PIC-based Room Temperature Control System Using Ventilation Fans

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Abstract

This paper is design of PIC-based room temperature control system using ventilation fans. This design is provided with a switch for determining whether the room temperature is increased or decreased. This control system can be used to adjust the temperature of the room automatically by using a few ventilation fans on it. PIC microcontroller is the main control unit. There are two temperature sensors in this device, one for indoor temperature detection and the other for outdoor temperature detection. In two different places, two fresh air fans are placed in the room and their fan circulations are designed as output parameters. Both of these fans have the same goal. It is to lower the high temperature as soon as possible. The temperature values are displayed on six 7-segment LEDs. The controller can be used in two different ways: UP mode to reduce temperature and DOWN mode to turn up temperature. This temperature control system can be used in small area such as home, office, mini market, etc.

1. Introduction

In order to reduce costs and optimize production, it is necessary to control the temperature changes in many applications such as industrial and agricultural areas. The temperature control is applied in buildings, departments, factories, vehicles and other areas. Simple temperature control systems can be found in home to regulate the room temperature, oven temperature and refrigerator temperature. Many designers find out more flexible design of temperature controller for home and departments to solve the heating problem. This paper focuses on the control system of the room temperature.

The main objective of this device is to prevent the room temperature going up with the heat. We can always keep the air-conditioner on for lowering the room temperature, but it is going to hurt our wallet badly, especially when we are paying for the extremely high electric bills.

In order to cut down the expenses, it's very important to create the equipment that can be used to adjust the temperature of the room automatically. The goal of designing this temperature control system is to build an effective temperature control system with low cost. It can also save the environment as it uses only fresh air fans. It keeps the room temperature at the desired condition as it provides the opportunity to control in every two seconds, which is a very short time period.

Many temperature controlled systems base on microcontroller, which receives many signals from the temperature sensor such as thermocouple or Resistance Temperature Detector (RTD), to precisely control the process temperature without extensive operator involvement. They compare the actual temperature with the desired control temperature, or setting value, and provide the output to a control element.

The controller is one part of the entire control system. The whole system should be analyzed in selecting the proper controller. The following items should be considered when selecting a controller:

1. Type of input sensor (thermocouple, RTD) and temperature range
2. Type of output required (electromagnetic relay, analog output)
3. Control algorithm needed (ON/OFF control, proportional control, Proportional with Integrated and Derivative (PID) control)
4. Number and type of output (heat, cool, alarm) [2]

In this paper, integrated-circuit temperature sensor as the input sensor, analog signal as the type of input, ON/OFF control as the control algorithm, limiting the range of temperature as output are selected to control the temperature condition. Such problems as the heat that computers and electronic devices emits, the balance of the air flow, dirty air produced by the personnel breathing are to be solved [1].

2. System block diagram

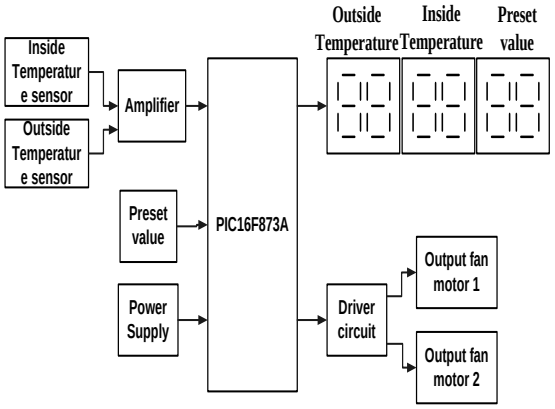

Figure 1. Block diagram of room temperature controller

Figure 1 shows the block diagram of the proposed temperature controller. In this controller, PIC16F873A makes decisions to turn ON or OFF the temperature control fans in the room based on the information adjusted by comparing the temperature sensor values and the preset value. To measure the temperature changes, temperature sensor LM35DZ is used in the circuit. To know the temperature changes and preset temperature conditions, 7-segment display is used. This display shows room temperature in degree Celsius. The fan to be used is the type which performs inhalation of air from the environment. Fan circulation depends on the comparison result of the room temperature and outside temperature to provide the ventilation of fresh air. In places where houses are populated, this room temperature control system is useful for many ordinary people and others.

3. Theory background

Temperature control is a variation of the feedback control. A control system is a group of components that maintains a desired result by manipulating the value of another variable in the system [4].

3.1. Open-loop control system

In an open-loop control system, the output from the system has no effect on the input signal [4].

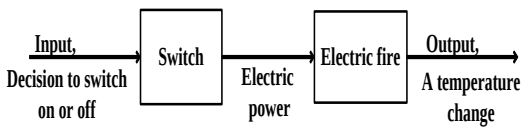

Figure 2. Open-loop control system

3.1.1. Close-loop control system In a close-loop control system, the output does have an effect on the input signal, modifying it to maintain an output signal at the required value. The term feedback is used because signals are fed back from the output in order to modify the input. Closed-loop systems have the advantage of being relatively accurate in matching the actual to the required values. [4]

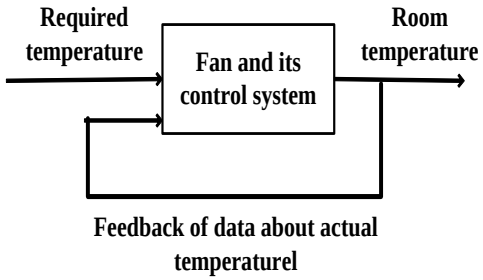

Figure 3. Close-loop control system

3.2. Basic elements of close-loop system

The more usual feedback control system has controller which automatically switches the fan on or off according to the difference between the set temperature and the actual temperature. This control system is maintaining constancy of temperature. [4]

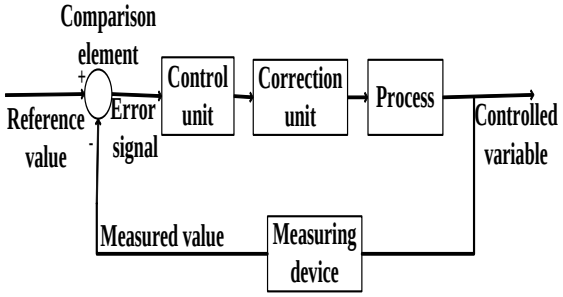

Figure 4. Basic elements of a close-loop system

1. Comparison element

This compares the required or reference value of the variable condition being controlled with the measured value of what is being achieved and produces an error signal.

Error signal = reference value signal – measured value signal

2. Control element

This decides what action to take when it receives an error signal. It may be a signal to operate a switch or open a valve. Control plans may be hard-

wired system in which the control plan is permanently fixed by the way the elements are connected together or programmable system where the control plan is stored within a memory unit and may be altered by reprogramming it.

3. Correction element (actuator)

The correction element produces a change in the process to correct or change the controlled condition. Thus, it might be a switch which switches on a heater and so increase the temperature of the process. It provides the power to carry out the control action.

4. Process element

The process is what is being controlled. It could be a room in a house with its temperature being controlled.

5. Measurement element

The measurement element produces a signal related to the variable condition of the process that is being controlled. For example, a sensor. [4]

For this automatic room temperature control system, the various elements are:

Controlled variable =the room temperature
Reference value =the required room temperature
Comparison element=the program inside the PIC
Error signal =the difference between the measured and required temperatures
Control unit =microcontroller PIC16F873A
Correction unit = relay to switch the fan
Process = the room with its temperature being controlled
Measuring device = a sensor

3.3. Control modes

There are a number of ways by which a control unit can react to an error signal and supply an output for correcting elements [4]. Control action is classified into three types:

1.ON/OFF,
2. Proportional and
3. PID.

Each action has unique characteristics which will meet specific requirements for different applications [5].

3.3.1. ON/OFF control ON/OFF control is the simplest and least expensive form of control. The output signal from the control is either full-ON or full-OFF depending on the direction of the deviation from set point. ON/OFF action takes place if any deviation occurs. This action has a quick response but it is sensitive to input noise that causes chattering (ON/OFF switching in short intervals). Therefore, in actual use, the ON/OFF action has some hysteresis referred to as dead band [3]. This hysteresis requires that the temperature exceed set point by a certain amount before the output will turn off or on again. In other words, the term dead band is used for the values between the on and off values. This hysteresis is called “adjustment sensitivity”. A high adjustment sensitivity is needed for application such as an air compressor of a freezer which frequent ON/OFF operation must be avoided [2]. ON/OFF control action tends to be used where changes are taking place very slowly. Thus, in the case of ventilating a room, the effect of switching the fan on or off on the room temperature is only a slow change. The result of this is an oscillation with a long periodic time. ON/OFF control is thus not very precise, but it does involve simple devices and is thus fairly cheap. ON/OFF control is usually used where a precise control is not necessary [4].

4. Proposed System Design

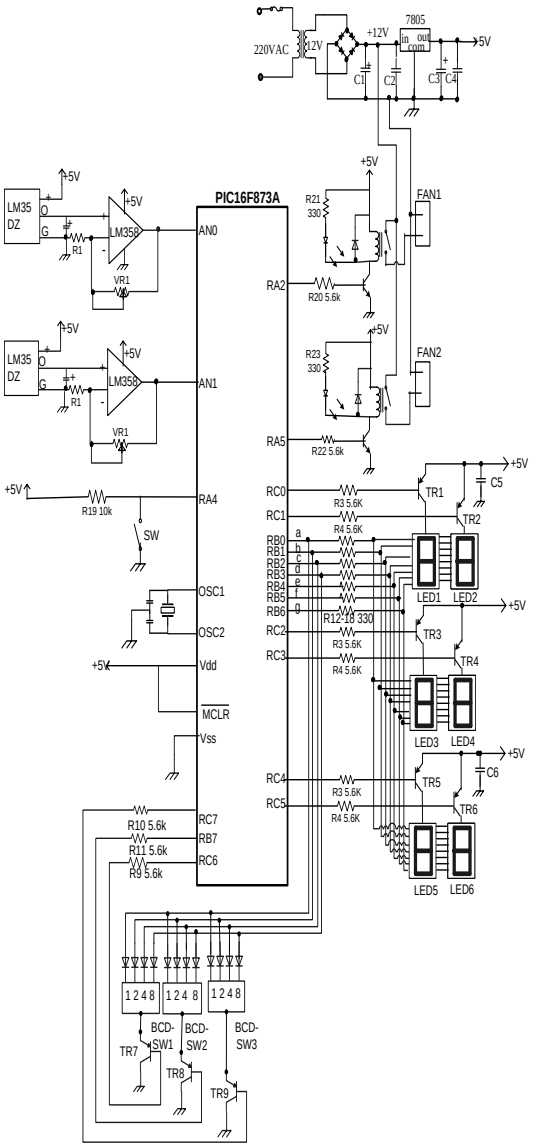

Figure 5. Overall circuit diagram of room temperature controller

Figure 5 shows the overall circuit diagram of the room temperature controller. A temperature sensor (LM35DZ) can measure from 0°C to 100°C. The output of LM35DZ is linearly proportional to Centigrade degree. The output of a temperature sensor changes at a 10mV/°C rate on the basis of 2°C. Therefore, the output voltage of 30°C is 280mV. It is amplified by the operational amplifier, LM358. +5V is used for the power supply of the operational amplifier in this circuit. The maximum output voltage of operational amplifier is 3.7V. The maximum measurable temperature is about 49°C. LM7805 is designed to generate 5V. It supplies power to microcontroller and sensors. In this proposed temperature control system, PIC16F873A makes decision to turn ON or OFF the temperature control fans based on comparison result of temperature values through the NPN transistor and the relay. For the input of preset values and interval time, binary coded decimal switches are used. In the UP mode, if the room temperature is higher than the setting value, fans will operate. Fans will stop automatically when the desire value is reached.

Figure 6 shows the process flow of proposed system. Input signals from the sensors are amplified by the amplifiers. These amplified signals are converted to digital form by using built-in ADC of the PIC. Control program uses these values and shows these values on the two-digit 7-segment displays. Then, the controller tests whether it is in UP or DOWN mode.

When the room temperature is higher than the expected temperature, it is in UP mode. The controller then compares the sensor input values and the desired set point which is chosen by the user. If the room temperature is greater than preset temperature, the controller will automatically switch on fan1. The fan will operate as long as the interval time which the user choose. The controller will switch on fan2 if the room temperature is still greater than the preset value after the interval time is time out.

When the room temperature is lower than the expected temperature, it is in Down mode. The controller will turn on the fans if the room temperature is lower than the preset temperature in order to balance the air flow.

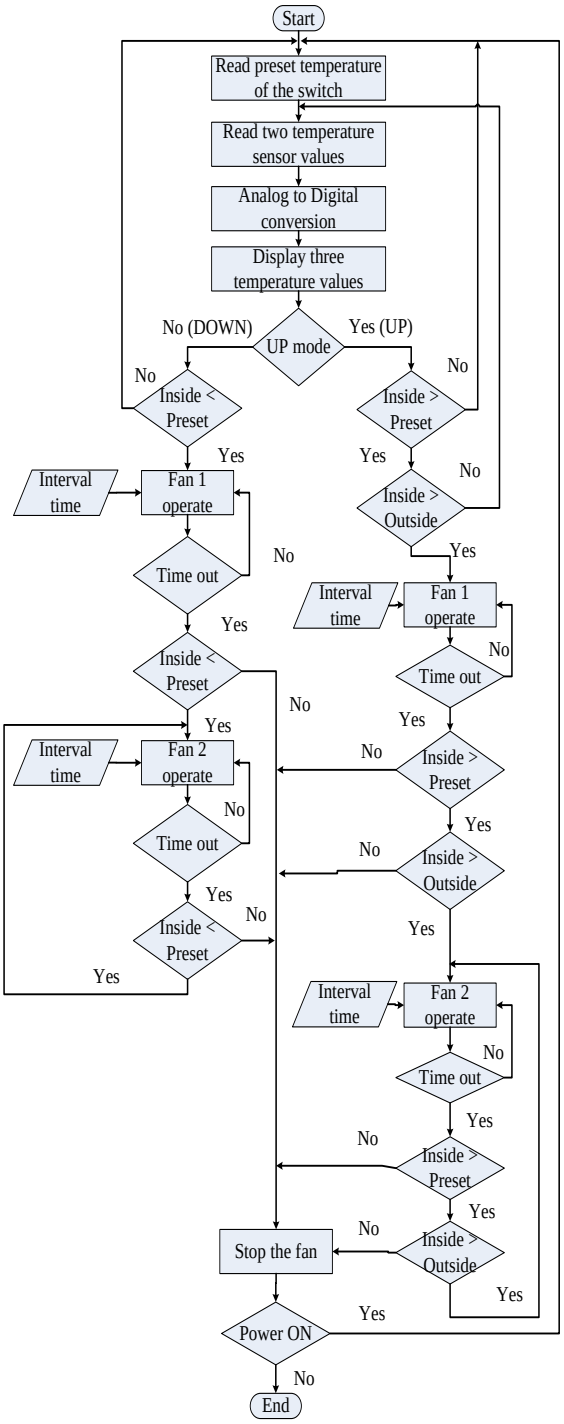

Figure 6. System flow diagram

5. Test and result of room temperature control system

Figure 7 shows the result of room temperature controller. When the power supply is turned on, the display shows preset value, inside and outside

temperature values. In this figure, the preset value is 20°C. Fans operate when inside temperature is greater than preset and outside temperatures if it is in UP mode.

Figure 7. Photo of room temperature control system for 20°C

The benefits of using this temperature control system compared to other room temperature control system are effective and low cost, bright and easy to read LED display. An adjustable dead band (1 minute to 10 minutes) lets the user to precisely control the system performance. The system can:

1. Determine the necessary process to be carried out by examining the input values.
2. Perform in two different ways: to lower the room temperature or raise the room temperature by easily choosing Up and Down mode by a switch.
3. Keep the room always in the desired condition as it provides the opportunity to control in every 2 seconds.
4. Easily install heaters in places of fans in case of raising the room temperature. So, this temperature control system can be applied in two different purposes. So it is economical.

6. Conclusion

In this study, a closed-loop controller used in room temperature control systems is implemented. In this proposed room temperature control system, PIC microcontroller makes decision to control the fan circulation and the room temperature. This system can measure the temperature from 2°C to 49°C, which is the very suitable temperature range for home, offices and departments. Moreover, the temperature setting values are variable as the user chooses. That is, the user can select the desired set point; these values are not fixed.

7. References

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[2] Khin Kyawt Kyawt Khaing, "PIC-based Temperature Controller", 2005.

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[4] W.Bolton, "Mechatronics Electronic Control Systems in Mechanical and Electrical Engineering", 2nd Edition, Addison Wesley Longman Publishing, New York, 1999.