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Design and Development of a PC- Based temperature monitoring system

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Abstract

This paper describes the design and development of a personal computer based temperature monitoring system that is capable of monitoring temperature of surroundings and displaying the results on a personal computer (PC) screen

The design of the work involves a circuit that measures the surrounding temperature using appropriate sensors and the sensor output is then converted to digital signals after due processing and conditioning of the signals. There is also an interface circuit configured to make it compatible with the PC hardware. This design consists basically of a temperature sensing circuit whose output is fed to the analogue to digital converter which feeds the converted digital signal to the interface circuit and PC.

The circuit was designed, constructed, tested and found to perform satisfactorily as the temperature readouts on the computer screen (monitor) were fairly in good accord with readings from a standard liquid in glass thermometer. A much more detailed comparism however between the developed PC – Based monitoring system and a standard liquid in glass thermometer shows a difference of $3^{O}C$ which indicates that the developed monitoring system appears accurate for temperature monitoring.

Keywords: Temperature monitor, personal computer, sensors, thermometer.

1.0 Introduction

Temperature is the degree of hotness or coldness of a substance.[1] Air temperature is one of the elements of weather that we experience directly. Humans are very sensitive to levels and changes in temperature because our bodies respond to preserve heat if it gets too cold or shed heat if it gets too hot.

Temperature is measured with the aid of a thermometer and most temperature scales today are expressed in degree Celsius (^{o}C) and the Fahrenheit (^{o}F). Fahrenheit scale is widely used in meteorology and climatology as well as in United States of America. On this relative scale water freezes at 32^{o}F and boils at 212^{o}F (at sea level). The Celsius scale is widely used in the non-English speaking world and by scientists. On this scale water freezes at O^{o}C and boils at 100^{o}C (at sea level). Kelvin (K) is an absolute temperature scale on which there is an absolute zero temperature scale. Absolute zero on the Kelvin scale is - 273.15^{o}c (-406 ^{o}F) and water freezes at 273.15K. The degree symbol (0) is not used on the Kelvin scale. The Kelvin scale is used at extremely low temperature mostly by physicists but rarely by climatologists and meteorologists [2]. The ordinary thermometer when used as a measuring device requires that an observer be present at the site of measurement so as to be able to take record of temperature variations with time. This implies that for the period when there is no human observer the information from the measuring device is lost and can never be recovered. Because of this fact that the ordinary thermometer lack any form of reliable memory, they cannot be used alone when high sampling rates and data storage are required. This has given rise to the need for computer based temperature monitoring systems. Temperature monitoring is important in many applications and systems as excessive changes in temperature can lead to detrimental effects and failure of operation.[3,4]

There are two types of temperature monitoring systems that can be interfaced with the computer. They are

(i) The Microcontroller - Based system, and
(ii) The PC - Based system

Many previous research on temperature monitoring systems have concentrated on the micro controller-Based system, because a high-speed data processing can be achieved by this method. Nazlia et. al. [3] developed a real-time temperature and voltage monitoring system for the purpose of monitoring and controlling semi conductor component devices which are heat sensitive in industry-based applications. The prototype involves the development of the software for monitoring

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purposes and a special electronic hardware designed to interface with the external devices by using the microprocessor parallel port communication. Mahmoud, O. [4] and Marhaerianto et al [5] developed a computer monitoring device to monitor air temperature, humidity and carbon dioxide in a green house environment using micro controller (A T 90S8535 CPU chip). The microcontroller receives data on green house environmental conditions from a number of sensors installed inside and outside and transfers the data to and from a PC via parallel port cable. This work concentrates on personal computer monitoring system PC – Based.

The PC- based temperature monitoring system uses a temperature sensor in order to be able to check the temperature of the surroundings. A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. [5] The temperature sensor used in this work is LM35IC. This type of sensor was chosen because of its linearity and accuracy. The temperature sensor measures the temperature and sends the output voltage to analogue to digital converter for processing [6,7]

1.0 DESIGN CONSIDERATION AND ANALYSIS

The design of the circuit of a PC-Based temperature monitoring system can be broken down into five main groups.

(i) Power supply
(ii) Temperature sensing circuit
(iii) Analogue to digital converter (ADC)
(iv) The Interface circuit
(v) The control switch

1.1 Power Supply

The circuit needs a power supply of +5V for the digital integrated circuit (I.C) to power the circuit. For this reason a 220/12V step down transformer was used to power the circuit.[8] The power supply circuit diagram is shown in Figure 1.0

Output Secondary Voltage = 12V rms.

Peak Voltage Vp = 12 x √2 = 16.9V

Peak output voltage from bridge Rectifier (VP.R)

$$VP.R = Vp - 2Vd \tag{1}$$

$= 16.9 – 2 (0.7)$

$= 16.9 – 1.4$

$= 15.5V$

Were Vd is the barrier potential voltage of a diode at room temperature and it is approximately 0.7volts for silicon.

An Integrated Circuit (I.C) bridge Rectifier RBPC6010A was used in the design and has the following specifications.

RBPC6010A Bridge Rectifier

Output Current = 6A at 50^{o}C

Current surge (maximum) = 125A

Reverse voltage VRM = 100V

$$\text{Ripple Voltage} = \frac{IO}{2FC} \tag{2}$$

Where IO = regulator Output Current

V_r = Ripple voltage $= \frac{IO}{2FC}$

For IO = 200mA, Vr = 1V, F = 50Hz

$C_1 = \frac{2.0 X 10^{-3}}{2 X 50 X 1}$ = 0.002F = 2000 μF

Thus a capacitor with at least 2000μf and working voltage of 16.9V would have been needed. But the one chosen for the design is 25V, 2,200 μf because of its availability. In order to get the needed regulated voltage, I.C voltage regulator was used in the power supply.

Regulator data: 7805

Maximum Input Voltage = 30V

Maximum Output Voltage = 5.5V

Drop out Voltage = 2 V

Operating temperature = 0^{o}C – 150^{o}C

The power supply circuit is shown in Figure 1.0.

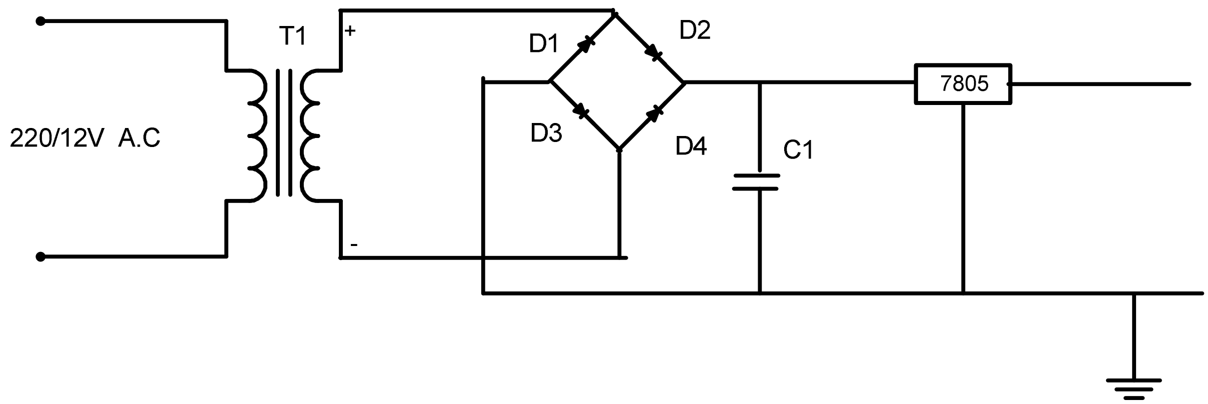

Figure 1.0: Power supply circuit

2.2 Design of the Temperature Sensing Stage

The temperature sensor chosen for the design is the popular LM35 IC temperature sensor. LM35 is a three terminal integrated circuit temperature sensor giving a linear voltage output of 10mV per degree Celsius. Available in two versions, one operating from ^{0}C to 100^{0}C (DZ version) the other is from -40^{0}C to + 100^{0}C (CZ version).[9]

These devices are housed in TO-92 plastic packages and provide a low cost solution to temperature measurement. Ideally suited for ambient temperature measurement such as providing cold junction compensation for thermocouples.

2.3 Design of the Analogue to Digital Converter (ADC)

The analogue to digital converter function is to convert the analogue voltages from the temperature sensors and that from the supply voltage to digital information. The type of ADC of choice is one that can output the information in binary format. The ADC 0804 fits this type of ADC of choice. The analog to digital converter stage was designed using a dedicated ADC chip ADC-0804.

2.4 Design of the Interface Circuit

The interface circuit function is to connect the output of the three sensor stage units to the computer parallel ports. The interface circuit is basically made up of a buffer circuit. The buffer used for the design is the 74LS244 TTL (transistor – transistor logic) chip. It has eight buffers and pin-layout.[10,11]

2.5 Design of Control Switch

The control switch consists of a transistor relay switch arrangement that is activated whenever the set limit is exceeded.

Relay specification

Relay resistance = 400Ω

Relay operating Voltage = 12V

$$\text{Operating Current, Ic} = \frac{V}{R} = \frac{12}{400} \quad (3)$$

Ic= 30mA

The transistor is the C945 NPN type.

2.0 OPERATIONAL PRINCIPLE OF THE PC-BASED TEMPERATURE MONITORING SYSTEM

The complete circuit diagram is as presented in Figure 3.0. The power supply stage consists of the transformer TI, bridge rectifier DI-D4, filter capacitor CI, and 7805 voltage regulator. The transformer steps down the mains voltage of 220V to 12V ac. The bridge rectifier rectifies the ac to dc. Capacitors C_1 is a filter capacitor to filter off ac ripples in the dc voltage. 7805 is a positive 5V voltage regulator meant to supply a constant 5V to the circuit.

The main control circuit starts with the PC parallel port which is an interface between the PC and the control circuit. The temperature sensor used in the design is the IC temperature sensor LM35DZ. The function is that is gives an analog voltage output per degree change in temperature. This voltage is then converted to digital data by the ADC 0804 analog to digital converter. This information is fed to the P.C via the parallel port. The PC sends control pulse to enable a transistor relay switch to control a fan whenever the set temperature is exceeded. This analog voltage from the sensor is fed to the ADC chip IC1 to convert it to digital as binary while IC2 serves as a buffer to drive the parallel port.

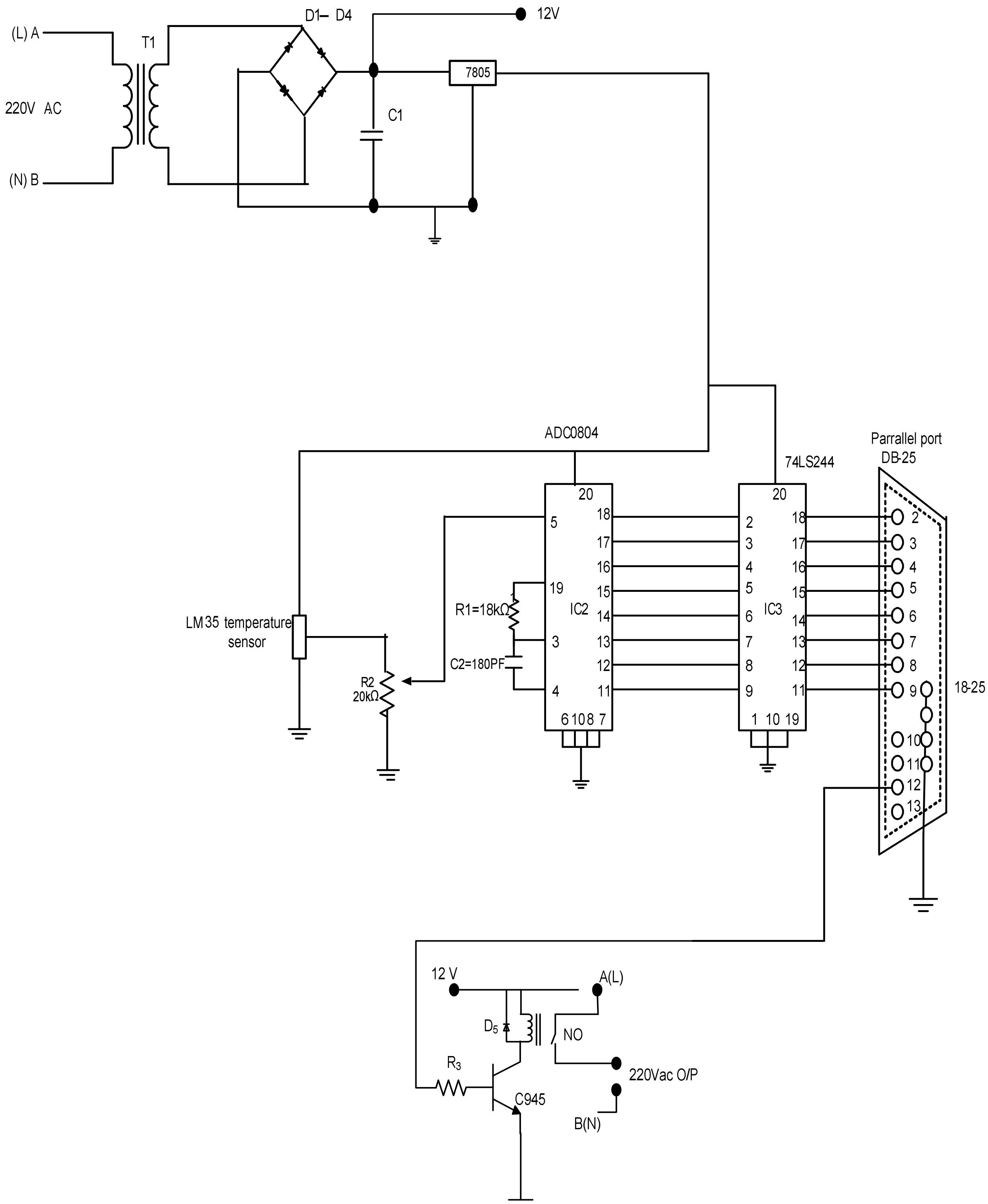

Figure 3.0 Complete Circuit Diagram of the PC- Base monitoring system

3.0 Construction

The construction work started immediately after the completion of the design calculations and selection of components. The components were initially set up on a bread-board to test the circuit before being transferred to the Vero board.

The breadboard stage started with the connection of both temperature sensors, followed by the analog to digital converter (ADC) circuit. The ADC data output were then connected to the PC parallel port cable DB-25.

The power supply stage was finally connected after making sure all other stages and their components were rightly connected. Each stage had its components mounted according to the circuit design specifications. The layout of the components was carefully done so that the circuit can work as planned. Each of the stages and their components were then connected to the others using jumper wires. All stages were set up according to design. Power was supplied to the circuit and the appropriate tests carried out, followed by the visual basic code development and careful debugging.

After the circuit has been tested and adjustments made, the components were then transferred to the vero board for permanent soldering. The soldering work started with the power supply stage since it was needed for testing the other stages of the design. The power stage was followed by the temperature sensor stages, analog to digital converter (ADC). These were connected to the PC parallel port. With the aid of a multimeter these stages were confirmed to be in good working condition. Care was taken during soldering to ensure proper soldering joints and portions of the copper strip-lines that needed isolation were properly isolated. After the complete construction work the unit was tested.

4.1 Casing

The completed circuit was placed in a white PVC plastic box and sensor leads for the parallel port cable was brought out with power switch and power cable.

4.0 Results And Discussion

5.1 Components Test Results

The testing was done stage by stage as each stage construction was completed. This approach is best as it enables one to quickly identify stage that are not working properly and be corrected.

5.2 Performance Test Results

The performance of the developed PC- based temperature monitoring and that of the standard liquid in glass thermometer were compared and the following results were obtained.

Table 1.1: Comparism between PC- Based Temperature Monitoring System and Liquid In Glass Thermometer.

Date	Time of the day	PC- Based temperature monitoring system (^{o}c)	Liquid in glass thermometer (^{o}c)	Difference (^{o}c)
20th September 2009	12-1pm	32.4	32.4	0.0
	1-2pm	33.5	33.0	0.5
	2-3pm	33.5	33.5	0.0
	3-4pm	31.4	31.0	0.4
	4-5pm	31.4	31.4	0.0
	5-6pm	30.5	30.4	0.1
21st September 2009	12-1pm	28.0	28.0	0.0
	1-2pm	28.0	28.0	0.0
	2-3pm	29.5	28.0	0.0
	3-4pm	29.5	29.0	0.5
	4-5pm	28.5	29.0	0.5
	5-6pm	27.0	28.5	0.0
22nd September 2009	12-1pm	27.0	27.0	0.0
	1-2pm	27.5	27.0	0.5
	2-3pm	28.0	28.0	0.0
	3-4pm	30.2	30.1	0.1
	4-5pm	29.0	29.0	0.0
	5-6pm	28.0	28.0	0.0
23rd September 2009	12-1pm	30.2	30.2	0.0
	1-2pm	30.2	30.2	0.0
	2-3pm	30.2	30.1	0.1
	3-4pm	30.0	30.0	0.0
	4-5pm	30.5	30.2	0.3
	5-6pm	29.0	29.0	0.0

5.3 Discussion

The developed PC- Based temperature monitoring system was used to take measurements at a house located in Siluko area of Benin City, Edo State for Four Days, September 20^{th} to 23^{rd} 2009 between 12 noon and 6 pm daily. A standard liquid in glass thermometer was also used to measure temperature at the same venue on the same day and time. The total difference between the two measured values for four days measurement were computed and found to be 3^0C . This indicates that the developed work is sufficiently accurate for temperature monitoring.

5.0 Conclusion

In this work a PC- Based temperature monitoring system was designed, constructed and implemented. It can be used to measure temperature of surroundings at any time. When it is installed, it starts working. The results are displayed on the computer screen. The work differs from the previous work done on references 3,4 and 5 in that it does not use a microcontroller but still can be used to monitor surrounding temperature accurately.

A comparism of the developed personal computer based monitoring system and the standard liquid in glass thermometer shows minimum difference. This indicates that the developed work is sufficiently accurate for temperature monitoring.

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