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MEASUREMENT OF RELATIVE HUMIDITY USING A SIMPLE ARRANGEMENT & BY ANALOG TO DIGITAL DATA CONVERSION METHOD

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ABSTRACT

This paper represents the simple & economical way to measure an important parameter which is useful in both industrial & domestic purposes; Relative humidity. Wet & dry bulb temperature is measured by thermocouples. Dry bulb temperature reading is compared & calibrated with readings from Mercury thermometer. Wet bulb temperature is obtained artificially by a simple arrangement. By using parallel port with ADC converter these data is sent to computer. A C++ program code is developed which take this data as input & give the value of Relative humidity using psychrometric chart. Values of Relative humidity have been set to the code within a range of dry & wet bulb temperatures. Alternative method measures humidity using humidity sensor.

Keywords: Relative Humidity, Wet & Dry Bulb Temperature, Thermocouples, Mercury Thermometer, Parallel Port, ADC, C++ code, Psychrometric Chart, Humidity Sensor.

1. INTRODUCTION

Psychrometrics or psychrometric are terms used to describe the field of engineering concerned with the determination of physical and thermodynamic properties of gas-vapor mixtures. The term derives from the Greek *psuchron* meaning "cold" and *metron* meaning "means of measurement". One important parameter of psychrometry is relative humidity. Relative humidity is directly concerned with human comfort. According to ASHRAE 55-1992(Ameen, 1995) for proper thermal comfort relative humidity in winter should be between 90 to 25 percent & for summer it should be between 80 to 20 percent depending on temperature. Maintaining proper relative humidity is also very important in industries as humidity determines the moisture content in air.(Carey,1995) That is why in recent years there has been significant development in determining relative humidity. Many portable devices has been developed which very accurately & precisely determines relative humidity.(Dorgan et al., 1994) But these devices are very costly & are unknown to the industries of third world countries. They often suffer from problems due to corrosion of machine parts, destruction of raw materials, products because of improper maintaining of humidity. This device will be an important one for those industries of the third world countries because it is simple, cheap & compact. It uses one RTD to read two temperatures (wet & dry) in between a few minutes & gives the value of humidity using psychrometric chart.(Cengel et al. 1998) This value is quite accurate. If microcontroller is used this time gap or interval can further reduced. Two temperature sensor will then send simultaneous data to the processing unit & result will be obtained within a very few seconds. The especial feature of the first system is that the program code is written in visual c method so everyone can change code according to their requirement. Both the methods has been analyzed in this paper so that anyone can choose according to their will.

2. COMPONENTS

The project are divided into two sections:

1. Mechanical Component: Mechanical parts contain the main setup. It consists of a computer fan along with a 6x5x4 aclkyne box
2. Electrical Control: Electrical parts consist of circuits' amplifiers, ADC, MUX, RTDS, parallel port & others.

2.1 Function of Mechanical Components

A computer fan is used to supply air along with moisture for a certain time in the acklyne box to make it saturated with the temperature inside the room.

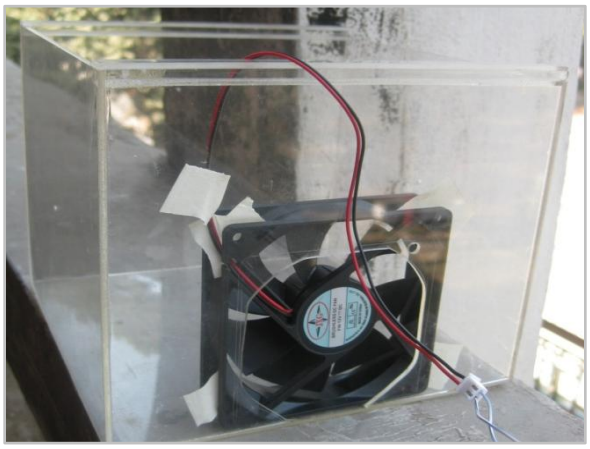

Fig 1. Mechanical Component

2.2 Function Of Electrical Components

A. LM741

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709.Non inverting low voltage signal is given to pin 3.A 5v supply is maintained between pin 7 & to operate the amplifier. The device gives a high output voltage signal at pin 6; the circuit configuration is shown in Figure 2.

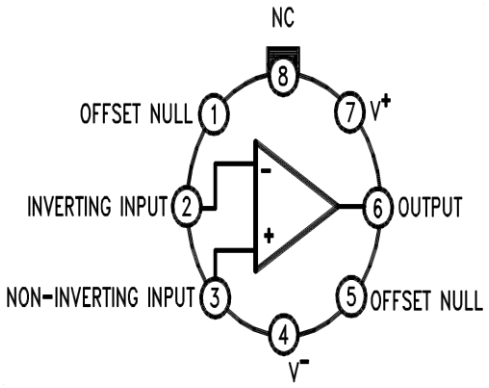

Fig 2. Connection Diagram of LM741

B. MULTIPLEXER74157

The 74157MUX are quad 2-input multiplexers which select 4 bits of data from two sources under the control of a common data select input (S). The four outputs present the selected data in the true (non-inverted) form. The enable input (E) is active LOW. When E is HIGH, all of the outputs (1Y to 4Y) are forced LOW regardless of all other input conditions. Moving the data from two groups of registers to four common output buses is a common use of the "157". The state of the common data select input (S) determines the particular register from which the data comes. It can also be used as function generator. The device is useful for implementing highly irregular logic by generating any four of the 16 different functions of two variables with one variable common. The "157" is the logic implementation of a 4-pole, 2-position switch, where the position of the switch is determined by the logic levels applied to S. (Mazidi et al. 2007).

PIN DESCRIPTION

1 S common data select input

2, 5, 11, 14 1I 0 to 4I 0 data inputs from source 0

3, 6, 10, 13 1I 1 to 4I 1 data inputs from source 1

4, 7, 9, 12 1Y to 4Y multiplexer outputs

8 GND ground (0 V)

15 E enable input (active LOW)

16 V CC positive supply voltage

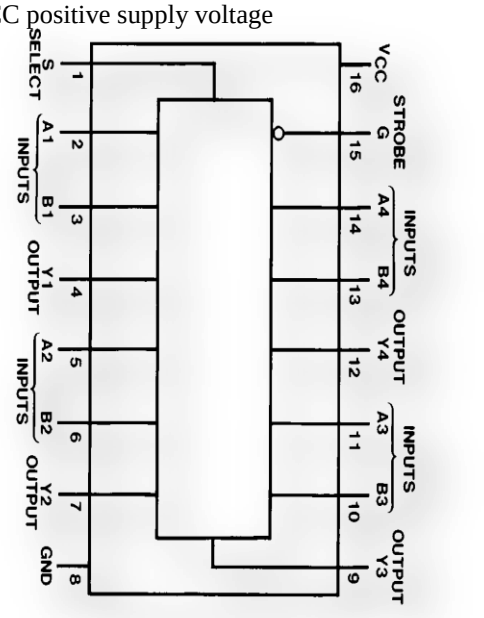

Fig 3: Connection Diagram of MUX74157

C. ADC0804

This device operate on the successive approximation Principle. Analog switches are closed sequentially by successive approximation logic until the input to the auto zero converter[$V_{in}(+)$-$V_{in}(-)$] matches the voltage from the decoder. After all bits are tested & determined, the 8 bit binary code corresponding to the input voltage is transferred to an output latch. Conversion begins with the arrival of a pulse at the WR input if the CS input is low. On high to low transition of the signal at the WR or CS input, the SAR is initialized. The shift register is reset, and the INTR output is set high. The A/D will remain in the reset state as long as the CS and WR inputs remain low. Conversion will start from one to eight clock periods after one or both of these inputs make a low to high transition. After the conversion is complete the INTR pin will make a high to low transition. (Mazidi et al. 2007).

D. RTD501

Resistance thermometer also called the resistance temperature detectors or resistive thermal devices are temperature sensors that exploit the predictable change in

electrical resistance of some materials with changing temperature. As temperature increases the resistance of these materials goes down, so the sensor gives high voltage.

E. PARALLEL PORT

This port is used to interface with computer. Status port shows the status of transferred data, Data port is used to send data to computer and control port controls the inverting and non-inverting mode of transferred data.

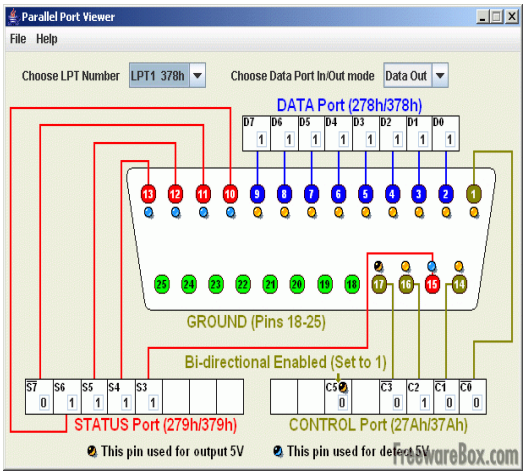

Fig 4. Parallel Port

3. WORKING PROCEDURE

The Psycrometer operates as the normal humidity measurement system but more easily. At first the cooler fan is operated for 7-8 minutes by the (+)5V supply by a transformer. Moisture Input was done by hanging a wet cloth just behind the fan. Then (+)12V and (-)12V is supplied from a 12x2V transformer and output is controlled by 7812 & 7912 IC which goes to pin 7 & 4 of the op-amp LM741.Temperature sensor RTD501 gives input to the op-amp at pin 6,op-amp magnifies the input voltage upto 100 -120 times. This amplified signal then goes to ADC0804 where it is précised and interpolated. Then this analog data is transferred to the MUX74157. MUX records data on a 4-4 bit system & finally converts it to a 8 bit or 1 byte digital data. Parallel port then takes the digital data from the control pin in non-inverting mode. During data input WR pin is made low & RD pin is made high. After obtaining the data from the data port it will be taken as the wet bulb temperature for the previously built C program. The program gives a value of relative humidity corresponding to the dry and wet bulb temperature of the system whose humidity is to be measured. These values are set in the program in array from in the code. The code is developed for dry bulb temperature range of about 20 to 40^0C & 15 to 35^0C wet bulb temperature in respect to the general weather condition of Bangladesh. Also the code will give accurate result for full valued temperature & an approximated value for fractional values of temperature. For example: if the dry bulb temperature is 27.5^0C the code will take it as 27^0C. After taking the wet bulb temperature reading the box or system is opened to atmosphere for about 2-3 minutes to reach to atmospheric condition. RTD501 then take the dry bulb temperature and send to computer code in the same way. Corresponding to the 2 inputs code will then give the relative humidity of the system. A (+)5V supply should be maintained to the circuit during PC interfacing.

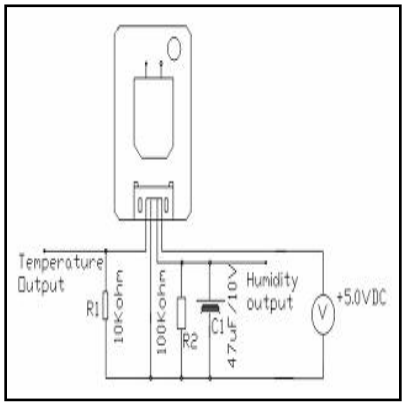

Fig 5. Data Transferring

4. ALTERNATIVE METHOD

The relative humidity measurement device can be built another way using microcontroller & temperature sensing devices. In this method a relative humidity sensor HSM-20G along with a microcontroller Atmega 8 is used to measure humidity directly. Program coding is done using AVR studio compiler.

4.1 HSM-20G

Humidity sensor is a device consisting of special Plastic material whose electrical characteristics change according to the amount of humidity in the air. Basically it is a sensor that senses the amount of water vapour in the air. The module of HSM-20G is essential for those applications where the relative humidity can be converted to standard voltage output. To use the Humidity Sensor, a connector cable has to be built. Then the 4-pin header of the device to be connected to the circuit so that the (-) pin connects to ground, the (+) pin connects

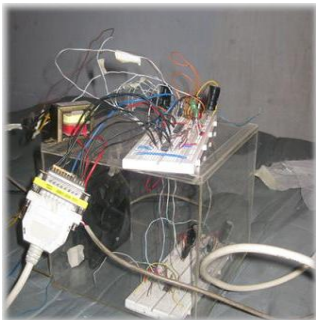

Fig 6. Basic Circuit

to Vcc, H pin and T pin connects to the microcontroller's I/O pin. The microcontroller's I/O pin needs to be set to ADC mode. The circuit in Figure 6 shows the example circuit for humidity sensor.

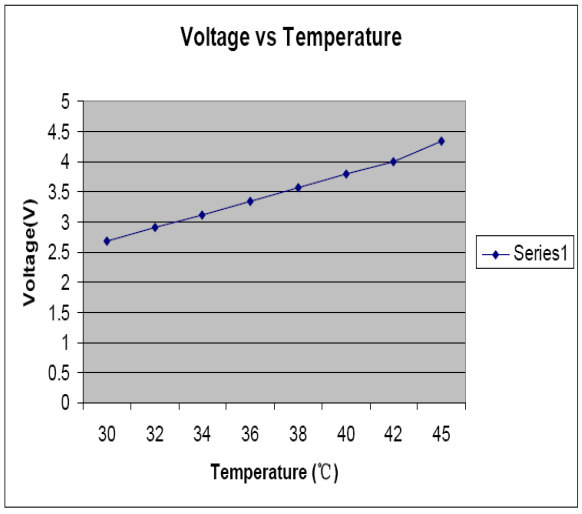

Fig 7. Characteristic Curve

The relationship between output voltage and temperature shown in Figure 7. Please take note that when the temperature is higher than 45^0 the result becomes unstable.

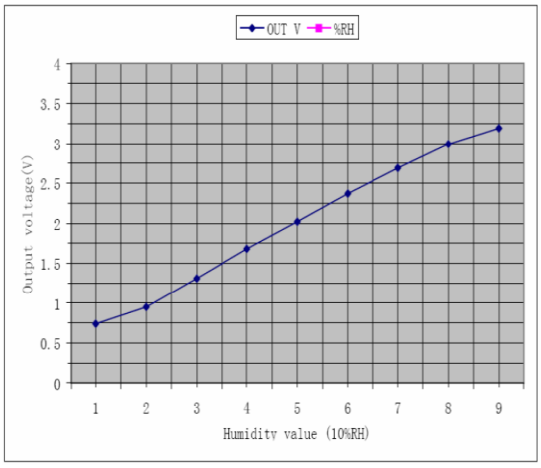

Fig 8. Characteristic Curve

Figure 8 shows the relationship between output voltage and humidity while Table 1 shows the standard characteristics of the humidity sensor.

Table 1: Accuracy Measurement
(Source: Cytron Technologies, 2009)

%RH	10	20	30	40	50	60	70	80	90
OutpotV	0.74	0.95	1.31	1.68	2.02	2.37	2.69	2.99	3.19

4. 2 ATMEGA AT89C2051

The AT89C2051 is a low-voltage, high- performance CMOS 8-bit microcomputer with 2K Bytes of Flash programmable and erasable read only memory (PEROM). Port B is a 8 bit bi-directional I/O port with internal pull-up registors. The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs port B pins that are put externally low will source Current if the pull-up registors are activated. Port C operates the same way as port B but the only difference is that Port C is a 7 bit bi-directional I/O port with internal pull-up registors. PC0 toPC3 of Port C can be used as ADC input channel. (Heath et al. 2003).

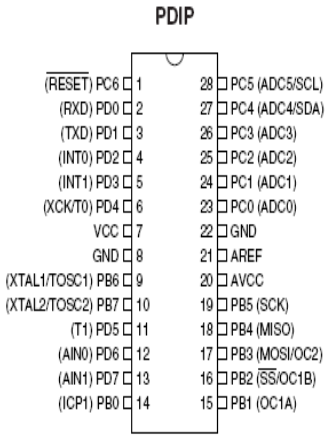

Fig 9. Pin Configuration

5. WORKING PROCESS

To operate the device HSM-20G it is connected to the microcontroller at to construct the basic circuit as shown in Figure 6. A hex file has been programmed to the Atmega 8 using AVR studio so that the microcontroller's Port C started operating in the ADC mode. The Port B of the controller is connected to a 20X8 LCD display. Pin 2 of the LCD is connected to the 5V supply and Pin 3 of the controller is connected to a 10K potentiometer. Pin 1 of the display has set ground. The basic construction of the circuit is shown in Figure 10.

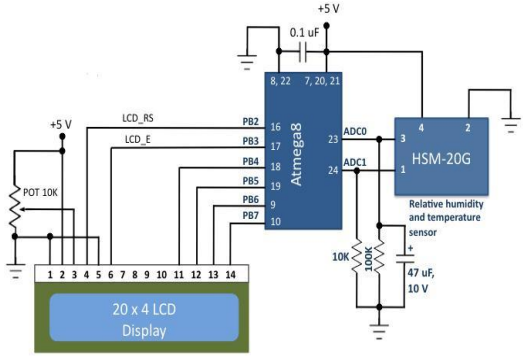

Fig 10. Construction Circuit

When the circuit starts operating the built in temperature sensor of the device HSM-20G reads the dry bulb temperature of the system under inspection. Then according to the figure 7 curve it gives a voltage which is taken as input to the microcontroller. It also has a humidity sensor which operates according to the dry bulb temperature output voltage a gives a value of the relative humidity. Then this analog signal is converted to digital signal by the microcontroller by ADC0 and ADC1 channel. The ADC converts an analog input voltage to a 10-bit digital value through successive approximation. The minimum value represents the GND and the maximum value represents the voltage on the AREF pin minus 1 LSB. The analog input channel is selected by writing to the MUX bits to ADMUX in the program code. The ADC is enabled by setting the ADC enable bit, ADEN in ADCSRA because voltage reference and input channel selection will not go into effect until the ADEN is not set. The ADC does not consume power when ADEN is cleared, so ADC mode is set off when the microcontroller is going to power saving sleep mode. The ADC generates a 10-bit result which is presented in the ADC data registers, ADCH and ADCL.(Axelson, 1994) This converted output is then represented by the LCD. The LCD is programmed to show the ambient temperature and relative humidity of the system. The figure 11 shows the analog to digital conversion procedure of the microcontroller.

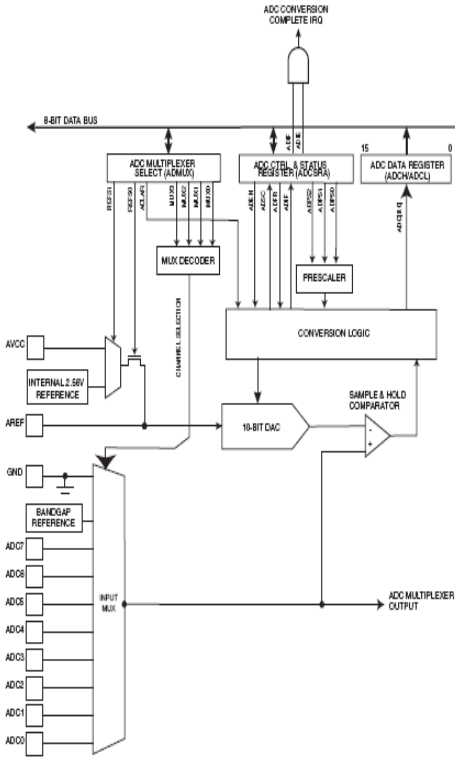

Fig 11. Analog to Digital Conversion

6. RESULTS AND COMPARATIVE ANALYSIS

The process one is an easy one and suitable for the Beginners. One can easily perform the project if they know C/C++ programming language and parallel port data transferring or PC interfacing. This process is also very economical. But the result obtained from this process contain relatively high amount of error and it also gives the result after some minutes later. Moreover the result is unstable because of the rapidly changing RTD sensor's voltage. So it is suitable for the fields where very accurate results are not required. The second process is very quick and gives very accurate result because the humidity sensor has accuracy of about 5% RH. But in order to built such a portable construction a humidity sensor and a microcontroller is essential. Besides programmers have to be expert in microcontroller's programming language and they must have to know about the different operating modes of microcontroller. This compact structure is suitable where very fast and accurate results are required. Both the processes is described in the paper so that users can compare and select the process suitable for their purpose.

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