Design and Development an Embedded System for Detection Of Dimensional Change In Different Wood Samples Due To The Change In Relative Humidity

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Abstract

The dimensional property of wood variety is an important aspect in the areas of engineering applications for its effective use. An innovative measurement technique is employed for detecting the dimensional changes of wood for small rectangular block in respond to the change in Relative humidity. The technique incorporates the measurement of low resistance change of strain gauge attached to surface of wood sample and the system set up includes the design of signal conditioning circuitry and embedded data acquisition system using PIC18F452 microcontroller and development of system software for logging the acquired data. Traditional psychrometric technique is used electronically to measure relative humidity which increases reliability and accuracy of the developed system.Data analysis results the detected change of dimensional property for wood variety and also shows the variation of respond from sample to sample.

1. Introduction

Measurement of humidity (water vapour present in air) is essential for different scientific research and various situations where monitoring and control of environment is necessary. Relative Humidity (RH), Absolute Humidity and Specific Humidity are the different measurement terms used for the measurement of humidity. The most important RH is defined as the ratio of partial pressure of water vapour in a certain amount of air to the saturated vapour pressure of water at a prescribed temperature.

Accurate measurement and control of RH can improve the quality of product and can reduce the production cost in different domain of industrial applications. Several human comfort and heath related issues demand the measurement of RH [Ref.1].

There are various possibilities of using biological material for the measurement of Relative Humidity. Horse hair has been used as a humidity sensor since decades. The instrument is commonly known as the hair hygrometer [Ref.2].

Another possible biological material that is affected by ambient RH is wood. To use wood to its best advantage and most effectively in engineering applications specific characteristics or physical properties must be considered. The versatility of wood is demonstrated by a wide variety of products. This variety is a result of a spectrum of desirable physical characteristics among many species of wood [Ref.3].

Wood is a hygroscopic material. Wood exchanges moisture with air, the amount and direction of the exchange (gain or loss) depend on the relative humidity and temperature of the air and the current amount of water in the wood. It is a common experience that wood responds to humidity changes but there is no scientific data on how this response varies from sample to sample. Therefore proper use of wood products requires an understanding of their interaction with moisture.

To study the dimensional change of wood it is very essential to have an efficient and accurate measurement system for measuring both change in RH and corresponding changes in physical dimensions of the sample. A robust, low-cost and efficient measurement system is always preferred. Considering all these, a low cost system is developed which is efficient as well as accurate. Accurate signal conditioning as well as calibration techniques are employed to increase the efficiency and reliability of the developed system. For increasing system performance digital approach is adopted and implemented on PIC18F452 microcontroller [Ref. 4]. The system software for microcontroller is developed on MPLAB-IDE and suitable codes are written on C-language for handling data in the PC side.

2. System Description

The block diagram of the developed system is shown below in Figure 1.

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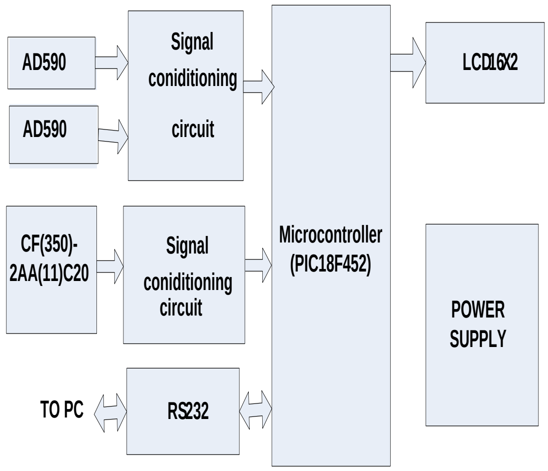

Figure1. Block diagram of the measurement system

3. Implementation

For implementing the system different modules are developed separately and finally integrated together for proper functionality. Psychometric method for measurement of RH is implemented electronically by measuring the temperature of dry and wet condition using electronic temperature sensor. Strain gauge is used to measure the dimensional change of the wood sample. Signal conditioning circuitry is designed and interfaced to the integrated ADC of the PIC microcontroller developing proper algorithm. Developed algorithm is implemented on PIC microcontroller for data display on 16X2 LCD and data transmission via RS232 communication.

3.1. Sensors

For the measurement of the temperatures of dry and wet conditions, two AD590 (TO-52) are used. These are two-terminal integrated circuit temperature transducers that produce an output current proportional to absolute temperature. The device acts as high impedance, constant current regulator passing 1 µA/K. For supply voltages between +4V and +30V Laser trimming of the chip's thin-film resistors is used to calibrate the device to 298.2 µA output at 298.2K (+25°C)[Ref.5].

3.2. Signal conditioning

Circuit schematic for the signal conditioning of AD590 is shown in fig.2.

Since AD590 provides output current of 1µA/K, to change the scale into Celsius, the above circuit is used [Ref.7]. At 0K current output of AD590 is 273.2µA is compensated using 43.92kΩ resistor. The output of the circuit is adjusted at 12mV/^{0}C to get 0.4^{0}C resolution for the 10-bit on chip ADC of the microcontroller.

For measuring dimensional change of wood sample CF350-2AA (11) C20 strain gauge is used which has the normal resistance 350Ω with gauge factor 2.13 ± 1% [Ref.6].

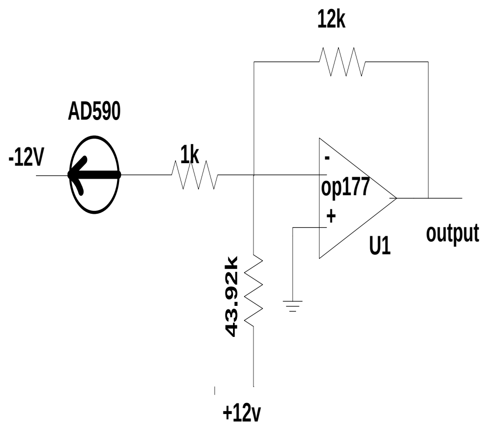

Figure2. Signal conditioning circuit for AD590

The circuit schematic for specified strain gauge is shown in fig.3. Phase shift oscillator U1 generates 1 kHz signal to excite the bridge containing strain gauge [Ref7][fig.3]. The bridge output is amplified using differential amplifier U3 of gain 10. The output is then fed to ac-to-dc converter shown in fig.5.The dc output is finally connected to the on-chip ADC of the microcontroller.

3.3. Interface

Analog interface of the sensors with the microcontroller is done with the on-chip 10- bit ADC at 4.8mV step size keeping the reference voltage of the ADC equal to the supply voltage (internal). 16X2 LCD is interfaced to display the data. For PC interface via RS232, MAX232 is used as level shifter. The communication is done at 9600 baud rate, 8 data bits, 1 stop bit and no parity bit.

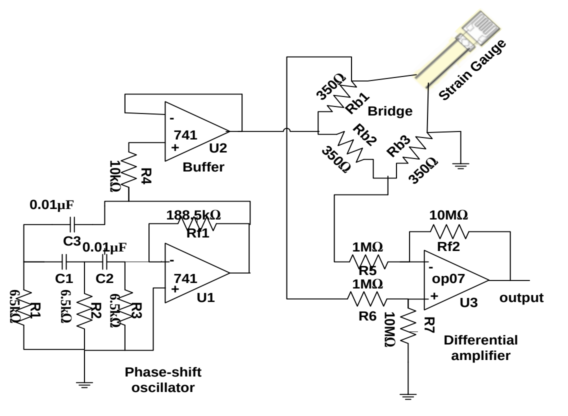

Figure3. Signal conditioning circuit for strain gauge (part1)

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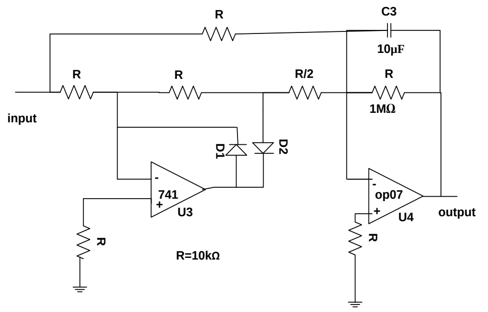

Figure4. Signal conditioning circuit for strain gauge (part2)

3.4. System Algorithm

The algorithm for the system is developed using MPLAB-IDE and implemented on PIC 18F452 microcontroller. The simplified flowchart of developed algorithm is shown in fig.5.

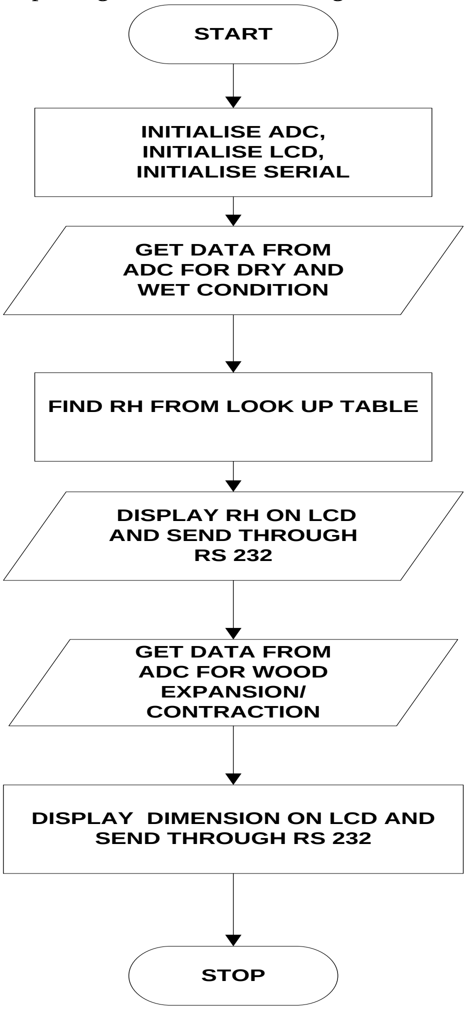

Figure5. Simplified flowchart of the algorithm

Table1. Strain gauge calibration

Serial No.	Resistance in Ω	Output voltage of differential Amplifier(P-P)	System output in V(DC)
1	350	0.2	0.1
2	450	3.0	1.5
3	550	5.2	2.6
4	650	6.8	3.4
4	750	8.0	4.0
5	850	9.2	4.6
6	1000	10.4	5.2

3.5. Calibration of the System

The measurement system is calibrated both for specified strain gauge and temperature sensors. For the strain gauge calibration standard precision resistors in place of actual strain gauge are used in the range covered and the corresponding output voltages are recorded [Table 1] and plotted on graph [Fig.6].

Temperature sensors are factory calibrated.

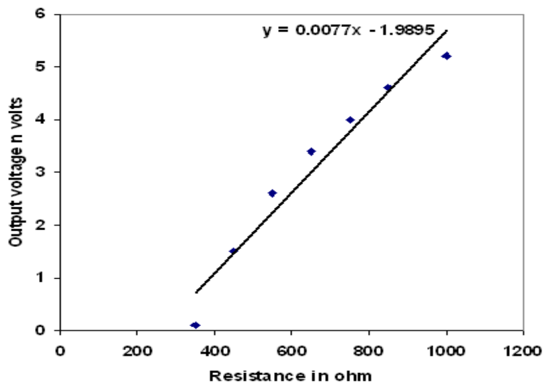

Figure6. Calibration curve of strain gauge

4. Sample preparation and experimental setup

Goomar Teak (*Gamelina arborea Roxb)*, Teak (*Tectona grandis linn*), Golden champak (*Michelia champacal*) are chosen as sample and prepared for experiment. The samples have dimensions of 6.8cm X

1.7cm X 1.7cm. The wood samples are cleaned well and sanded with grit size 150 for smoothing. Prior to experiments, the samples are oven dried at 90^{o}C and stored in a desiccator.

The strain gauge is fixed to one end of the sample by cyanoacrylat adhesive and connection leads are soldered. Finally the leads are connected to the bridge circuit.

The wood sample with the attached sensor is connected to the above system and the outputs are recorded for each sample exposed to the environment .Variations of the output were observed as the sample is subjected changing R/H in the environment. Simultaneous measurement of R/H was also done as described above.

5. Result and Discussion

Data was collected from wood samples of Goomar teak (*Gamelina arborea Roxb)*,Teak (*Tectona grandis linn*), Golden champak (*Michelia champacal*). Following graphs show the results of the collected data [fig.8, fig.9, fig.10].

From the results it is seen that the physical property of wood changes linearly with the change in RH. Again the slop of the different samples are different i.e. different woods behave differently to the moisture content. The slope of Goomar teak is 13.471 mV/RH in %, Teak is 11.487 mV/RH in %, Golden champak is 7.8261 mV/RH in %.

Further study will give more accurate results for the physical changes of the wood samples due to its moisture contents.

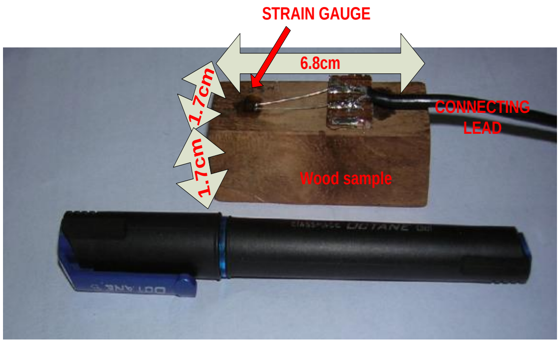

Figure.7. Installation of strain gauge

Standard deviation for 1. 80% RH is 5.77
2. 81% RH is 5.77
3. 82% RH is 5.77

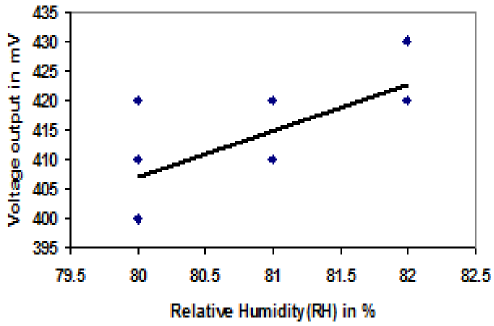

Figure8. Result of golden champak (*Michelia champacal*)

Standard deviation for 82% is 5.77

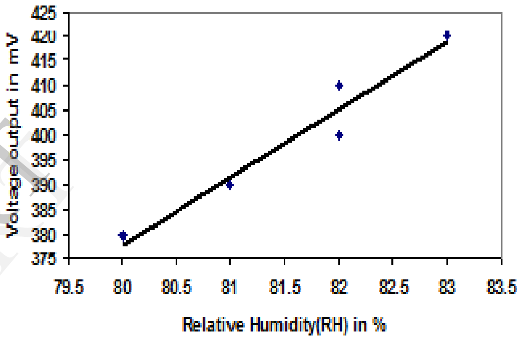

Figure9. Result of goomar teak (*Gamelina arborea Roxb*)

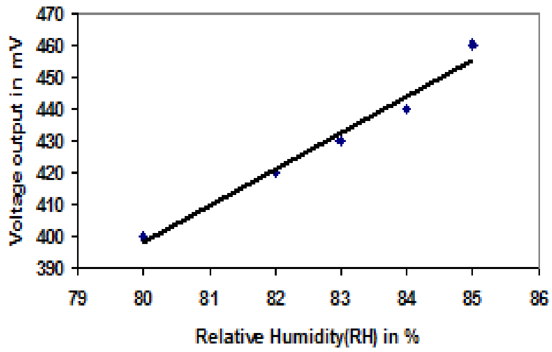

Figure10.Result of teak(*Tectona grandis linn)*

6. Conclusion

By preliminary observations it is seen that the system detects the physical change of wood sample which is encouraging. The performance of the developed measuring system is well satisfactory. The system detected the physical change of the wood samples in terms of voltage in the range of 30 mV for Golden Champak, 60mV for Teak and 40mV for Goomar Teak. A detailed study of various wood samples can be made, the result of which will obviously help in the selection of proper wood for various engineering applications.

Original moisture contents of the wood samples should be removed before data collection. Another considerable point is the polishing of the samples. Well polished sample will absorb moisture uniformly and better result may be expected.

If the samples would have been taken in chips form instead of block, changes might have been more.

7. References

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