Proc. Annual Symposium on Research & Industrial Training, 03(2016) 149-154
Department of Electronics – Wayamba University of Sri Lanka

LOW COST TEMPERATURE CONTROLLER DEVICE FOR WATER BATH

H.B.H. Jeewan*, L.D.R.D. Perera

Department of Electronics, Wayamba University of Sri Lanka, Kuliyapitiya, Sri Lanka
*harsha112189@gmail.com**

ABSTRACT

This project is to develop a low cost and flexible device for controlling the temperature of a water bath. The purpose of the temperature controller is to facilitate heating a system to a specified temperature, then maintain it at that temperature in a controlled manner. Microcontroller ATMEGA328P was used for precision control with low cost. DS18B20 was used as a temperature sensor for measuring temperature of the system. The Proportional–Integral–Derivative (PID) controlling was used for temperature controlling part in this work. PID controlling was implemented through the microcontroller.

Keywords: Temperature controller, Zero crossing detection, Microcontroller

1. INTRODUCTION

Temperature controlling is really important to monitor and adjust temperature without much operator involvement. Basic process first requires the measuring of the temperature of the room/tank which you are attempting to control and also to maintain that target temperature. There are various types of controllers in the market such as ON/OFF, Proportional and Proportional–Integral–Derivative (PID) controller[1]. In this project microcontroller has been chosen as the controller. The advantages in using microcontroller are the number of components for example relay and timer, the wiring and additional hardware of each new configuration of logic can be reduced and easy to troubleshoot when an error occurred. The PID was used to temperature controlling part in this device. The PID is widely used in feedback control of industrial processes on the market and has remained the most widely used controller in process control today. Thus, the PID controller can be understood as a controller that takes the present, the past, and the future of the error into consideration[2]. When using the

PID for tuning the system, that can have an ability to reach the target point existing the overshoot. A keypad was used to give a target value to the system there present temperature of the water and target value are displayed on the LCD display.

What is PID?

PID stands for Proportional, Integral and Derivative. Controllers are designed to eliminate the need for continuous operator attention. Cruise control in a car and a house thermostat are common examples of how controllers are used to automatically adjust some variable to hold the measurement (or process variable) at the set-point. The set-point is where would like the measurement to be. Error is defined as the difference between set-point and measurement.

(error) = (set-point) - (measurement)

The variable being adjusted is called the manipulated variable which usually is equal to the output of the controller. The output of PID controllers will change in response to a change in measurement or set-point. Manufacturers of PID controllers use different names to identify the three modes. These equations show the relationships[3]:

P- Proportional Band = 100/gain

I- Integral = 1/reset (units of time)

D- Derivative = rate = pre-act (units of time)

2. EXPERIMENTAL

The block diagram of the prosed system is shown in the figure 1.

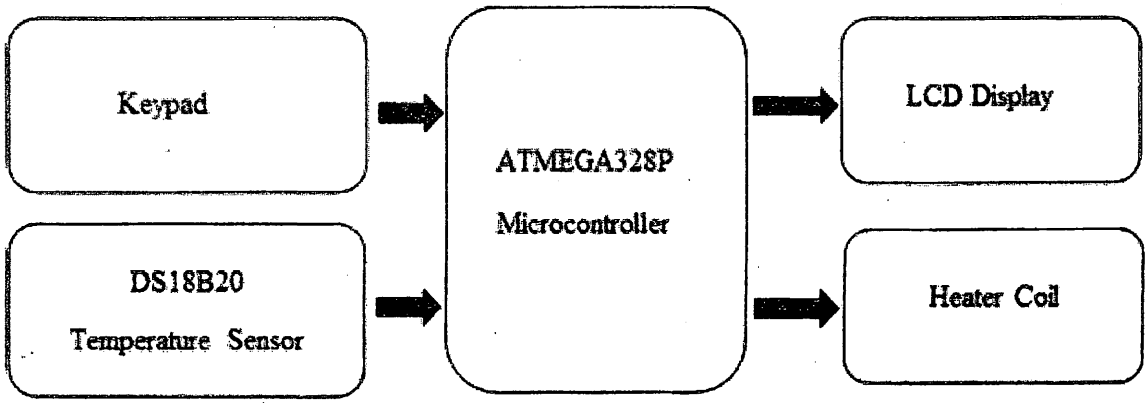

Figure 1: Block diagram of the system

In the proposed system, temperature controller part of the target point is the most important part in this project. There are various types of controllers in the market such as ON/OFF,

Proportional etc. Zero crossing phase controller circuit was used to control the given voltage of the heater coil. The PID is used to tune the device until better temperature controlling is obtained.

The current temperature was received by temperature sensor and the target temperature was input by keypad. To get the temperature difference, the following equation is used in the Arduino code of the device.

$$D_i = (T_t - T_0)K_p + (D_i - D_{i-1})K_d \quad (1)$$

Where D_i is temperature difference between current temperature reading & target temperature, D_{i-1} is temperature difference between previous stage temperature reading & target temperature, T_t is target temperature, T_0 is present temperature in the water bath, K_p is proportional gain and K_d is derivative gain

The result of the above equation is updated in the code and the zero cross point is detected by the zero crossing detector circuit. The zero crossing points are detected and the heater coil power supply is turned off for an inversely proportionally time between two zero crossing points. The K_p and K_d values were changed several times for implementing the better system[3].

$$t_{off} \propto \frac{1}{D_i} \quad (2)$$

Where t_{off} is the heater power supply off time between two zero detection points

The flow chart of the PID controlling process of the system is shown in the figure 2.

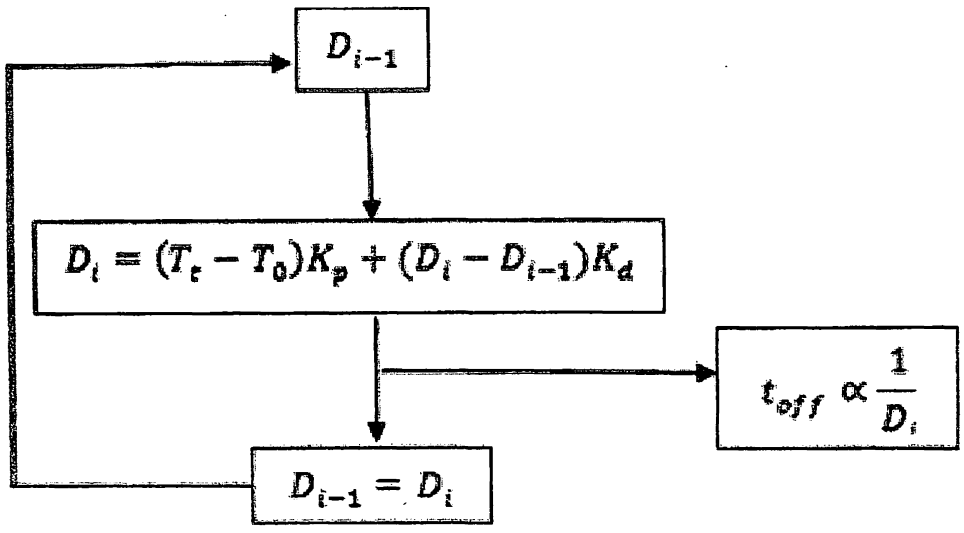

Figure 2: Flow chart of the PID controlling process

The proposed circuit design is shown in the figure: 3. Both zero crossing detection part and AC phase controlling part are included in the design.

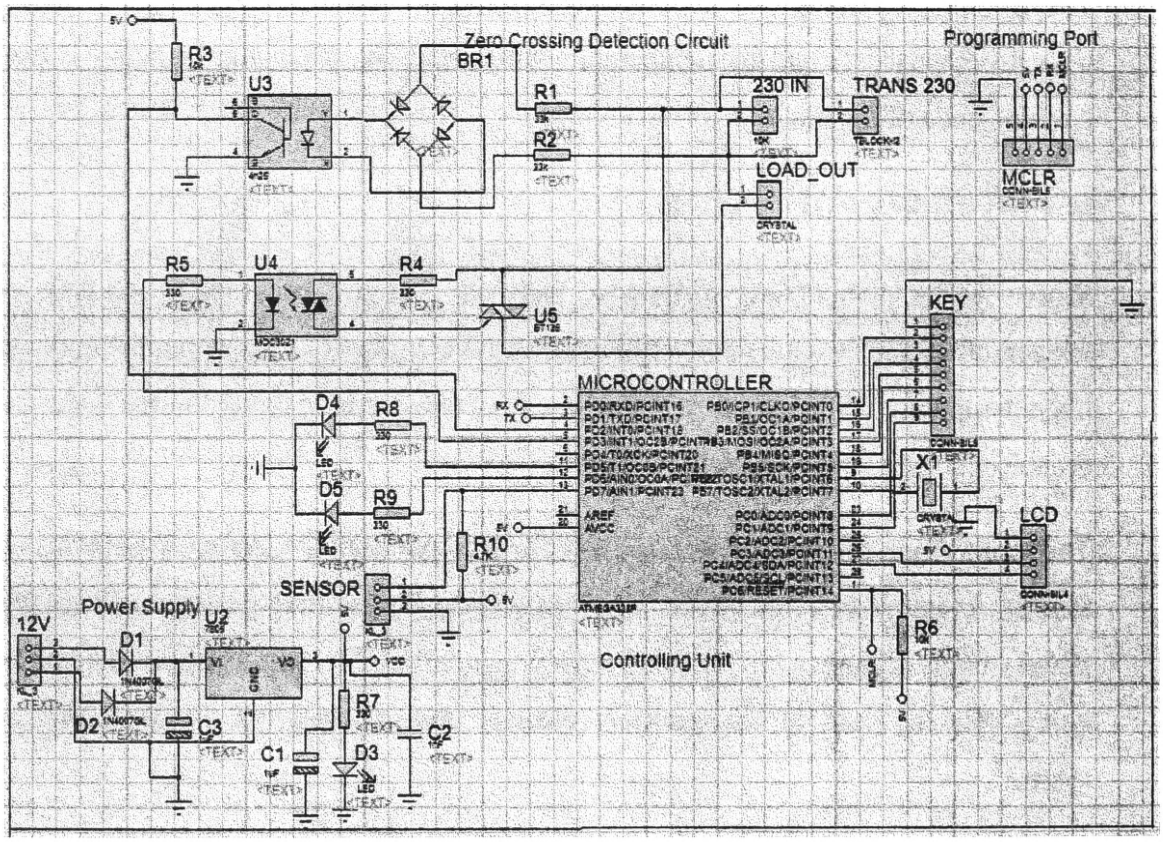

Figure 3: The circuit diagram of the system

3. RESULTS AND DISCUSSION

The PID control combines the improvement that proportional control offers with an integral and derivative function. The integral function prevents the initial overshoot, while the derivative function eliminates the temperature instability once the set-point is achieved.

The P and D parameters are used in equation that used in the program of the device. The part of the testing values and variation of the resulting temperature values are shown in the following table. Each and every time 70 ^{0}C was given to the device as target value.

Table 1: Testing results of the system for temperature target of 70^{0}C

Parameter Values		Temperature Values (^{0}C)	
K_p	K_d	Minimum Value	Maximum Value
1.0	1.0	66.3	72.2
7.0	3.0	68.4	72.6
17.0	4.0	68.5	75.1
19.0	4.0	69.0	75.8
19.2	4.5	69.4	71.4
19.4	4.7	68.7	70.2
19.5	4.2	69.4	69.7
20.0	4.3	68.7	72.3

According to the testing value K_p =19.5 and K_d =4.2 are most efficiency for the system. Therefore these values were used as K_p and K_d values for the program of the device. Because at that state over shoot and variation of the temperature values were very low.

This project is to develop a low cost and flexible circuitry for controlling the temperature in a water bath. The purpose of the temperature control is to facilitate heating system to a specified temperature, then maintain it at that temperature in a controlled manner. The temperature of a water bath could be controlled within ±1°C.

Additionally, the PID was applied to the system for controlling the supplied power to the heater. Therefore, the device has an ability of achieving the target point smoothly existing overshoot.

A water bath could be used as a laboratory or domestic equipment made from a container filled with heated water. Utilizations include warming of reagents, melting of substrates or incubation of cell cultures. It is also used to enable certain chemical reactions to occur at high temperature. Water bath is a preferred heat source for heating flammable chemicals instead of an open flame to prevent ignition. Different types of water baths are used depending on application. For all water baths, it can be used up to 99.9 °C. When temperature is above 100 °C, alternative methods such as oil bath, silicone bath or sand bath may be used[4].

4. CONCLUSIONS

This Temperature control device is user friendly and cheaper. User can easily provide his required temperature through key pad. There is also display option for both current value and set value through seven segment display. DS18B20 temperature sensor was used in this project which has maximum error of ±1°C.

The device has ability of achieving the target point smoothly and without overshoot because of using PID.

ACKNOWLEDGEMENTS

Authors would like to extend their sincere thanks to all the staff members of the Department of Electronics, Wayamba University of Sri Lanka and for all those who supported for this project's success.

REFERENCES

[1]. Manish Mishra (2013) Design of Microcontroller Based Temperature Controller, Department of Electronics & Communication Engineering National Institute of Technology, Rourkela: Prof. Munshi Nurul Islam.

[2]. Garry Jackson and Jason Jocson (2006) Automatic Temperature Control System, San Jose State University: Professor: Burford Furman, Ph.D.

[3]. Kambiz Arab Tehrani, Augustin Mpanda (2012) 'PID Control Theory', in Rames C. Panda (ed.) *Introduction to PID Controllers - Theory, Tuning and Application to Frontier Areas.* : InTech, pp. 213-215.

[4]. Zhi Yong Zhang, Tie Liang Guo (2012) 'Design of Water Bath Temperature Control System Based on DS18B20', Advanced Materials Research, Volume 462, pp. 753-756 [Online]. Available at: http://www.scientific.net/AMR.462.753