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Novel Approach of IC-Based User Defined Temperature Control System

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***Abstract*—**Temperature is one of the most important process variables which are required to be measured and as well as controlled in the field of different process industries. So, accurate and reliable measurement of temperature is always treated as one of the most essential requirements in any process industry. The main objective of this work is to design and implement an automated user-defined temperature control system using the IC-based temperature sensor and embedded system. In order to control the temperature of a system in a very compact way,the temperature window should be user-defined. An automatic temperature controlling system is a device that helps keep the temperature of a particular region within a defined temperature window. A temperature window selects the range of temperature where the lower limit and the upper limit of the temperature is user-defined. This means the temperature window within which the temperature is to be maintained purely depends on the user. Any time the user can change the set temperature range accordingly. It is generally used for measurement as well as controlling the temperature within the range of -55^{o}C to 150^{o}C.

***Keywords*—**Temperature measurement, IC-based temperature sensors, Microcontroller

I. INTRODUCTION

Nowadays the demand to measure or control the environmental factors like temperature is the most vital physical parameter in different process industries.For that purpose, there are so many temperature sensors commonly used to detect the hotness or coldness of an object, like thermometers, thermocouple, resistance temperature detectors (RTD),thermistors, pyrometers, IC-based temperature sensors etc. In process industries, the measurement of physical parameters is not only the main aim, the prime objective is to control the physical parameters. For the controlling purposevarious controllers are used which take a signal from the sensor, generally an electrical signal, as input of the controller. The output of the controller, controlled signal feed to the final control element (FCE) to control the main measured variable by changing the manipulated variable [1-5].

II. RELATED WORK

C. Rameshu and A. P. Shivaprasad has developed highly accurate with ±0·3°Cand wide temperature-ranged in between 50-100°C, a microprocessor-based indicating device with a K-type thermocouple as sensor [6]. Theophilus Wellem and BhudiSetiawan have installed Atmel ATmega8535 microcontroller and LM35 temperature sensor to monitor Room temperature [7]. A portable and inexpensive temperature and thermal conductivity measuring device without any AC power source has been designed by M. Rehman et.al.[8].A.K.Sanyal and A.Pal have designed a system where temperature input of a thermistor transducer converts into its equivalent analog signal and hence equivalent digital signal using Analog to Digital Converter (ADC), this digital signal is displayed in a LED display [9]. Trio Adiono et.al.have demonstrated a mobile and low-cost humidity as well as temperature monitoring device operated through smartphone or alike interface devices [10]. The safe range of Room temperature is monitored via Bluetooth control, this embedded system has been made by T. O. Loup et.al. [11]. Deviation in temperature causes the change in speed of a fan, controlled through an Arduino programmed microcontroller has been proposed by Adeloy et.al. [12]. Zhang Xiaodong and Zhang Jie have developed a smart home control system by embedding STM32F407VGT6 - microprocessor and μC/OS-IInamed operating system [13]. Sun Kai and et.al. have designed a device to control temperature intellectually by incorporating a temperature sensor-DS18B20 and processor chip-AT89S8252; can set up various time periods and temperatures for the conservation of energy sources [14]. Using a Single Chip Microprocessor (SCM) - C8051F, integrated with CO2 concentration and detection of light intensity-more user-friendly temperature and humidity control and measurement system has been fabricated by Peng Wang [15]. Baruah.J et.al have created a temperature monitoring and controlling system, after sensor senses temperature, LCD shows reading what the microprocessor's inbuilt ADC gives [16]. Reetam Mondal and Sagarika Pal have shown an 8051 microcontroller-based device that can control temperature, having the main objective to show the relation of a controlled variable with changing load [17]. Using TRIAC as a power controller in an integral cycle control mode for easier programming in that microprocessor which is used to design the temperature control system by A Damodar and T. Rajagopalan [18]. C. Rameshu and A.P. Shivaprasad have developed highly accurate & wide ranged a microprocessor-based temperature indicator with a thermistor as sensor [19]. C. Rameshu and A. P. Shivaprasad has designed highly accurate and wide ranged a microprocessor-based temperature indicator with platinum resistance as sensor [20]. By interferometry optical sensors system and implementing Phase Modulation Principle, the 8085microprocessor operated temperature monitoring system has been designed by D. Hazarika, K. C. Sarma and P. K. Sarmah [21]. With PWM technique, by varying duty cycle-as per room temperature and hence fan-speed; Vaibhav Bhatia, Gavish Bhatia have elucidated fan speed control system [22]. Minli Tang and et.al.have proposed a digitalized temperature controller operated through a mono chip - 78F9234 with a temperature sensor DS18B20 [23].

LM35temperature sensor is a small IC based sensor with accurate measurement ability as it generates tiny amount of heat within it(0.08°C).Its circuit is very lucid and does not require any type of signal conditioning. The output voltage generated is directly proportional to the temperature measured of about 10mV per degree Celsius for experimental purpose, in the making of projects involving use of pasteurization machines, digital thermometers etc.

III. METHOD OF APPROACH

The proposed temperature controlling system follows a smooth path of working that approaches asoutput of the temmperature sensor(LM35) goes to ADC,therefrom to Micro-controller which hence controlls three discrete unit simulataneously,these are Display Unit,Heating Unit and Cooling Unit which is as shown in Figure 1.

LM35 is a precised integrated circuit temperature sensor that has been installed to sense the temperature to be measured, its electrical output voltage has linear relation to the temperature applied (in ^{o}C). LM35 has been chosen for its mostaccurate temperature measurement ability. The sensor circuitry is sealed and not subject to oxidation, etc. As LM35 generates large amount of output voltage, amplification may not require further.LM35DZ draws only 60 micro amps current from its supply and possesses a low self-heating capability (< 0.1^{o}C temperature rise in air) which makes it more usable.The details schematic circuitry of proposed temperature controlling unit is shown in Figure 2.

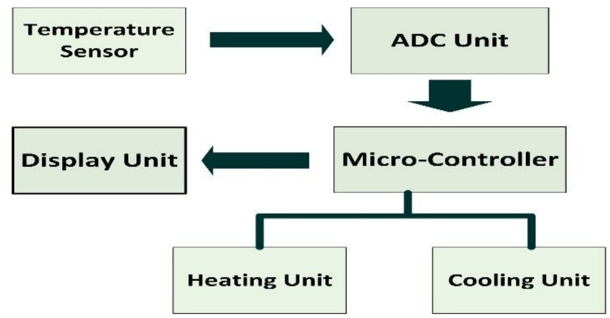

Figure 1:Basic Block Diagram of proposed temperature control system

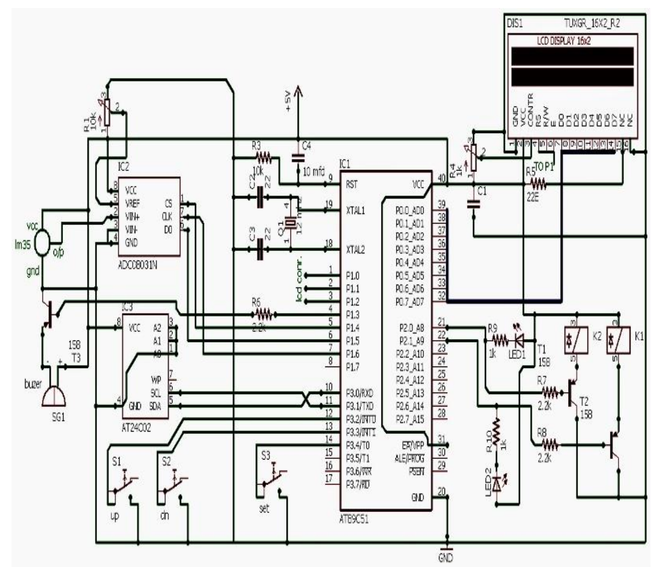

Figure 2:Schematic Circuit Diagram of Proposed System

Lets consider,V_{out} is the output voltage of LM35 sensor by taking the values of Temperature from full workingrange of LM35 sensor i.e. from -55℃ to +150℃, The output voltage of the LM35 is fed to the ADC (ADC0831-N),thus analog input gets converted into 8-bit digital output by using successive approximation methods. The ADC converter has configurable input multiplexers up to 8 channels.It measures an analog voltage sample at its input and converts into a binary number that describes the sample.For voltage scaling, consideration of 0 to 5volts representing 00000000 to 11111111 respectively as an 8- bit binary number.

The input output relationship for ADC conversion can be done by the following equation,

$$V_{dout} = \frac{(2^N - 1) \times V_{out}}{V_{ref}} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\text{i.e.} Decimal\ Data\ output = \frac{(2^N - 1) \times \text{Analog input voltage}}{\text{Refrence voltage}} \ldots \quad (2)$$

Where, V_{dout} is the decimal output data from ADC, N is the number of bits in ADC.As the resolution of ADC0831N is 8 bits, decimal data output of the ADC is converted into its equivalent 8-bit binary form.This 8-bit binary data is fetched by the microcontroller and it operates as the flow chart as shown in Figure 3, to fed back the analog temperature value to the display unit.Again, conversion into analog value from the 8-bit binary data can be done by equation,

$$A = D_0 2^0 + D_1 2^1 + D_2 2^2 + D_3 2^3 + D_4 2^4 + D_5 2^5 + D_6 2^6 + D_7 2^7 \quad \text{.................................} (3)$$

By using bellow equation, we get accurate analog voltage output,

$$A_0 = \frac{Vr*A}{2^N-1} \quad \text{..................................} \quad (4)$$

Where, A_0 is Analog Output Voltage, A is the equivalent decimal output for N-bit binary input, $V_r$is the reference Voltage and*N*is the Number of bits.

This analog voltage output on the display unit in form of temperature parameter is mostly accurate to the input temperature that LM35 has sensed.Now, controller checks whether this measured value lies between the user defined temperature window or not.

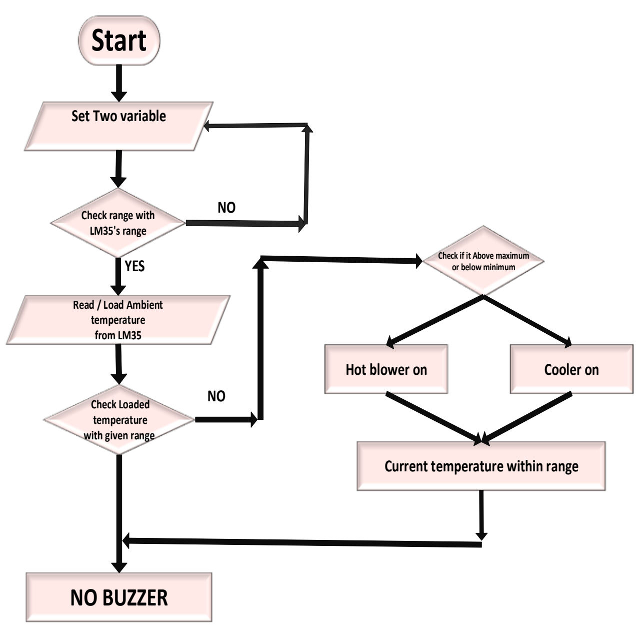

Figure 3: Flowchart of Microcontroller Programming

The whole operation is influencedby microcontroller 8051in where microcontroller accepts the user defined temperature range and the flow-chart of the program of the microcontroller is shown in figure 3.The software of 8051 microcontroller implements users' ingress onto the LCD unit through Assembly Language. The software works in an algorithm of fetching measurement values of sensor,analog to digital conversion, displaying the temperature in the 16*2 LCD display and mass control. The assembly level programming is doneon ALP, the developed program is installedin the ATMega328 microcontroller.The AC input power is taken from a centre-tap transformer wherefrom This AC signal is converted to DC using a rectifier. Rectified DC signal is needed a filtration to wipe out ripple; this causes reduction of ripple factor of utmost 1%. Filtered DC supply of 5V is necessary to operate every component of this hardware. EEPROM is used in the circuit to store all the data and to store the defined temperature range when the power supply is turned off and all the records are displayed in a 16*2 LCD. This LCD displays the current temperature, temperature range, status of current temperature indicated in the form of Hot-blower or Cooler. The brightness of the screen can be adjusted by using a rotating potentiometer.

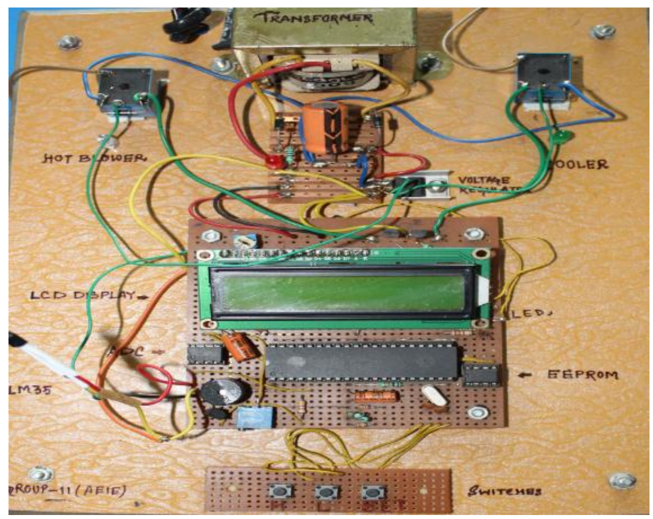

Figure 4:Hardware implementation of the proposed system

IV. DESIGN

In this hardware, a step-down transformer is used to convert the high voltage (HV) -low current from the primary side to the low voltage (LV) - high current value on the secondary side. The range is being taken within -9 to +9 volts. 7805 series voltage regulator stabilizes the overall voltage to 5V. This IC does not require additional components to provide a constant, regulated source of power, making them easy to use, as well as economical and efficient uses of space.

The entire process is carried out in four steps. First step consists of the voltage supply and its regulation. The power supply unitrelates to full wave rectifier using centre-tapped step-down transformer.

In the second step, the temperature is sensed by the temperature sensor LM35. The output voltage is linearly proportional to the Celsius (Centigrade) temperature and is in analog form. It relates to the analog to Digital

Converter(ADC). The output of LM35 gets converted into its equivalent digital form. This output is then fed to the AT89C52 microcontroller. These ADC seems like its memory operation or I/O, not any peripheral device. The microcontroller helps in regulating the temperature within the given range and then the sensed temperature gets displayed on the LCD screen. It is an output device for presentation of information in visual form.

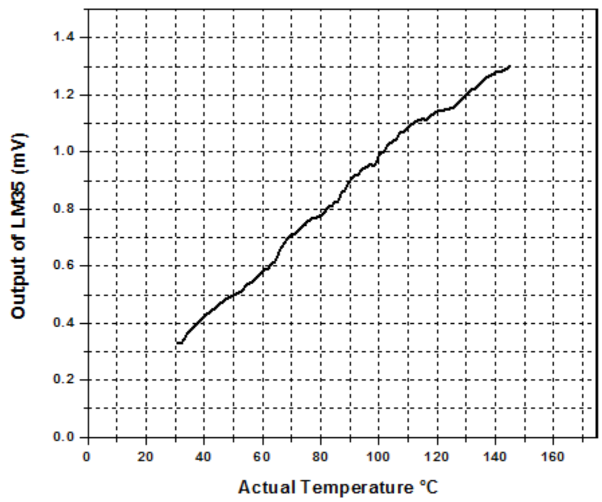

Figure 5:Variation of the output voltage of LM35 with applied Temperature

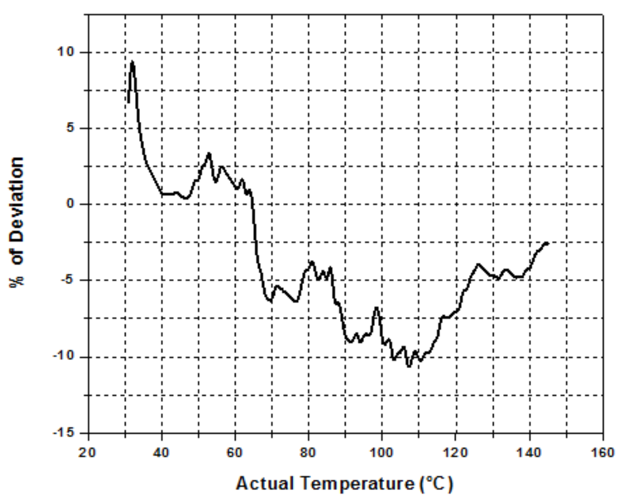

Figure 6:Percentage of Deviation of the Temperature controlling system

In the hardware implementation part, a breadboard is used to make up temporary circuits for testing or to try out an idea. 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. The snapshot of the prototype temperature control unit is shown in Figure 4.

V. RESULT AND DISCUSSION

The experiment has been performed after fabricating the setup. The desired range of the temperature is given by the user as input, and the temperature sensor LM35 senses the temperature of the surrounding or ambient temperature. If the immanent temperature which is sensed by the LM 35 is greater than the given range then the cooler starts and if it is less than the desired range, hot-blower starts. The cooler is indicated by the green LED and the heater is demonstrated by the red LED in our prototype proposed system. Here an IR (Infrared) bulb is installed as a source of the change in ambient temperature which is measured by the temperature sensor LM35 and the controlled by the micro-controller.

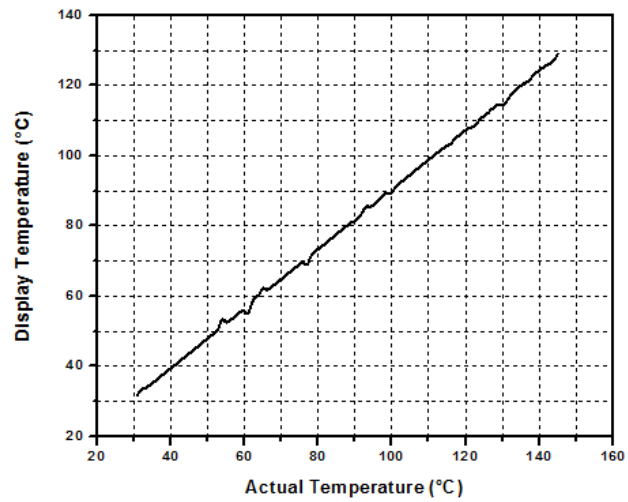

Figure 7:Relation between Actual Temperature and Display Temperature

For measuring the actual temperature, here we used a standard industrial mercuryfilled thermometer as a temperature measuring instrument whose temperature measuring range satisfies the temperature range of LM35. The output voltage of the LM35 which is in the range of mV is measured by the Digital Storage Oscilloscope (DSO) (Maker: Tektronix, Model: TDS 1001). The experiment is repeated more than six times in increasing and decreasing order of varying applied temperature range of 31℃-135℃, and the average display reading from LCD display are noted. During this course of experiment the corresponding output voltage of the LM35 are alsonoted down for analysis of static characteristics of the proposed temperature controlling system.The mean reading of the output voltage of the LM35 with the varying applied temperature has been calculated. This result is as shown in Figure 5. From the figure 5 it can be said that the output voltage of the LM35 is quite linear with the applied temperature range.The error during measurement in percentage deviation from the linearity is shown as Figure 6.Despite the presence of some deviation, the graphs are almost linear and match the both temperatures.So, this error analysis of the proposed temperature controlling unit can be acceptable for this temperature range.The actual temperature from the standardtemperature moniroring instrument and the measured temperature from the display unit has been ploted which is shown in Figure 7.By acumen of the static characteristics that are mentioned above, developed hardware is working smoothly with having almost proper working implementation though it has not exacted linearity.

VI. CONCLUSION

After discussing all the function of this system,it can be concluded that the status of current temperature elated with the selection temperature window, implied throughhot-blower and cooler,having use of existing conventional temperature controller in the fields precisely. Sensor LM35 can sense temperature very precisely and the ADC is calibrated such that microcontroller is fed by voltage input in binary form. The controller gives a very fast responsefor instantaneous measurement of temperature values. Implementation of buzzers detects the measured value whether it is within desired range or not. Installation of EEPROM helps to store previously set data in absence of power supply.This setup is fabricated through inexpensive electronic components, high-performance microcontroller for which this setup seems to be commercial rather more usable.

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Authors Profile

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