International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
(Vol. 29, Issue 01) and (Publishing Month: April 2016)
(An Indexed, Referred and Impact Factor Journal)
ISSN: 2319-6564
www.ijesonline.com

# Weather Monitoring System

**Husham Mohammed Elhassan[1] and Dr. Amin Babiker Abd Alnabi[2]**

**[1]MSc, Embedded System Department, Al-Neelain University**
**Sudan, Khartoum**
***hushamelberiar@gmail.com***

**[2]Faculty, Electric and Electronics Engineer Department, Al-Neelain University**
**Sudan, Khartoum**
***amin31766@gmail.com***

**Publishing Date: April 18, 2016**

**Abstract**

The system designed for monitoring climate changes such as (Temperature, Atmospheric pressure, Relative humidity, Wind speed), it helped the observers to get accurate reading in real time and record the sample of data in specific time to predict the weather changes in future, in this design we used appropriate sensors, the analogue outputs of the sensors are connected to a PIC 16F877A microcontroller through an analog to digital converter (ADC) for digital signal conversion. An LCD 20x4 display is also connected to the microcontroller to display the measurements, for analysis and archiving purposes, the data also transferred from microcontroller to a PC using a serial communication interface.

The PC server program receives data from microcontroller unit via serial port; the data received are decoded, stored in database file, displayed in graphical user interface (GUI) and then transmitted to clients through a network using (TCP/IP) protocol. The client's software provides display the received data from a network in a graphical user interface (GUI).

The system has many advantages as compared to other systems in terms of cost, accuracy of measurement, smaller size, huge memory capacities, on device display (LCD), and greater portability [1].

***Keywords:*** *PIC 16F877A Microcontroller, Analog to Digital Converter (ADC), PC Server, Graphical User Interface (GUI), Database File, (TCP/IP) Protocol, Clients.*

## 1. Introduction

After visited weather station and navigation center in Khartoum Airport and after the discussion with the team workers for different sections, we noticed many problems that faces the observers that system it still using a traditional weather station for monitoring and recording data.

In spite of its high accuracy, the observers face many problems in delivering the weather reading from different locations to the central unit and in recording them in hardware database (notebooks).

Normally the transmission of these data is usually done through telephone calls and there might be an error in the hearing of the person who receives the call. Another problem is related to absence of data measurement outside the normal working hours. Despite of all previous problems, they have very good weather database. Beside the needs of increasing the reliability of measurements.

The aim of this project is to provide computerized, weather monitoring system to increase the reliability of measurements by using sophisticated technology and modern, digital measurement techniques with an easy accessibility and availability of this measurement and finally the real time of measurements. So it explains the design and implementation of the aim real-time weather monitoring system, data acquisition and data presentation, figure (1) shows the system block diagram.

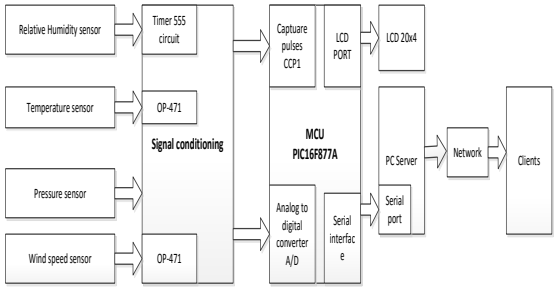


**Figure 1: System Block Diagram**

## 2. Materials and Methods

### 2.1 LM35 Temperature Sensor

The LM35 is the precision integrated circuit temperature sensor, whose output voltage is linearly proportional to the Celsius temperature + 10.0 mV/°C. The features of LM35 sensor are low cost, low output impedance 0.1Ω for 1 mA, linear output, used with single power supplies 4 to 30 volts, has very low self heating draws only 60 µA from its supply [2].
The basic centigrade temperature sensor connection appears in figure 2.

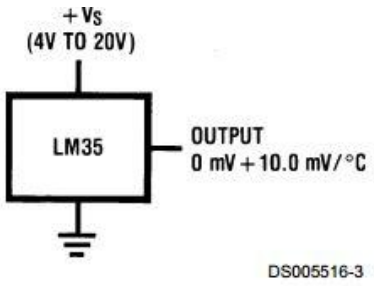


**Fig. 2 Basic centigrade temperature sensor (+2 to +150C)**

.

### 2.2 HS1101LF Relative Humidity Sensor

The (HS1101LF) sensor based on a unique capacitive cell. The features of this sensor are suitable for linear voltage or frequency output circuitry , very low temperature coefficient, very fast response time , long term stability and high reliability [3].

From data sheet of HS1101LF sensor the relation between output frequency and relative humidity is consider in table (1).

**Table1: Relationship between Output Frequency and Relative Humidity**

| RH (%) | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fout (Hz) | - | - | 7155 | 7080 | 7010 | 6945 | 6880 | 6820 | 6760 | 6705 | 6650 |
| RH (%) | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 | |
| Fout (Hz) | 6600 | 6550 | 6500 | 6450 | 6400 | 6355 | 6305 | 6260 | 6210 | - | |

The relation between relative humidity and output frequency are calculated by using Matlab program, figure (3) shows the result.

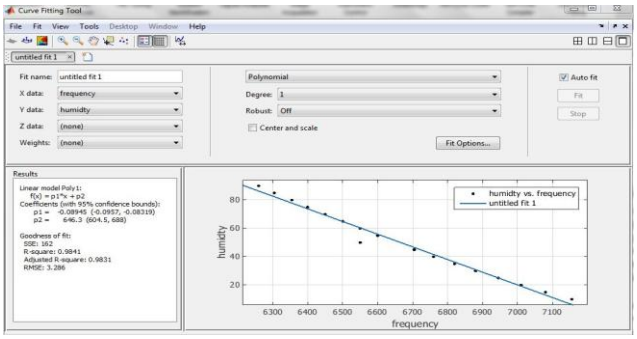


**Figure 3: Relation between Relative Humidity and Output Frequency**

Equation (1) considers the relation between relative humidity and output frequency

$$RH=565.1-0.076725 \times freq \quad (1)$$

### 2.3 Wind Speed Sensor

An anemometer is a device used for measuring wind speed, and is a common weather station instrument [4], the features of an anemometer sensor are:
Output: 0.4V to 2V
• Testing Range: 0.5m/s to 50m/s
• Start wind speed: 0.2 m/s
• Resolution: 0.1m/s
• Accuracy: Worst case 1 meter/s
• Max Wind Speed: 70m/s

**Figure 4: Anemometer Sensor**

### 2.3.1 Anemometer Sensor Connection:

Three wires of anemometer black, brown and blue are connected as flows, the brown wire should be connected to the positive power source 9 volt. The black should be connected to ground, and the blue is the output signal for the anemometer.

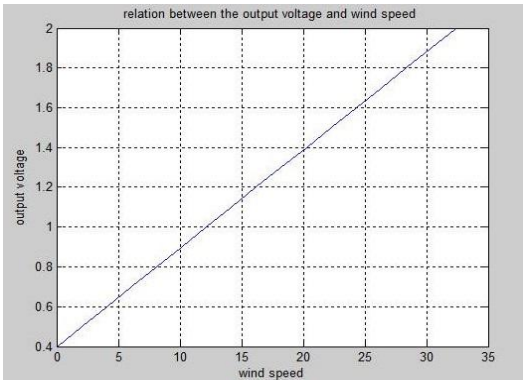


**Figure 5: Relation between Output Voltage and Wind Speed**

Equation 2 shows the relation between wind speed and output voltage

wind_speed= 20.25 x(output voltage - 0.4 );

(2)

### 2.4 Integrated Silicon Pressure Sensor MPX4115A

The pressure sensor is used to sense absolute air pressure in an altimeter or barometer applications. Free scale's barometer sensor integrates on-chip, bipolar op amp circuitry and thin film resistor networks to provide a high level analog output signal and temperature compensation [5].

The Features of MPX4115A sensor are the maximum error at 0° to 85° C is 1.5%, Ideally suited for Microprocessor or Microcontroller-Based Systems.

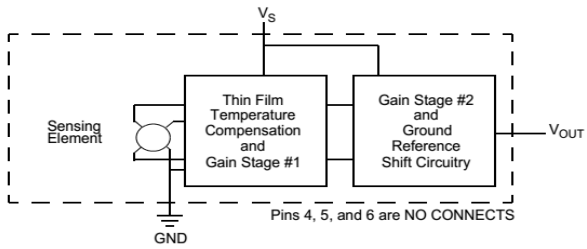


**Figure 6: Integrated Pressure Sensor Schematic**

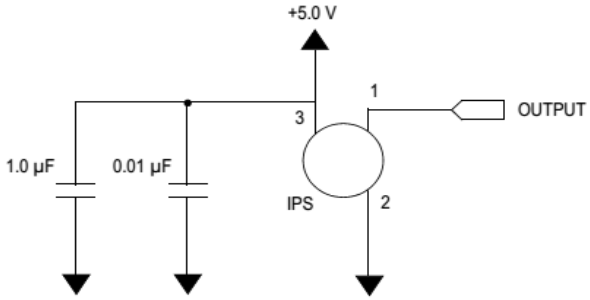


**Figure 7: Recommended Power Supply Decoupling**

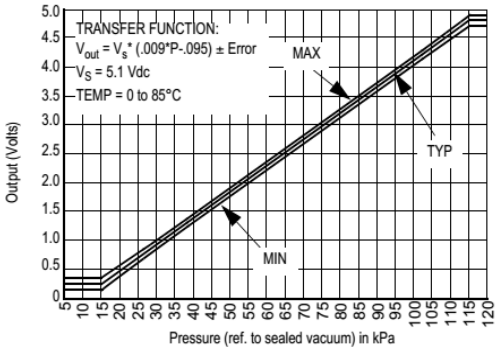


**Figure 8: Relation between Output Voltage and Absolute Pressure**

The transfer functions of MPX4115A pressure sensor:

$V_{out}$= VS (P x 0.009 - 0.095) ± (Pressure Error x Temp. Factor x 0.009 x VS) (3)

Where:

P =atmospheric pressure (kilopascals)
$V_{out}$ =output voltage of the sensor (V)
VS = voltage supply = 5.1 V ± 0.25 $V_{dc}$

Pressure Error= ± 1.5 KPa at pressure 15 to 115 KPa
Temp Factor = 1 at 0° to 85° C.
Temp Factor = 3 at 0° to -40° C.
Temp Factor = 3 at 85° to 120° C.

## 2.5 Signal Conditioning Circuit

In this system the signal conditioning circuit is composed of power supply circuit, amplification circuits, filtering circuit, and isolation.
The analog output signal from temperature sensor and wind speed sensors are too small compared with reference voltage of a microcontroller.
In temperature sensor LM35 the maximum output voltage = 1.5 volt at 150 °C and the minimum output voltage = 0.2 volt at 2 °C, according to the connection in Figure (2).
To improve the accuracy, we used non- inverting operational amplifier with gain 3.3 to increase the maximum analog input voltage to 4.95 volt.
In wind speed sensor the maximum output voltage = 2 volt at wind speed 32.4 m/s and the minimum output voltage = 0.04 volt at wind speed 0 m/s .
To improve the accuracy, we used non inverting amplifier with gain 2.5 to increase the maximum analog input voltage to 5 volt.
The maximum output voltage of Pressure Sensor MPX4115A = 4.9 volt at 115KPa and the minimum output voltage =0.4 volt at 15 KPa, the output signal is proper for reading.

The HS1101LF it connects with timer 555 in a stable circuit as shown in figure (9).

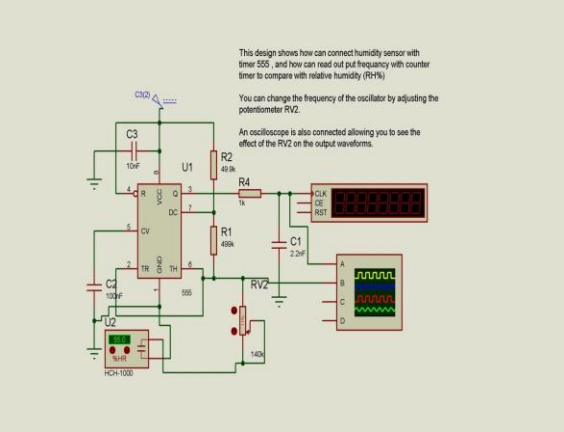


**Fig.9 HS1101LF sensor connected as variable capacitance**

## 2.6 Micro Controller Unit (MCU)

PIC16F877A is the heart of whole system. It receives analogue signals and digital signals equivalent to the quantity of the weather variable to be measured from sensors connected to it and conversion and processing through pre-programmed instructions written in MikroC Pro for PIC software[12] ,to ensure that corresponding measurement made by these sensors are available in forms that are meaningful and useful for human analysis, interpretation and record.
In this proposed system, we have used PIC16F887A microcontroller for the measurement of weather conditions and send data using serial interface to Pc server.
The simple linear relationship between ADC input and ADC output is given by:

(ADC_ Result / 1023) = (V in / V ref ) (4)

The CCP configured as capture mode that capture every rising edge of the pulses when capture it's occurred save the TMR1 value in CCPR1H:CCPR1L registers, the interrupt request flag bit, CCP1IF is set. The interrupt flag must be cleared in software. If another capture occurs before the value in register CCPR1 is read, the old captured value is overwritten by the new value [7].

## 2.7 System Hardware

The LM35 sensor is connected to non inverting amplifier with gain A_v =1.3 , and then connected MCU at PORTA channel 0 , MPX4115A Pressure Sensor is decoupling supply as shown in fig (7) for filter output and then the output signal is connected MCU at PORTA channel 1 , An anemometer is connected to non inverting amplifier with gain A_v =2.5, and then the output signal is connected to MCU at PORT A channel 4, HS1101LF sensor is connected with timer 555 in a stable mode as shown in figure(4) , external reference voltage Vref+ is connected to PORT A channel 3 and VREF- is connected PORT A channel 2,Battery is connected with 7805 regulator and then supply the MCU , LCD 20x4 is connected to PORT B ,PORTC is sending data from PIN 6 which is connected to max232 for converting TTL level to serial level, A 16MHz crystal is connected to the OSC1 and OSC2 pins. Also, an external reset push button is connected to the MCLR input to reset the microcontroller when required. The circuit diagram of the system is shown in Figure (10).

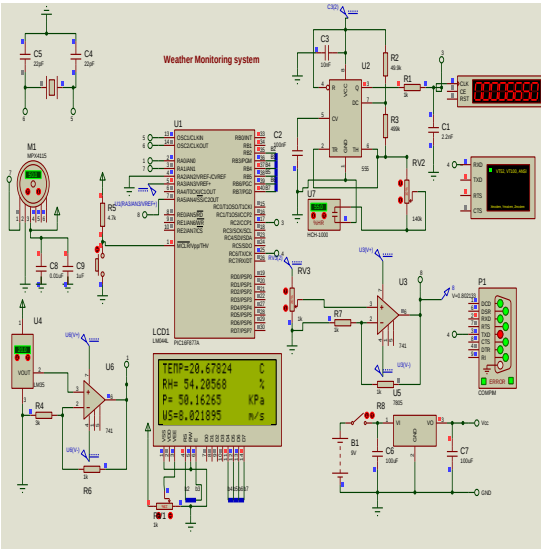


**Figure 10: The Circuit Diagram of the System**

## 2.8 Software Description

### Microcontroller Firmware

The code are created using MikroC Pro for PIC software, it comes with rich resources, such as a large number of library functions and an integrated development environment.

The program starts with initialize the main components such as (A/D converter module, CCP module, LCD display)

The CCP1 module check if the second rising edge it is captured from train input pulse ,while it captured then disable interrupts and clear flag (CCPIF) until complete the processing .

In the interrupt services routine (ISR) the period between the two rising edge pulses are calculated (P = t2 - t1) , in the main program function the relative humidity are calculated according to equation (1),and A/D start to convert analog signals of sensors (temperature sensor at channel 0 ,pressure sensor at channel 1, wind speed sensor channel 4 ) to digital.

The temperature values are calculated according to equation (4), the pressure values are calculated according to equation (3), The wind speed values are calculated according to equation (2), the relative humidity are calculated according to equation (1).

For displaying the gathered data, it must be converting into string data and then sending to an LCD.

Data sent to the PC server through serial interface, Figure (11) shows the Flow chart of the microcontroller firmware.

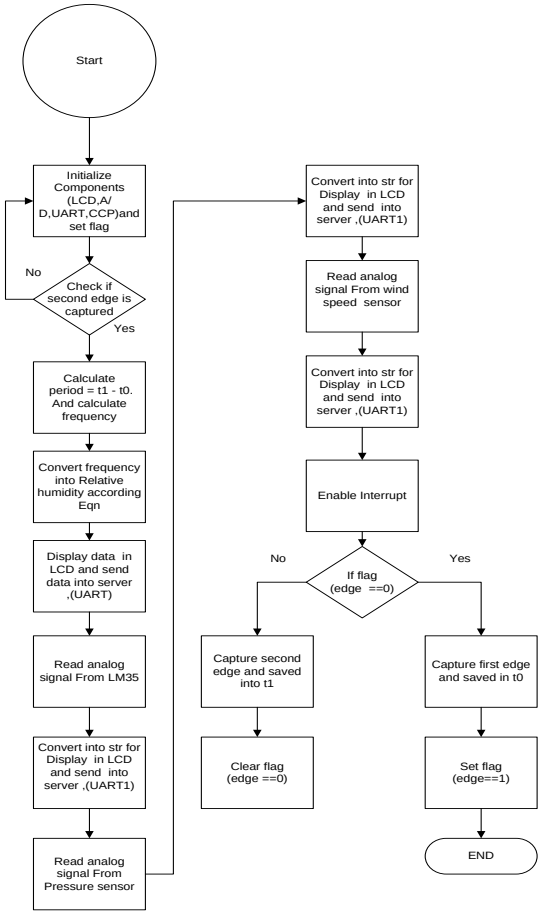


**Figure 11: Flow Chart of the Microcontroller Firmware**

The microcontroller sends data as string format, including temperature, wind speed, atmospheric pressure and relative humidity via serial interface connection to the Pc server Figure (12) shows the message format.

| H | Relative Humidity | T | Temperature | P | Atmospheric pressure | W | Wind Speed |
|---|---|---|---|---|---|---|---|

**Figure 12: The Message Format, the Size of the Massage or (Packet) is 8 byte**

The server receives string data or(packet) and provides filter to separate (relative humidity data, temperature data, Atmospheric pressure data, Wind Speed data), displays the parameters in Graphical User Interface (GUI) , it helps the user to monitor and access to the data base.

The server communicates to the clients through TCP/IP protocol, the communication starts with client request, and server listen to the port, the server accepts connection, the client send query, the server process query and send back to client, the client send acknowledgement, this procedure its repeated until the client or server close connection, figure (13) shows the flow chart of server program.

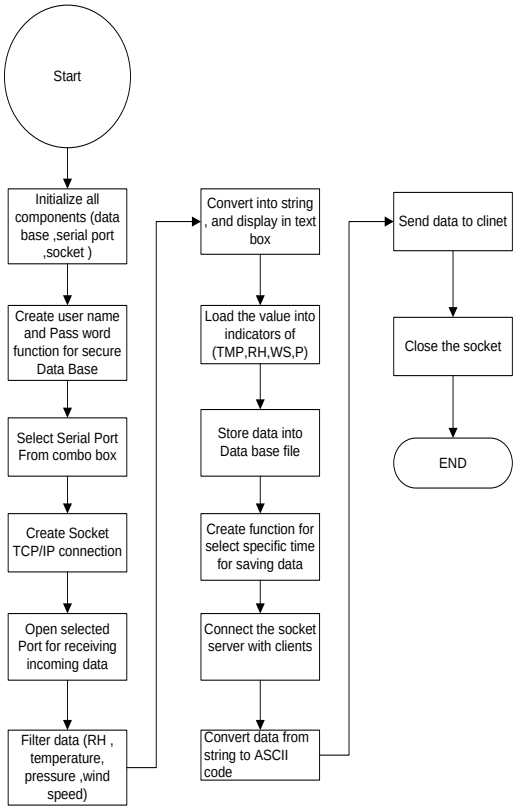


**Figure 13: Flow Chart of Server Software**

The client initiates the communication by sending query to the server, waits until server send response it receive the packet from server as ASCII data, it converts data to string, provide filter (separate relative humidity data, from temperature data from wind speed data from atmospheric pressure data), displays the parameters in GUI, figure (14) shows the flow chart of client program.

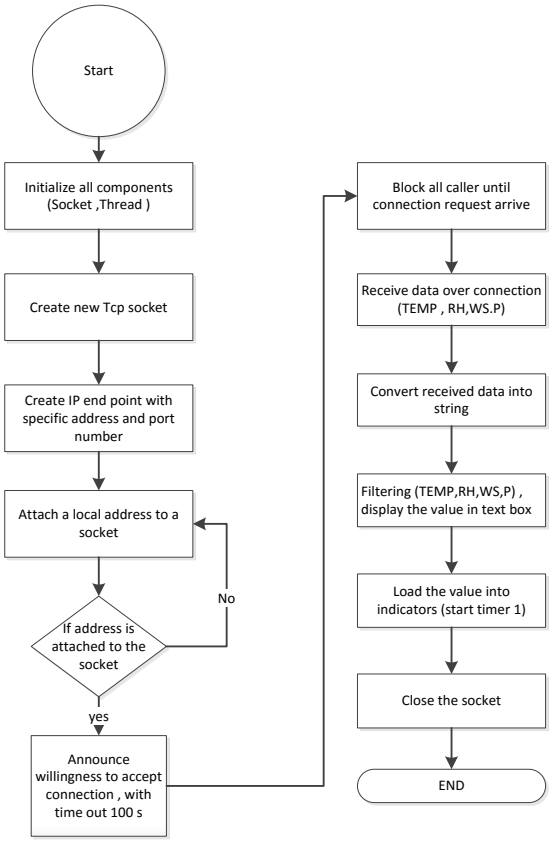


**Figure 14: Flow Chart of Client Software**

## 3. Results

The monitoring system is designed with high accuracy in measurement of (humidity, temperature, wind speed and atmospheric pressure). It offers data base for archiving and also it can send data to clients through TCP/IP. The simulation result is summarized in Table 2, Table 3, Table 4 and Table 5.

**Table 2: Comparison of Temperature Measurements**

| Ideal temperature of LM35 in˚C | Temperature measured by system design in ˚C | Difference ˚C |
|---|---|---|
| 25 | 25.41 | 0.41 |
| 30 | 30.30 | 0.30 |
| 35 | 35.19 | 0.19 |
| 40 | 40.07 | 0.07 |
| 45 | 44.96 | 0.04 |

**Table 3: Comparison of Relative Humidity Measurements**

| Ideal Relative Humidity of HS1101LF sensor in % | Relative Humidity measured by system designed in % | Difference % |
|---|---|---|
| 20 | 19.52 | 0.48 |
| 30 | 31.12 | 1.12 |
| 40 | 41.6 | 1.6 |
| 50 | 51.4 | 1.4 |
| 60 | 60.43 | 0.43 |

**Table 4: Comparison of Wind Speed**

| Ideal Wind speed of anemometer In (m/s) | Wind speed measured by system designed in (m/s) | Difference (m/s) |
|---|---|---|
| 8.1 | 8.02 | 0.08 |
| 16.2 | 16.03 | 0.07 |
| 20.2 | 20.04 | 0.06 |
| 24.3 | 24.05 | 0.295 |
| 28.3 | 28.05 | 0.295 |

**Table 5: Comparison of Pressure Measurements**

| Ideal Pressure of MPX4115A sensor in (KPa) | Pressure measured by system designed in(KPa) | Difference in (KPa) |
|---|---|---|
| 15 | 15.2 | 0.2 |
| 20 | 20.2 | 0.2 |
| 30 | 30.1 | 0.1 |
| 40 | 40.1 | 0.1 |
| 50 | 50.1 | 0.1 |

The Pc server program is designed and it proves all functions, figure (15) shows the software server after run

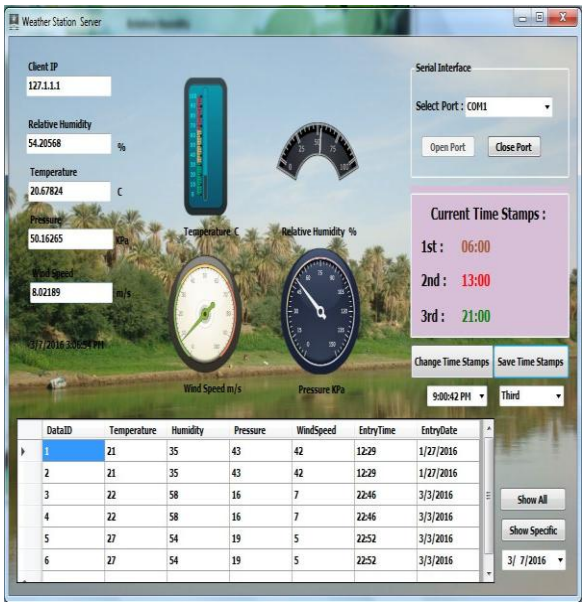


**Figure 15: Server Program after Run**

The client program prove all functions figure (16) show program after run


**Figure 16: Client Program after Run**

## 4. Discussion

The signal conditioning circuit is helped to increase the accuracy and resolution of measurement as shown the result in Tables 2, 3, 4, 5).

From Table 2, it can be observed that the temperature sensor shows a good level of stability as well as accuracy. The average error of 0.5°C, the humidity sensor of the proposed system also shows a very good accuracy as sown in Table 3. An average error of 1% is observed mainly due to the hysteresis effects of the sensor.

The average error of wind speed sensor is 0.16 m/s, as shown in table 4.

The pressure sensor produced the most accurate measurements compared to other sensors with an average error of ± 0.14 kPa as shown in Table 5.

The clients server program are designed using C sharp language which provides large library of modules such as (serial communication, converting data type, timers, TCP/IP Protocol,...).

Data is sent from MCU to PC server through serial interface as 8 bytes(massage format), the server software receive data, filter data, convert to string to display, store data in data base in

specific time, converting to ASCII, and then send to clients through TCP/IP protocol. The client program receive packet of data and display it in GUI.

## 5. Conclusions

This work focused on solving the problems that faced the observers of weather station and navigation center in Khartoum Airport, we have proposed a robust and cost effective system design that can suit local industries for data acquisition and signal processing.
This inexpensive system is designed with high accuracy of measuring relative humidity, temperature, wind speed, atmospheric pressure.
The problems of transferring data from station to clients is solved by using computer network instead of using traditional method (telephone center), the problems of storing data, it also solved by creating a database file in Pc server, database provided automatically store data .

### Acknowledgments:

Thank God for helping me to complete this work, thanks to electro optics center for supporting this work, thanks to Prof Ismail AL azhari, supervisor of MSC Embedded system, Prof sharif fadul, special thanks for MSc Ahmed Kh. Mohammed, thanks for all staff of ALneelain University.

## References

[1] A Low-Cost Microcontroller-based Weather Monitoring System by : Kamarul Ariffin oordin , Chow Chee Onn and Mohamad Faizal Ismail
[2] LM35 Temperature sensor data sheet
[3] HS1101LF Relative humidity sensor data sheet
[4] Anemometer wind speed sensor data sheet
[5] Integrated silicon pressure sensor PX4115A data sheet
[6] PIC16F877A data sheet
[7] Design and implementation of weather monitoring and controlling system by: Susmitha, G. Sowmyabala
[8] Weather Monitoring Station with Remote Radio Frequency Wireless Communication by: Helman Muhammad
[9] Embedded DAQ System Design for Temperature and Humidity Measurement by: Tarique Rafique Memon
[10] A Microcontroller-Based Data Acquisition System for Solar Radiation and Environmental Monitoring by: Raphael Mukaro and Xavier Francis Carelse.
[11] Design and Development of an Integrated Relative Humidity, Temperature Measurement
and Gas (LPG) Sensing System Using PIC18F25K20 by: Rajeswari Cherukuri, Raghavendra Rao Kanch
[12] Implementation of Microcontroller Based Sensing Unit in Transmitter for Wireless Weather Station by: Lay Nandar Soe, Kyaw Soe Lwin, Hla Myo Tun
[13] WEB based Weather Data Acquiasition System by: Vidyasagar Kalapala