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DESIGN AND PERFORMANCE EVALUATION OF AN AUTOMATIC INDOOR TEMPERATURE CONTROL SYSTEM

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Abstract*- This paper proposes a system based on automation. Nowadays almost all industries are going through automation. In present world it is a big challenge, how to minimize production time and how we can get final product more efficiently. As a result we are thinking about automation process. This project is based on automatic thermal control of a closed space, is a process of automation also. The temperature of the environment will be shown on LCD display. We have used a temperature sensor LM35 which sense the surrounding temperature & converts this temperature to proportional analog voltage & this voltage is given to Microcontroller. When the temperature of the environment exceeds the critical level the heater will be switched off automatically. This automation process will be programmed in a microcontroller. In industry for doing this job only a few workers is needed and monotony for work can be removed. It is just a part of full production process. So the concern is an Automatic room temperature control which is more economic and has ergonomic design for mass production*.

Keywords: Microcontroller, Temperature Sensor (LM35), Liquid Crystal Display (LCD), Set Value, Embedded C.

1. INTRODUCTION

The concept of this project is to create an automatic temperature control system to control the temperature of a closed space. Temperature measurement & controlling is a prime physical phenomenon in the industrial production as well as in scientific research and development. Traditional thermometer can't fulfill the demand of efficient and accurate temperature measurement. On the other hand, in our designed system data is collected in binary format so this data can easily be transmitted to control room and appliances for processing and analysis. This project has been designed on two basic steps. First, hardware with some devices has been designed and then the software has been designed for the single chip microcontroller. The circuit maintains the temperature of the system in a particular value. This system consists of Temperature Sensing Unit, PIC16F877A micro-controller unit, LCD Module, Switching devices, driver, and heaters. It will operate based on the value of temperature in the system. The microcontroller will be used for processing the data and control the remaining circuit while the LCD module will be used to display the present temperature.

2. METHOLODGY & SYSTEM DESCRIPTION

The basic blocks of the System include the following blocks; Temperature Sensing circuit, PIC 16F877A micro-controller, LCD Display, Switching and Drivers, Heater. The Temperature Sensor detects the temperature of the environment. The Temperature Sensor consists of an LM35 IC. It has the measuring range of -55°C to 150°C [1]. The temperature sensor is connected to an ADC of PIC micro-controller. The LCD display used is a 16x2 Alphanumeric Display. The LCD module is also connected to the PIC microcontroller & displays the present temperature of the room.

First, we have to select a threshold value of temperature which can be selected as any arbitrary value. Here two push button switches are used for selecting the threshold value or reference temperature so that it can be changed need fully. The PIC micro-controller switches on the heater using an electro-mechanical relay. When the room temperature is more than the threshold temperature, the electro-mechanical relays starts operating and turn off the heater automatically. To eliminate the fluctuation of the heater on off, the heater will be turned on when the temperature is below 5 °C of the threshold temperature, which can be changed. The basic block diagram of our system is given in figure 1.

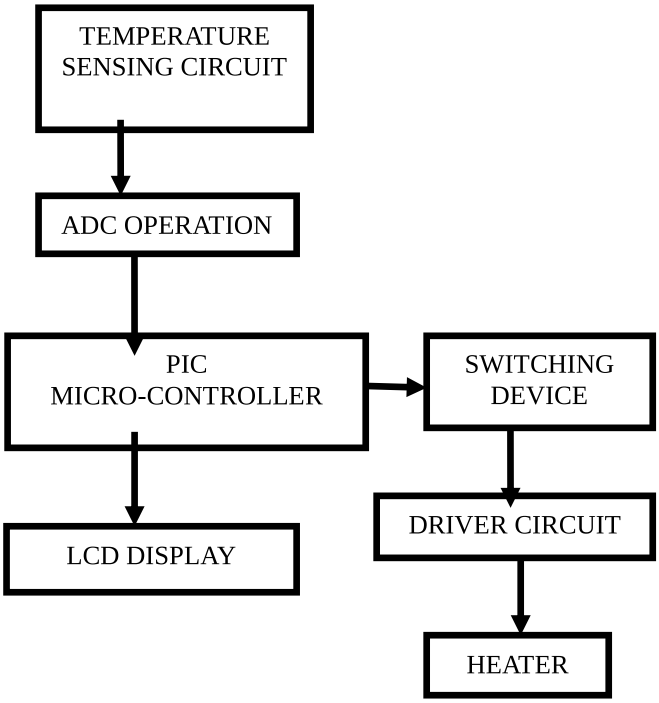

Figure1: Basic block diagram.

The block diagram for basic automated controlling scheme is shown in figure 2.

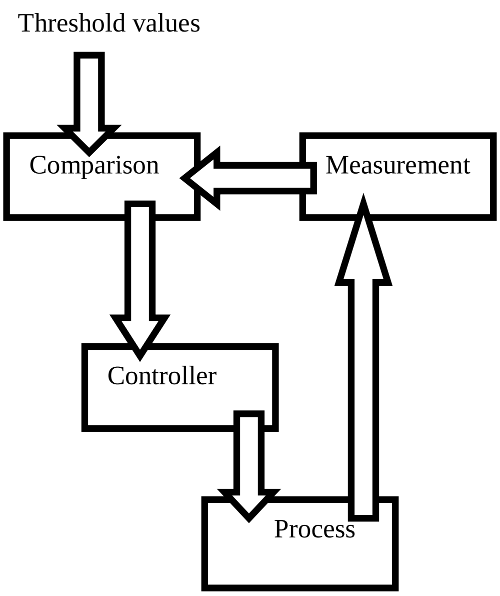

Figure 2: Block diagram of automated controlling scheme

2.1 HARDWARE SECTION

Diagram in Figure 3 shows the steps taken in developing the hardware. It started off with information searching or literature study followed by acquiring the components needed, and then circuit design to the component soldering on the PCB (Permanent Circuit Board).

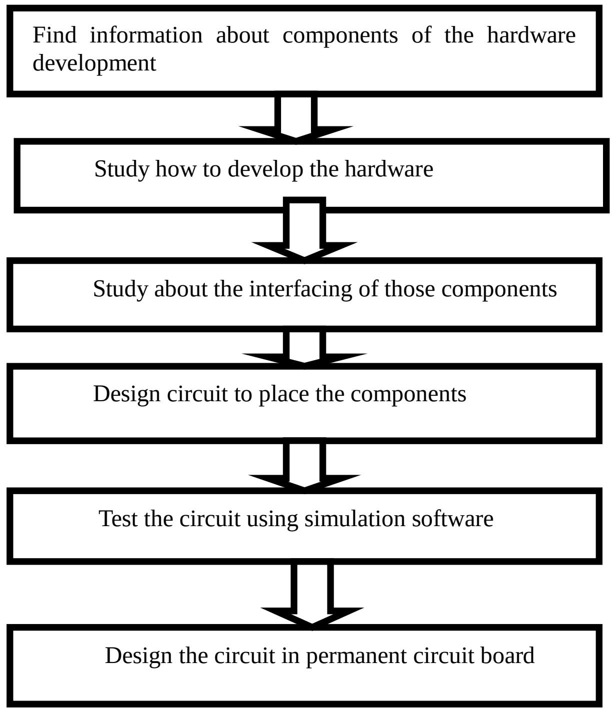

Figure 3: Flowchart of hardware development.

2.1.1. MICROCONTROLLER

A microcontroller can be classified as a single chip computer, because all of the basic integral things that a computer needs are being provided in a single chip. One of the advantages of this microcontroller is that it has a Flash Program Memory and it also has an EEPROM (Electrically erasable Programmable Read Only Memory) data that has the ability to rewrite the program that has already been written in the EEPROM. In our system we used PIC16F877A which is a low-power, high-performance CMOS 8-bit microcontroller. The PIC16F877A is a powerful microcontroller which provides a highly flexible and cost-effective solution to many embedded control applications. The PIC16F877A has the following features which are essential for our system [6].

- Up to 8K x 14 words of Flash Program Memory,
- Up to 368 x 8 bytes of Data Memory (RAM),
- Up to 256 x 8 bytes of EEPROM Data Memory
- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)

2.1.2. TEMPERATURE SENSOR

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range [3]. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air [4]. The output of LM35 is voltage which increases as the temperature increases [7]. This voltage signal is fed to an 8- bit microcontroller in this case a PIC16F877A which will do the analog to digital conversion (ADC) & convert this voltage to corresponding temperature in Celsius scale. This temperature is then shown in LCD (Liquid Crystal Display).

2.1.3. RELAY

Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits). In our system we used 3 pieces of 12VDC SRD electromechanical relay to control 3 piece of room heater.

Figure 5: Relay SRD 12 VDC.

Figure5 shows a picture of relay SRD 12VDC which is used in this project. Relay consists of five pins which are Positive Coil Pin, Negative/ Ground Coil Pin, Normally Open (NO) pin, Normally Close (NC) pin, and Common (C) pin. Figure 6 shows the connection of the relay to the electrical appliances and other components.

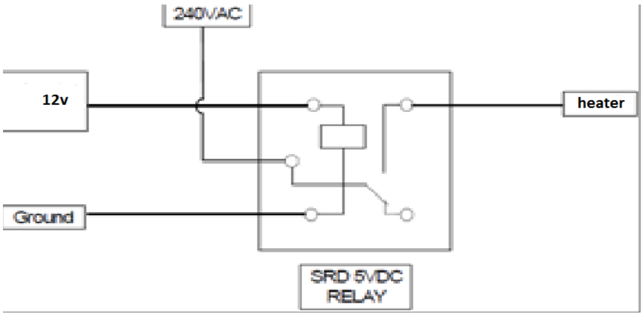

Figure 6: Relay Connection for Heater

2.2 .SOFTWARE SECTION

To enable the system (hardware) running, the microcontroller needs to be programmed first. PIC 16F877A microcontroller acts as a control unit that control all the operation in the display system, signal processing & switching of relays. The “ON” and “OFF” state of the appliances also depends on the relay switching hence on programming. For programming PIC 16F877A microcontroller, two software are used namely mikroC Pro for PIC and pickit2. The first one is the platform for writing the codes & converting them to hex code. Pickit2 is used for downloading the hex code compiled from MikroC Pro for PIC platform to microcontroller. The basic algorithm of programming of this problem is given in figure 7.

2.2.1. MikroC Pro for PIC

The mikroC PRO for PIC is a powerful, feature-rich development tool for PIC microcontrollers. It is designed to provide the programmer with the easiest possible solution to developing applications for embedded systems, without compromising performance or control. MikroC PRO for PIC allows quickly developing and deploying complex applications. It is possible to write C source code using the built-in Code Editor (Code and Parameter Assistants, Code Folding, Syntax Highlighting, Auto Correct, Code Templates and more) [5].

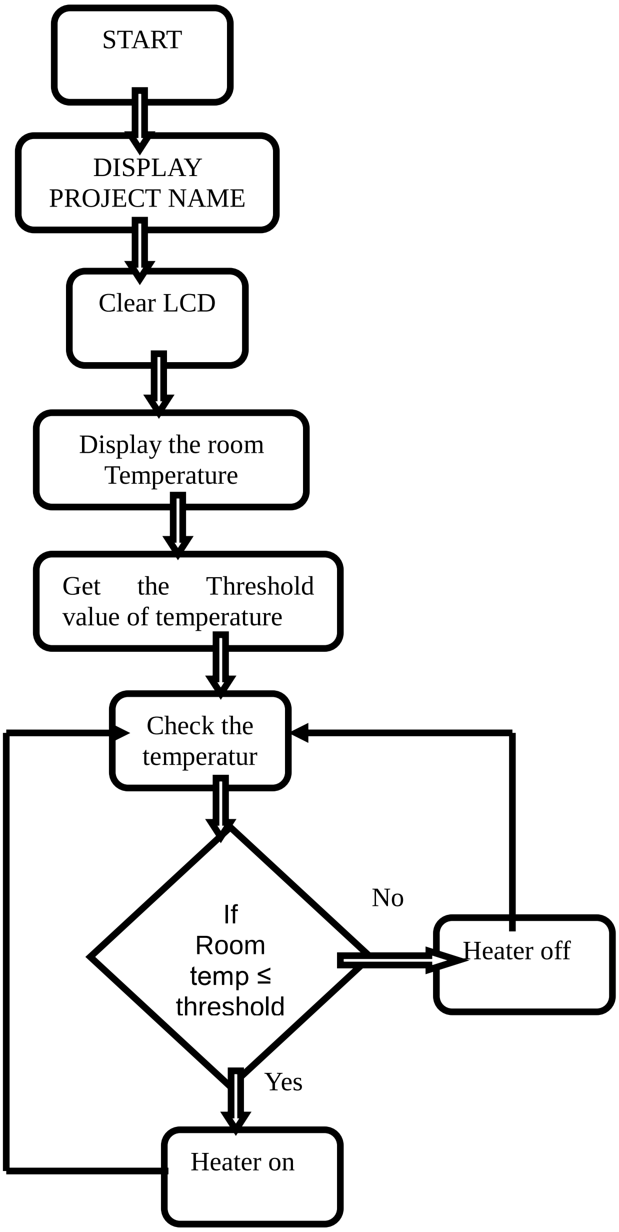

Fig. 7: Basic algorithm for temperature control.

2.3. CALCULATION

In our project, thermometer reference voltage (V_{ref}) is 5V, and resolution of analog to digital conversion (ADC) is 10 bit. Input voltage is sensed from 0 to 5V range. So it

will be mapped to a digital number which is in between 0 to 1023. The resolution of analog to digital converter (ADC) is shown below Resolution = 5/1023 = 0.004883 V/Count.
So, corresponding to any input voltage digital output is $V_{outdigital} = V_{in}*204.6$. This output digital value of voltage is used to measure temperature. LCD (Liquid Crystal Display) displays the corresponding temperature. The temperature sensor changes it output voltage 10 mV for change in per °C.
Therefore, temperature = $V_{outdigital}*0.4901$.
Our designed system shows the average value of temperature which is calculated from 10 corresponding temperature values at any instant. All the corresponding values are stored with 500ms interval.

3. DESIGN IMPLEMENTATION

An embedded system described above was installed successfully in Civil department, CUET which consist of a power supply unit(5 & 12 V DC), a microcontroller motherboard, LCD display circuit, relay driver circuit, sensor circuit board & relays as shown in figure 8 & figure 9. Testing results show that the installed system has an error rate of about 0.5%.

Figure 8: Control system with LCD & relay driver

Figure 9: Temperature sensor (LM35) circuit board

4. FUTURE MODIFICATION

The goals of this project were purposely kept within what was believed to be attainable within the allotted timeline. As such, many improvements can be made upon this initial design. That being said, it is felt that this design represents a functioning miniature scale model which could be replicated to a much larger scale.
The following recommendations are provided as ideas for future expansion of this project:
• Changeable threshold temperature limits can be applied by adding a matrix keypad.
• High precision sensors such as Platinum Wire can be used. This makes it possible to measure more range of temperature.
• This system can be interfaced with computer to create a continuous graphical representation of temperature & time relationship & can be used to analyze the thermal condition [2]. So a real time data acquisition device can be formed.

5. CONCLUSION

This paper has presented a means of controlling the temperature of a system. This system helps to maintain the temperature within a limit. This system is very marketable because of its simplicity, low cost, low power consumption and small size. It can be used in various industrial applications such as to control the temperature in boilers, refrigerator, AC, Computers and Laboratory equipments.

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8. NOMENCLATURE

Symbol	Meaning	Unit
T	Temperature	(K)
V	Voltage	(volt)