Analysis and Evaluation of the Efficiency of Laser Temperature Control System

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***Abstract*— This article describes a method for temperature controlling of the semiconductor laser. There are various wavelengths of temperature in the semiconductor laser. The paper provides a comparative analysis of the effectiveness of control using PID and FLC controllers. The PID controller cannot exactly control temperature with an extensive rate of accuracy. Therefore, we used an FLC regulator to improve the temperature accuracy with an extensive rate for the laser temperature regulator. A comparative analysis describes that the effectiveness of the FLC regulator is better than that of other regulators.**

Keywords—PID controller; FLC controller; Laser temperature control system

INTRODUCTION

Semiconductor lasers are distinguished by high efficiency among optical quantum generators. One of the key characteristics is that these devices are very small, with characteristic linear dimensions of the order of several hundred microns per side. These lasers have the type of solid-state, which, unlike ordinary solid-state lasers, are made of semiconductor materials. Pumping of semiconductor lasers is carried out directly from the electric current, which is transmitted through the device. In this article, we have tested various kinds of temperature controller systems, such as the PID regulator, the Fuzzy logic regulator and the Fuzzy-PID regulator. We have used the control methods which are the Fuzzy logic control and the Fuzzy-PID control because it is not enough to obtain satisfactory control results when just using the conventional PID controller. The object of the laser is a type of the first-order control system for control purposes. The feedback sensor of temperature is $\frac{1}{ts+1}$ in the transfer function, where t is the time of the monitored object, t1 is the time of temperature sensor, where t = 2, t_1 = 0.5 is determined by a laser temperature sensor.

MODEL OF CONTROLLER

(i)Proportional-integral-derivative controller (PID)

The PID controller is a very common regulator. Currently, about 80-90% of regulators have been used in the PID controlling. The PID controller ensures high efficiency and ease-of-use. Among PID regulators, 64% are single-loop regulators and 36% are multi-loop ones. The controllers with feedback cover 85% of all applications, the controllers with direct communication - 6%, and the controllers connected in cascade - 9%.

A proportional-integral-derivative is a feedback loop system, and it is often used in machine control systems and for modeling various kinds of applications The PID controller continuously ensures the minimum parameter deviation from the set value.

(ii)Fuzzy logic controller

Fuzzy controllers are formed with two input variables, error and error variation, and one output variable. In the fuzzy Mamdani system, a method based on a linear function for input and output variables, where triangular functions are used, is developed. There are a total of 7 triangular accessory functions. Thus, only 49 rules were created.

These 49 rules can be the structure of negative feedback control under all conditions for maintaining stability. The linguistic data of fuzzy rules of 49for 7*7 two inputs are shown in Table 1.Fig. (1), (2) and (3) show the triangular (membership functions) of varying data developed in the FIS editor in the MATLAB package.

The fuzzy logic controller is designed to control the data of two input and one output variables to simulate a semiconductor laser, temperature controller. A schematic diagram of the fuzzy fragment of the variable alignment regulator and the output data is presented. The data values for each fuzzy set of input fuzzification transform the sensor input. The knowledge base defines the fuzzy inference of each rule (if-THEN) that operates on the determinants of decision logic, in terms of fuzzy logic. These two components are combined into an output block. Fuzzy rules can be expressed as a matrix R=XO KP * Ki * KD

Then, an aggregation operation is performed, which is a procedure for determining the degree of truth of the conditions for each of the rules of the matrix R fuzzy data output system, where the “Maxi-mini” aggregation method is used to obtain fuzzy output results. The purpose of the fuzzification stage is to establish a correspondence between the specific numerical value of a separate input variable of the fuzzy inference system and the value of the membership function of the corresponding

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term of the input linguistic variable. After completing this step, all input variables must have specific membership function values for each of the linguistic terms used in the fuzzy inference rule base sub-conditions. In this paper, the “centroid” method was used for defuzzification, which provides accurate values of KP, ki and kd coefficients used to adjust the PID controller.

Seven language accessories are formed from fuzzy sets, i.e. Nero-large, Nero-medium, Nero-small, zero, peso-small, peso-medium, peso-large, which are defined by NB, Nm, n, g, PS, PM, and PB respectively. Then fuzzy sets are defined by triangular membership functions).

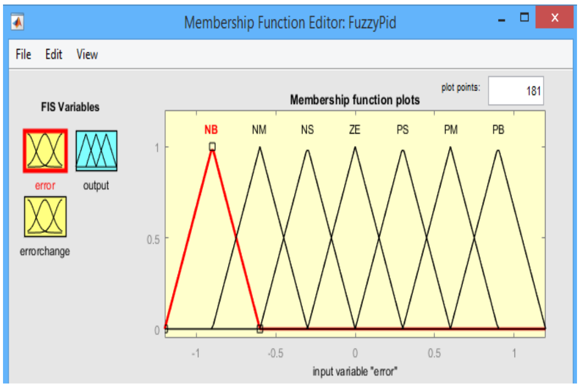

Fig. 1.The membership function of an error

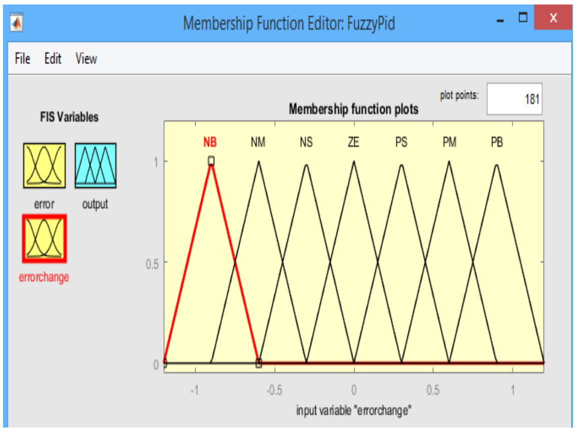

Fig. 2. The membership function of an error change

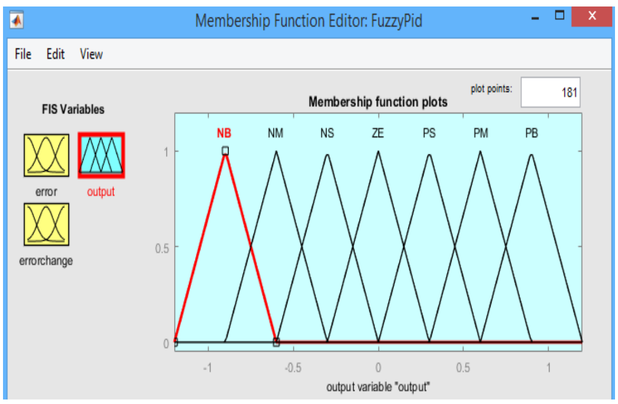

Fig. 3.The membership function of the output

Triangular (membership function) on the base 7*7 rules. We use a group of seven functions of triangular membership for input/output variables. The table includes 49 rules for 7 * 7 two inputs.

TABLE I THE BASE OF FUZZY RULES OF 49 RULES FOR 7 * 7 TWO INPUTS

e/ed	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NS	NB	NB	NM	NS	ZE	PS	PM
ZE	MB	NM	NS	ZE	PS	PS	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

PROJECT DESIGN

The format of this project is to enhance exactly the temperature control of the semiconductor laser in the Fuzzy Logic Controller (FLC) and the conventional PID controller by using MATLAB/Simulink. The results of the simulation FLC and PID regulator are expressed and discussed in the simulation results in sections 4 and 5.

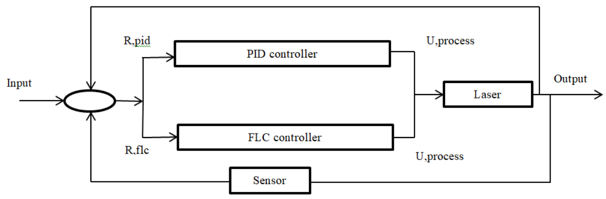

Fig. 4.Block diagram of temperature control of semiconductor laser

Fig 4 consists of (6) various blocks. We can determine the temperature of the laser by processing the signals from the sensor. If the error signal is between the set value and the actual output, it can be reduced by adjusting the controller

This flow chart shows the performance between the Fuzzy Logic regulator (FLC) and the PID regulator in the laser temperature control system. At firstly, we simulated both PID and FLC controllers with the same variable by using Matlab Simulink. Comparison of the simulation results allows one to make a conclusion about the work of PID and FLC controllers.

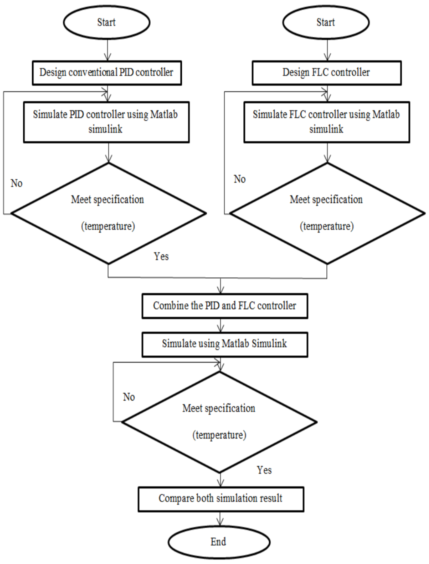

Fig. 5. Methodology flow chart

SIMULATION RESULT

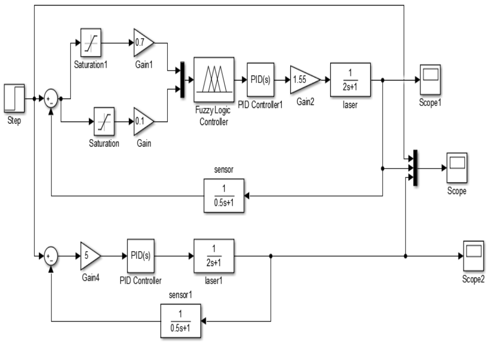

Fig. 6.Simulink control model of PID and Fuzzy-PID

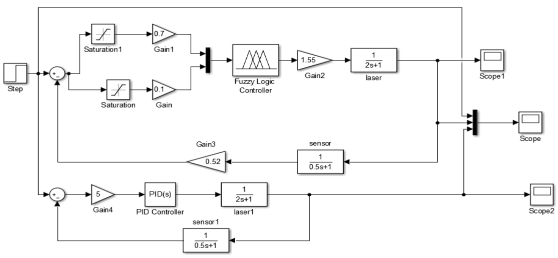

Fig. 7.Simulink control model of PID and Fuzzy

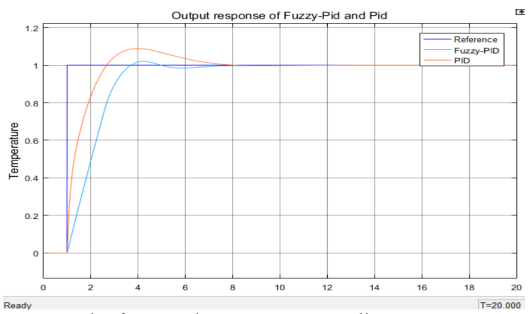

Fig.8. Output result of PID and Fuzzy-PID controller

Figure 8 compares the two controllers, the Fuzzy-PID regulator, and the conventional PID regulator. According to the results, it is clearly seen that the Fuzzy-PID regulator is better than the performance of the conventional PID regulator.

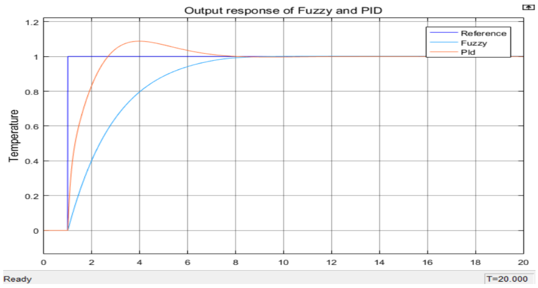

Fig. 9. Output result of fuzzy and PID regulator

Figure 9 compares the two controllers, the Fuzzy regulator, and the conventional PID regulator. The results of the simulation show that of all three regulators, which are called the conventional PID regulator, FLC, and Fuzzy-PID, the Fuzzy regulator has zero excess, a short settling time, better adaptability and reliability.

CONCLUSION

Finally, this paper presents the comparative results of the temperature control system of a semiconductor laser using a conventional PID controller, an FLC controller, and an FLC-PID controller. The simulation result shows that the FLC regulator has better dynamic performance, stronger adaptive reliability and more inertia than other regulators.

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