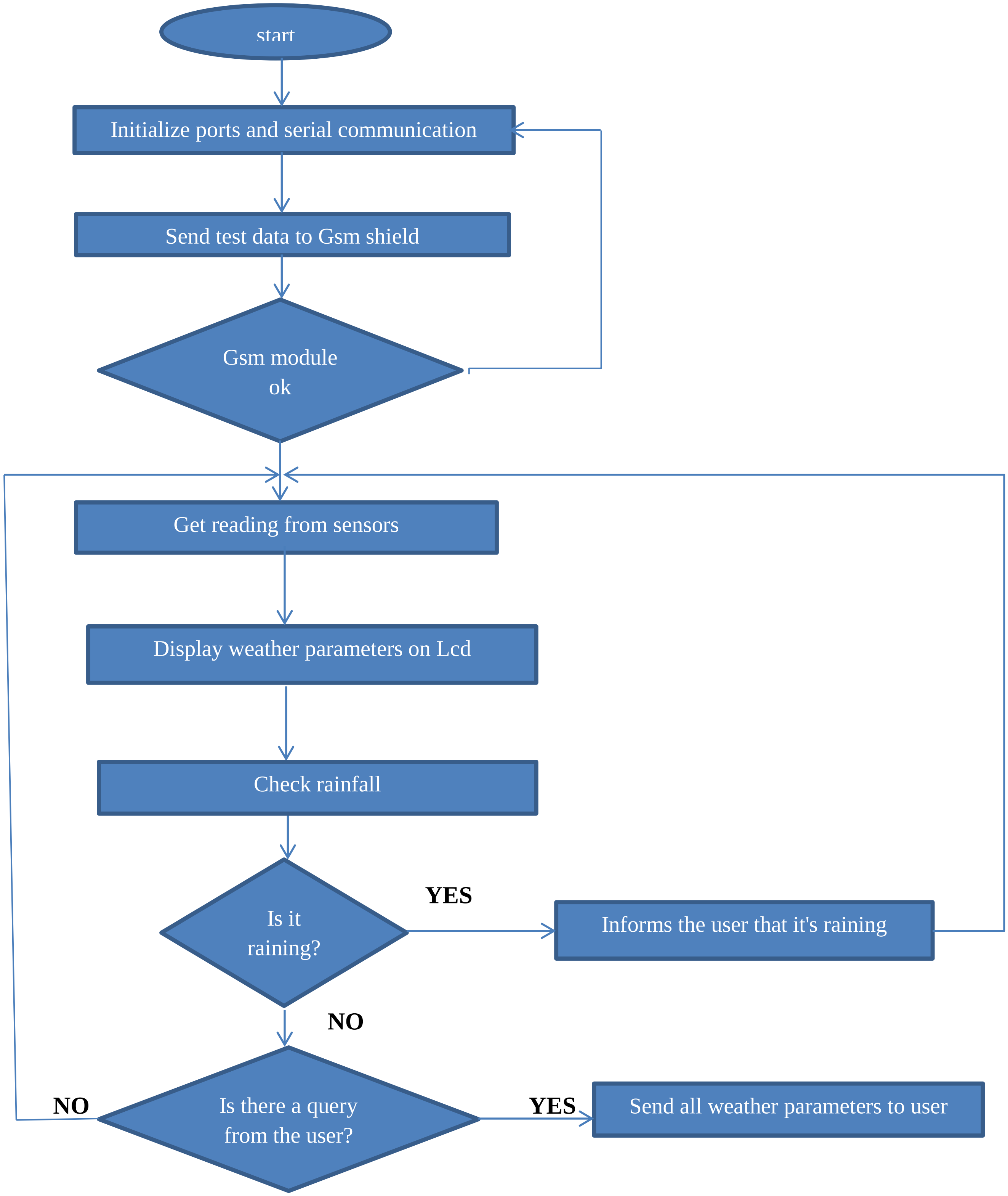

Fig 3.8: system flowchart diagram

3.5 INTEGRATED SYSTEM

Proteus 8 professional software was used to design the circuit diagram for the whole system. All the sensors and the GSM shield were connected to arduino as illustrated in the system schematic diagram in figure 3.9 below

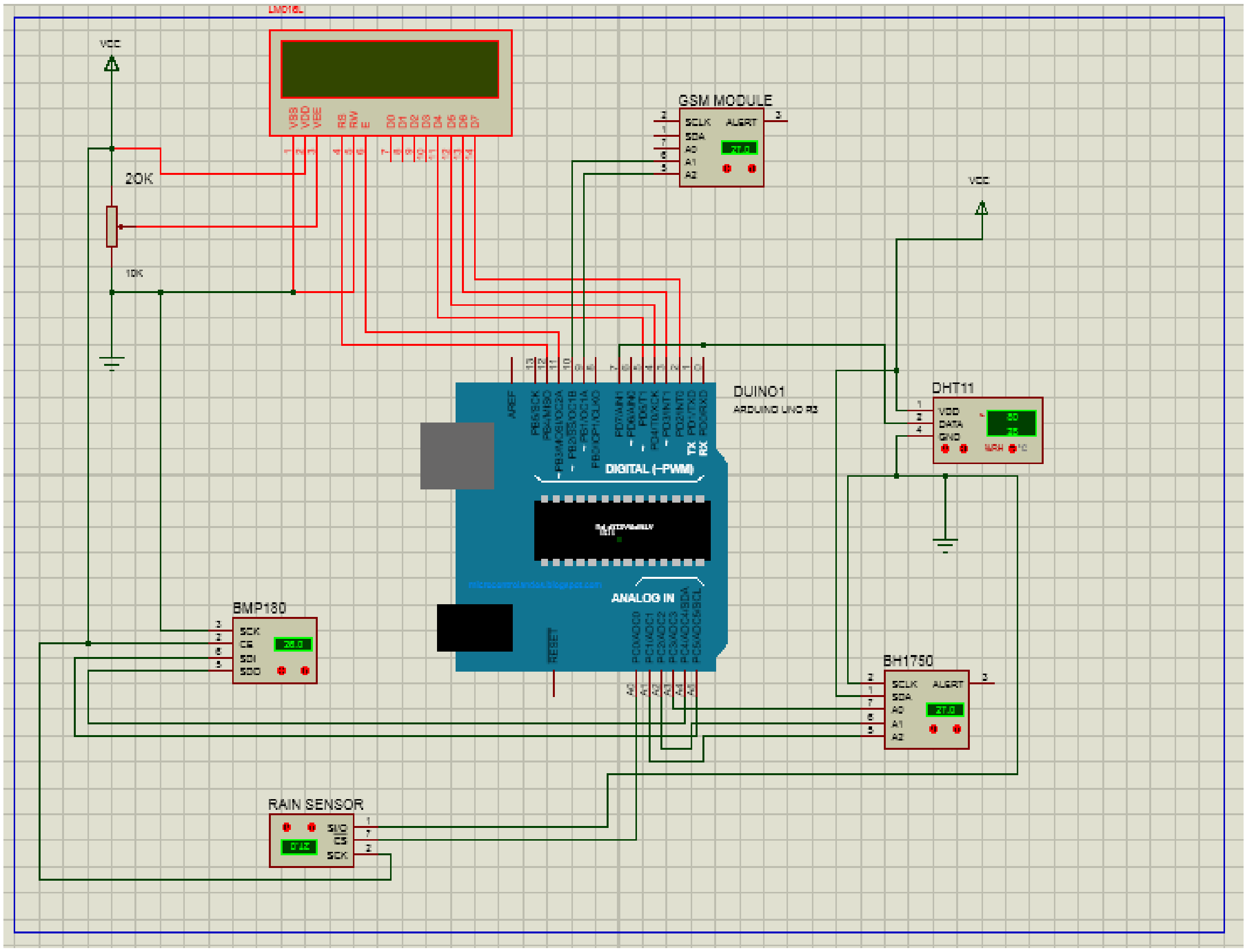

Figure 3.9: System schematic diagram

The code that was written and uploaded to Arduino uno board is shown in the appendix

REFERENCES

[**1**] P.Susmitha *"Design and Implementation of Weather Monitoring and Controlling System"*, International Journal of Computer Applications (0975-8887), Volume 97-No.3, July-2014.

[2]. KarthikKrishnamurthi, SurajThapa, LokeshKothari, Arun Prakash, March 2015, "Arduino Based Weather Monitoring System",International Journal of Engineering Research and General Science Volume 3, Issue 2.

[3] *ATmega32 Datasheet,* Atmel Corp., 2006.

[4] Subhani Sk., Sateesh, Chaitanya and Prakash Babu , "Implementation of GSM Based Heart Rate and Temperature Monitoring System," *Research Journal of Engineering Sciences,* vol. 2, pp. 43-45, april 2013.

CHAPTER 4: RESULTS AND ANALYSIS

4.1 INTRODUCTION

This chapter presents the experimental results of the developed system prototype. The measured weather parameter's data collected from each sensor is presented using screen shots. A discussion of the results and problems faced during the project is also outlined. The circuit diagram was connected and it worked as expected, Figure 4.1 below shows the developed weather station model.

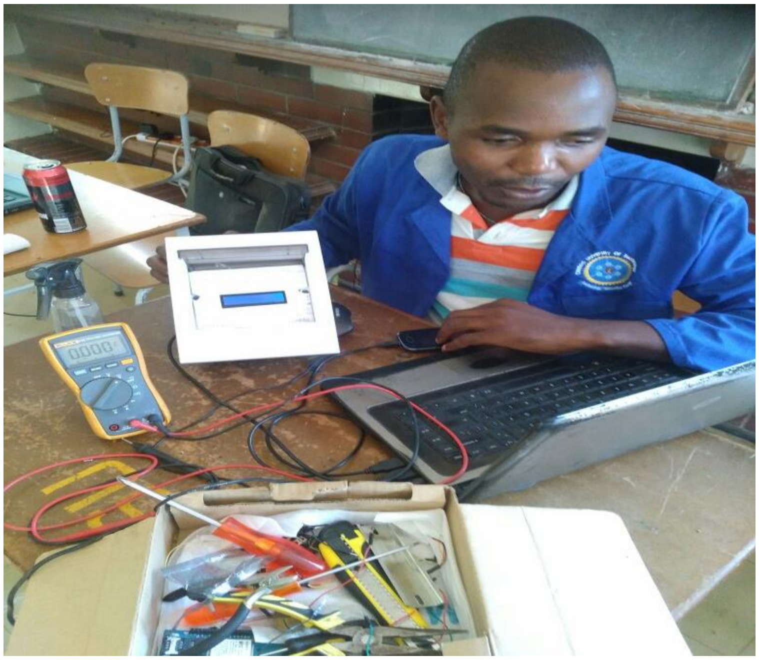

Figure 4.1: developed prototype

4.2 RESULTS

4.2.1 HUMIDITY AND TEMPERATURE MEASUREMENTS

The humidity and temperature measurements from the DHT11 sensor are shown in figure 4.2 below

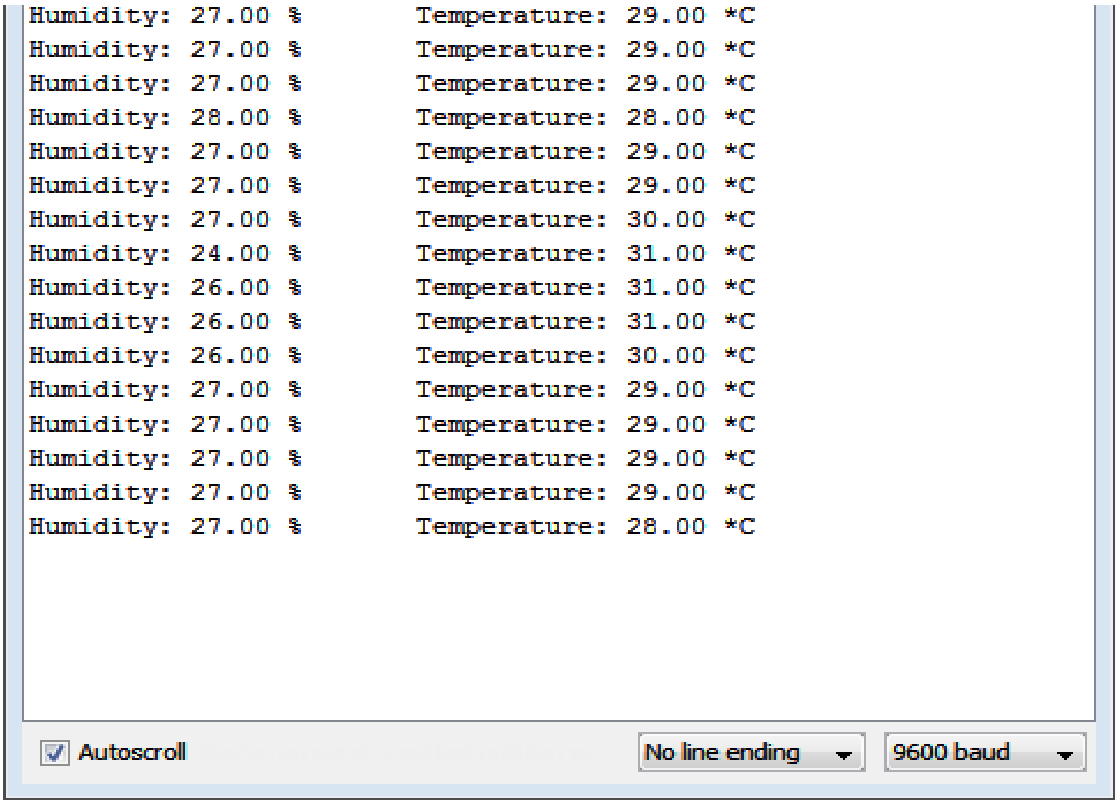

Figure 4.2: temperature and humidity measurement

4.2.2 PRESSURE MEASUREMENT

The BMEP280 barometric pressure sensor was used to measured pressure of the surrounding environment. In addition the BMEP280 sensor is also capable for measuring temperature and altitude. The measured values from the sensor are displayed in figure 4.3 below

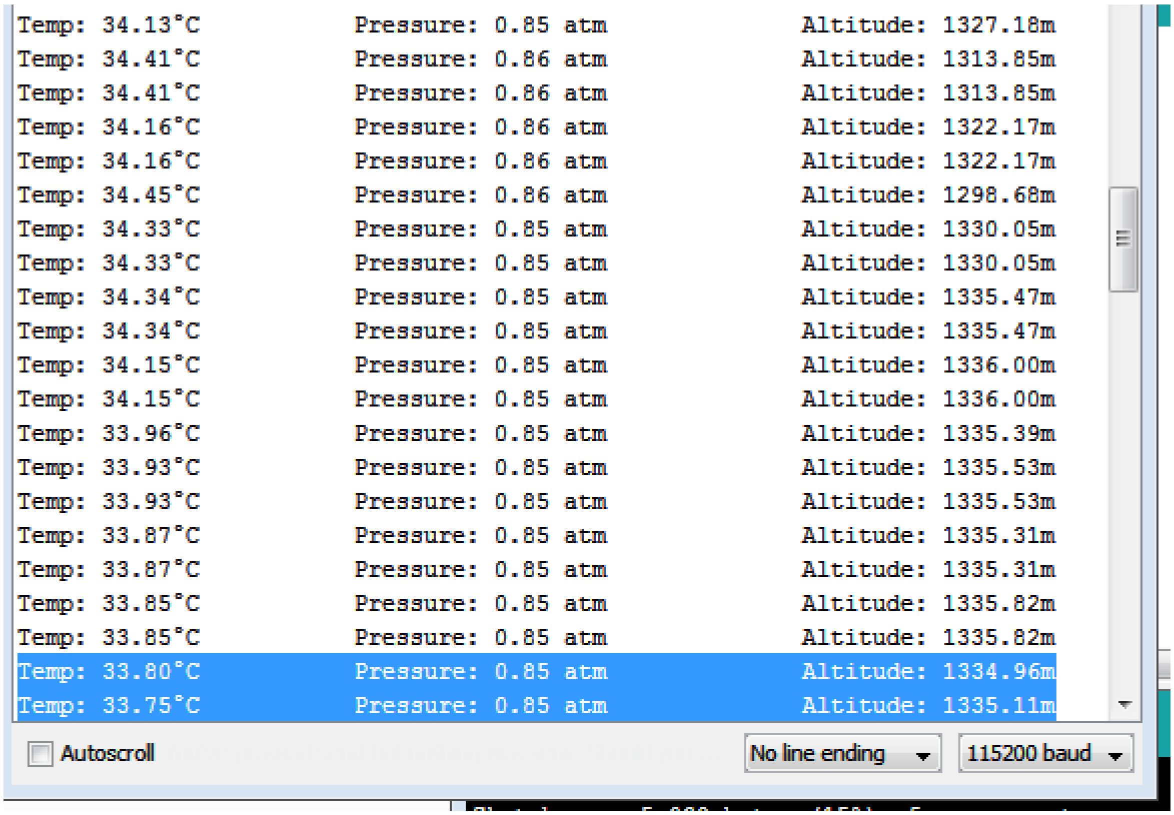

Figure 4.3: BMEP280 pressure, altitude and temperature measurements

4.2.3 LIGHT INTENSITY MEASUREMENT

The BH1750 sensor was used to measure light intensity using the lux unit. The variations in light intensity at the weather station will indicate cloud cover in the sky. High light intensity will indicate a clear sky with absence of clouds, while low light intensity during the day will indicate the presence of clouds in the sky. Figure 4.4 below show light intensity measurements from the sensor.

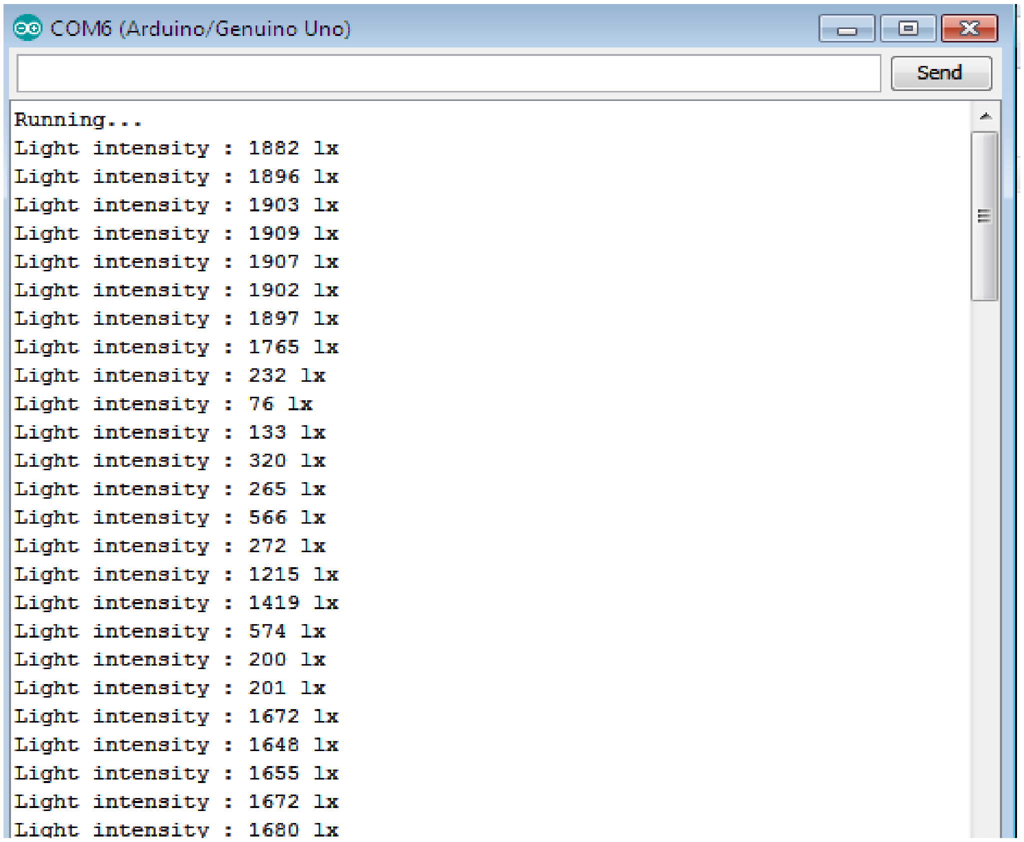

Figure 4.4: light intensity measurements

4.2.4 OVERAL WEATHER STATION RESULTS

The overall system weather parameter measurements that are send to the user are displayed in figure 4.4 below.

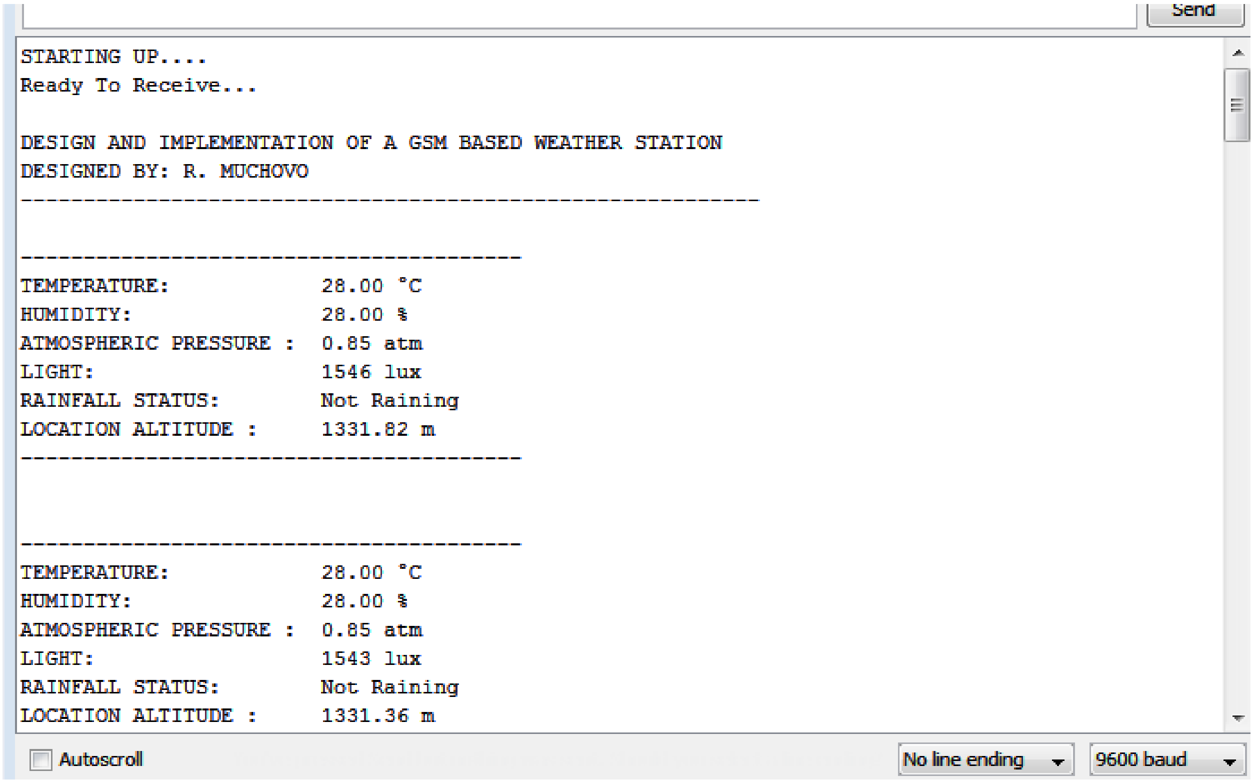

Figure 4.4: overall system measurements

The displayed weather station parameters in figure 4.4 above are transmitted to the user using the GSM shield upon receiving a valid text message from the user. These parameters are displayed on the user’s mobile phone as a text message. Figure 4.5 below shows the received message on user’s mobile phone.

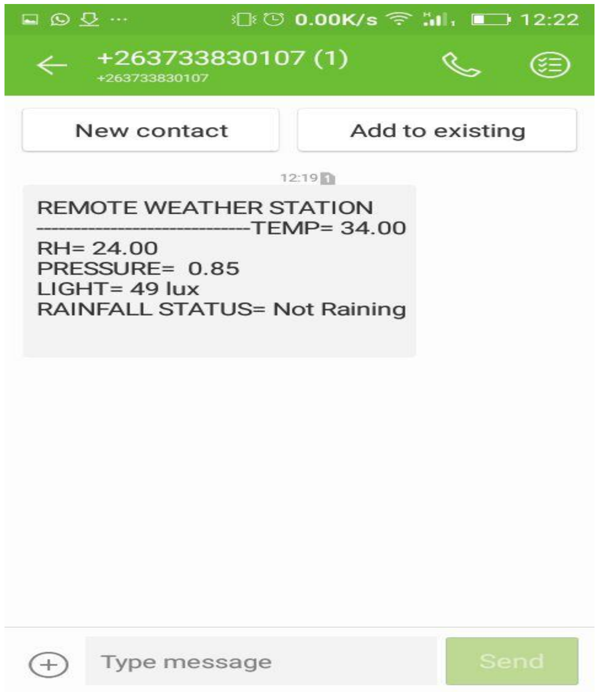

Figure 4.5: received text message on user's phone

When the rain sensor detects the presence of rain a message stating that it's raining is send to the user's cellphone. Figure 4.6 below show the message received.

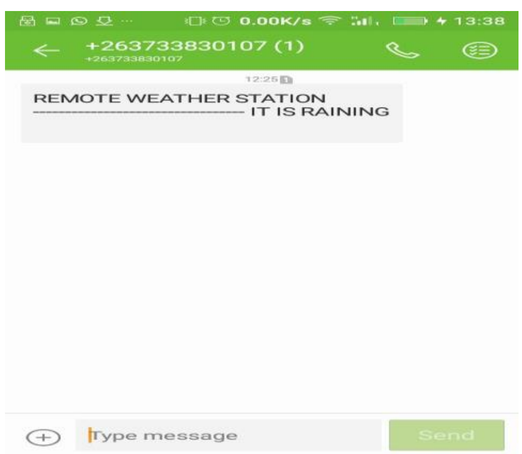

Fig 4.6: raining message

4.2.5 ANALYSIS OF RESULTS

The experimental setup results obtained are purely theoretical values. A reliable analysis of the results could not be performed due to unavailability of standard weather measuring instruments like the barometric pressure measuring instrument, hydrometer for measuring relative humidity and optical photo meters for measuring light intensity. No system is completely immune to defects and the same should be expected on the developed weather station. This may cause variations in measured weather parameters as compared to that of standard measuring instruments. In addition every electronic communication system experiences inherent noise such thermal noise and shot noise, which will definitely affect measures by sensors. However the results of temperature measurements are compared to temperature measured by a thermometer. Fig 4.7 below shows a graph of temperature measured by the DHT11 sensor and that of a thermometer.

4.2.6 LIMITATIONS

The designed prototype is not ideal and the results obtained are purely theoretical values since no comparison was made with measurements by standard weather instruments. The system can be criticized on many scientific aspects:

- The weather station cannot measure all the weather parameters, therefore it is very difficult to accurately forecast and predict future weather conditions using the model.
- The weather station is not equipped with sensors to measure amount of rainfall, wind speed and direction, these results in inaccurate weather forecasting and prediction.
- The system availability and reliability relies on the availability of the GSM network at the location of the weather station. If the GSM network link is down the weather station cannot be remotely accessed.
- The weather station does not have the capability to log data locally at the weather station
- The weather station can only display two parameters on the LCD display locally; hence there is need for a mobile phone to receive all the weather parameters measured by the station.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

CONCLUSION

The design and implementation of the GSM based remote weather station system was successfully designed and practically implemented .The project met all the objectives specified in the proposed solution therefore it means the project was a success . The system can find a wide range of applications in agriculture, tourism, mining, airports and weather reporting. The system can also be useful to students studying meteorology and can be used by ordinary people to help them dress properly according to prevailing weather conditions. The project was made with the best of my abilities in a limited timeframe, but with future enhancements the system will definitely become more useful.

RECOMMENTATIONS

- Further improvement of the system can be achieved by adding sensors that measure amount of rainfall received, wind direction and speed.
- Improve the hardware design so that it allows to be powered by batteries rechargeable by a solar energy.
- Adding a real time clock (RTC), for further improving the statistics of measured parameters.
- Improve the code by considering various problematic cases such as the GSM module may not respond, or the sensors might not respond too.
- Further the system can be improved by making the system web based so that it can be online from anywhere in the world.

APPENDIX: WEATHER STATION CODE USING ARDUINO SOFTWARE

```
#include <SoftwareSerial.h>
#include <LiquidCrystal.h>
#include <BME280.h>
#include <Wire.h>
#include <BH1750.h>
#include "DHT.h"
#define DHTPIN 7
#define DHTTYPE DHT11
BME280 bme;
DHT dht(DHTPIN, DHTTYPE);
BH1750 lightMeter;
SoftwareSerial telecel(9,10);
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

float humidity = 0.0, temperature = 0.0;
int rain_sensor = 8;  //Rain Drop Sensor pin
String msg_to_be_send="";
String msg_received;
String rainfall_status;
bool metric = true;
uint16_t lux =0;
float  bmp_temp =0.0;
float pressure =0.0;
float height;
void get_humidity_temperature();
void lcd_display();
void SendMessage();
void rain_detection();
void printBME280Data(Stream * client);
```

```
void printBME280CalculatedData(Stream* client);
void light_intensity();
void rain_message();

void setup()
{
  lcd.begin(16, 2); // columns, rows. use 16,2 for a 16x2 LCD, etc.
  lcd.print("Starting up"); // start with a "blank screen"
  pinMode(rain_sensor, INPUT);
  digitalWrite(rain_sensor,HIGH);
  Serial.begin(9600);
  telecel.begin(9600);
  lightMeter.begin();
  delay(1000);
  Serial.flush();
  Serial.println("STARTING UP....");
  delay(1000);
  telecel.println("AT\r");
  delay(1000);
  telecel.println("AT+CMGF=1\r");
  delay(1000);
  telecel.println("AT+CNMI=2,2,0,0,0\r");
  delay(1000);
  Serial.println("");
  Serial.println("SYSTEM INITIALISATION SUCCESSFULL!!! ");
  Serial.println(" ");
  Serial.println("");
  Serial.println("DESIGN AND IMPLEMENTATION OF A GSM BASED WEATHER
STATION");
  Serial.println("DESIGNED BY: R. MUCHOVO");
  Serial.println("-----------------------------------------------------------");
```

```
  Serial.println("SYSTEM READY TO RECEIVE.......");
  Serial.println("");
  delay(1000);
   while(!Serial) {} // Wait
  while(!bme.begin())
   {
     Serial.println("Could not find BME280 sensor!");
     delay(1000);
     lcd.setCursor(0, 0); // set cursor to column 0, row 0 (the first row)
     lcd.print("Ready To Receive...");

  }

}

void loop()
{
    delay(100);
    get_humidity_temperature();
    lcd_display();
    rain_detection();
    pressure_sensor();
    light_intensity();
    serial_display();

     delay(500);
  while (telecel.available()>0)
  {
    delay(10);
    msg_received = telecel.readString();
    delay(100);
```

```
    Serial.print(msg_received);
    if (msg_received.indexOf("All") >= 0)
    {
      SendMessage();
    }
  }

}

void SendMessage()
{

  telecel.println("AT+CMGS=\"+263774222696\"\r"); // Replace x with mobile number
  delay(1000);
  telecel.println("REMOTE WEATHER STATION");// The SMS text you want to send
  telecel.println("------------------------------");
  delay(1000);
     telecel.print("TEMP= ");
     telecel.println(temperature);
    // telecel.print(" ");
    // telecel.print(char(176));
     //telecel.println("C");
     telecel.print("RH= ");
     telecel.println(humidity);
     //telecel.println(" %");
     telecel.print("PRESSURE=  ");
     telecel.println(pressure);
    // telecel.print(" atm");
     telecel.print("LIGHT= ");
     telecel.print(lux);
     telecel.println(" lux");
```

```
    telecel.print("RAINFALL STATUS= ");
    telecel.println(rainfall_status);
    //telecel.println("ALTITUDE= ");
    //telecel.print(height);
    //telecel.println(" m");
    telecel.println((char)26);// ASCII code of CTRL+Z
    delay(3000);
 }

void lcd_display()
  {
    lcd.clear();
    delay(1000);
    lcd.setCursor(0,0); // set cursor to column 0, row 1 (the first row)
    lcd.print("temp: ");
    lcd.print(temperature);
    lcd.print(" ");
    lcd.print((char)223);
    lcd.print("C");
    lcd.setCursor(0,1); // set cursor to column 0, row 1 (the first row)
    lcd.print("Hum: ");
    lcd.print(humidity);
    lcd.print(" %");
    delay(2000);
  }

void get_humidity_temperature()
  {

    // Check if any reads failed and exit early (to try again).
     if (isnan(humidity) || isnan(temperature))
```

```
      {
        Serial.println("Failed to read from DHT sensor!");
        return;
      }
   humidity = dht.readHumidity();
   temperature = dht.readTemperature();
   delay(100);

 }
void serial_display()
  {
   Serial.println("<html><head></head><body><h1>test</h1><p>");
   Serial.println(" ");
   Serial.println("----------------------------------------");
   Serial.print("TEMPERATURE:           ");
   Serial.print(temperature);
   Serial.print(" ");
   Serial.print(char(176));
   Serial.println("C");
   Serial.print("HUMIDITY:              ");
   Serial.print(humidity);
   Serial.println(" %");
   Serial.print("ATMOSPHERIC PRESSURE :  ");
   Serial.print(pressure);
   Serial.println(" atm");
   Serial.print("LIGHT:                 ");
   Serial.print(lux);
   Serial.println(" lux");
   Serial.print("RAINFALL STATUS:       ");
   Serial.println(rainfall_status);
   Serial.print("LOCATION ALTITUDE :     ");
```

```
    Serial.print(height);
    Serial.println(" m");
    Serial.println("----------------------------------------");
    Serial.println("");
    delay(1000);
    Serial.println("</p></body></html>");
   }

void rain_detection()
{
 int temp = digitalRead(rain_sensor); // Read Digital value from raindrop detection sensor
  if (temp == LOW)
 {
   rainfall_status ="It's Raining";
   rain_message();
   delay(1000);
 }
 else
 {
   rainfall_status="Not Raining";
   delay(2000);
 }
}

void pressure_sensor()
  {
    printBME280Data(&Serial);
    printBME280CalculatedData(&Serial);

  }
```

```
void printBME280Data(Stream* client)
{
  float temp(NAN), hum(NAN), pres(NAN);
   uint8_t pressureUnit(3);   // unit: B000 = Pa, B001 = hPa, B010 = Hg, B011 = atm, B100 = bar,
B101 = torr, B110 = N/m^2, B111 = psi
  bme.ReadData(pres, temp, hum, metric, pressureUnit);                // Parameters: (float&
pressure, float& temp, float& humidity, bool hPa = true, bool celsius = false)
  bmp_temp =temp;
  pressure =pres;

}
void printBME280CalculatedData(Stream* client)
{
  float altitude = bme.CalculateAltitude(metric);
  height = altitude;

 }

void light_intensity()
{
   lux = lightMeter.readLightLevel();
   delay(100);
}

void rain_message()
  {



  telecel.println("AT+CMGS=\"+263774222696\"\r"); // mobile number of receiver
  delay(1000);
  telecel.println("REMOTE WEATHER STATION");// The SMS text you want to send
```

```
telecel.println("---------------------------------");
delay(1000);
telecel.println(" IT IS RAINING ");
telecel.println((char)26);// ASCII code of CTRL+Z
delay(3000);
 }
```