Design and Implement Temperature, Direction and Wind Speed meter by using computer

Lec. Dr. Fouad S. Tahir
Assi. Lec. Ayad M. Salman
Assi. Lec Waleed K. Ibrhem
Energy and Fuel Research Center
University of Technology

Abstract

This paper aims to build a low-cost, t reliable, weather monitoring system capable of acquiring and recording data. The proposed system has three sensors that measure the temperature, wind speed and wind direction, respectively. The analogue outputs of the sensors will be transmitted through the air and received by the weather system to be converted to digital signals and further processed by a microcontroller, acting as data logger. The logged data can then be transferred to a PC having a graphical user interface program for further analysis or printing the .measurements

The system has many advantages like it is a small size and have huge memory capacities, have on device LCD display, lower cost if compared with other climate monitoring system and have high processing speed, high precision and greater portability.

1-Introduction

The measurement of out door and indoor temperature, wind speed, wind direction and relative humidity remotely by using the appropriate sensor is not only important also crucial for many industrial processes control in daily life for building safely and security monitoring, traffic flow measuring, weather condition monitoring … etc. [1]

Weather or climate plays an important role in human life. The thermal comfort of human being is known to be influenced mostly by six parameters, i.e., air temperature, radiation, air flow, humidity, activity level and clothing thermal resistance.[2]

Data acquisition system have become one of the most important aspects in the industrial process and control. A data acquisition system performs the complete function of converting the raw output from one or more transducers into the equivalent digital signals usable for further processing, control or monitoring. [3]

Data acquisition system are widely used in this day because the complexity of circuits become low-cost, more accurate, and relatively simple to implement. In addition there is rapid growth in the use of microcomputers to perform difficult digital control and measurement functions. In this paper we were used the proposed computerized data acquisition system for collect the physical parameters of weather like outdoor temperature, wind speed and wind direction. The collected climate parameters are then saved in computer to be used as weather data base for future.

2-Proposed System Description.

Our system can be divided into three main ports, namely, the sensors and transducer circuits, , digital climate data logger system and system software ,the sensor circuit contains the IC temperature sensor, anemometer sensor and van sensor.

The analogue output from these sensors are collocated and transmitted through air space to the climate data logger. The receiver circuit built in data logger send the received signal to ADC to convert it into digital signal before being fed into climate data logging system which represents by microcontroller. The system have a capable of transfer data between weather data logger and personal computer (PC) through the facilitates of a Universal Serial Bus (USB) interfacing circuit.

USB is a protocol that allows two way communication between peripheral devices and a host computer. It is hot pluggable, allowing the device to be connected and/or removed while the computer is running.The block diagram which represent the overall component of weather data acquisition system is shown in figure (1).

3-Weather parameter measurement Requirement of the Present Work

The weather monitoring system comprises mainly of the following unit:

- sensors and Transducer
- Data logger system.
- System software

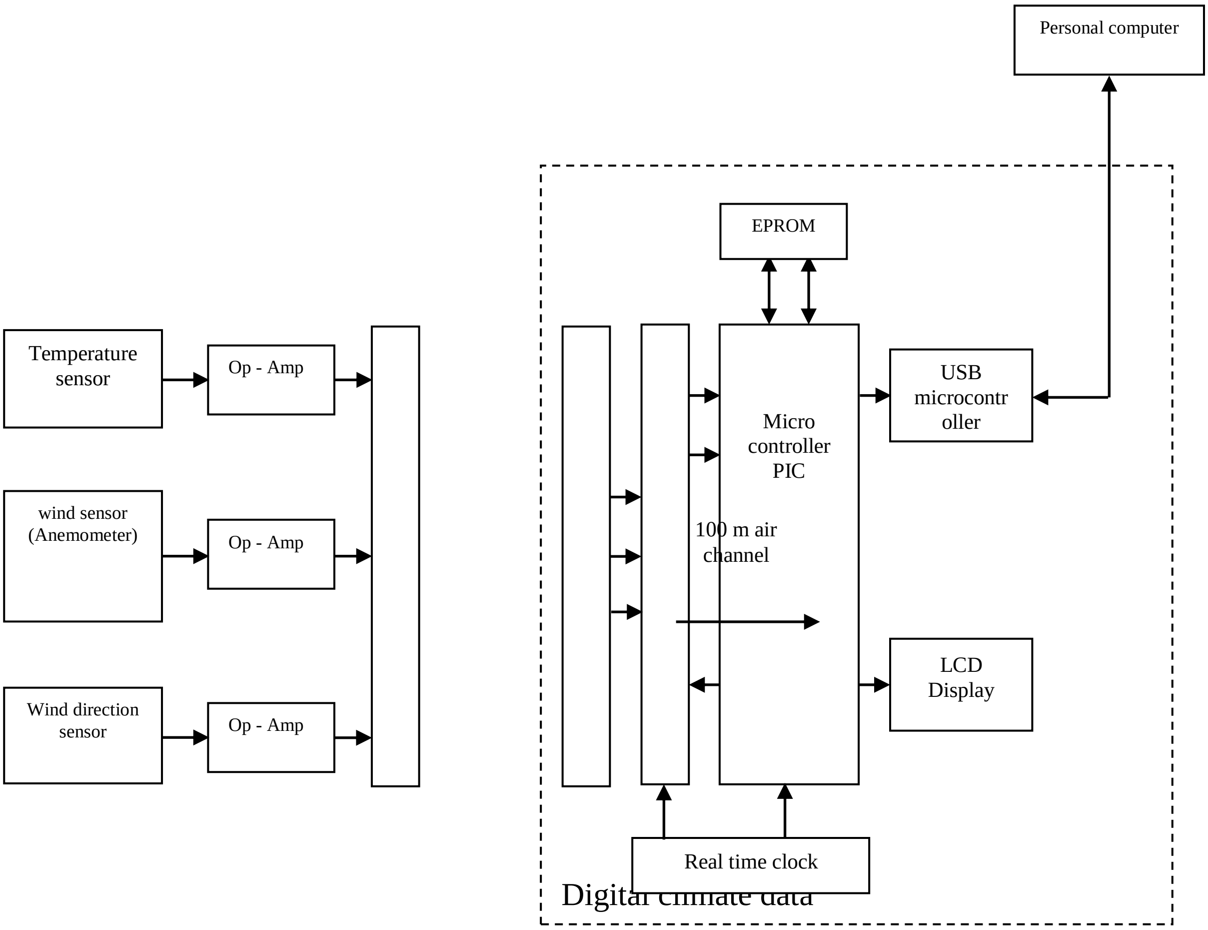

Figure (1): Block diagram of the proposed

Types of Instruments for Weather Temperature, Wind Speed and Direction Measurement:

The two instruments commonly used to measure wind speed and wind direction are the anemometer (wind speed) and the wind vane (wind direction). The wind vane, illustrated in **Fig. 2**, generally consists of a weighted pointer connected to small flat plate. This combination is attached to a rotated vertical shaft. The force of air molecules striking the flat plate causes the shaft to rotate, aligning the plate with the direction of the local airflow.

The weighted pointer serves as a damper to reduce the effect of small variation in actual wind direction, as will as providing a visual indication of the direction the instrument is pointing for alignment purposes.[4]

Direct-wind direction readout (or a potentiometer for remote readings) is usually attached to the rotating shaft of the wind vane. The terms anemometer is derived from the Greek world anemo meaning wind and refer to any instrument used to measure wind velocity. A few popular anemometer types are reviewed below.[4,5]

3-1Pitot Anemometer

The Pitot-static system is the classic method for measurement of aircraft and airflow velocity**.Fig.3a** illustrates the pitot anemometer, one of the simplest instruments that can be used to measure wind speed. This anemometer consists of a simple pitot tube and a pressure-measurement system. It is based on the principle that moving air molecules flowing in the pitot orifice exert a dynamic pressure proportional to the velocity of the air molecules in the tube .[4,5]

3-2. Hot-Wire Anemometer

A hot-wire anemometer consists of an electrically heated, fine-wire element (0.00016 inch in diameter and 0.05 inch long) supported by needles at its ends (see **Fig.3b**). Tungsten is used as the wire material because of its strength and high temperature coefficient of resistance. When placed in a moving stream of gas, the wire cools; the rate of cooling corresponds to the mass flow rate. For every accurate laboratory type measurements the hot-wire anemometer is often used .[4,5]

3.3 Acoustic Anemometer

This sensor has no moving parts. Wind speed determination is as follows. An ultrasonic pulse emitted by a transducer is received by a nearby detector and the transit time calculated. Next, the transit time is measured for the return path. In the absence of wind, the transit times are equal; but in the presence of wind, the wind component along the direction between the transmitter and receiver affects the transit time. This type of anemometer is shown in **Fig.3c** .[4,5]

3-4. Rotational Anemometer

The rotational anemometer **Fig.3d** should be familiar to you as it is the most common type used for meteorological measurements. This anemometer consists of a windmill, propeller or as is most often the case, three semi conical cups attached to a rotating horizontal shaft. Moving air molecules striking this anemometer exert a force on the cups, causing the shaft to rotate about its axis. As air velocity increases, the anemometer shaft's rotational velocity increases proportionality. The shaft is often directly coupled to an electric generator that measures shaft rotation speed and wind speed. In most generator-type rotation anemometer, the magnitude of the generators AC voltage output increases with the shaft frequency. A precision rectifier and filter can by used to convert the AC voltage generated by the rotation shaft in to a more useful DC voltage.

This DC voltage is then directly displayed on a voltmeter calibrated to wind speed. More common, is an electronics switch output. In these anemometers, there is at least one (and often more) switch closure for each rotation of anemometer shaft. The frequency at which switch closure occur is proportional to the wind speed. This frequency covert to an analogue voltage for measurement or computer can measure wind speed directly .[5]

3-5. Integrated Circuit Temperature Sensor

This very cheap, simple means of temperature measurement or compensation for temperature in the range -40°C to +110°C. the integrated circuit, which looks like a small transistor, operates on a power supply between 4 to 30 volts, giving a linear output of 10 mV deg./°C, with an accuracy of ±0.4 °C .[6]

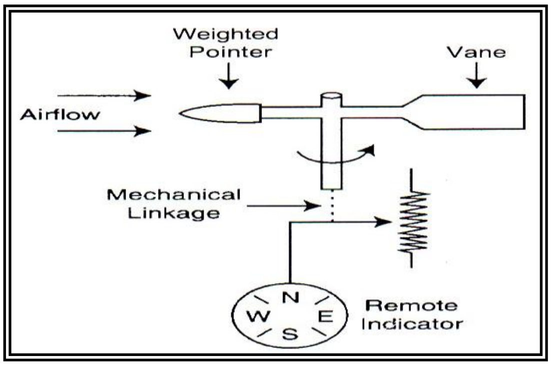

Fig. 2 Illustrates Wind Direction Sensor.

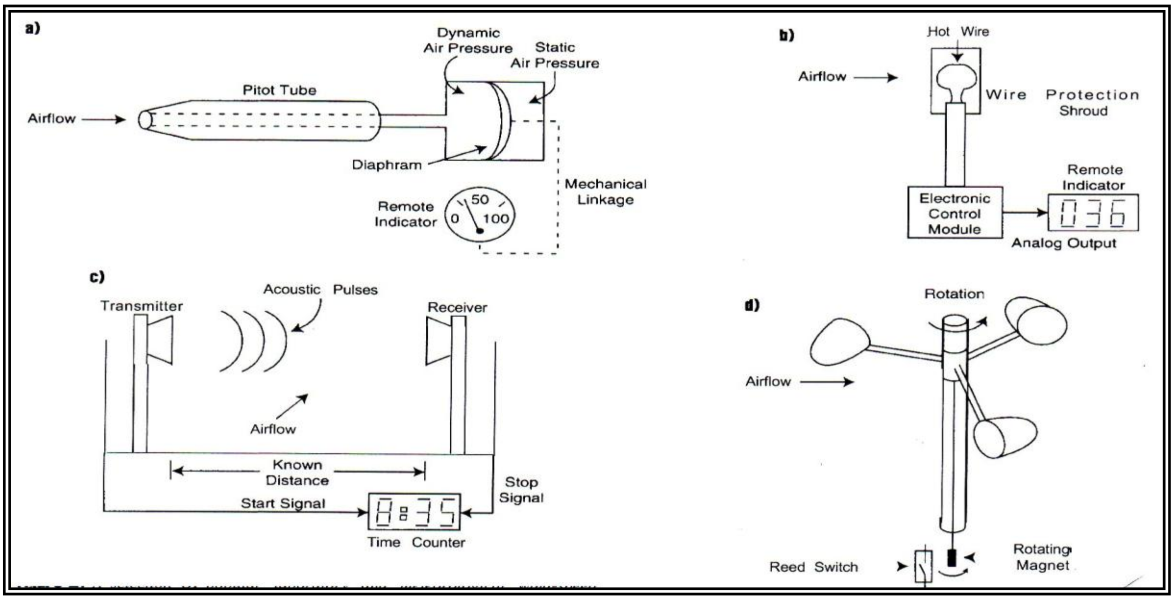

Fig. 3Illustrate types of wind speed sensor.

4. The Transducer .[6,7,8]

The wind-vane transducer shaft is internally coupled to 20kΩ potentiometer for measuring shaft position and wind direction; this potentiometer has a complete 360° rotation with no rotation stop.

The anemometer shaft is internally coupled to magnetic reed switch. Each revolution of the anemometer produces one contact closure of the reed switch.

The data acquisition system has a number of 8-analogue channels inputs designed to be connected to analogue type measurement sensor. Other analog inputs can be added if we use network modules, these analog inputs are designed to interface to ground-referenced (0-5) VDC analog signals. The interfacing is capable of measuring the frequency of a periodic input signal (digital) with the accruing required for this interface. To be compatible with interface analog input, a signal is needed that varies from 0 to 5 VDC and is proportional to wind direction. The wind-vane shaft is directly connected to the wiper of 20-k potentiometer. Therefore the position of the pot wiper always indicates wind direction.

It's a simple matter to connect the ends of the potentiometer to ground and to +5VDC. The wiper voltage then varies from 0V(0 degree) to 5V(360 degree) as the wind vane is rotated. The relationship between the wiper output voltage and wind direction can be determined by:

$$Wind\ \text{Direction} = \frac{\text{Vout}}{5\text{V}} \times 360^{o} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

This relationship assumes that the potentiometer is completely linear. The first step in the design of the wind speed interface is to calibrate the anemometer to correlate wind speed versus switch-closure frequency. To accomplish this step, we mounted the wind transducers to the spare tire carrier at the rear of our truck. Then, we drove the vehicle on a virtually windless morning at speeds spanning the input range of the anemometer while measuring the switch-closer frequency. Before attempting this experiment we also had our vehicles speedometer professionally calibrated since our new tire diameter differed from the original tires. The recalibration resulted in a fixed indicted speed offset of about +3MPH. The results of our data collection which has measured experimentally are presented in **Fig.4**. The manufacturer subsequently verified our finding-one switch closure per second (or 1 Hz) equaled 2.33MPH. Thus, over the wind speed range of interest (0-115MPH) the switch closure frequency varies from (1Hz=2.3MPH) to (50Hz=115MPH).

There are many ways to convert a variable frequency signal in to DC voltage. This type of circuit, often known as a tachometer circuit is implemented most often using a single-chip FN converter integrated circuit. The circuit consists of an input comparator, one-shot, and integrator.

Each time the input signal crosses the comparator threshold; it activates the one-shot, which switches a precise amount of charge in to the integrator input for a measured time period. As the input signal increases in frequency, the charge injected into the integration capacitor increase proportionally. The result is an average output voltage from the integrator proportional to the input signal frequency.

Obviously, this job was better suited to a digital counter or micro controller. We choose microchips PIC16C54 due to the circuit designs simplicity, low parts count, and program flexibility. In the approach we followed, the wind speed transducer is connected directly to an input bit of the PIC micro-controller.

An 8-bit D/A configured for an output range 0-5 volts DC is connected to eight of the PIC general-purpose I/O bits, which are configured as outputs.

To measure wind speed, the PIC simply counts the number of anemometer switch closures during a predetermined time period (frequency). This count is then scaled to obtain the 8-bit digital value, which drives the DAC. The scale factors ensure that the digital output is equal to 225 when the input frequency is equal to 50 Hz (115 MPH).

The DAC output voltage is always proportional to the wind speed as measured by the anemometer. The software programmed to measured frequencies up to 50 Hz in 1Hz increments. Thus, wind speeds up to 115 MPH can be measured in increments of 2.3 MPH. Therefore, at a wind speed of 0 MPH, the output voltage of the circuit is 0 volt, and it is 5 volt with a wind speed of 115 MPH.

The relationship between the DAC output voltage and wind speed can be found by the following equation:

$$windspeed = \frac{V_{out}}{5V} \times 115MPH \quad ....(2)$$

By using a micro-controller, we can measure switch closure frequency (and thus, wind speed) with greater resolution than 1 Hz. in our application, however, this level of precision was unwarranted. The circuitry required to interface the wind speed and direction transducers is shown in **Fig.5**.

For weather temperature measurement we need a transducer to sense this temperature. For our work we use LM334 a three terminal adjustable current source, as a temperature sensor because it is reliable, economical and compact in size. The output current I_{set} of the LM334 is directly proportional to absolute temperature in Kelvin (k) and is given by

$$I_{set} = \frac{(227uv/k)(T)}{R_{set}} \qquad \text{.................................} \ (3)$$

where:

I_{set}= output current of the LM334.

R_{set}=resistor that determines I_{set} and is connected between R and V terminals of LM334.

T=temperature in Kelvin.

To express the output voltage V_o of the LM334 in terms of I_{set} and R_L we will using the connection diagram of the LM334 shown in **Fig. 6**. And equation (3). In other words the output voltage will be.

$$V_o \approx I_{set} R_L$$

$$V_o \approx 10m\ V/K \qquad \text{.................................} \ (4)$$

To conditioning the output signal of the temperature transducer to make it suitable for the ADC we will use a voltage follower and differential amplifier as shown in **Fig.7**. Because the voltage follower eliminate loading and differential amplifier provides the gain necessary to make the signal suitable for the ADC. The unit sensors have Been developed and installed on the roof of continuing education center at the University of Technology at a height of approximately 25 meters from the earth surface for the purpose of collecting weather data as shown in figure(8)

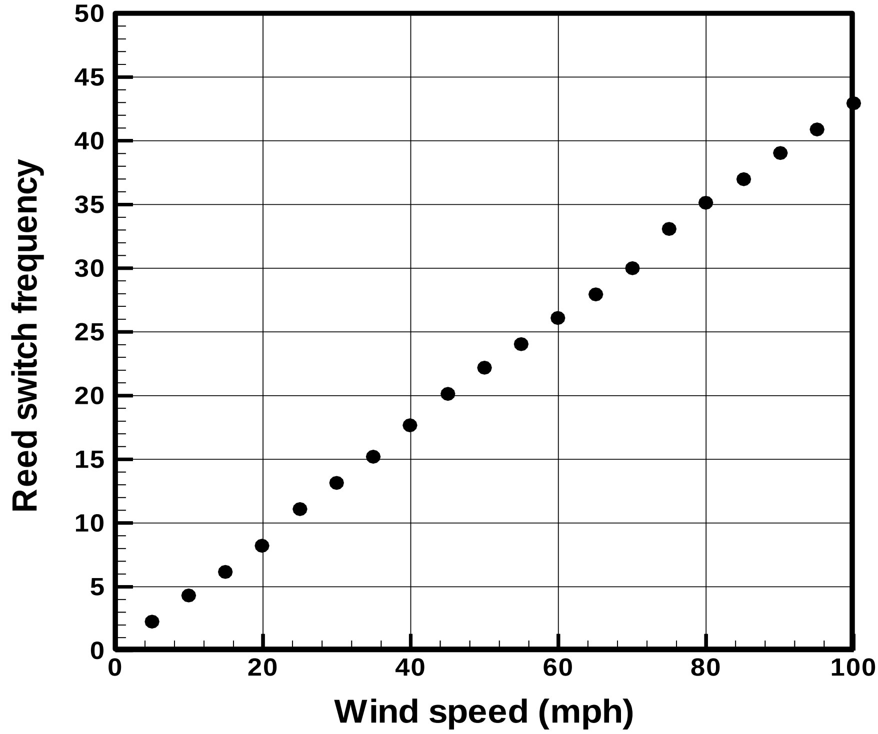

Fig. 4 Illustrate A Relations Ship Between The Reed Switch Frequency and Wind Speed.

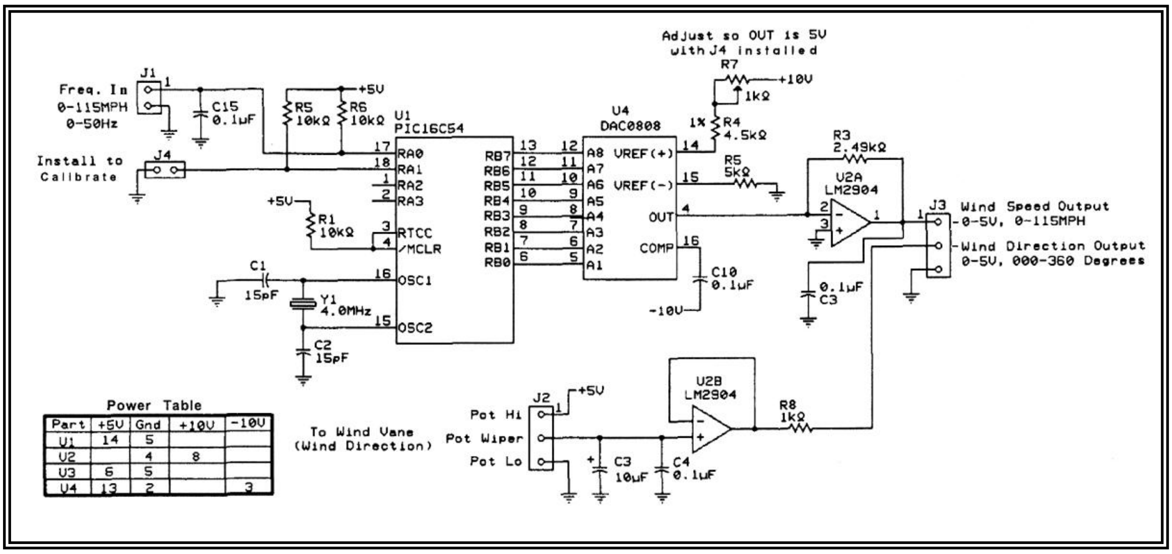

Fig.5 Illustrate the Electronic Circuit Details Wind Speed and Direction Transducer.

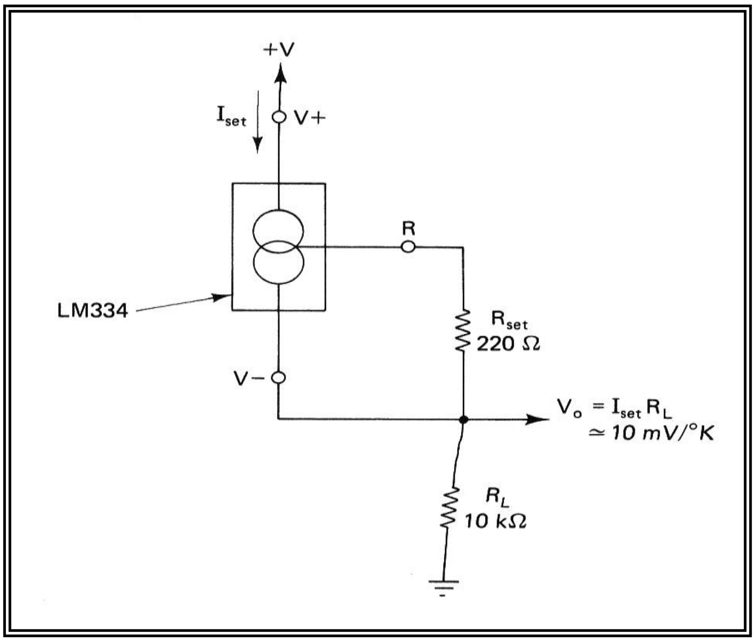

Fig. 6 Illustrate LM334 Connection Diagram.

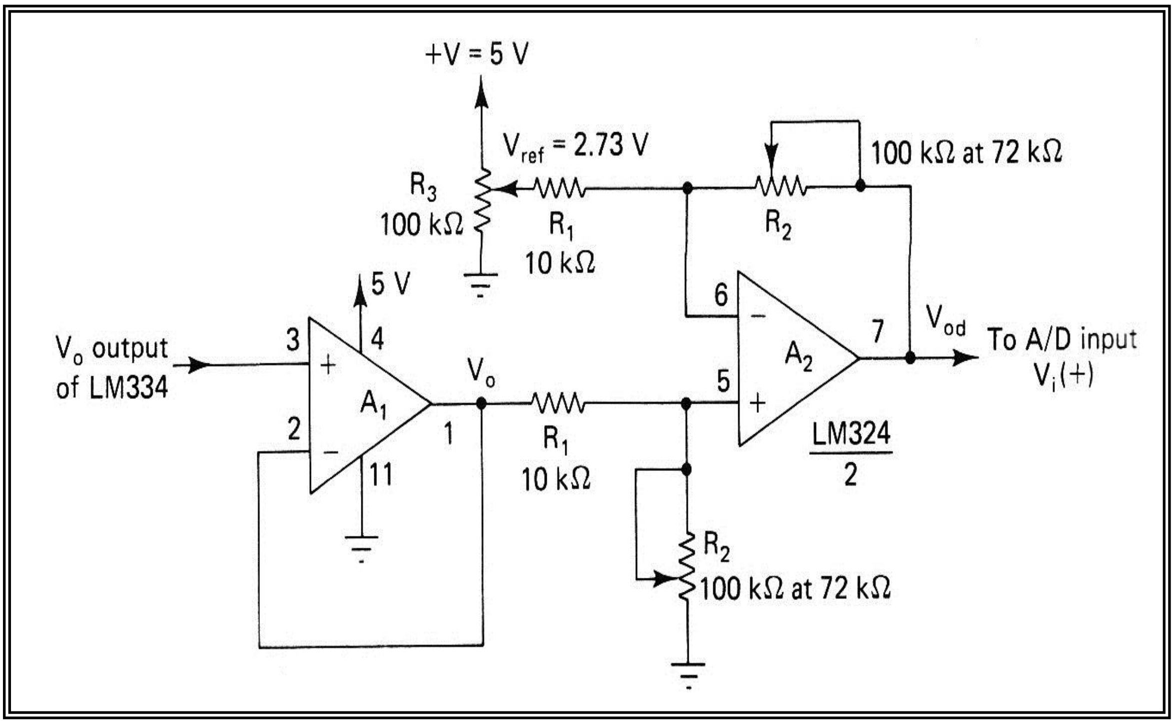

Fig. 7 Illustrate the Signal Conditioning Through Voltage Follower and Differential Amplifier.

Fig. 8 Illustrate unit sensors of the proposed weather system

5-Hardware: [9,10]

Data logger system was design to received data system variable (temperature, wind direction, wind speed) from climate sensor system Which were transmitted through space in wireless way to a distance of 100 meters, and in this way we can get ride on the problem of wire linked losses which may be pose through the transfer of data by wire. An 8-bit multi-channel unipolar (ADC) analog to digital converter based on successive approximation is used for measuring three different variable (wind speed, wind direction, temperature) each one of the measured variable use a separated input channel in analog to digital unit. The ADC performs the conversion of all analog output receiving data from sensors into digital signal to be fed to the microcontroller (PIC).

The microcontroller which is equipped with internal 16 kb flash memory and high processing speed is used to control the system and is also to synchronize all the module operations.

An EPROM with 512 kb is connected to the microcontroller for storing the data with a capacity reading up to 30 days for 30 second sampling interval. An LCD touch screen module is also connected to the microcontroller to display the measurement parameter of sensors and the current time. The stored data in EPROM can be accessed directly with personal computer (PC) through Universal Serial Bus (USB)connection. This connection established via a USB interface microcontroller type PIC16c745,the circuit diagram of the USB interfacing controller is shown in figure (9).

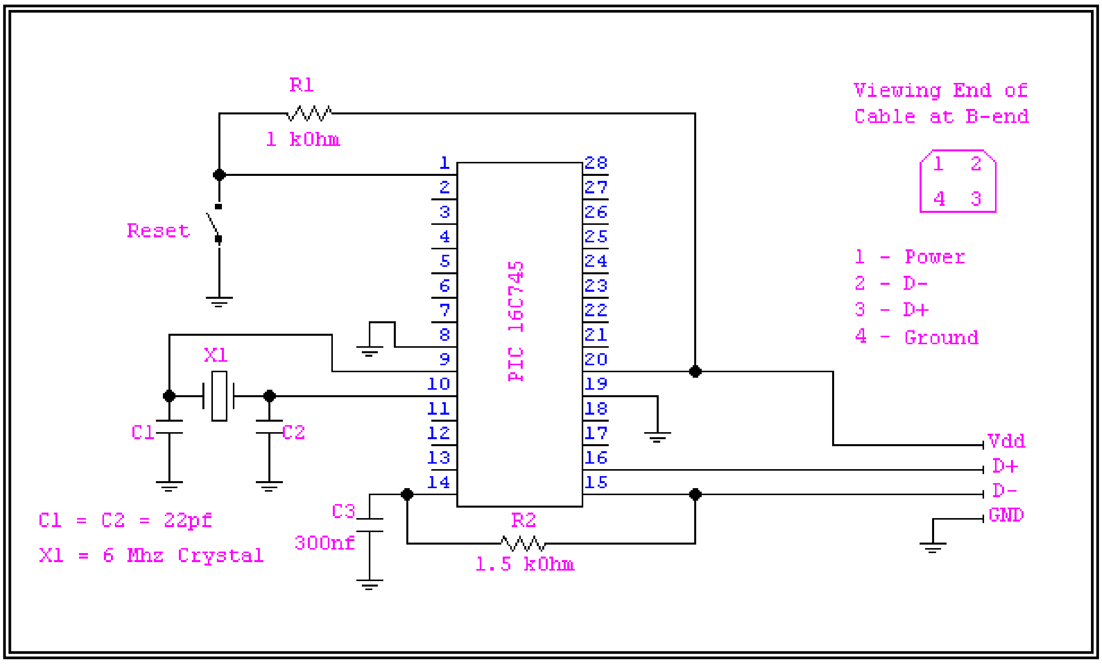

Fig .9 Illustrate USB Interfacing Connection circuit

6-System software: [11]

The proposed system has been running by relying on developed ready program. This program is accomplished with visual basic which easy to use and which has a speed adequate for most application, the software of the system consists of two main parts: the graphical user window software and the control software. The graphical user window software allows the user to download data from EPROM, completely or partially in personal computer to analyze it or to display recorded history data. The user window software can also enable the user to change the sampling parameters such as data, time and sampling interval. The data can be also plotted with a built in graph plotter for further analysis. The control software is specified in process control of the internal chips unit of the system and can no be tampering by user or beneficiary. The control software is lightly linked to the graphical user window software, and the two must be worked together to make the system software function. The user window, which represents the graphical user interface software, is shown in figure (10 **)**.

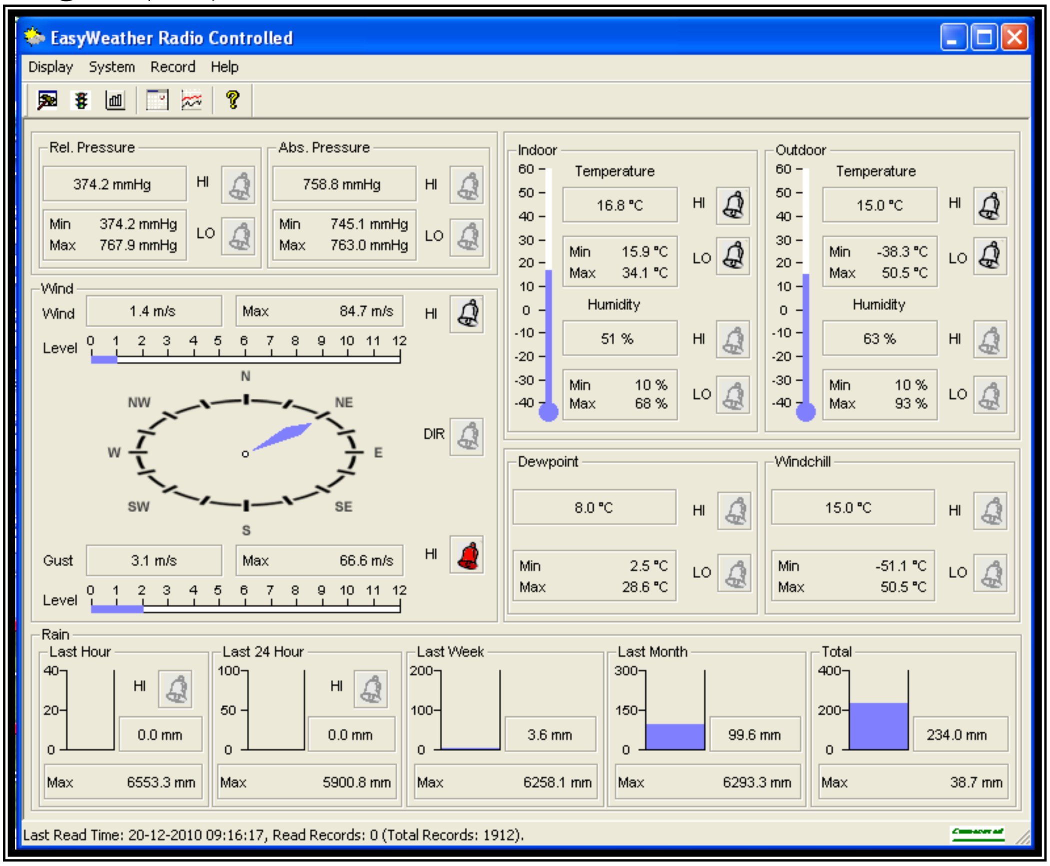

Fig. 10 Illustrate the graphical user interfacing program window

7-Discussion of the results :

We have been performance a calibration comparison between the proposed weather data acquisition system and laboratory system type PROVA in order to determine the accuracy in measuring the changes in the weather parameter. From the comparison we found there is a high precision and system more close between the climate data of the two systems.

The laboratory measurements systems have advanced equipment sensors to measure both the temperature coefficient and the coefficient of wind speed. In order to clarify the approach in the comparison between the proposed system and the calibration and testing system we can seen the graphs shown in the figure (11) and figure (12) which represent the comparison between temperature and wind speed, respectively where it is noted there is little difference between the two reading of each case and can be omitted.

This difference have been result from the error in the reading of each sensor and the losses resulting from the transmission signal over the air in addition to losses in the internal wiring between electronic chips.

The results which were obtained have been summarized in table (1), table (2) table(3), table(4) and table (5) for the variable in five different days. These variables can be plotted as graphic chart through the use of personal computer to determine changes in the coefficients weather and make comparison for closely spaced or far apart, depending on the user or beneficiary and then archived the data for the purpose of adoption as evidence of climate in that part of the earth.

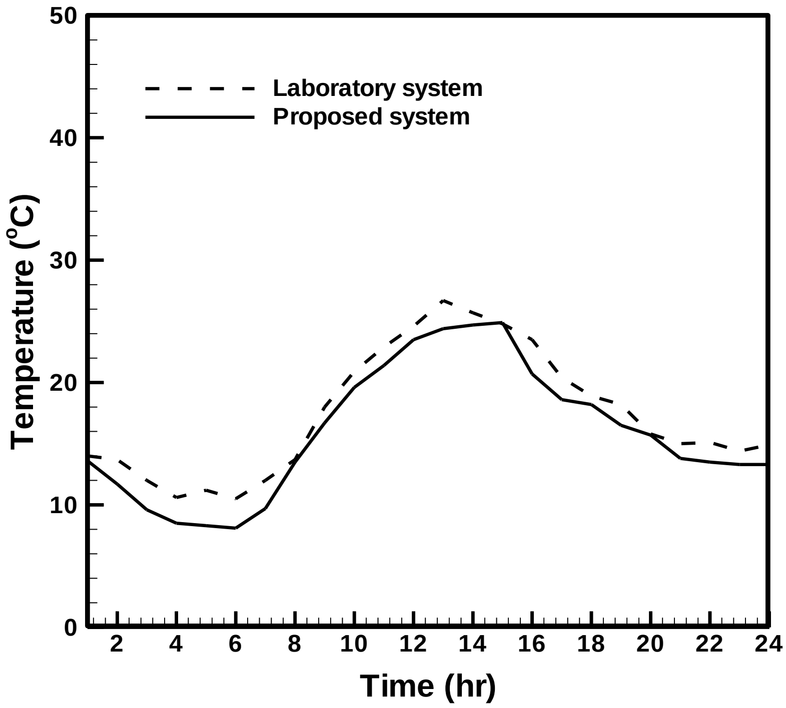

Fig. 11 Illustrate the comparison of temperature for proposed system and laboratory system.

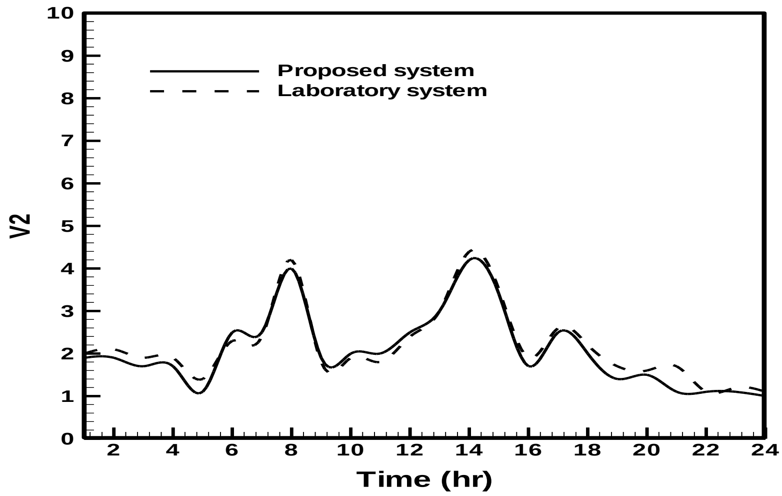

Fig. 12 Illustrate the comparison of wind speed for proposed system and laboratory system.

Table(1) the measure of weather parameter for the first day.

Date : 1/12/2010			
Time (hr)	**Temperature °C**	**Wind speed m/sec**	**Wind direction**
1	13.6	1.9	NW
2	13.4	1.9	NW
3	11.7	1.7	NW
4	10.3	1.7	N
5	10.8	1.1	NW
6	10.0	2.5	NW
7	11.7	2.5	NW
8	13.4	4.0	NW
9	17.6	1.9	W
10	20.5	2.0	NW
11	22.4	2.0	NW
12	24.5	2.5	WN
13	25.8	3.0	WN
14	25.6	4.2	NW
15	24.5	3.4	NW
16	22.8	1.7	W
17	20.7	2.5	W
18	18.5	2.0	WN
19	17.8	1.4	NW
20	15.5	1.5	NW
21	14.8	1.1	NW

22	14.5	1.1	N
23	14.0	1.1	N
24	14.0	1.0	NW

Table(2) the measure of weather parameter for the second day.

Date : 2/12/2010			
Time (hr)	**Temperature °C**	**Wind speed m/sec**	**Wind direction**
1	13.6	2.5	NW
2	11.7	1.2	NW
3	9.6	1.7	NW
4	8.5	1.7	SW
5	8.3	2.4	WN
6	8.1	1.1	WS
7	9.7	0.7	W
8	13.5	2.0	WN
9	16.7	2.5	NW
10	19.6	1.2	N
11	21.4	3.4	W
12	23.5	3.0	W
13	24.4	3.5	WN
14	24.7	4.0	NW
15	24.9	2.4	WS
16	20.7	2.3	WS
17	18.6	2.0	W
18	18.2	3.0	NW
19	16.5	2.5	N
20	15.7	1.2	N
21	13.8	1.4	WS
22	13.5	1.6	WN
23	13.3	2.7	WN
24	13.3	2.5	NW

Table(3) the measure of weather parameter for the third day.

Date :3/12/2010			
Time (hr)	Temperature °C	Wind speed m/sec	Wind direction
1	12.7	2.0	W
2	12.4	1.7	WN
3	10.7	1.8	NW
4	10.5	3.0	NW
5	10.3	2.5	W
6	10.7	2.3	W
7	11.0	1.7	SW
8	12.0	2.4	NW
9	13.2	4.0	WN
10	16.4	3.3	WN
11	19.6	3.5	NW
12	21.6	2.5	N
13	23.3	3.5	N
14	24.7	4.9	NW
15	24.9	3.5	NW
16	23.5	2.5	N
17	21.6	1.3	N
18	18.6	1.5	WN
19	16.5	2.0	WN
20	16.7	2.5	W
21	16.8	2.7	NW
22	15.5	2.6	NW
23	14.3	1.7	WN
24	13.0	2.0	WN

Table(4) the measure of weather parameter for the fourth day.

Date :4/12/2010			
Time (hr)	Temperature °C	Wind speed m/sec	Wind direction
1	11.5	1.2	WS
2	11.2	1.7	W
3	11.0	1.6	WN
4	9.5	1.5	WS
5	9.3	2.4	w
6	9.0	2.3	WN
7	10.5	3.0	WN
8	12.7	2.4	W
9	17.6	2.4	W
10	19.3	2.5	WN
11	21.3	4.3	NW
12	23.5	4.0	NW
13	24.5	3.3	NW
14	24.7	3.1	W
15	24.3	3.4	W
16	21.4	1.3	WN
17	19.7	1.4	WN
18	18.3	1.6	N
19	17.5	1.5	N
20	15.4	1.2	NW
21	14.6	1.1	WS
22	14.1	1.7	W
23	13.0	1.3	NW
24	12.0	1.2	WS

able(5) the measure of weather parameter for the fifth day.

Date : 5/12/2010			
Time (hr)	Temperature °C	Wind speed m/sec	Wind direction
1	12.8	1.3	WN
2	12.5	1.7	WN
3	11.6	1.4	NW
4	10.7	0.8	N
5	9.8	1.2	NW
6	8.6	1.2	NW
7	8.3	1.7	W
8	9.5	2.3	N
9	12.5	1.7	N
10	14.5	0.5	N
11	17.4	1.7	NW
12	21.4	1.4	NW
13	24.3	1.2	SW
14	24.6	1.2	SE
15	25.0	1.1	SW
16	24.4	1.1	SW
17	21.3	1.2	SE
18	18.5	1.4	W
19	16.7	1.1	NW
20	15.5	0.5	WN
21	12.4	1.2	WN
22	12.6	1.4	WN
23	12.2	1.4	WN
24	12.0	0.7	NW

8-Conclusions:

The potential benefits of this paper lead to conclusions that the implementation of the most modern technologies for sake of better system performance. The proposed system has many advantages like it have huge memory capacities, high precision, have a high processing speed, lower cost if compared with other climate monitoring system and greater portability, in addition to these advantages the following point: are another most important outline which obtained from this paper.

1. Data acquisition system based on microcomputer is more efficient and economical than conventional system because it can be programmed at predetermined time.
2. The graphics capabilities of the microcomputer have been exploited so that several system variables can be observed simultaneously. Consequently, no additional recording instruments are required.(It means ,that the computer will store all the data on harddisk and we don't need an external storage devices).
3. Data acquisition system based on microcomputer provides the user with flexibility of selecting various variable type of process measurement.
4. The system has the ability to deal with multi-variable at the same time.
5. The use of digital techniques for data acquisition system makes these systems more accurate, reliable, and simpler.
6. The designed system affords the scientific user the opportunity to learn about computerized data acquisition system.

References

1-Gerd Wostenkuhle ,"Measuring system Design", john wiley & sons,Ltd,2005
2-John D .Garrison,"Environmental Measurement.",CRC Prees.2000.
3-Barry B. Brey , "The Intel Microprocessor, Programming and Interfacing" prentice –Hall, Inc., 2007.
4-D.C. Ramsay, ”Principles Of Engineering Instrumentation”, Halstead Press an Imprint Of Wiley & Sons INC., New York,1996.
5-Telemetry Group, "Instrumentation Engineers Handbook", December, 2005
6-K. Lacanette, "National Temperature Sensor Handbook.",Nattional Semiconductor Corporation,1997
7-Ian R.Sinclair"sensors and transducers", Butterworth-heinemann,2001.

8-Chuck Hellebuyck"Programming PIC Microcontroller with PICbasic",Elsevier science USA,2003.
9-Gods Atul P., "Microprocessor Microcontroller and Applications", India Technical Puplications Pune, 2008.
10-Patil C. Y., "8-Bit Microprocessor Microcontroller", Delhi Satya Prakashan, 2008.
11-Steve Brawn ,"Visual Basic 6 in record time" prentice –hall,Inc,2003

تصميم وبناء منظومة حاسوبية لقيلس درجة الحرارة واتجاه وسرعة الريح

م. د.فؤاد شاكر طاهر

م.م. أياد محمود سلمان

م. م. وليد خالد إبراهيم

الخلاصة

تهدف الورقة الحالية لبناء منظومة منخفضة التكلفة وموثوق بها لرصد الأحوال الجوية ولها القدرة على اكتساب البيانات وتسجيلها . تمتلك المنظومة المقترحة ثلاث متحسسات لقياس كل من درجة الحرارة وسرعة الريح واتجاه الريح على التوالي. يتم إرسال إشارة خرج المتحسسات التماثلية من خلال الهواء وتستسلم عن طريقة منظومة الطقس لغرض تحويلها إلى إشارات رقمية يتم معالجتها من خلال مسيطر يعمل كمسجل بيانات.البيانات المسجلة يمكن نقلها إلى الحاسوب الشخصي من خلال استخدام برنامج واجهة المستفيد الرسومية للحصول على المزيد من التحليل او طباعة معاملات القياس يمتلك النظام الحالي العديد من المزايا مثل صغر حجم المنظومة وذاكرة بحجم كبير واحتوائها على شاشة عرض تعمل بتقنية الكرستال السائل كما ان المنظومة تعد منخفضة التكلفة بالمقارنة مع غيرها من أنظمة الطقس إضافة إلى ذلك فأنها تمتلك قدرة عالية في معالجة البيانات وبالغة الدقة إضافة إلى إمكانية حملها.