Microcontroller Based Temperature Monitoring and Controlling System

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***Abstract*— Data acquisition plays an important role in industry. This paper incorporates the design and development of a temperature monitoring and controlling system using microcontroller and LCD. The main target for this system is to have it designed and implemented such that it is cost-effective. This project consists of two modules- one is the temperature monitoring and the other is the temperature controlling. The temperature sensor senses the temperature and the inbuilt ADC in the microcontroller produces corresponding analog signal which is further processed by the microcontroller and the temperature is displayed in the LCD. The user's temperature requirement is given in the form of a setpoint and the microcontroller then compares the ambient temperature against this setpoint and further necessiates the controlling action using relays. If the temperature goes above the setpoint then the cooler goes on and if the temperature goes below the setpoint then the heater is switched on. The values of temperature obtained from the sensor are analysed using MATLAB.**

Index terms -Microcontroller, Temperature Sensor, LCD, Measurement and Control, ATMega 328, LM35

I.INTRODUCTION

The temperature monitoring and controlling system is an integrated device that allow users to input specific requirement of temperature for any environment say any industrial process. Monitoring and control of process parameters by embedded systems using microcontrollers are very much effective in industrial and research oriented requirements. The purpose of this project is to explore the possibility to continuously monitor and control temperature. LM35DZ temperature sensor is used to sense the temperature. Microcontroller ATMega328 is used as the heart of this system which holds the monitoring and controlling program and the temperature is displayed on an LCD screen. The system is also equipped with necessary hardware to initiate control action for temperature as soon as it reaches a value higher than the particular setpoint or a value lower than the particular setpoint. For controlling the temperature, relays are used which are connected to a heater and a cooler.

II. RELATED WORK

Dusyant Pande et al [1] have discussed about The Real Time Hardware Design to Automatically Monitor Light and Temperature. In this paper, temperature and light monitoring is done with the help of two sensors and displayed on an LCD screen and the desired values of temperature and light are set with the help of provided keypad. They have used PIC microcontroller and an ADC 0809 for analog to digital conversion for their system. In our system, we have used ATMega 328 microcontroller which has an inbuilt 6 channel 10 bit ADC. The desired setpoint in our system is given through a potentiometer.

A. Goswami et al [2] have proposed an Embedded System for Monitoring and Controlling Temperature and Light. In this system microcontroller AT 89S52 is used which is a 40 pin IC. The temperature measurement and light intensity from the channels of ADC 0809 are taken. The performances of the channels are distinguished on the basis of its accuracy. The accuracy indicates how accurately the sensor can measure the actual and the real world parameter. In our system we have used a 28 pin IC ATMega 328.

R. A. Eigenberg et al [3] have development a system for Rugged Environmental Monitoring Units for Temperature and Humidity. This system has additional complexity of construction and calibration for certain applications that involve harsh environment. The system also doesnot have any hardware control unit to meet specific conditions.

M Ramu and CH. Rajendra prasad [6] have discussed about Cost Effective Atomization of Indian Agricultural System using 8051 Microcontroller and GSM technologies. This project finds application in domestic agricultural field. In civilian domain, this can be used to ensure faithful irrigation of farm field, since we have the option of finding the moisture level of soil in a particular area.

I. G. Saidu et al [7] have designed a Temperature Monitoring and Logging System suitable for use in Hospitals, incorporating GSM Text Messaging. Their system design using ATMega16 helps to manage the temperature of a patient that is possibly critically ill in the hospital or to monitor the operations of other hospital operations such as preservation of food, drugs, etc. Here, they have discussed the implementation of intelligent sensors that finds application in distributed measurement and monitoring systems like meteorological stations etc. However, the major limitation in this system is that the accuracy of the measured value may have an error of ± 0.5° C which needed improvement by improving ADC resolution. Also, the LM35 sensor needed to be attached to the body of the patient which has been found to be very inconvenient.

III. BLOCK DIAGRAM OF THE PROJECT

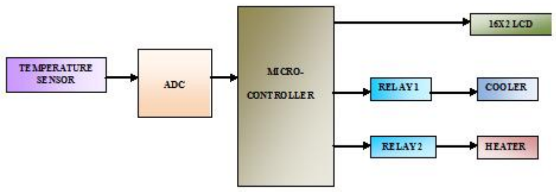

Figure 1. Block diagram of the Temperature Monitoring and Controlling System

IV. CIRCUIT DIAGRAM

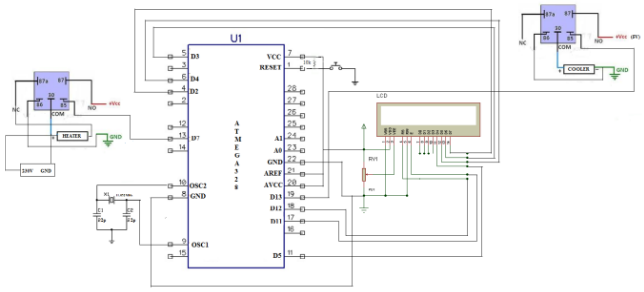

Figure 2. Circuit Diagram

V. WORKING PRINCIPLE

The circuit is based on LM35 analog temperature sensor and ATMega 328 microcontroller. For example, if the temperature is 38°C, the output voltage will be 38 x 10mV = 380mV. ATMega 328 has an inbuilt ADC that is used to is used to convert the analog output voltage of the LM35 to a proportional 10 bit digital value suitable for the microcontroller. The microcontroller accepts the output of ADC, performs necessary manipulations on it and displays it numerically on an LCD display. Output of the LM35 is connected to the analog input pin (pin 23) of the microcontroller. Data lines are Pins 4, 5, 6, 11, 17 and 18 of the microcontroller which are the digital inputs D2, D3, D4, D5, D11 and D12 respectively. These Pins are interfaced with the LCD as- LCD RS pin to digital pin 12, LCD Enable pin to digital pin 11, LCD D4 pin to digital pin 5, LCD D5 pin to digital pin 4, LCD D6 pin to digital pin 3, LCD D7 pin to digital pin 2, LCD R/W pin to ground and 10K resistor: ends to +5V and ground, wiper to LCD V_o pin (pin 3) for contrast adjustment of the LCD. The reset switch is connected to pin 1 of the microcontroller through a 10k resistor. A crystal oscillator is connected between pins 9 and 10 of the microcontroller through two 22picoFarad capacitors. The setpoint is controlled through Pin 24 of the microcontroller. The signals for the two relays are taken from pin 13(digital 7) and pin19 (digital 13) for driving the heater and the cooler respectively.

VI. FLOW CHART OF THE SYSTEM

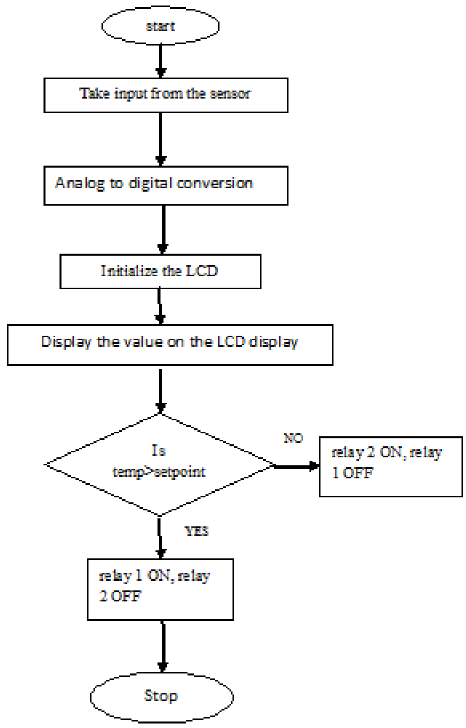

Figure 3. Flow chart for the system

VII. IMPLEMENTATION OF THE TEMPERATURE MONITORING AND CONTROLLING SYSTEM

A. Software implementation

In the software implementation part we have developed the assembly code for measuring temperature and controlling it according to the user's requirements and displaying the temperature in LCD module. The software includes the reading of various measurements from sensor, converting analog value to digital values, displaying the temperature in the 16X2 LCD display and the program for controlling action. The assembly level programming is done on Arduino IDE software, the developed program is installed in the ATMega328 microcontroller. The Arduino IDE combines project management, make facilities, source code editing, program debugging, and complete simulation in one powerful environment. The Arduino platform is easy-to-use and helps one to quickly create embedded programs that work. The Arduino editor and debugger are integrated in a single application that provides a seamless embedded project development environment. The Arduino IDE supports Windows, Mac OS X and also Linux. The circuit diagram has been drawn using Diptrace software.

B. Hardware implementation

In the hardware implementation part, a breadboard is used to make up temporary circuits for testing or to try out an idea. No soldering is required, so it is easy to change connections and replace components. Parts will not be damaged in this manner so that they will be available to re-use afterwards. The breadboard has many strips of metal (copper usually) which run underneath the board .These strips connect the holes on the top of the board. This makes it easy to connect components together to build circuits. To use the breadboard, the legs of the components are placed in the holes (the sockets).The holes are made so that they will hold the components in place. Each hole is connected to one of the metal strips running underneath the board. Each wire forms a node. A node is a point in a circuit where two components are connected. Connections between different components are formed by putting their legs in a common node. On the breadboard, a node is the row of holes that are connected by strip of metal underneath. The long top and bottom row of holes are generally used for power supply connections. Finally, the required components are assembled and soldered in a general purpose printed circuit board and the connections are made accordingly. A power supply of +5V DC for the microcontroller and operation of the relays is used.

1. Power Supply Module: This module is basically designed to achieve 5V regulated power supply for the circuit. It mainly consists of a transformer which is used to step down the AC voltage, IN4007 diodes used to form a full wave bridge rectifier to convert AC to DC, capacitor 1000µF used as a filter circuit and 7805 regulator IC to obtain 5V at the output of the regulator.

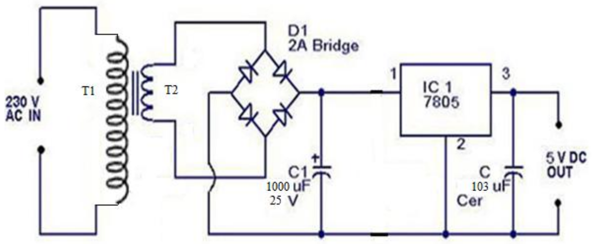

Figure 3. Circuit diagram of the power supply section

2. LM35 Temperature Sensor: National semiconductor's LM35 IC has been used for sensing the temperature. It is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in˚C). The temperature can be measured with it more accurately than using a thermistor. The sensor circuitry provides accurately linear and directly proportional output signal in millivolts over the temperature range of 0˚C to 155˚C. It develops an output voltage of 10 mV per degree centigrade change in the ambient temperature. Therefore the output voltage varies from 0 mV at 0^0 C to 1V at 100^0 C and any voltage measurement circuit connected across the output pins can read the temperature directly. Its accuracy is 0.5^0 C.

3. Signal Conditioning: Atmega 328 has an inbuilt ADC. Microcontroller is programmed to read data from LM35. The first thing in our program is to write a routine that enables the ADC to read and write data and convert the analod sensor values to digital values.

4. ATMega328 microcontroller: The ATmega 328 microcontroller is the current top of the line in the 28-pin ATmega x8 series. It has 32kB flash memory, 2kB RAM, and 1kB EEPROM. It can be considered a step up from the ATmega8. It will run at 3.3V with a 16MHz crystal, although it is not recommended due to the possibility of corrupting the EEPROM contents. It has 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter, programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. Its maximum operating frequency is 20MHz.

This is the CPU (Central Processing Unit) of our project. We use microcontroller ATMega328 for reading the temperature and holding the monitoring and the controlling program. It receives the analog voltage signal coming from the sensor. After the conversion into digital signal, it checks whether the sensed value is in the set value. If the data doesnot come under the set parameter, then the microcontroller starts its controlling action.

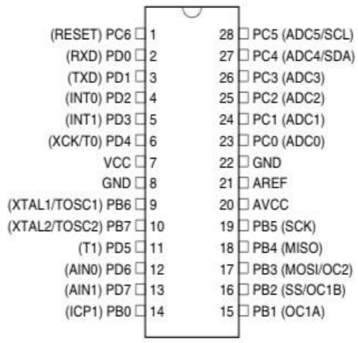

Figure 5. Pin diagram of ATMega328

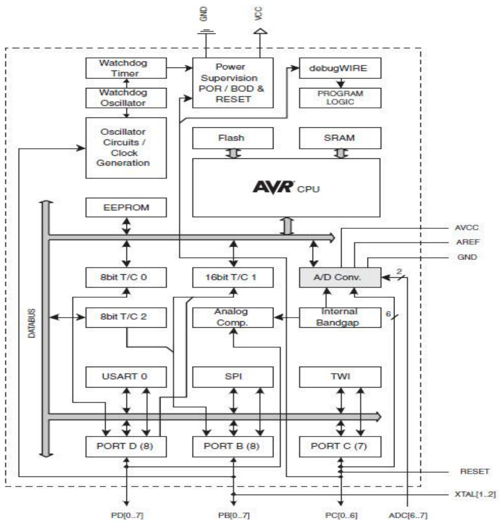

Figure 6: Block diagram of Atmega 328

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5. LCD Display: Since the data from the microcontroller needs to be displayed a HD44780 based Liquid Crystal Display – JHD162A is used. The display section consists of 16*2 LCD, which is used to display the temperature.

6. Relays: There are two relays connected. It operates in two modes-Normally Open (NO) and Normally Closed(NC). Different devices can be controlled i.e they can be turned on/off whenever required. Two 5V relays are used to control the hardware for maintaining temperature as set by the user, one for the heater and the other for the cooler.

7. Pot for Contrast-Control: The contrast in the LCD can be varied using a Pot on Pin 3 of the LCD. One of the two outer pins of the pot can be connected to the positive voltage and the other to ground (pot has no polarity). The output of the pot can be obtained from its middle point. This output voltage of the pot varies in accordance with the position of the rotable screw present on the pot. This adjustable screw is used to adjust the brightness of the LCD screen.

8. Pot for Setpoint-Control: Similar to the pot for contrast control of LCD, another 10k pot can be used for adjusting the setpoint according to the user's requirement.

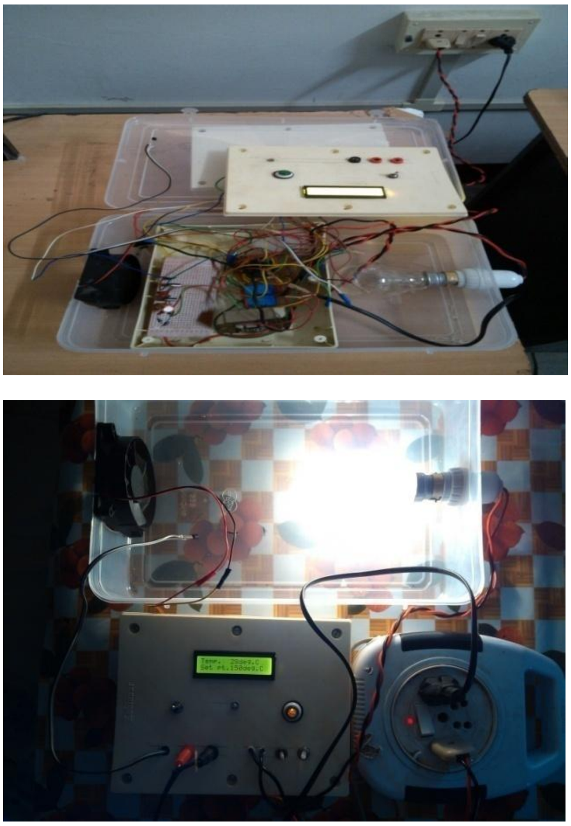

Fig 7: Views of the complete hardware system

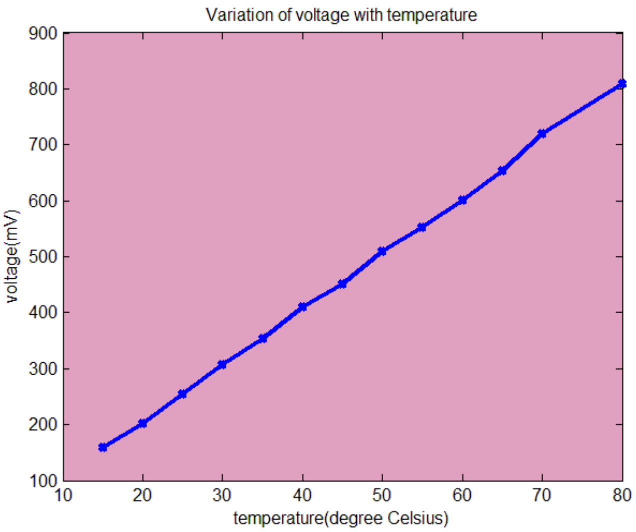

Fig 8: Change in temperature (^{0}C) with the change in voltage(mV)

VIII. RESULTS

A step-by-step approach in designing the microcontroller based system for the measurement and control of temperature is followed. The results obtained from the measurement have shown that the system performance is quite reliable and accurate. This system requires a number of hardware components, properly integrated in accordance with their specifications. They need to have a continuous and reliable power supply provided to them.

IX. CONCLUSION

Temperature monitoring and controlling is done with the help of a microcontroller and LM35DZ is the temperature sensor. The temperature is displayed on the LCD screen and the desired value of temperature is also set. The entire decision making is done with the help of a microcontroller ATMega328. This type of system can be installed in any place where we need to maintain temperature approximately constant. Also, by applying more sensors like light intensity sensor, barometer, humidity sensor etc, more parameters like light, atmospheric pressure and humidity etc can be monitored and controlled which are vital for any industrial process. The system has various advantages over other similar systems such as cost-effectiveness, smaller size, on-device display, less complexity and greater portability. This project can be used in industries to measure the temperature and control the temperature as per requirement. It can be used in tea factories to continuously monitor and control the temperature required for processing the tea leaves. It can also be used in confectioneries for preservation of the sweets. The system can be used in green houses to control the temperature for the proper growth of plants. Temperature monitoring and controlling action can be used in home or various halls like conference room, seminar hall to control the temperature of room.

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