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DESIGN OF DIGITAL THERMOMETER BASED ON PIC16F77A SINGLE CHIP MICROCONTROLLER

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Abstract*- This paper elucidates simple design method of a low cost digital thermometer based on PIC16F77A microcontroller and temperature sensor LM35. LM35 is an analog sensor which converts the surrounding temperature to a proportional analog voltage. The sensor's output is connected to one of the Analog to Digital Converter (ADC) channel inputs of the microcontroller to originate the equivalent temperature value in digital format. Within a short duration 10 digital values of temperature are stored and computed to have maximum, minimum and average temperature among these. Then, the computed formats of temperature are displayed in a 16×2 character LCD in °C scale correspondingly. This design process is more convenient than others as it is more economical, efficient and simple.*

Keywords: Digital thermometer, LM35 sensor, Microcontroller, PIC16F77A, Temperature etc.

1. INTRODUCTION

Temperature measurement is a cardinal physical parameter in the industry as well as in modern high tech scientific research and development. Traditional temperature thermometer can't fulfill the demand of efficient and accurate temperature measurement. Recently with the time being microcontroller and sensor technology has developed in various fields. So this digital thermometer design is based on microcontroller based control. It displays the average temperature by processing the maximum and minimum temperature by the controller using microcontroller PIC16F77A. LM35 has been used here as a temperature sensor for wide range of temperature sensing. A 16×2 character liquid crystal display has been used to display the temperature in °C scale. Comparing with the traditional thermometer digital thermometer is more convenient as it shows convenient reading, wide range of temperature measurement and accurate temperature measurement. The digital display system for the output of the temperature is simple and economic, operation reliable and environmental friendly. Digital thermometer based on PIC16F77A single chip microcontroller has been designed on two cardinal steps. First some hardware with some devices has been designed and then the software has been designed for the single chip microcontroller. In the hardware design the electronic devices has been installed with the microcontroller. After that software has been designed for the microcontroller. Finally along with all the devices and the microcontroller with software has been simulated to check its accuracy as well as efficiency.

2. METHODOLOGY

The temperature sensor LM35 which has been used in the project takes the input signal as the analogue signal [1]. Then this analogue signal is converted into digital signal by an analogue to digital converter and by the direction of microcontroller consists of directed software the sensing input signal is shown in the liquid crystal display as digit format. A block diagram of the total system has been depicted below.

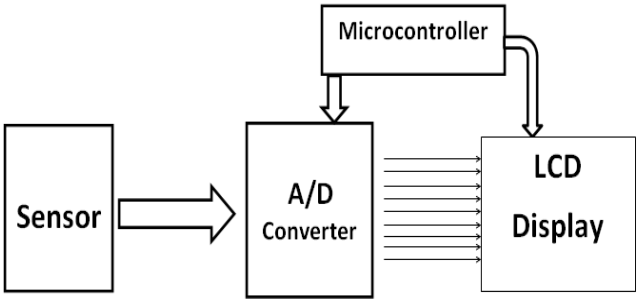

Fig. 1: Block diagram of the digital thermometer based of PIC16F77A

3. CIRCUIT SIMULATION

LM35 temperature sensor can be operated in a long span which is -55 °C in the negative temperature and

150 °C in the positive temperature [3]. It is a smart choice for its long range of temperature sensing and accurate input acquisition as well. Moreover, this sensor output voltage is proportional to the input sensing temperature and that's why it doesn't need any external calibration. Input temperature signal to output voltage conversion scale factor is 10 mV/ °C [4].

For negative temperatures measurement below 0°C requires negative voltage source as well. However, considering the tropical zone we have used only positive voltage source in this project. Therefore, this circuit setup will measure the positive temperature from 0°C to 155°C. An internal analog to digital converter (ADC) of the PIC16F77A microcontroller converts the sensor output voltage to 10 bit digital number [1] [3]. Analog to digital converter (ADC) voltage measurement range is from 0 to 5 V [4].

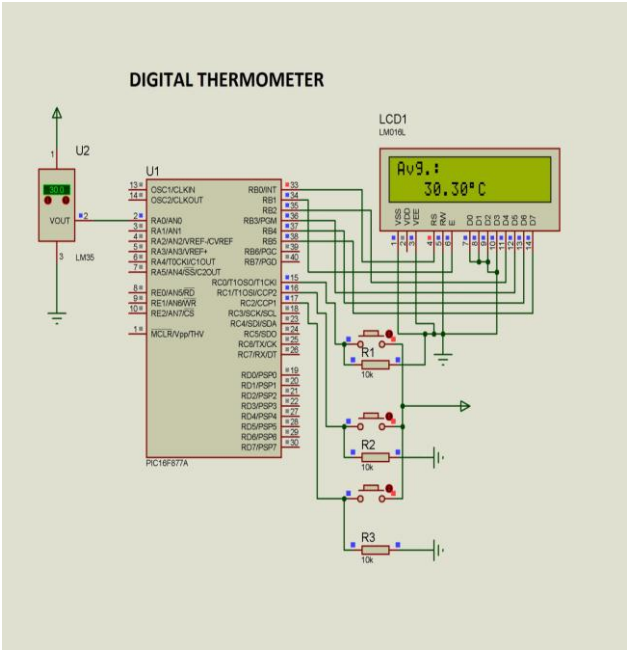

Fig. 2: Circuit simulation of digital thermometer

4. HARDWARE

4.1 *Sensor and Microcontroller*

LM35 temperature sensor is used in the implementation of this digital thermometer. This sensor has a wide range of sensing which is from -55 °C to 150°C [4]. Considering wide range of sensing, accuracy, effectiveness, external calibration, cost and some other factors this sensor can be an optimum choice for an economical and effective digital thermometer [4]. It's a three pin device. We have connected the +Vs Pin to 5v and GND pin to ground while output connected to the analog input pin 0 of the PIC16F877A MCU [2]. Pin number 2 on the 40 pin package is known as RAO because it is shared with PORTA0.

PIC16F877A microcontroller is used for this thermometer. It contain 40 pin package with 5 ports named port A, port B, port C, port D and port E [6]. It is a 10 bit analog to digital module with 8 input channels [2]. We operate it at 20 MHz clock frequency. It is available and broadly used in electronic projects.

4.2 *Display and Other Devices*

A 16x2 liquid crystal display is used to get the output of the thermometer. This display can be programmed easily and more economical. Moreover, it has no limitation of displaying. It can display 16 characters per line and there are 2 such lines [5]. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, Command and Data [5].

A 20MHz clock pulse crystal oscillator is placed between the microcontroller pin no. 13 and 14 with 22pF capacitor. Two 10K resistors have been used at MCLR pin and LCD correspondingly while others used as pull down resistors. Some capacitors are used in between V_{dd} and V_{ss} pin of MCU and to the crystal oscillator [6].

5. SOFTWARE

The software function of this digital thermometer design is achieved by Assembly Language. The program basically highlights data acquisition from the temperature sensor and display real-time data of temperature. The software code algorithm is as follow-

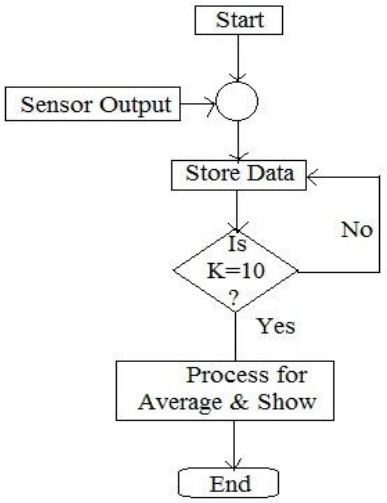

Fig. 3: Algorithm for the device.

6. CALCULATION

In this thermometer reference voltage (V_{ref}) is 5V; 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 = 5/1024 = 0.004883 V/Count.

So, corresponding to any input voltage digital output is $V_{out} = V_{in}/0.001168$. Finally, doing all the conversion and process the temperature can be found back from the 10-bit digital number. So need to divide V_{out} by 10mV.

Therefore, temperature = $V_{out}/10m = 100V_{out}$

The thermometer shows the average, maximum and minimum temperature of 10 corresponding temperature value which are first converted into ADC values and averaged, maximized, minimized those ADC, then the calculated average, maximum, minimum ADC value transformed into temperature by above-mentioned calculation and shows in centigrade scale. All the corresponding values are stored with 500ms interval.

7. IMPLEMENTATION

After installing all the devices the circuit has been designed for the printed circuit board. An schematic design of the printed circuit board has been illustrated below.

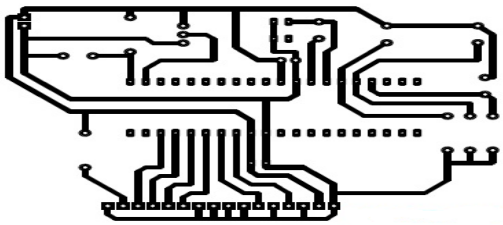

Fig. 4: PCB layout design of digital thermometer

8. PERFORMANCE EVALUATION

After the construction of this device, it is necessary to test its performance with a used standard temperature meter. That's why we selected a conventional temperature meter for this purpose and the following values of table 1 have been recorded while the device in the test runs. Recorded data helps to determine the error of our developed thermometer.

Table 1: Comparative Study of Actual and Measured Temperature.

Actual Mean Temperature (^oC)	Measured Mean Temperature (^oC)	Error (%)
25	24.33	2.68
26	26.12	0.46
28	28.01	0.04
30	29.83	0.56
30.50	30.30	0.65
36	35.09	2.52
44	44.9	2.0
55	56.5	2.7
62	63.2	1.9
73	70.63	3.2
78	77.30	0.9
85	83.19	2.12
92	94.09	2.3
100	105.01	5.01
109	115	5.5
135	143	5.9

Table 1 represents the data of measured by digital thermometer based on pic 16f877a single chip microcontroller and actual value measured with standard thermometer. There are found some very small scale errors when temperature rises which are plotted in figure 4 as a function of measured temperature.

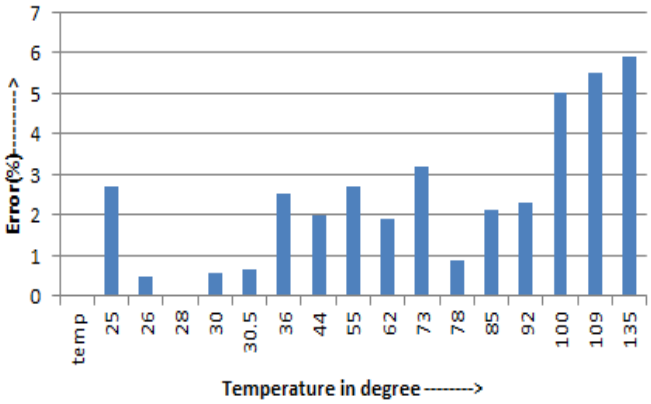

Fig. 5: Percentage of errors as a function of temperature.

9. CONCLUSION

As a temperature sensing devices the digital thermometer has a huge application in practical life. It can be used in domestic purposes, in medical sectors and also in industrial purposes as well. By sensing heat of surroundings at certain time any machine can make a decision what to do in certain temperature such as in case auto control of electric light, fan, heater, smart home and temperature controlled machines. But by using this sensor it is not possible to sense more than 150°C temperature as it made by using LM35 sensor. The sensor input signal of this thermometer is analog which is converted finally into digital by an ADC which is used always in integer. So where there is a very precise temperature measurement is necessary there is will give a little bit trouble.

10. REFERENCE

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