Implementation of Home Temperature Sensing Control System Using Microcontroller

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Abstract: This paper focuses on the home temperature control system which can maintain the temperature at certain level. The home temperature controller is commonly used in all area of the world as the human thermal comfort becomes necessary. It can also reduce unfavourable condition in the home due to the unpredictable weather. The proposed system is not only the automatic home temperature sensing and control system but also the PIC microcontroller based controller. This control circuit is functioning without needed support from the human to control all the process. There are several temperature sensing techniques in widespread usage. Among these, the temperature sensor LM35DZ is used in this home temperature control system. In this control system, the temperature of the home is kept within 20°C and 28°C. By sensing the temperature inside the home, high temperature conditions and very low temperature conditions can be detected and actions can be taken to keep the temperature of a home within the desired temperature ranges. The microcontroller drives the heating and cooling elements to adjust the temperature. The LCD display is also provided to know the temperature status of the home easily.

Keywords: *Home Temperature Sensing Control System, Microcontroller, Control System Design, Applied Control, Embedded System*

I. INTRODUCTION

Temperature control is a process to maintain the temperature at certain level. This process is commonly used in all area of the world. Recently in globalization era, this process become important element because there are many applications in daily life involves this process especially residential building.

Automatic temperature control referred as the best method in any application by controlling the temperature automatically. This method shows significant improvement in temperature control as the process is functioning without needed support from the human to control all the process. The result obtain from the process shows the temperature is controlled effectively and more accurate. In addition, this finding makes human works become easy and system that automatically controlled and function is developed.

Moreover, strategies to reduce and optimize energy consumption are a global challenge, both economically and environmentally. The energy consumption in residential buildings consists mainly of two parts: energy required for heating and energy required for driving electrical devices. In recent decades, new construction techniques and insulating materials have been developed which remarkably reduce the heat loss of buildings, enabling high energy savings at the cost of a diminished natural air exchange. In this situation, sufficient indoor air quality must be guaranteed by appropriate heating and ventilation of rooms. Improvements of HVAC systems in residential buildings are aimed at a reduction of energy consumption and an adjustment of comfortable climate in rooms. Decentralized automated thermal climate control in sense of heating and ventilation control separately for each room offer good possibilities to achieve these demands.

The input parameter for the control system is obtained from the temperature sensor in the room. The climate response state of rooms is very complex and nonlinear.

This implies that the designed climate control system should work as a network between a large variety of different sensors and actuators. The survey for the home has three important goals: the determination of appropriate parameters for the physical room model, the concept for an optimal thermal control separately for each room, and the estimation of the achievable energy savings depending on the user's behavior. The following section introduces the proposed home temperature control system for the applications such as home automation system and HVAC system.

System Description for the Proposed Home Temperature Controller

The block diagram of home temperature sensing and control system is shown in Fig.1. This control system is intended for a home. The home is fitted with both a heater and a cooler, also linked to the automatic switching ON/OFF system. The home temperature controller makes decisions to adjust the home temperature based on information collected by a temperature sensor. The temperature sensor LM35DZ is used to sense the temperature status of the home. It is a voltage output analogue sensor and its output voltage is proportional to 10mv/°C. The voltage amplifier circuit amplifies the small voltage of LM35DZ to be able to provide the suitable amplified voltage to the microcontroller. The microcontroller has a program reading the output voltage of LM35DZ which is linearly proportional to the Celsius (Centigrade) temperature and comparing these values with the desired temperature set-points. When the temperature falls below 20°C, the heater is turned on by the microcontroller to get warm. When the temperature is higher than 28°C, the cooling system is activated by the microcontroller. The LCD display allows the user to acquire the current temperature data inside the home through the microcontroller and LM35DZ.

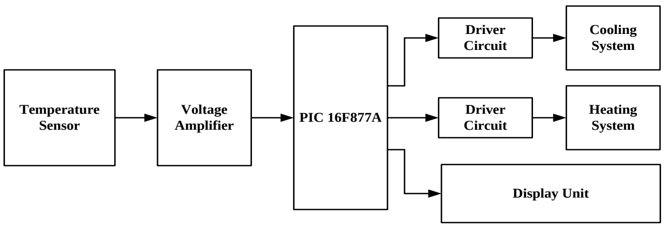

Fig.1. Block Diagram of the Proposed System

This home temperature control system can monitor the conditions night and day with immediate response to any changes. By controlling actuators such as heater or cooling fan, it is able to provide favorable environment for the home automatically. The main purpose of this paper is to control the daily heating of the home to the pleasure of everyone.

Hardware Design of Home Temperature Control system

In the proposed home temperature control system, PIC microcontroller 16F877A makes decisions to turn on or off the heater or cooling fan in the home based on information adjusted by comparing the temperature sensor values and the required set-points. This system can keep the home temperature within 20°C and 28°C which is the acceptable temperature range for a man. To get the required control functions, the complete circuit diagram is designed as shown in Fig. 4.1. It consists of six portions. They are:

- Power supply,
- Temperature sensor,
- Non-inverting amplifier
- Microcontroller and
- Driver circuit.

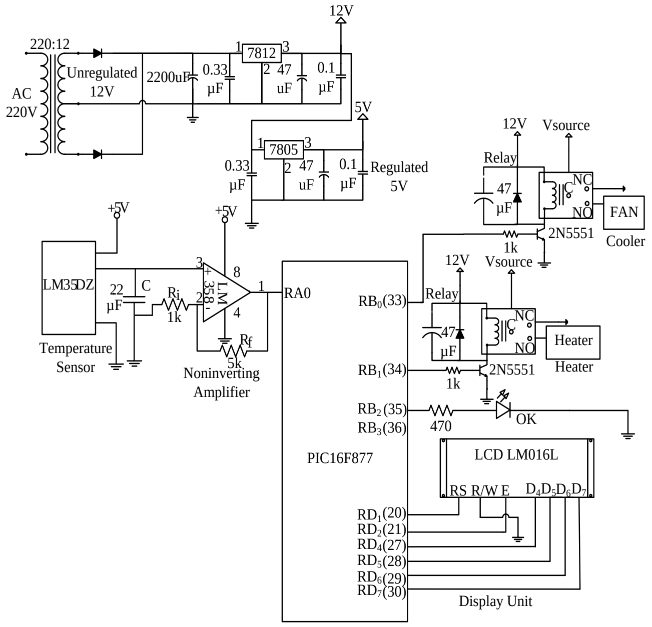

Fig.2. Complete Circuit Diagram of the Proposed System

In this system, the main control functions are performed by using the microcontroller, PIC16F877A. The IC temperature sensor, LM35 is used as the sensing unit. The output of the LM35 is proportional to 10mV/1°C. Therefore, a signal conditioning circuit is required to send the small millivolt of LM35 to the main control unit. The non-inverting amplifier including LM358 is used as the signal conditioning circuit. It can amplify the small output voltage from LM35 to be three times.

The ambient temperature is sensed by the LM35. The LM35 provides the output voltage. After this voltage has been amplified by three times, it is sent to PIC16F877A. The microcontroller receives it from RA0 and converts it to digital value by using ADC module. As the required set point for this system is between 20°C and 28°C, the A/D results are compared with these temperature values. Before that process, the A/D results have already been changed to be the same as the actual temperature value. It can be simulated and designed well in Proteus (ISIS) simulation software in advance.

When the temperature is higher than 28°C, the microcontroller drives the relay to turn on the cooling element. The cooling element is 12VDC fan for demonstration of this proposed system. When the temperature is lower than 20°C, the heating element is driven by the microcontroller. The lump is used as the heating element for demonstration of the circuit operation. If the temperature reaches between 20°C and 28°C, both of the cooler and heater are turned off through the switching system of the microcontroller. The LED indicator is also used to know clearly that status.

As the function, the LDC display is also provided in this system. It can show the different messages relating to the temperature status in the home.

According to Fig. 2, all the circuit components using in this system are supplied by the 12V and 5V power supply units. 12V supply unit is for the relay driver circuit, DC cooling fan and the lump while 5V supply unit is for the remaining circuit portions.

Software Development of Home Temperature Control System

Among of Microchip Technology's series of microcontrollers, also called peripheral interface controller (PIC) chips, PIC16F877A is chosen to perform the control functions for temperature adjustment of the home.

The main purpose of choosing PIC16F877A is to do analogue to digital conversion process for the temperature sensor output to be able to compare with the desired decimal temperature set-points. According to these collected values, the microcontroller controls the home temperature by turning on or off the heater or cooler.

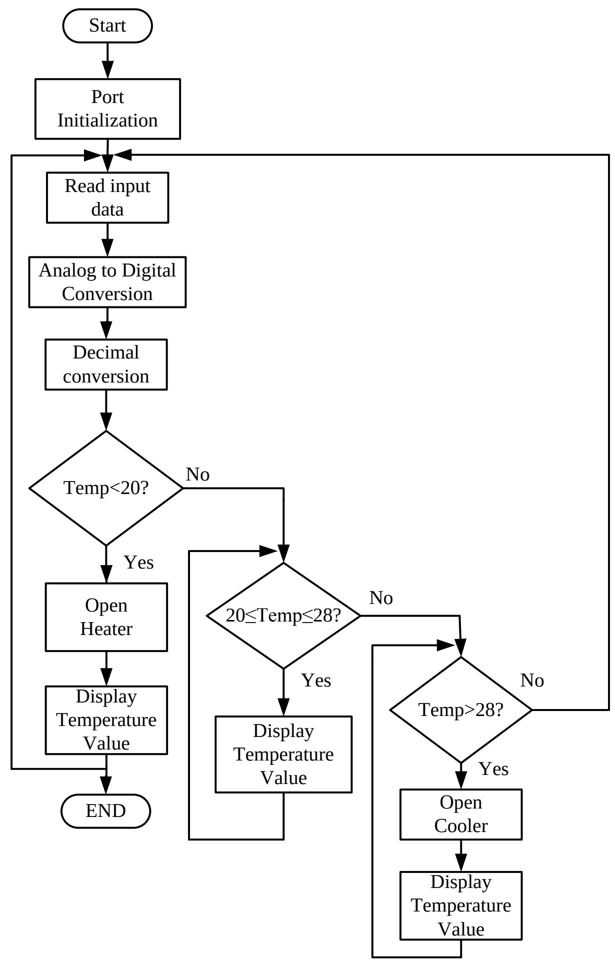

Fig.3. Flowchart for PIC16F877A

Another function of PIC16F877A is to send the temperature values to LCD display for the user. So, the user can easily be seen the temperature on LCD display occurring inside the home. The flow chart including the functions of PIC16F877A is shown in Fig. 3. The control assembly program in the microcontroller generates the necessary signals based on the gathered data sensing by the LM35DZ temperature sensor to drive the heater or the cooling fan.

Simulation and Test Results when Turning on Heater

The main control unit of the proposed system is PIC16F877A. The temperature sensor, LM35, Opamp LM358, microcontroller 16F877A and other required components are first selected from the mode toolbar of Proteus (ISIS) software. The whole drawing is shown in Fig. 4.

The program source code presented in Appendix B is written and saved as .ASM file. It is assembled by using MPASM and the hex file is created. This file is named as qq.asm. The component propertied dialogue is opened by using right-click on the MCU. And then, the resulting machine (hex) code is attached to the MCU. The process is shown in Fig. 5.

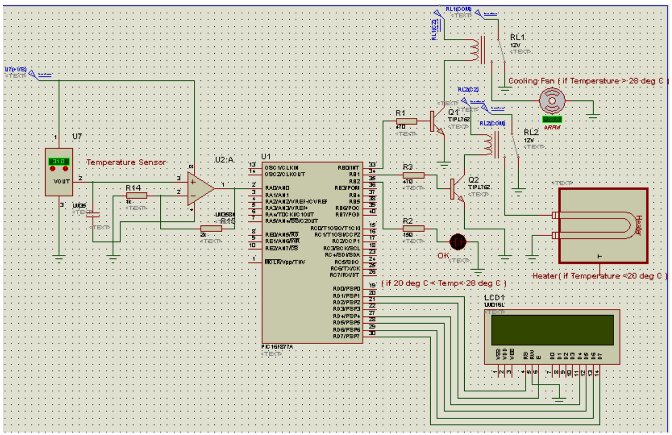

Fig.5. Drawing of the Proposed Circuit

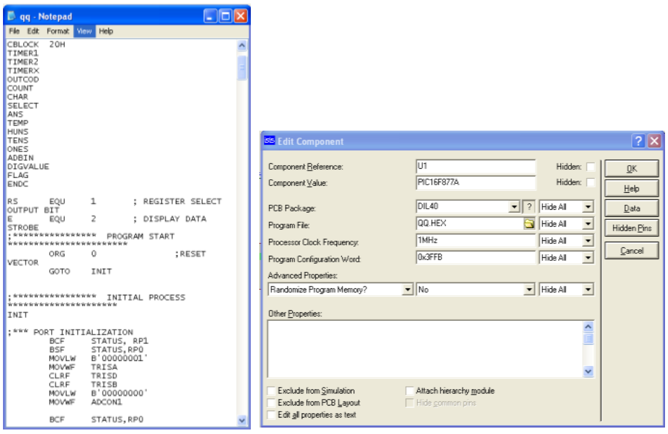

Fig.6. Attachment of the Source Code to Microcontroller

The simulation is run by clicking on the run button in the set of control buttons at the bottom of the screen. The circuit operates in real time shown in Fig. 6 and the temperature sensor is manually set 16°C to test for turning on heater. The heater heats up the home when the temperature is under 20°C.

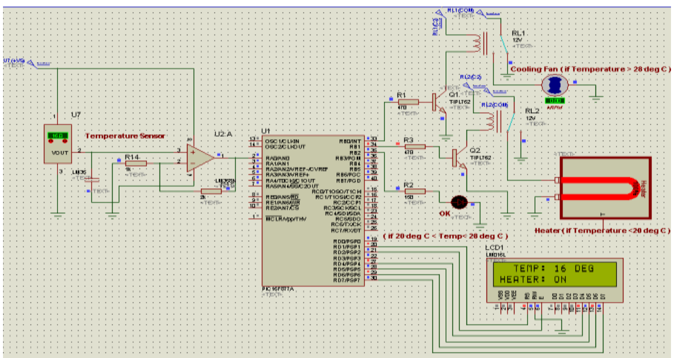

Fig.7. Simulation Result when Turning on Heater

After the channel 0 of PORTA, RA0 has read the temperature value and compared with the desired set point, 20°C, the microcontroller drives the heater which is connected with RB0 of PORTB. The LCD display shows these messages, “TEMP:16 DEG” on the first line and “HEATER:ON” on the second line.

In the practical test, the ice is placed near LM35 to decrease the temperature to test the above simulated condition. When the temperature decreases to 16°C, the LCD display shows “TEMP:16 DEG” and “HEATER:ON”. Therefore, it can be found that the simulation results and the practical results are the same.

Fig.8. Test Result when Turning on Heater

Simulation and Test Results when Turning off Heater and Cooler

The proposed system is the automatic home temperature control system. The heater and cooler are automatically turned off when the temperature reaches between 20°C and 28°C which are the required set points for this proposed system. To test this condition, the temperature value is manually set 28°C and the simulation is run by clicking the play button. In Fig. 9, this simulation result is shown with these messages “TEMP:28 DEG” and HEAT&COLD:OFF” on the LCD display.

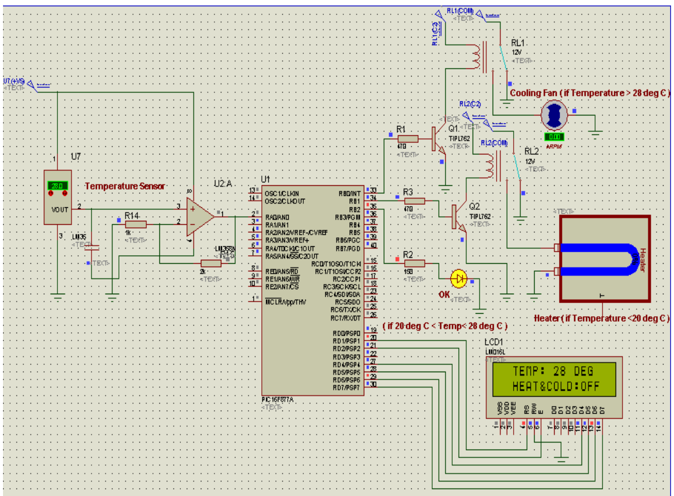

Fig.9. Simulation Result when Turning off Heater and Cooler

In the practical test for the above simulated result, it can be found that the circuit operates well as the simulation result according to Fig.10.

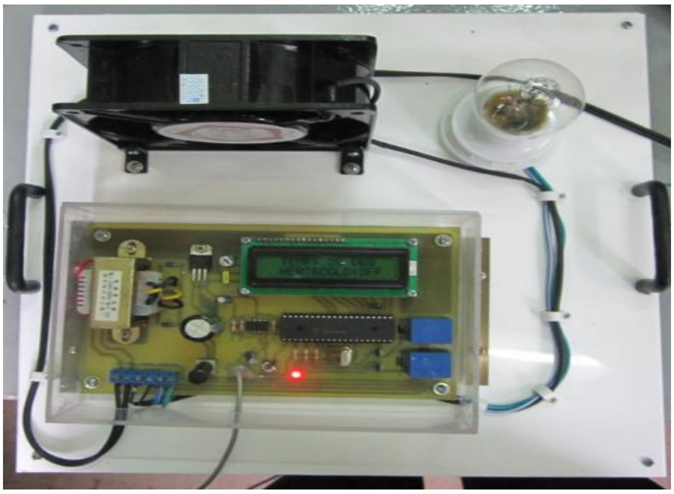

Fig.10. Test Result when Turning off Heater and Cooler

Simulation and Test Results when Turning on Cooler

When the temperature increases above 28°C, the microcontroller drives the cooler. To be able to test this condition, the temperature sensor, LM35, is manually set to reach 31°C as shown in Fig. 11. According to this simulation result, the cooler is turned off up to 28°C and it is turned on after 28°C.

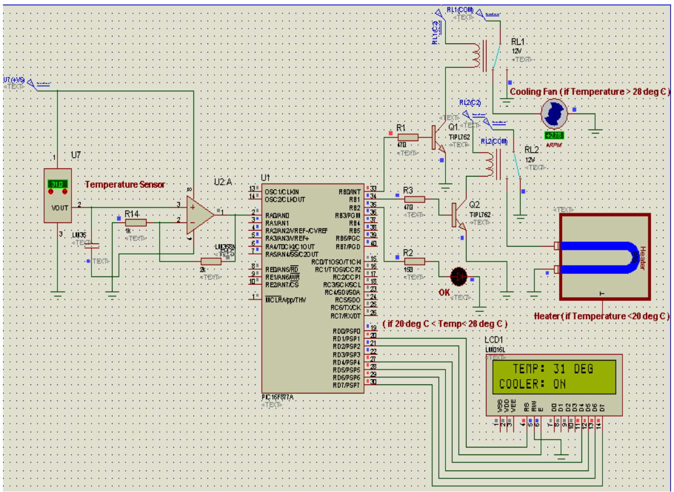

Fig.11. Simulation Result when Turning on Cooler

In the practical test, the gun is used to heat up the LM35. When the temperature is 31°C, the LCD display shows the status with full messages on the screen shown in Fig. 12. The relay is turned on and it drives the 12V DC fan.

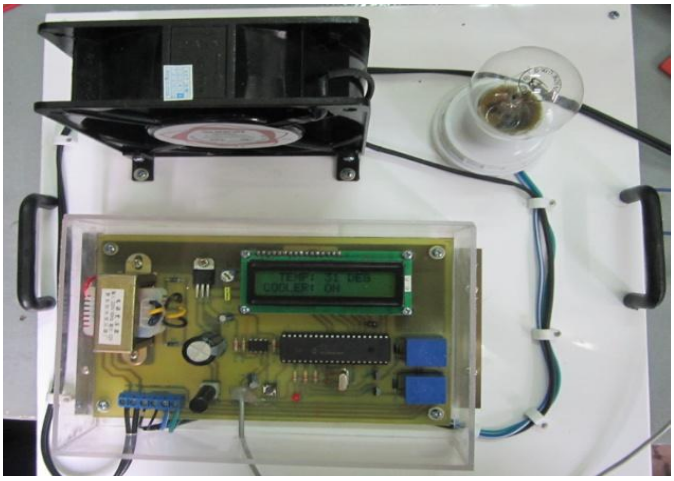

Fig.12. Test Result when Turning on Cooler

CONCLUSION

The home temperature control circuit has been constructed successfully and the control program for this circuit has also been written with the assembly programming language. The microcontroller, PIC16F877A, turned on the heater when the temperature was below 20°C. It turned on the cooler and turned off the heater when the temperature was above 20°C. Both of the heater and cooler were turned off when the temperature was between 20°C and 28°C. The proposed control circuit was suitable for home automation system and HVAC system. After constructing this control circuit without any difficulties, about the temperature sensing techniques, about the non-inverting amplifier, how to write the control program for PIC16F877A, how to download the hex file into the PIC16F877A, and how to display the messages on the LCD screen could be studied fully.

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