TEMPERATURE CONTROL SYSTEM USING THERMISTOR

Gracy Philomina K. L.

Lecturer, Department of Electronics Engg.,
Govt. Polytechnic College, Perinthalmanna - Kerala

ABSTRACT

The thermistor is an electrical component that can measure temperature differences by sensing the change in resistance with temperature. Once calibrated against the thermistor equation, the temperature around the thermistor can be electronically determined by detecting the change in voltage across it as its resistance changes. The thermistor has been used to regulate a specified temperature between 30℃ and 100℃ , to an accuracy of 3℃ , when coupled with a circuit-controlled heater and controlled by a microprocessor, demonstrating its capability to maintain temperature for the alexandrite laser rod.

Keywords: *Temperature control System; Thermistor; Calibrate Thermistor; Thermistor temperature accuracy measurement.*

INTRODUCTION:

Precision temperature control and air freshening control are now required in many industrial sectors, including process heat, automotive, industrial settings, and office buildings where cool air is needed to keep occupants comfortable. The realisation of the desired temperature and the optimisation of consumption are two of the most important concerns in the heat domain. As a result, an automatic temperature control system is necessary to regulate fan speed in reaction to temperature changes. This research proposes a user-friendly technique for reducing electricity consumption and increasing electrical component efficiency. Electrical equipment efficiency has had to improve as science and technology have advanced. Only then will cutting-edge technology be able to control the upcoming digital era.In the proposed work, the LM 35 sensor, which senses the room temperature and regulates the fan speed proportionally to the environmental room temperature, would replace the regulator used in regular model fans in residential and industrial equipment. This campaign promotes people to use less energy in their homes and workplaces by utilising technology. Numerous studies concentrating on the application of automatic temperature control systems in various industries will yield benefits.

TEMPERATURE CONTROL SYSTEM:

Temperature is the degree to which a body or environment is hot or cold. A control system is a device or system that manages, commands, directs, or regulates the behaviour of other devices or systems. Thus, a Temperature Control System is literally defined as a device or group of devices that control, command, direct, or regulate the behaviour of other devices or systems in order to influence the degree of hotness or coldness of a body or an environment.

A Temperature Control System is similar to a programmable thermostat in that it can maintain a constant temperature in the home or business independent of outside weather conditions. The advantage of a temperature management system over a standard thermostat is that it saves energy and money by automatically maintaining varied temperatures throughout the day and night. It is typically a feedback system with a control loop that includes sensors, control algorithms, and actuators/effectors and is configured to try to regulate a variable at a set point or reference value. When a measured temperature falls, one example is to increase the fuel supply to a furnace. [1]

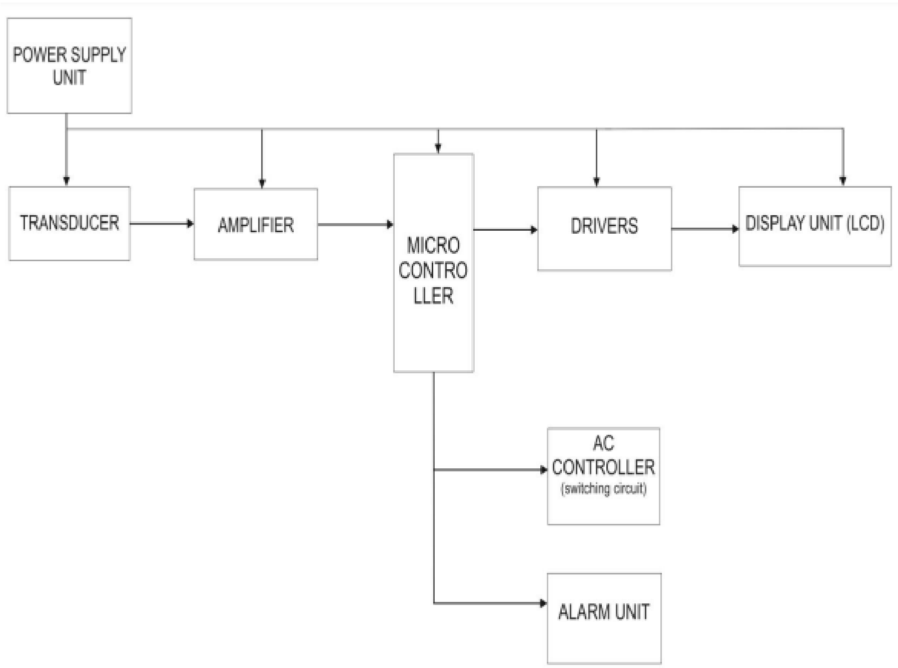

Figure 1: Block Diagram of Temperature Control System

BASIC COMPONENTS OF TEMPERATURE CONTROL SYSTEM:

Temperature Control Systems down through the years have been made up of the following five major units:

I. **The Power Supply Unit**: This unit delivers the Electrical Energy that powers the Temperature Control System. In this situation, the Power Supply Unit is made up of a step down transformer that operates on the induction principle. The transformer reduces the voltage received from the power outlet from 230V to 15V, which is all the voltage required to power the system. This voltage is further rectified and filtered) to provide the system with a perfect and undistorted voltage. About 5V of the 15V input voltage powers the microprocessor. The remainder are required to power the circuit's other units.

II. The Sensor Unit: This Module is made up of devices that detect the present state of the temperature. These devices detect the current room/surface temperature and provide the result to the Control Unit and the Display Unit.

III. The LCD/Display Unit: This shows the current temperature of the environment as reported by the Sensor Unit. In this example, it comprises of a 7-bit graphic large-digit display device that displays the temperature sensor's results/readings to the external user.

IV. The Control Unit: The Control unit houses the Controller and accompanying devices that process information in order for the system to produce effects/action. In this example, the microcontroller that stores the set-point temperature is housed in this device. The control programme takes temperature information from the sensor unit and ensures that the set-point is not compromised by beginning the required sequence of operations.

V. Menu/Function Unit: This device is made up of input buttons that are used to send commands to the control programme as well as to programme the system's set-point. In this scenario, a variable resistor that alters the set-point temperature by varying its resistance.

VI. The Alarm Unit: This unit comprises of an alarm system that warns the environment's inhabitants of a temperature breach. Temperature Control Systems might include this as an optional component. Most commercial Temperature Control Systems prefer to keep a silent profile in the environment where they function, thus it comes largely with those systems that are designed to standards. [2]

THERMISTOR

Thermistor, which has been used to monitor temperature rise, is the fundamental component of this temperature regulated fan circuit. A thermocouple is a temperature-sensitive resistor whose resistance varies with temperature. NTC (Negative Temperature Co-efficient) and PTC (Positive Temperature Co-efficient) thermistors are used; we are employing an NTC thermistor. A NTC thermistor is a resistor whose resistance lowers as temperature rises, whereas a PTC thermistor's resistance increases as temperature rises. We also used Thermistor in a variety of intriguing applications, including a fire alarm circuit employing Thermistor, temperature controlled AC, and a Thermistor Based Thermostat Circuit.

The purpose of this project is to find an economical way to keep the alexandrite laser rod at a temperature between 30℃ and 100℃ that is accurate to 3 ℃. The temperature controller is designed to be an easily available and reasonably priced negative temperature coefficient (NTC) thermistor. It has a small footprint, allowing for easy embedding into a variety of devices, and it is extremely sensitive to slight temperature changes.

In comparison to the other type (positive temperature coefficient), the NTC thermistor operates over a wider temperature range, typically 50 ℃ to 150℃ , which encompasses the temperatures required for the alexandrite laser. These ceramic semiconductors have a voltage-temperature characteristic curve that is stable and predictable, as well as a decrease in electrical resistance as temperature increases. [3]

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This investigation was divided into 2 stages:

1) To verify the thermistor behaviour against theory and to calibrate it, and

2) To develop a prototype with the thermistor for temperature regulation

The sections that follow discuss the theory for thermistor behaviour, the experimental apparatus and procedure for studying and employing a thermistor, and the investigation's findings.

The Steinhart-Hart equation is extensively used to approximate a thermistor's temperature, T, as a cubic function of its resistance, RT. It is written as follows:

$$\frac{1}{T} = a + b\ln R_T + c(\ln R_T)^3 \qquad \text{.................................... 1}$$

Where a, b and c are physical constants depending on the system. Within the small temperature range of 30˚C to 100˚C, the further linear approximation.

$$\ln R_T = \ln R_0 + \frac{T_0}{T}, \qquad \text{.................................. 2}$$

Is satisfactory, where T0 > 0 and R0 > 0, or more intuitively,

$$R_T = R_0 \exp\frac{T_0}{T}. \qquad \text{.................................... 3}$$

By measuring RT as T fluctuates, Equation (3) can be validated. R0 and T0 are calculated using equation (2) and a linear regression. As shown by the previous calculations, resistance diminishes exponentially as temperature rises. Uncertainties in T0, ln R0, single-measurement T, and ln R can be estimated using some error analysis and the errors associated with the linear fit of equation (3).

To meet the project's goal, two tests are set up: the first to calibrate the thermistor against equation 2.4, and the second to test it as a temperature controller. Control is assigned to the National Instruments Lab PC + microprocessor in both trials via a programme ran from a Pentium III 500MHz computer running Windows 98. A mercury thermometer is also used as the calibrating device.[4]

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Stage 1:

To calibrate the thermistor, R0 and T0 are determined following the procedure:

a) Set up the computer system and diagnostic circuit

b) Write a controlling program

c) Test the circuit, and read RT values for various T values

d) Analyse the data and determine R0 and T0 the circuit for the experiment is shown in Figure 2.

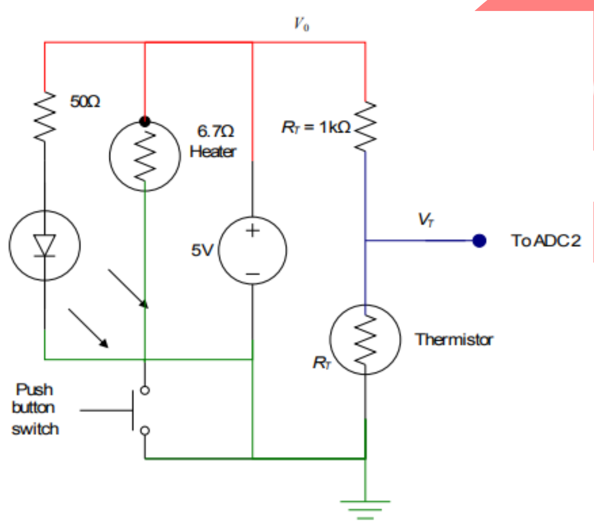

Figure 2: Circuit for Stage 1 to Calibrate Thermistor

To improve the precision of temperature measurement surrounding the heating element, both the heater and the thermistor are attached to the bulb of the thermometer in a compact metal box. The potential across the thermistor, VT, is measured at Lab PC + microprocessor port ADC2. When the temperature changes, the change in VT can be monitored and the change in RT can be calculated using,

$$R_T = \frac{V_T}{V_0 - V_T} \qquad \text{(1)}$$

Where, V0 is the source voltage, 5V, in this case.

Heating and cooling are used to test the thermistor's temperature sensitivity. RT values are calculated and recorded for temperatures ranging from 30.0 C to 89.0 C in 3.0 C increments during heating and down to 29.0 C during cooling.

Stage 2:

Once calibrated, the thermistor is subjected to testing as a temperature controller. Its efficiency to regulate a specified temperature within the range of 30˚C to 100˚C, to an accuracy of ±3˚C is determined by:

e) Modifying the computer system and circuit for prototyping

f) Writing another controlling program

g) Testing the circuit, for some chosen temperature, TSET, to regulate at, and recording changes in T

h) Analysing the data and verifying sufficient temperature control The circuit for the experiment is shown in Figure 3.

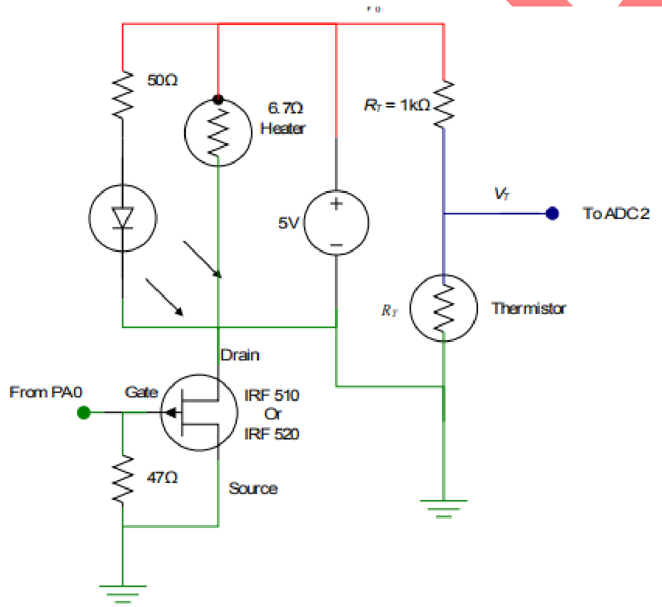

Figure 3:Circuit for Stage 2 to Prototype Temperature Moderator

The push button switch has been replaced with a power transistor (HEXFET), allowing the heater to be turned on and off programmatically. When a 5V signal is applied to the HEXFET's gate lead, current can flow from the drain to the source, closing the circuit and turning on the heater.

To use the prototype, enter the target temperature, TSET, into the computer command prompt to begin temperature measuring. If the current temperature falls below the required temperature, the microprocessor's port PA0 will output 5V, activating the heater. The signal is maintained until temperature exceeds TSET by an offset of δT. PA0 would then be set to 0V, causing the heater to be switched off. Subsequently, when temperature cools below TSET by δT, the heater is turned back on. In the current implementation, δT = 1˚C serves to reduce the frequency of turning the heater on and off, to help to extend its life-span, while still keeping temperature regulation sufficiently tight. [5]

OBJECTIVES:

1) To study of basic components of temperature control system.

1) To verify the thermistor behaviour against temperature control system and to calibrate it.

2) To study of to develop a prototype with the thermistor for temperature regulation.

3) To illustrates the effectiveness of the thermistor to maintain temperature within a tolerance of ±3˚C.

RESEARCH METHODOLOGY:

Books, educational and development magazines, government papers, as well as print and online reference resources, were just a few of the secondary sources we examined to research temperature Control System Using Thermistor.

REVIEW OF LITERATURE

According to the research of Tito Smailagich, removing the typical ON/OFF switch reduces electrical energy consumption and increases power consumption efficiency, resulting in energy and financial savings. According to Lawrence Berkeley National Laboratory papers, fans alone in the manufacturing sector consume 78.7 billion kilowatt-hours of energy each year. According to this report, the motor alone accounts for 15% of overall electricity use. In light of the preceding articles, this project replaces the standard type of regulator with an LM35 sensor and varies the fan's speed in reaction to the temperature of the room, thereby using less energy overall and allowing for various uses for the energy saved. In the systems that are being presented, the development of smart systems depends heavily on the controller. [6]

RESULT AND DISCUSSION

Thermistor temperature reading over a few oscillations of temperature regulation, with 1˚C overshoot. Temperature is maintained within the ±3˚C tolerance, after eliminating the spikes in the readings.

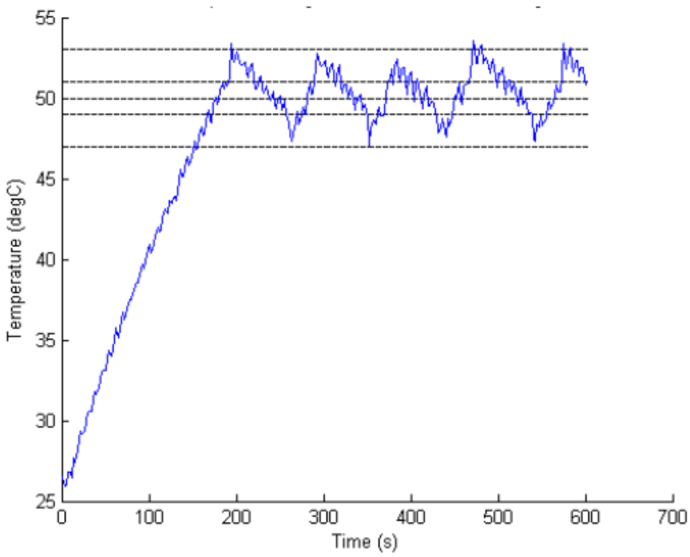

Figure 4:Temperature Regulation w/ overshoot of 1deg C

Above graph illustrates the effectiveness of the thermistor to maintain temperature within a tolerance of ±3˚C. TSET = 50 C in this experiment, and temperature remained between 47 C and 53 C (as indicated by the highest and lowest bars in figure 4). The characteristic spikes that appear each time the HEXFET is turned on or off are caused by abrupt changes in V0 when the heater is turned on or off. This has been taken into account when deciding if the temperature is suitably managed. [7]

The fundamental advantage of thermistors is their great sensitivity, but this comes at the expense of non-linearity and a variable range of readings for tiny temperature swings. The Steinhart Hart equations, which are used to characterise the nonlinear form of the thermistor characteristic, have limitations. Six temperature sensors were measured in the trials to establish their temperature resistance functions.

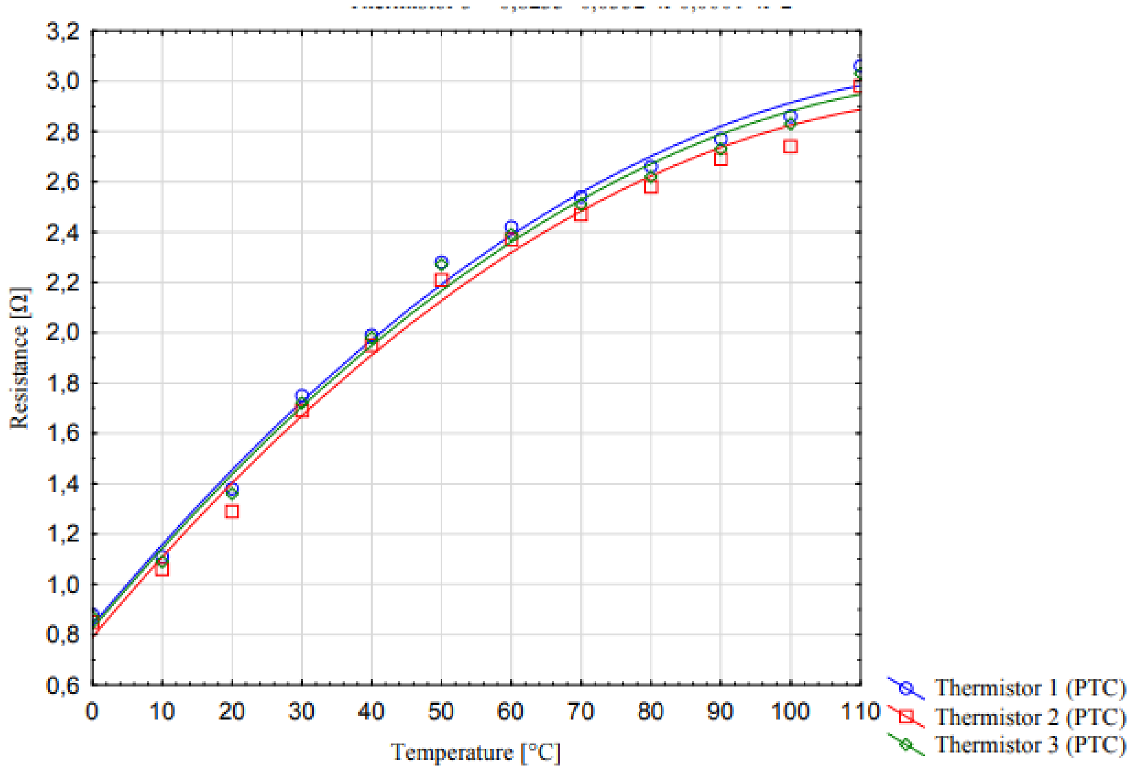

Figure 5: Polynomial representation of data obtained for PTC thermistors

In the case of PTC thermistors according with the Figure 5 a polynomial representationcan be used to predict their behaviour function of temperature.[8]

CONCLUSION

The linear approximation of the Steinhart-Hart equation for thermistors has been derived for the thermistor, allowing for calibration. A stronger heater should be used to test the thermistor's performance at temperatures over 89 C, up to 100 C, to see if it fulfils the project's requirements, but there should be no reason why it shouldn't. However, repeated measurements at same temperatures can be taken to reduce the uncertainty in temperature instead of relying on single measurement uncertainty to maximize the lifespan of the heater, the largest value of the temperature offset from the target temperature, δT, could be determined to minimize the number of times the heater is turned on and off. Furthermore, the temperature regulation test was only performed with the goal temperature set to 50˚C. To further validate its effectiveness, additional testing should be performed across the entire temperature range of30˚C to 100˚C.

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