Low Cost Sensor Base Portable Local Weather Station

Design research seminar report

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By

Roopa Narayan Sahoo

(Roll No. 126336001)

Supervisor

Prof. Girish Dalvi

Industrial Design Center

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

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Abstract

The measurements of various weather parameters temperature, atmospheric pressure and relative humidity locally by using the appropriate sensors is not only important in environmental or weather monitoring but also crucial for many Industries, including energy, agriculture, forestry, power generation, utilities, mining, petrochemicals and tourism, as well as urban growth and transportation each have the potential to affect air, land, water and biodiversity. The potential environmental impacts of these activities must all be measured, evaluated and managed. All these monitoring efforts undertake responsibility to provide knowledge and information for policy-makers and public concerning global environmental issues over the long-term.

A device for weather monitoring has been developed as described in this paper to monitor and display the temperature, pressure and relative humidity of the atmosphere, using analogue and digital components. The analogue outputs of the sensors are connected to a microcontroller through an ADC for digital signal conversion and data logging. For analysis and archiving purposes, the data can be transferred to a PC with a graphical user interface program, through a USB link. The interface program allows sampling parameters such as the date and time of the data-logging operation to be configured. The device has many advantages as compared to other weather monitoring systems in terms of its smaller size, huge memory capacities, lower cost and greater portability.

Key words: Weather monitoring, Temperature, Relative humidity, Pressure, Sensors, Microcontroller

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Introduction

Sensors are essential components in many applications, not only in the industries for process control but also in daily life for buildings' safety and security monitoring, traffic flow measuring, weather condition monitoring and etc. In weather monitoring, for instance, parameters such as temperature, humidity and pressure need to be measured thus sensors have always been given the task for doing so. Weather or climate plays an important role in human life.

The advancement in technology has made these small and reliable electronic sensors capable of monitoring environmental parameters more favourably. We have developed monitoring systems, using sensors for local climate and environment based on the parameters mentioned. Combination of these sensors with data acquisition system has proved to be a better approach for temperature and relative humidity monitoring. The aim this seminar paper is to build a low-cost, yet reliable, weather monitoring system capable of acquiring and recording data. The proposed system has three sensors that measure the temperature, relative humidity and pressure, respectively. The analogue outputs of the sensors will 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. Using easily-available components and simple circuitry, the system should be beneficial in providing a portable and low-cost local weather monitoring system.

Block diagram of the system

The system is divided into four main parts, namely, the sensor circuit, the data-logging circuit, the time-keeping circuit and the USB interfacing circuit. The sensor circuit contains the IC temperature sensor, resistive humidity sensor and barometric pressure sensor. The analogue outputs from these sensors are converted into digital signal by an

ADC before being fed into the data-logging circuit which encompasses a microcontroller. The current time for data-logging purposes is provided by the time-keeping circuit while the USB interfacing circuit facilitates the data transfer between the data logger and a PC. The block diagram of the overall system is depicted in this figure.

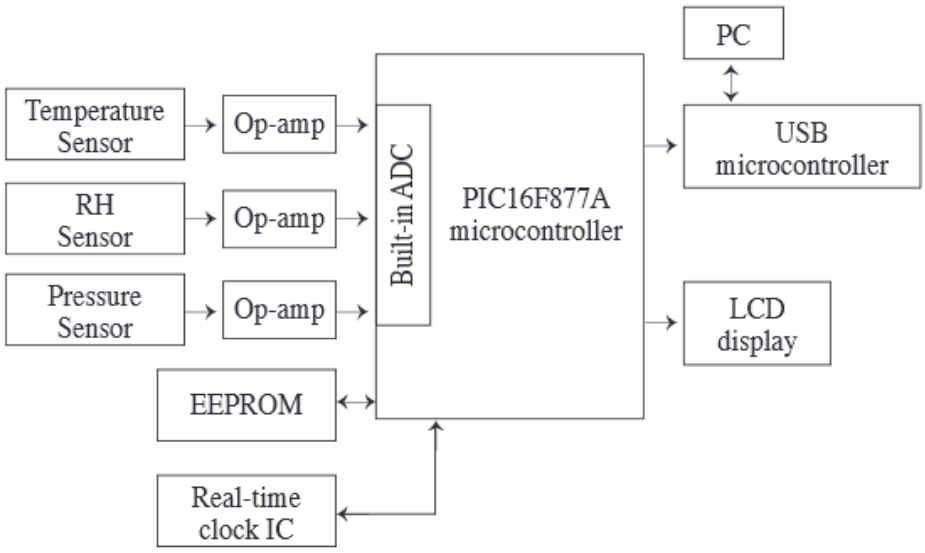

Figure 1 The block diagram of the system.

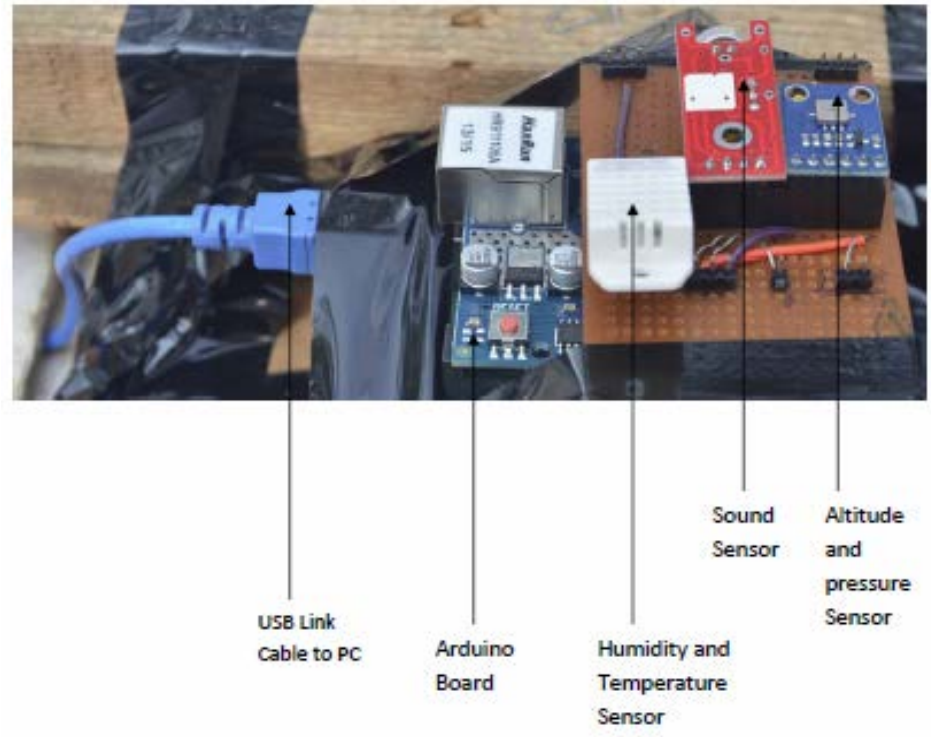

Figure 2 Arduino Base Portable weather Station Device.

Results and discussion

The accuracy of the proposed system has been tested through extensive experiments. The measurements have been compared with those obtained; using traditional equipment used by the IIT Bombay Physics Department, which contains a thermometer, a relative humidity sensor with chart recorder and pressure transmitter for temperature, relative humidity and pressure measurements respectively. The results obtained are summarized in Table 1, Table 2 and Table 3.

Table 1. Comparison of temperature measurements.

Recording Time	Lab thermometer (°C)	Proposed system (°C)	Difference (°C)
00th (24th)Hour	21.9	22.1	-0.2
02nd Hour	21.9	21.7	0.2
04th Hour	21.3	20.5	0.8
06th Hour	20.8	20.2	0.6
08th Hour	22.2	21.7	0.5
10th Hour	29.1	28.4	0.7
12th Hour	33.1	32.1	1.0
14th Hour	32.7	31.6	1.1
16th Hour	28.4	27.4	1.0
18th Hour	26.7	25.9	0.8
20th Hour	24.6	23.7	0.9
22nd Hour	23.7	23.2	0.5

From Table 1, we can be observed that the temperature sensor shows a good level of stability as well as accuracy. The average error of 0.7°C is observed. The plotted graph also shows stability label of temperature sensor as both the plots are very close to each other .

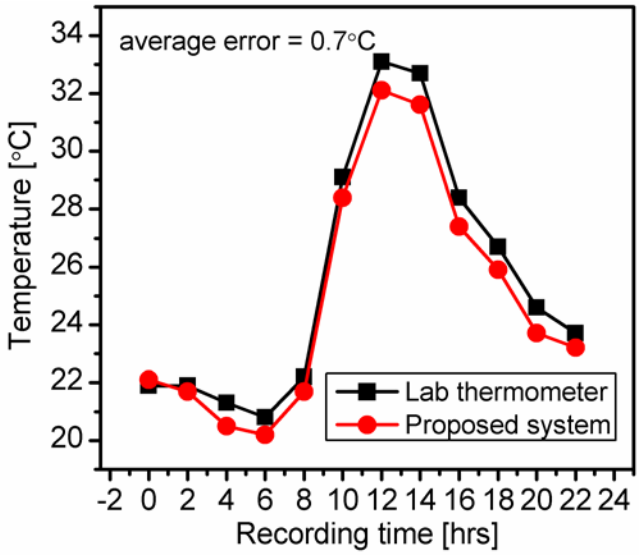

Figure 3 Temperature versus recording time plot.

Table 2. Comparison of relative humidity measurements.

Recording Time	Lab RH sensor (%RH)	Proposed system (%RH)	Difference (%RH)
00th (24th)Hour	87	85	2
02nd Hour	87	86	1
04th Hour	96	99	-3
06th Hour	96	97	-1
08th Hour	87	85	2
10th Hour	65	60	5
12th Hour	49	47	2
14th Hour	48	47	1
16th Hour	52	54	-2
18th Hour	59	58	1
20th Hour	75	72	3
22nd Hour	78	77	1

In Table 2 we can see the humidity sensor of the proposed system also shows a very good accuracy of an average error of 2%. Here also both the plots are very close to each other because the average error is very less(2%).

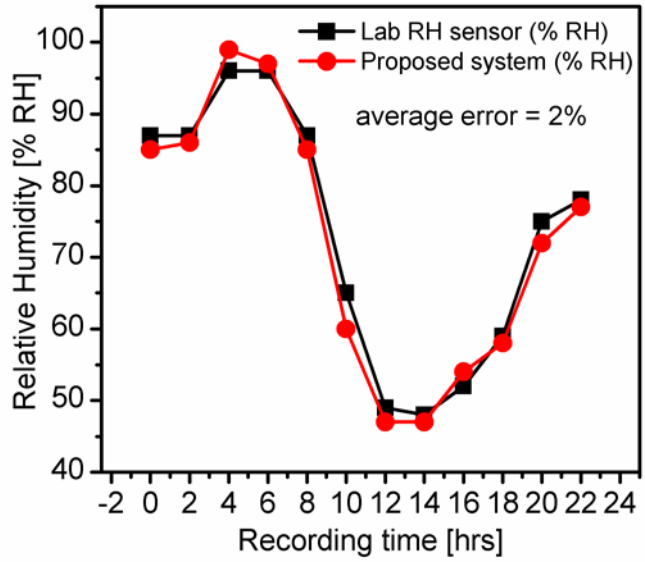

Figure 4 Relative humidity versus recording time plot.

Table 3. Comparison of pressure measurements.

Recording Time	Pressure Transmitter (kPa)	Proposed system (kPa)	Difference (kPa)
00th (24th)Hour	100.54	100.71	-0.17
02nd Hour	100.47	100.63	-0.16
04th Hour	100.35	100.51	-0.16
06th Hour	100.29	100.52	-0.23
08th Hour	100.31	100.68	-0.37
10th Hour	100.52	100.76	-0.24
12th Hour	100.38	100.66	-0.28
14th Hour	100.39	100.58	-0.19
16th Hour	100.18	100.48	-0.30
18th Hour	100.22	100.55	-0.33
20th Hour	100.58	100.70	-0.12
22nd Hour	100.59	100.76	-0.17

The pressure sensor also produced the accurate measurements compared to other sensors with an average error of ±0.2 kPa as shown in Table 3. As we can see both the plots are close and similar in nature.

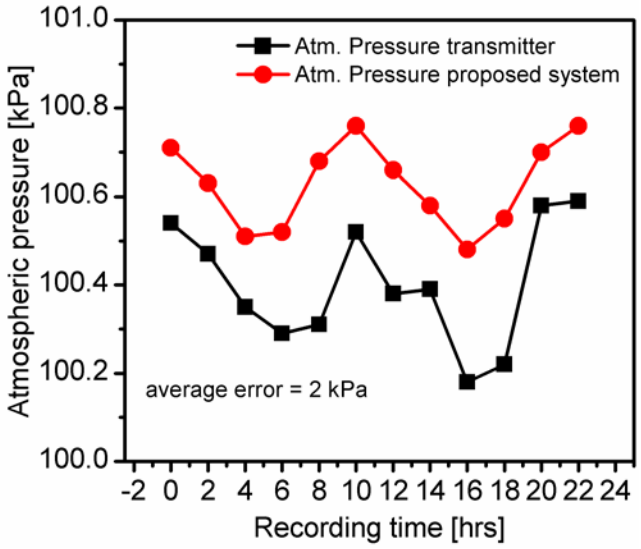

Figure 5 Atm. Pressure versus recording time plot.

There are various portable weather station devices available in the market are compared with the proposed system in terms of features and accuracy. The comparisons are listed in Table 4. It can be seen from Table 4 that the proposed system has a much larger memory capacity for data-logging purpose compared to other weather station devices in which one of them needs a separate data logger. The system also offers the range and accuracy comparable to industrial-grade equipment. The cost of the system which is significantly lower compared to other systems with similar features is another advantage of this system.

Table 4. Comparisons of other weather station devices with the proposed system.

Parameters	SKYWATCH	Kestrel 4000	Grant Mini-met Weather Station	Proposed System
Temperature	±0.5°C	±1°C	±0.4°C	±0.7°C
RH Accuracy	±3%	±3%	±2%	±2%
Pressure Accuracy	±0.2 kPa	±0.3 kPa	±0.03 kPa	±0.2 kPa
Memory Capacity	N/A	250 measurements	64000 Measurements (separate data logger)	512 Kb
Backup power	CR2032 lithium battery	2 AAA Alkaline batteries	12 V Rechargeable battery and solar power supply	Rechargeable 9V battery
Price (US$)	380	330	N/A	< 70

Conclusions

A framework has been presented that incorporates the uses of sensors in developing a low-cost, high-accuracy weather monitoring system, using analogue and digital components. The proposed system has been tested through extensive experiments and the results have proven the accuracy and reliability of the proposed system. Besides, a comparison on the features of different types of monitoring systems has been carried out and it shows that the proposed system is of better choice in terms of cost, portability, memory capacity and logging interval-setting capability.

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