Design and Development of a Microcontroller Based Room Temperature and Humidity Control System

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Abstract

A microcontroller based room temperature and humidity control system has been designed and developed to maintain temperature and relative humidity of a room at predefined level. The developed microcontroller system could also control the air conditioner, heater, humidifier and de-humidifier of the same room. Parameters are displayed on a two line liquid crystal display (LCD). The display unit is capable to show the set value and present value of temperature and relative humidity. It can control the temperature in the range of 15°C to 40°C and relative humidity in the range of 40%RH to 90%RH. If the temperature and humidity are not set then the system would run with a set value of 25°C temperature and 65% the relative humidity. The system has a safety delay of 3 minutes to control after power ON or any kind of power OFF. The designed system has four switches. Three of them are applicable to set the room temperature and relative humidity. The fourth one is used as reset button. Six status indicator lights which is indicating the power, system status and status of air conditioner, heater, humidifier and de-humidifier.

Keywords: Relative humidity, liquid crystal display, microcontroller, air conditioner, humidifier, de-humidifier

1. Introduction

In Bangladesh various research laboratories, scientific stores, industries, medical places, insect rearing room, hospitals [1] etc. need a stable temperature and humidity for the proper functioning of consisting classified instruments and/or storage of food, beverage, medicine, growing of insects etc. Room temperature and humidity control system is crucial for the above places. Convinced on it an attempt has been taken to develop room temperature and humidity control system as air conditioner control systems only reduce the temperatures [2]. The system will increase or decrease temperature and humidity to maintain room temperature and humidity at desired level. It is accomplished by controlling four appliances namely an air conditioner, a heater, a humidifier and a de-humidifier.

2. Materials and Methods

Microcontroller PIC16F877A is used as the heart of the whole control system. Temperature sensor LM35DZ, humidity sensor HIH-4002 is used to measure the temperature and relative humidity, respectively. A 16 X 2 LCD liquid crystal display (LCD) is used applied to display the present and set temperature and relative humidity. An optocoupler MOC3010 and triac T6411M is used to design the control/driver circuit. All the peripherals are controlled by the microcontroller.

2.1 Block Diagram of the Designed System

Fig. 1 shows the block diagram of the total controlling system. The blocks are: Low voltage power supply, Temperature sensor , Humidity Sensor , Keypad Interface, Driver Circuit (I), Driver Circuit (II), Driver Circuit (III), Driver Circuit (IV), Microcontroller (PIC16F877) , Digital Display, Air Conditioner, heater, humidifier and de-humidifier.

Low voltage power supply supplies potential 5V to the sensors, microcontroller and other component of the device. Keypad Interface, Temperature sensor and Humidity sensor are input of the Microcontroller. Driver Circuit and Digital Display blocks are the output of the Microcontroller. Microcontroller controls four driver circuits individually. These four Driver Circuits control the Air Conditioner, heater, humidifier and de-humidifier according to the source code of the microcontroller.

2.2 Design of Temperature Sensing Circuit

To measure temperature LM35DZ [3] sensor has been used. The LM35DZ series are precision integrated circuit temperature sensors whose output voltage is linearly proportional to the Celsius (centigrade) temperature. The Temperature sensing circuit is shown in Fig. 2. The circuit consists of resistor R1, variable resistor VR3 and LM35DZ. The variable resistor VR3 is used to scaling the sensor. The sensor senses temperature and convert this value into voltage. This voltage is used as the input of microcontroller in pin number 2. Microcontroller processes this data using program code.

2.3 Design of Humidity Sensing Circuit

To measure humidity, HIH-4000 Series Humidity sensors has been used. The applied sensor is HIH-4002 [4]. From the Fig. 2 it can be seen that this circuit consists of resistor R4 and capacitor C9. The resistor R3 and variable resistor VR1 is used to scaling the sensor and the capacitor is used to minimize the noise. The sensor senses the humidity and converts it to voltage. This voltage sends as the input data of the microcontroller in pin number 3. Microcontroller process the data with the help of this program code.

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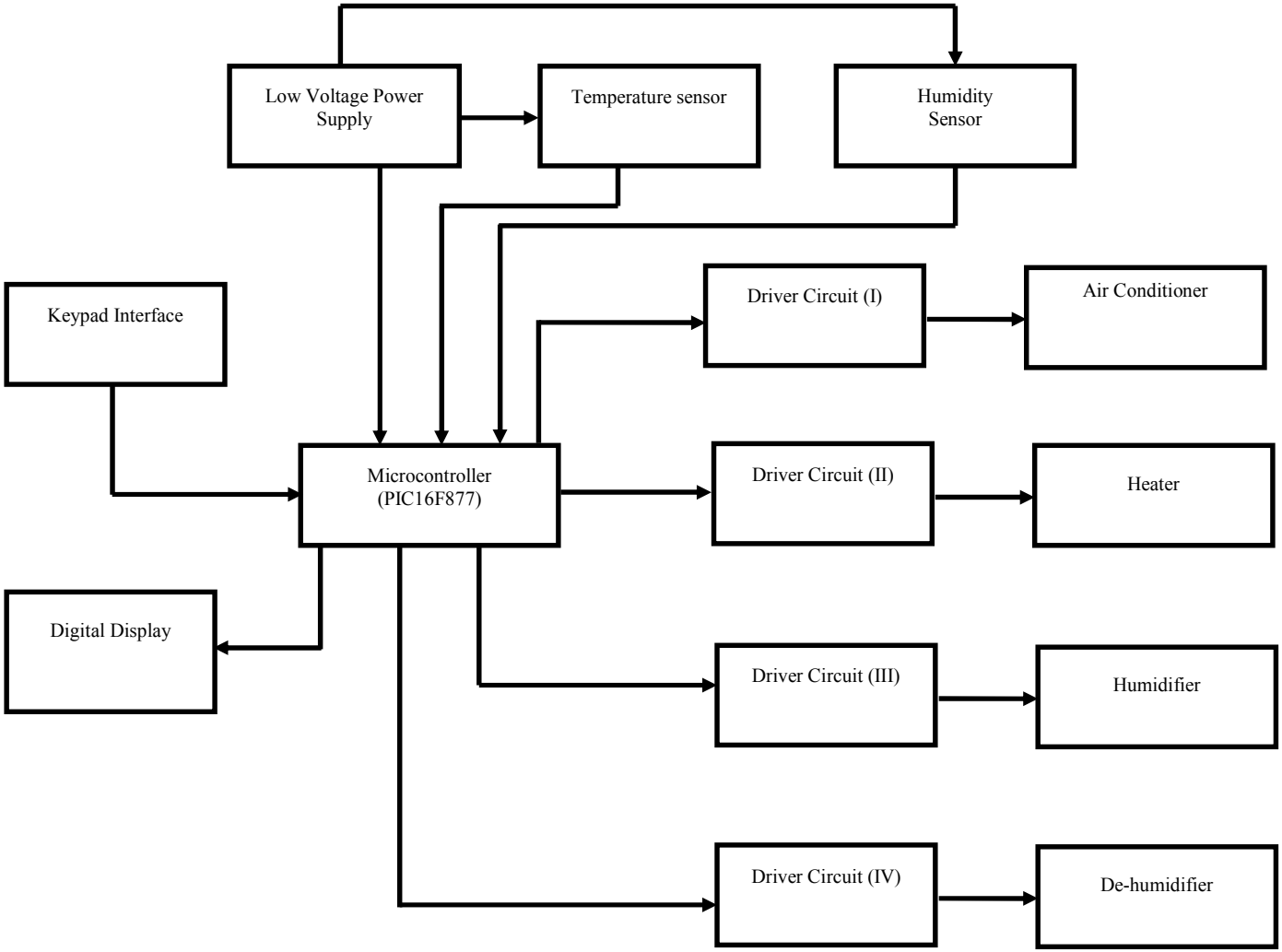
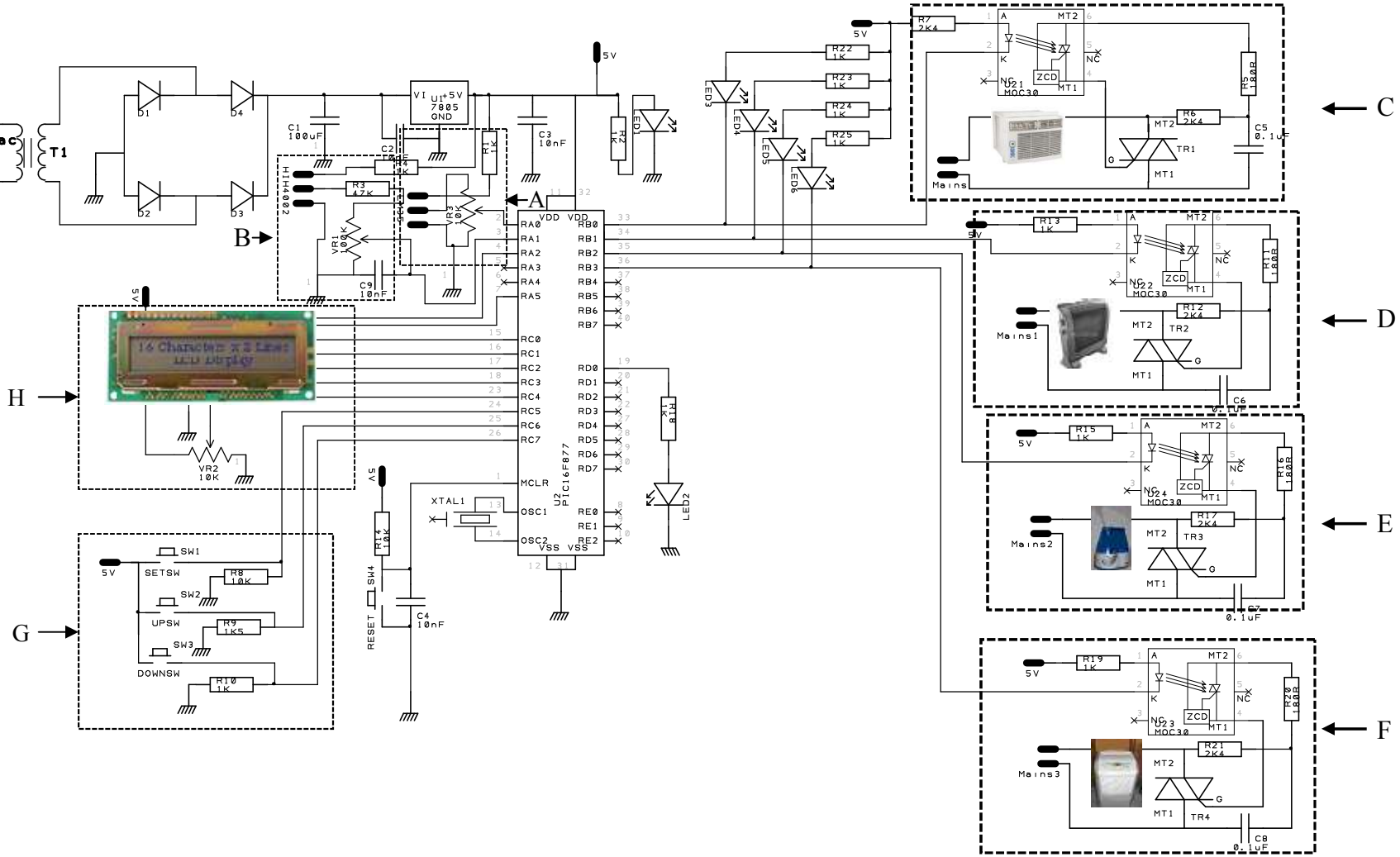


Fig. 1 Block diagram of room temperature and humidity control system



A - Temperature Sensing Circuit
B - Humidity Sensing Circuit
C - Air Conditioner Driver Circuit
D - Heater Driver Circuit
E - Humidifier Driver Circuit
F - De-Humidifier Driver Circuit
G - Keypad Interface
H - Display Circuit

Fig. 2 The complete circuit diagram of the designed room temperature and humidity control system

2.4 Air Conditioner Driver Circuit

The Air conditioner driver circuit as shown in Fig. 2 consists of resistor R5, R6, R7, capacitor C5, Opto-coupler MOC3010 [5] and Triac TR1 (T6411M) [6]. The microcontroller PIC16F877 [7] pin number 33 (RB0) sends instruction to the opto-coupler according to the program code. The output of the opto-coupler triggers the gate of the triac and the traic helps to turn on the air conditioner. The resistor R6 and capacitor C5 are used between MT1 and MT2. This is usually a RC type which called Snubber circuit.

Snubber circuits are used to suppress the rapid rise in voltage across a thyristor, preventing the erroneous turn-on of the thyristor and voltage spikes in the AC supply or those produced by inductive loads. The program code is written in such a way that if the temperature is set at any value which can be said as set value, the air conditioner will turn ON at the temperature of set value (+5^{o}C) and it will turn OFF at the temperature of set value (-3^{o}C). Usually, an air conditioner consumes the current of 15- 20 Amp. The triac using in this designed system can drive with the current of 30 Amp.

The main function of the opto-coupler circuit is to isolate the microcontroller circuit from the supply voltage 220V. The opto-coupler circuit gives enough voltage to fire the triac. With the supply voltage, one can easily use air conditioner or air cooler.

If considered the supply voltage, Vcc = 5V, R_7= 1KΩ and infrared diode forward voltage, V_{f1} = 1.8 V, then the Infrared diode forward current, I_{f1} is,

$$I_{f1} = \frac{V_{CC} - V_{f1}}{R_7} \qquad (1)$$

$$= \frac{5V - 1.8V}{1K} = \frac{3.2V}{1K} = 3.2mA$$

2.5 Heater Driver Circuit

Heater driver circuit as shown in Fig. 2 is consists of an opto-coupler MOC3010, triac TR2, resistor R11, R12, R13 and capacitor C6. The microcontroller pin number 34 (RB1) sends data to the opto-coupler according to the source code. The output of the opto-coupler trigger the gate of triac and helps to turn on the heater. R12 and C6 are snubber circuit. The temperature in the program is set in a specific value which we can be said as set value. The heater will ON at the temperature with set value (-5^{o}C) and heater will OFF at the temperature value of set value (-1^{o}C).

2.6 Humidifier Driver Circuit

Humidifier driver circuit as shown in Fig. 2 consists of an opto-Coupler MOC3010, triac TR3, resistor R15, R16, R17 and capacitor C7. The microcontroller pin number 35 (RB2) sends data to the opto-coupler through the source code. The output of the opto-coupler trigger the gate of the triac, which helps to turn on the humidifier. R17 and C7 are snubber circuit to protect erroneous turn-on of the thyristor and voltage spikes. The humidity in the program is set in a specific value which we can be called as set value. The humidifier will ON at the humidity of set value -5%RH and humidifier will OFF at the humidity of set value -1 % RH.

2.7 De-Humidifier Driver Circuit

The de-humidifier circuit as shown in Fig. 2 consists of an opto-Coupler MOC3010, triac TR4, resistor R19, R20, R21 and capacitor C8. The pin number 36 (RB3) of microcontroller sends data to the opto-coupler. The opto-coupler triggers the gate of the triac and the triac helps to turn on the de-humidifier. R21 and C8 are snubber circuit. The humidity in the program is set in a specific value which can be called as set value. The humidifier will turn ON at the humidity of set value+5%RH and humidifier will turn OFF at the humidity of set value -2 %RH.

2.8 Keypad Interface

To control the whole system, four individual key pad is used. The keypad interface circuit is also shown in the Fig. 2. SW1 (SETSW) uses to set the program. SW2 (UPSW) uses to increase the temperature and humidity of the room, SW3 (DOWNSW) uses for decrease the temperature and humidity and SW4 (RESET) is reset switch. The circuit also consists of the resistor R8, R9, R10 and R14. The keypads SW1, SW2, SW3 and SW4 are used as the input of microcontroller pin number 24(RC5), 25(RC6), 26(RC7) and pin number 1 (MCLR).

2.9 Display Circuit

Fig. 2 also shows the display circuit of the system. The display is a 16 X 2 LCD display [8], which display the current and set temperature and the relative humidity of the environment. A 10K variable pot VR2 is used to control the light of the LCD. The input of the LCD control through the microcontroller pin numbers of 5 (RA2), 7 (RA5), 15 (RC0), 16 (RC1), 17 (RC2), 18(RC3) and 23(RC4). The display can also show the set temperature and the relative humidity when the device is running, when the set button is pressed.

2.10 Regulated Dc Power Supply

Microcontroller, LCD panel, switches and other electronic components which are used in this designed system require a dc voltage (+5V). A highly stable regulated dc power supply is designed for this purpose. This circuit consists of a step down transformer, diodes, IC regulator 7805 [9], resistors and capacitors. The IC regulator have feature of internal thermal overload protection and internal short circuit current limiting. The IC regulator can drive the current up to 1 amp.

2.11 Flow Chart of the System

In the designed system the main part is the programming. The program is developed in assembly language in MPLAB IDE software. The program of room temperature and humidity control system has several subroutines. The Flowchart of the total system can be divided into some parts. Fig. 3 shows the flowchart of the total system. The flow chart contains of set routine, read temperature and humidity and store data and also all control routines. Fig. 4 shows the flowchart of the set routine. Fig. 5 shows the flowchart of the Air conditioner/ Heater /Humidifier/ De-humidifier control routine.

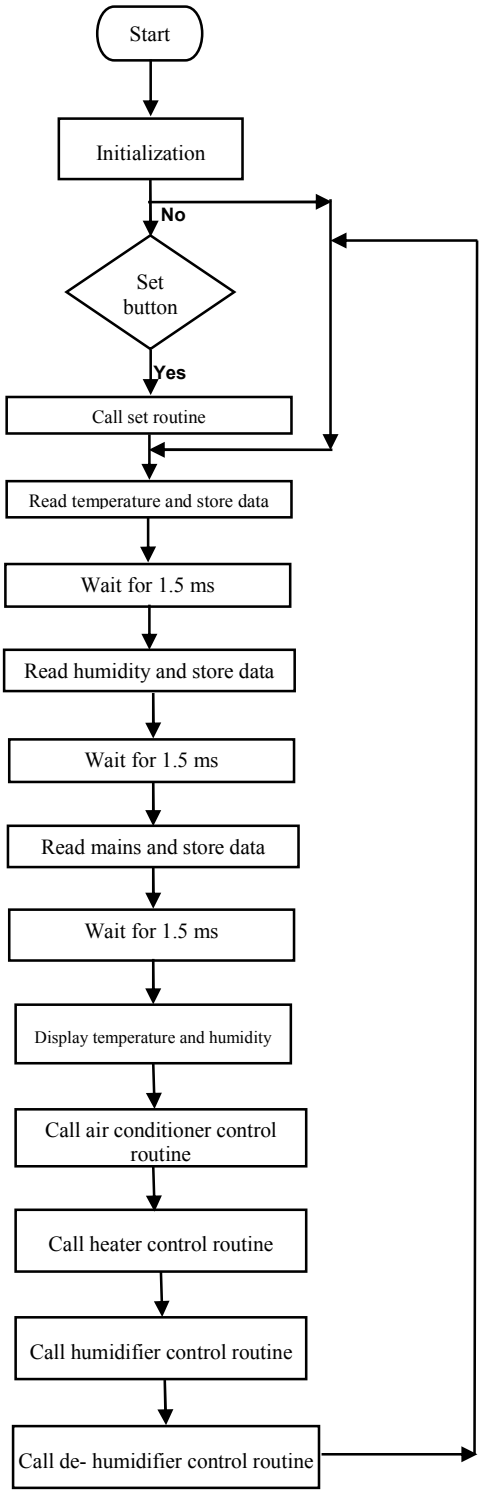


Fig. 3 Flow chart of the total system

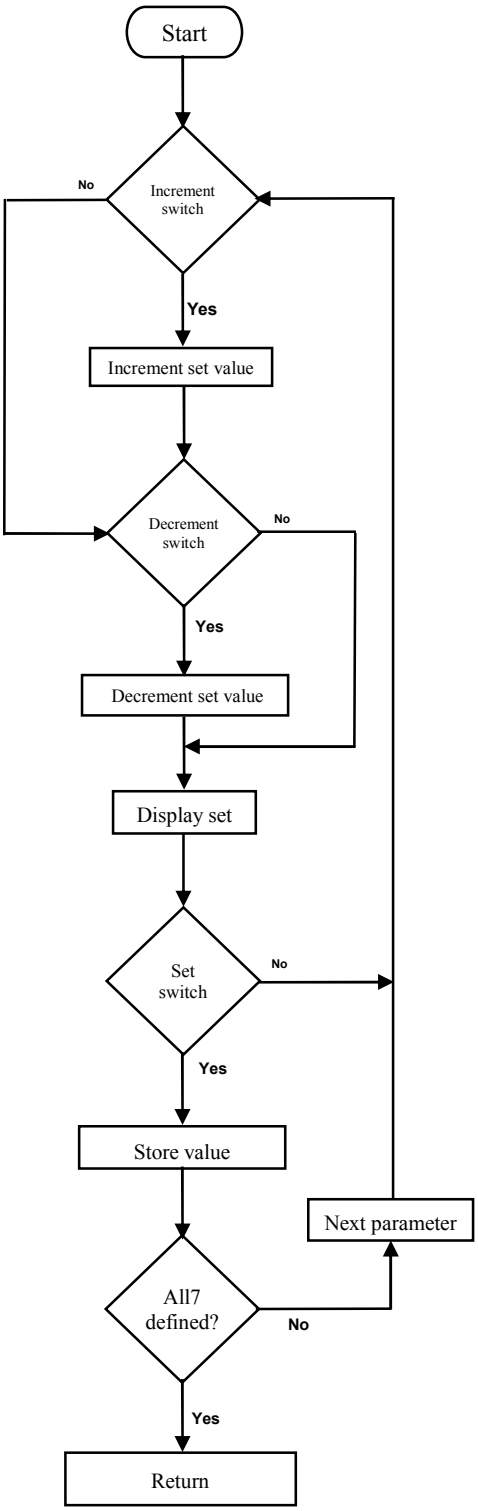


Fig. 4 Flow chart of the set routine

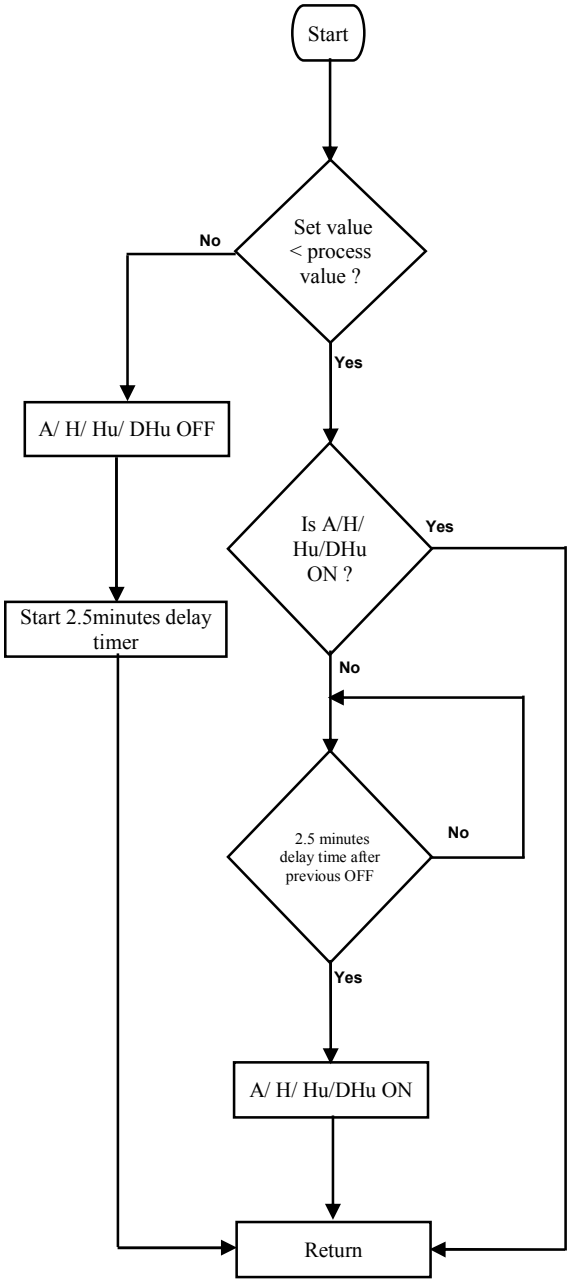


Fig. 5 Flow chart of the control routine

3. Results and Discussion

The accuracy of the proposed system has been tested through several experiments. The temperature and humidity of the system are compared with a standard HANNA instrument HI 8564 thermo hygrometer. Comparing the temperature of the designed instrument and standard instrument, temperature error has been calculated and temperature accuracy curve has been plotted which is shown in Fig. 6. It was observed that the temperature error is arround $\pm$ 0.3ºC. Humidity of the designed instrument and standard instrument was also compared. The humidity

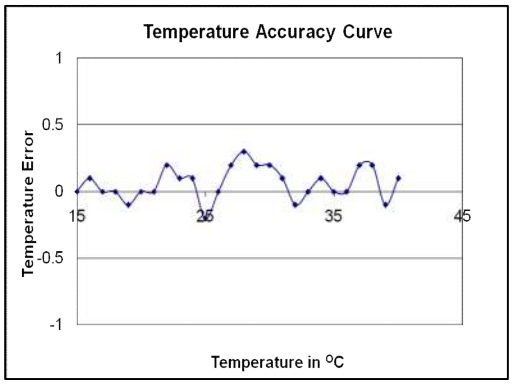


Fig. 6 Temperature accuracy curve

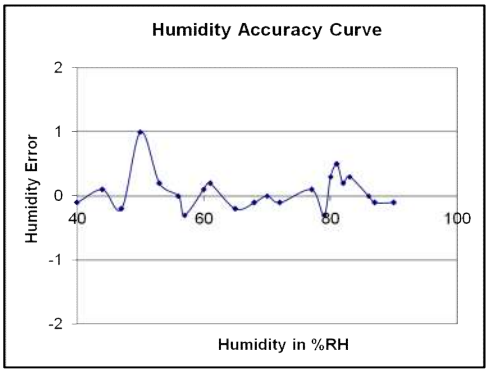


Fig. 7 Humidity accuracy curve

error was calculated and its accuracy curve is plotted which is shown in Fig. 7. It was observed that the humidity error is only ±1.

4. Conclusion

For controlling the temperature and relative humidity by controlling the runtime of air conditioner, heater, humidifier and de-humidifier is designed and tested. The designed system is simple, robust, reliable and inexpensive. The system can be used in research laboratories such as insect rearing room, growth room, greenhouse and stores like electronics store, medical store etc. where humidity and temperature is crucial to maintain the quality.

References

1. Thammanoon Sookchaiya , Veerapol Monyakul and Sirichai Thepa "A Study and Development of Temperature and Relative Humidity Control System in Hospital Buildings in Thailand" Proceedings of the EDU-COM 2008, 505-513. http://ro.ecu.edu.au/ceducom/40/
2. Farhana Hafiz, Md. Abdul Mannan Chowdhury, Fahmida Akter, Mohammod Abu Sayid Haque and Md. Serajul Islam, "Design and Development of Microcontroller based Air Conditioner Control System", Jahangirnagar Physics Studies, **17**, 25-30 (2011).

3. C1995 National Semiconductor Corporation RRD-B30M75/Printed in USA, December, 1994.

   http://pdf1.alldatasheet.com/datasheetpdf/view/8866/NSC/LM35.html.

4. Sensing and Control, Honeywell, 1985 Douglas Drive North, Golden Valley, MN 55422, 009017-5-EN IL50 GLO, Printed in USA, February 2010.

   http://sensing.honeywell.com/index.cfm/ci_id/140570/la_id/1/document/1/re_id/0.

5. SOES024A - August 1985 - Revised April 1998, Texas Instruments Incorporated, Post Office Box 655303, Dallas, Texas 75265.

   http://pdf1.alldatasheet.com/datasheetpdf/view/53871/FAIRCHILD/MOC3010.html.

6. http://pdf1.alldatasheet.com/datasheet-pdf/view/101076/ETC/T6411M.html, G E Solid state, T- 25-15.

7. PIC16F87XA Data Sheet 28/40-Pin Enhanced Flashed Microcontrollers, 2001 Microchip technology Inc., DS39582A.

8. Dot Matrix Liquid Crystal Display Controller/Driver, HD44780U (LCD-II).

9. KEC Semiconductor, 2010.5.19 Semiconductor Technical Data KIA7805AP-KIA7824AP, Bipolar Linear Integrated Circuit, Revision No: 1.

   http://pdf1.alldatasheet.com/datasheet-pdf/view/69437/KEC/7805.html,