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Demonstration of Control System by using Microcontroller

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Abstract: ***Temperature controllers based on proportional-integration-differentiation (PID) control strategy are widely used in many industries. The main reason for the versatility of (P-I-D) is relatively simple structure, which can easily understand and implemented in practice. This paper describes in detail the design of a PI, PD and PID controllers for temperature control of a heating coil the main aim is to show the temperature controlling in real time environment with the help of MATLAB. This method offers advantage such as high-speed computation, real-time processing, low power consumption and also results in cost reduction***

Keywords: proportional-integration-differentiation (PID), temperature control, Arduino Uno and heating coil

1. Introduction

In industries, the system is becoming very complex. It consists of a generator, transformer, transmission line various control and temperature depended operator. The industrial system needs to test the site equipment to track the state of the system for such non-stationary and the nonlinear system there is need such technology which minimizes the absolute error i.e. temperature difference.

Classification of controller
1. Proportional controller
2. Integral controller
3. Derivative controller

Combinations of the three controllers are:
1. Proportional and integral controller (PI)
2. Proportional and derivative controller (PD)
3. Proportional integral and derivative (PID)

The proportional controller is in which the signal is directly proportional to the error. The integral controller in which the signals is directly proportional to the integral value of the error. The derivative controller is in which the signal is directly proportional to the derivate value of the error. PID controller is still widely used more than 90% of the control loops are PID.PID controller has three constant i.e. P, I and D by tuning we can control action designed for a specific process.

Mathematical equation: The transfer faction of PID controller

$$G_C(S)= K_P+\frac{K1}{S}+K_DS\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Kp is the proportional gain Constant.
K_I is the integral Constant.
K_D is the derivative Constant

Implementation of digital PID controller has gone through several stages of evolution from the early mechanical and pneumatic design to the microprocessor based system but these systems have the drawback of demanding control requirement of modern power conditioning system which will overload most of microprocessor and computing speed limits the use of a microprocessor in the complex algorithm.

The design of PI, PD and PID controllers which was implemented for fast and accurate temperature control of an electro-thermocouple realized on a microcontroller. Although simple to implement; the controller used to provide better and fast performance.

The present can be useful as a reference or application example as the design is applied to the real system this paper can be interest in industrial control and control practitioners.

2. Literature Survey

With increasing need for cost effective and flexible system a huge number of embedded devices have been developed in a recent year and with further evolution of technology better system are being built. The present advancement in technology before us is the result of a chain of research and improvisations process.[1]. The idea of tuning the PID controller through frequency loop shaping; controller parameters are tuned to minimize the difference between actual and target loop transfer function; this approach provides an integrated method for quick and reliable tuning of controller [2].The main objective is to obtain a stable robust and controlled system by tuning PID controls. the proposed method utilize the particle swam optimization (PSO) algorithm. The PSO method is an excellent optimization methodology and a promising approach for solving the optimal PID controller parameters. [3] PID controller are still employed in 95% of industries; PID controller is implemented using two FPGA approach (Xilinx FPGA and Altera FPGA) they have their own advantages and disadvantages ;However the approach result in cost reduction and high closed loop performance using less resource[4] Controlling the temperature of the heating system employed in industries. PID controller is used because it provides less overshoot and low stability time the author show the temperature control application of the PID controller based on SCR control system by this they have high flexibility and temperature controlling reduce energy losses and therefore high productivity in the industries[5].the design of PID controller for temperature control of a polymers chain reaction(PCR); The design of the controller is done in continuous time domain then converted in discrete domain form; fast and accurate temperature control of PCR microreactor realized in a lab-on-chip research project.

3. Proposed System

The major industries in India include biomedical, food processing industries, power plant, textile industries which form the backbone of the countries economy. The continuous monitoring of temperature is a major criterion in all the above-mentioned industries. The proposed design aim at controlling the temperature in a real time environment. Any deviation or change in the environmental controlled conditions can lead to financial losses in agricultural and pharmaceutical industries and can be life threading to the users of biomedical industries.

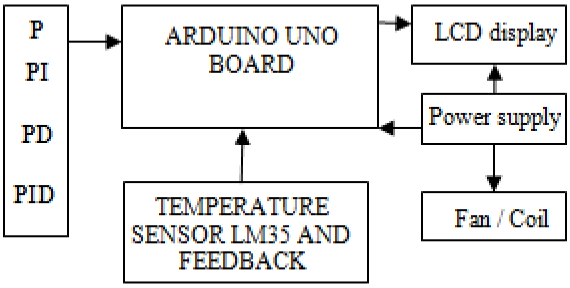

Figure 1: Block Diagram

The reference temperature is set by external means(MATLAB) also it can be always adjustable accordingly The measured temperature is then compared with the set point value to obtain the error; this error and the change of error is then applied to the PI-PD PID controller. The controller produces the control action according to the error; microcontroller then applies this control action to the heating coil and the fan through PWM .this process is repeated till the coil reaches the desired set point value.

4. Process Flow

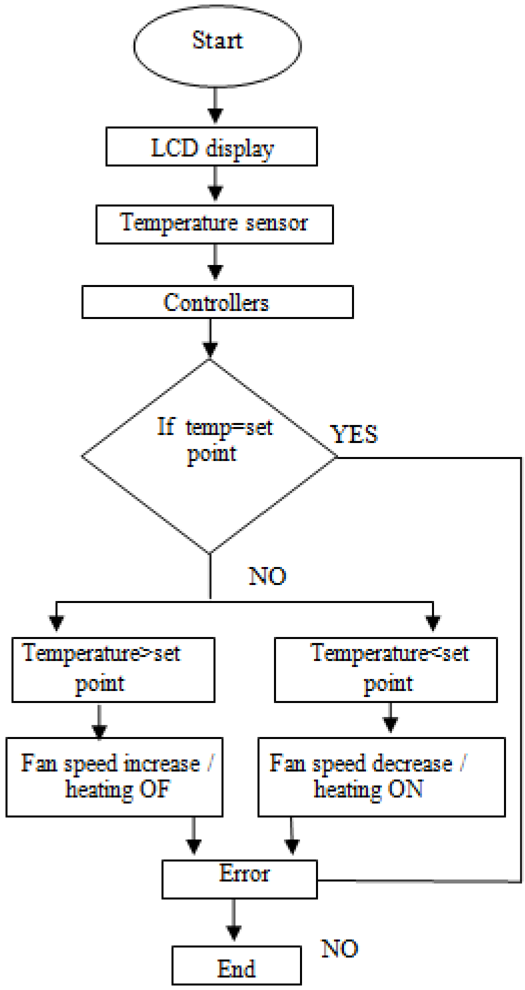

Figure 2: Flowchart

The flow chart of the system is shown above. It clearly explains how the system starts and step by steps process is carried out. The algorithm used in this system will maintain the temperature of the device (kept it in the predefined limits described as set point)

The steps followed for designing the system are:-

1) The flow chart shows the initialization of the system; when the system is in ON state the temperature sensor (LM35) gives the value of the temperature.
2) On giving the 12V supply to the device (electro thermocouple) will get heated
3) On selecting a particular controller with the help of its corresponding buttons (PI, PD, and PID) operation is performed.
4) If any error that is temperature difference occurs then the power is controlled with the help of PWM and the error is
5) Minimized and the temperature can be brought back in the particular range.

5. Hardware

1. Microcontroller: Arduino Uno is a microcontroller board based on the ATmega328.UNO means one in Italian. The Arduino Uno can be powered via the USB connection or external power supply .power source is selected automatically (ARDUINO UNO) Arduino board is a low cost and easy to use development platform it belongs to

Arduino family. In this project we had used Arduino Uno; targeted MCU (32kb flash memory).

2. Temperature Sensor: It's a transducer; it gives corresponding voltage output as temperature changes. It can be calibrated to degree Celsius.

3. LCD Display: A 16*2 LCD display is a basic model; these model one preferred over seven segments it can display 16 characters per line and these are 2 such lines each character display in the 5*7 pixel matrix.

6. Result

1) The behavior of PI controller: -Figure show the response of the PI controller when simulated with it parameter the graph shows that the controller has transient time it takes time the stabilize to the desired value the temperature from the graph we can also state PI controller have a large amount of steady state error that of the PID.
2) The behavior of PD controller: -The figure shows the response of the PD controller when simulated with its parameter the graph shows that the controller transient time has an it takes its time to stabilize to the desired value of the temperature from the graph. We can also state PD controller have a large amount of steady state error than that of PID.

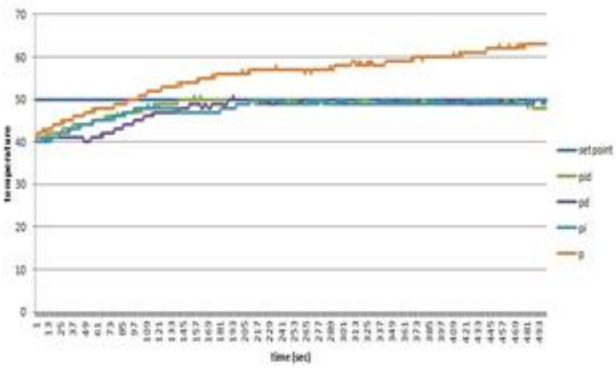

Figure 4: PD Controller Behavior

3) Behavior of PID controller
   Figure show the response of the PID controller when simulated with it parameter it is clear by the graph the PID controller as the small steady state error and settling time is less as compared to the PD and PI controller and also stabilizes quickly provide an accurate level of the temperature controlling.

Graph Output of the controller temperature vs time

Table: Comparsion between controllers

Parameter	P	PI	PD	PID
Settling time	No	210 sec	190 sec	140 sec
Transient time(0 to T)	Infinite	210 sec	190sec	140sec
Rise time	NO	168 sec	152 sec	112 sec
Steady state error	NO	2%	2%	2%
Stability	NO	210 sec	190 sec	140 sec

7. Conclusion & Future Scope

7.1 Conclusion

The temperature control is been an integral part of any control system. In the present study, the behavior of the controllers (P, PI, PD, and PID) is been carried out at different set-point values. The controllers helped in obtaining the temperature of the system to the desired value but stability, rise time and settling time was still in the concern. For a non-linear and dynamic system, PID controller provides greater control action; better performance and stability was achieved by using PID controller. With PID it reaches the set-point quickly and provides less oscillation as compared to other respective controllers. One of our goals in this work is to maintain the temperature in the set point value range with +-2 degree Celsius tolerance range which was achieved by PID controller.

So we can conclude from the result given by the PID controller is better than that of P, PI, PD controller; it provides minimum settling time, rise time, transient time and improves the stability of the system and has better overall performances and shows the accurate result for the temperature controlling system.

7.2 Future scope

In future some improvements can be made in the control aspects of the proposed system design as follows:

- To implement SBC (single board computer) with necessary software as a tiny OS for temperature monitoring and controlling.
- To design and study the application of the above controllers to other process control systems such as speed control of D.C and A.C motor.

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