Comparative Speed Control Study Using PID and fuzzy Logic Controller

Mustafa RasemAbuzeid, and Nasr E Shtawa

***Abstract*—**This paper presents the most commonly used controller in the industry field is the (PID) controller. Fuzzy logic controller (FLC) provides an alternative to PID controller. The purpose of this paper is to design a Fuzzy Logic controller to improve the performance (speed) of the DC motor in order to control the angular speed of the motor. The purpose of Fuzzy Logic controller is to improve the performance of DC motor by controlling the speed of the motor using different system and to show that the Fuzzy Logic controller can be used on the DC motor control.

***Keywords*—**About four key words or phrases in alphabetical order, separated by commas.

I. Introduction

THE speed of DC motor can be adjusted to a great extent so as to provide easy control and high performance. There are several conventional and numeric controller types intended for controlling the DC motor speed at its executing various tasks, PID Controller, Fuzzy Logic Controller [1]. The terms fuzzy logic is used with a number of deferent meanings. Fuzzy logic has been successfully applied to many control problems, more than any other areas of applications. Various fuzzy programming tools have been developed to facilitate fuzzy rule of control. Fuzzy logic developed by Zadech is applied for controller design in many applications. A fuzzy logic controller (FLC) was proved analytically to be equivalent to a nonlinear PI controller when a nonlinear defuzzification method is used. The result from the comparisons of conventional and fuzzy logic controller techniques in the form of FLC and fuzzy compensator also showed fuzzy logic can reduce the effects of nonlinearity in a DC motor and improve the performance of a controller [2].

II. Optimizing of PID Controller

There are different tuning methods for the parameters of PID controller will be used. In this paper, Trims and Error method will be used in this paper [3].

A. Figures

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III. Trial and Error Method

Let's first try using a proportional controller with a gain of 100. Add the following value to a Simulink model containing a PID controller block. Now let's see how the step response looks, as shown in Fig. 1.

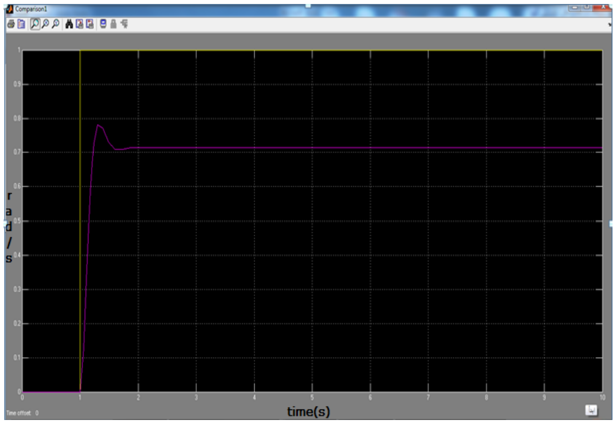

Fig. 1 Step response with proportion control

Fig. 2 shows that the response need to increasing proportional controller value when increase Kp to 150, can be get the following behavior as shown in

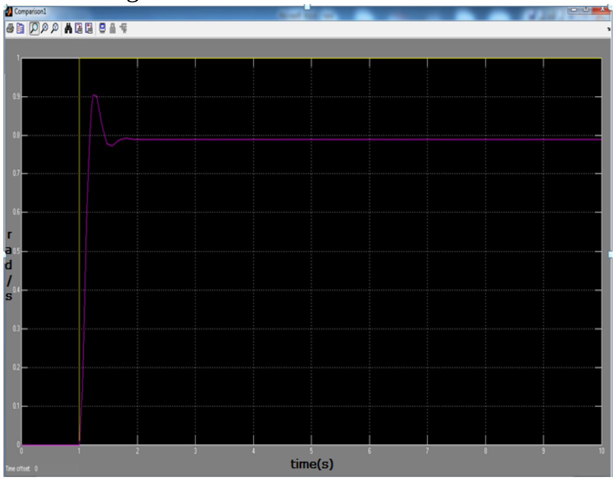

Fig. 2 Response at Kp = 150

When using a proportional controller with a gain 250, the response will be as shown in Fig. 3.

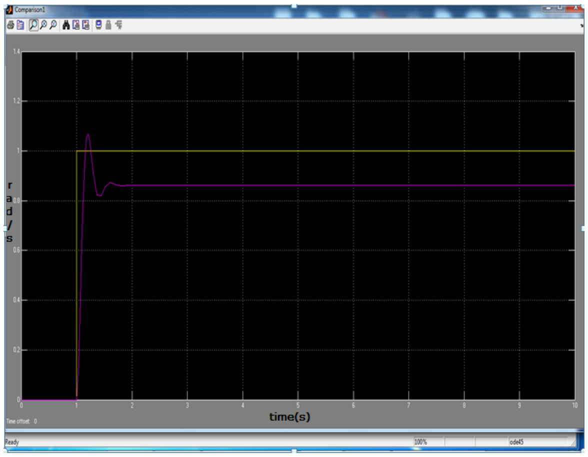

Fig. 3 Response at Kp = 250

From the Fig. 3, both the steady-state error and the overshoot are large. Let's try a PID controller with small Kp and Ki. Put Ki =100, Kp = 250.can be get the following behavior as shown in Fig. 4

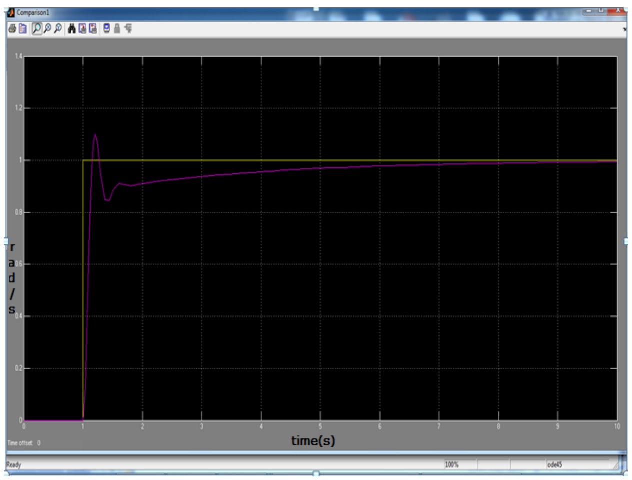

Fig. 4 Response at kp= 250, Ki= 100

From the Fig. above, both the steady-state error and the overshoot are too large. For a PID controller with small Ki and Kd. put Ki = 200, Kd = 10. Can be as shown in Fig. 5

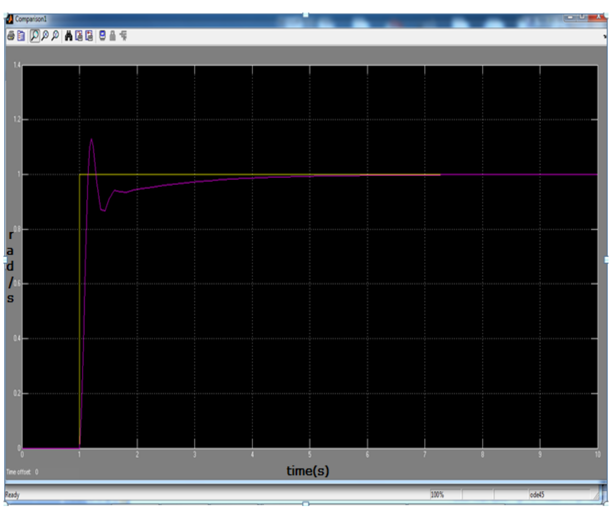

Fig. 5 Response at Ki=200, Kd=10

By changing the Kp, Ki and Kd until the best values achieved for PID controller as shown in Fig. 6

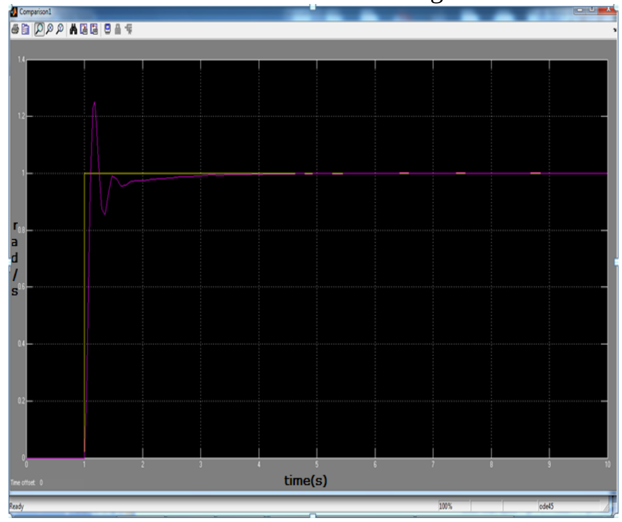

Fig. 6 Response at Kp =150, ki= 200, Kd = 10

So now know that if use a PID controller with Kp=150, Ki=200, Kd=10, all of design requirements will be satisfied The response on Fig. 6, shows that the PID controller can control the armature voltage output of the plant. The analysis of the response gives overshoot with 1.2s. The analysis of the rise time (Tr) is shown in the Fig. 6, and 4.3s to reach the steady state. The setting for the P,I, and D value for this experiment can be adjust manually depends on the output response and tuning method.

IV. Input Fuzzy Sets

The first step, the inputs and output variables for the Fuzzy controller has tobe set. The inputs are chosen as the speed error, and change of speed error, while the output is the controlled armature voltage. The universe of discourse for both the Input variables the speed error and change of speed error was divided in to seven sections. The universe of discourse for the output variable armature voltage of the DC motor was divided in to seven sections also with the same linguistic variables as for the inputs. These inputs are resolved into a number of different fuzzy linguistic sets. For error, there are seven fuzzy sets. The scale for this inputs -35 to 35. Error e(t)= r(t)-y(t).Change of error Ce = e(t) - e(t-1) [5].

V. Output Fuzzy Sets

The output level of the fuzzy system is armature voltage. It has seven fuzzy linguistic sets. Armature voltage is on a scale of -39.98 to +39.98 degrees.

VI. Membership Functions

Membership functions (MF's) for controller inputs, error (e) and change of error (Ce) are defined on the common interval [-35 35] and change in controllers output (armature voltage) is defined on the interval [39.98 39.98]. All MF's are symmetric triangles. These input membership functions are used to transfer crisp inputs into fuzzy sets [2] are shown in figures 7 and 8. Fig. 7 shows the input membership functions for speed error (e)While change of error (Ce) also has seven sets: scale for this input is -35 to 35 [6].

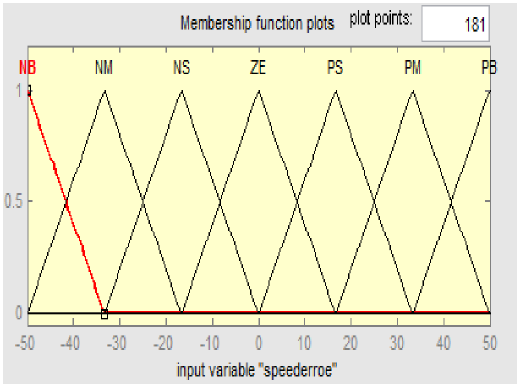

Fig. 7 Input 1 speed error.

Fig. 8, shows the input2 membership functions for change of error (Ce) while the output (armature voltage) also has seven sets: range for this output
[-39.98 39.98] as shown in Fig. 8 [7].

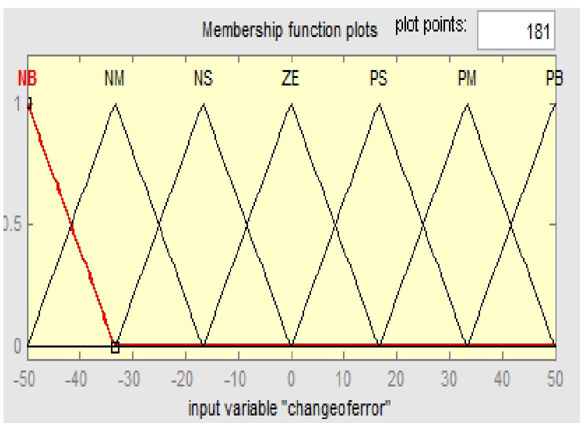

Fig.8 Input2 change of error

Fig. 9 shows the output membership functions for armature voltage.

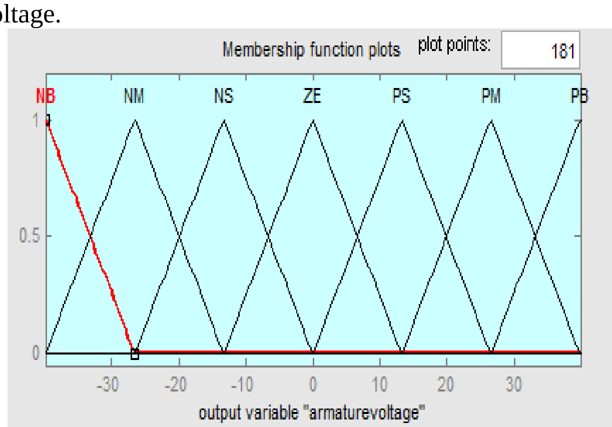

Fig. 9 Output fuzzy (armature voltage)

VII. Comparison Between Fuzzy Logic

Controller and PID Controller

A comparison between Fuzzy Logic and PID controller was done by using the same step input and the same DC motor plant. The dynamic performance between two controllers are shown in Fig. 10

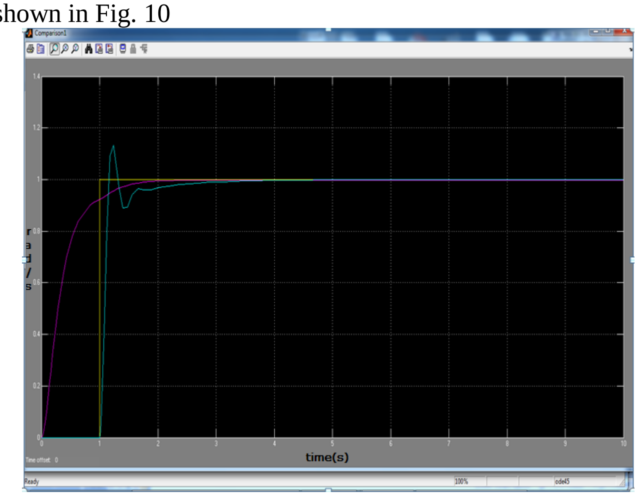

Fig. 10 PID and FLC controller dynamic response

VIII. Comparison of Results

Comparison between both controllers gives the different output response. The Fig. 10 shows that both controllers have own performance to analyze. For the red color of the response is a Fuzzy Logic controller and for the blue is a PID controller, the FLC controller has not percentage overshoot but the PID controller has percentage overshoot. The settling time is the time that taken to reach from steady state, for this output response the FLC is faster than PID controller. It gives the time 2.2s better than 4.3s.

IX. Conclusion

In this paper a Fuzzy Logic controller had been designed to controlling DC motor plant. It also involved with the design of the optimal controller which is adjusting the rule base and change the membership function to obtain the initial output of fuzzy logic controller before it is tuned to give better performance. In this paper was founded that the Fuzzy Logic controller can be implemented into the DC motor plant. The parameter identification and behavior of DC motor was studied, the Fuzzy Logic controller (rule-base) was developed using the control strategy based on behavior of DC motor.The real plant of DC motor was designed in Matlab/Simulink software by arranging the system as closed loop system using the Fuzzy Logic controller. Then, the simulation shows that the Fuzzy Logic controller also can be implemented into DC motor in order to control the angular speed.The comparison was done by comparing the Fuzzy Logic controller with PID controller; the simulation results shows that fuzzy logic controller has clearly better performance for providing Tr (rise time), ess (steady state error), % Mp (percent overshoot) criteria in comparison with PID controller. This wide-spreading of FLC's appears because these kinds of controllers becomes a very effective techniques for complicated and imprecise processes for which either no mathematical model exists or the mathematical model is severely nonlinear as induction motor.

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