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SPEED CONTROL OF DC MOTOR USING FUZZY LOGIC CONTROLLER

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ABSTRACT
Growth historically stems from economic growth via industrialization Today's industries totally based on control systems. Better control is sensitive to each and every steps in industry. DC motors have been famous in the industry control part since DC motors have high starting torque features, good response parameters, reliability, flexibility and less cost. DC motors are used where there is a requirement of speed and position control. To control the speed of DC motor there is a need of controllers. The control systems have various issues such as undesirable overshoot, long settling time, vibrations and stability when going from one state to another state. PID controllers gives benefits in process control industry while PID controllers do not give satisfactory work for nonlinear systems. Real world systems are considered as linear as well as nonlinear. To handle with nonlinear systems intelligent control methodology are adopted i.e. knowledge depend expert system, Fuzzy Logic and neural networks. Here to coincide the control issues, Fuzzy Logic method has been accepted. Fuzzy Logic method gives better result when compared to conventional controllers, they almost cover wide range of operating conditions and can also handle noise and disturbances of a nature.
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Keywords: DC Motor, PID Controller, FLC (Fuzzy Logic Controller)

I. INTRODUCTION
Due to increasing reliabilities, flexibilities less costs, DC motor is considered better in industrial application, home appliances, toys, lifts, and robot manipulators where there is a requirement of position and speed control of motor. Better control is sensitive to each process that results in to different types of controllers which are widely used in industries. Types of control systems suffering from the issues i.e. undesirable overshoot, long settling times, vibrations and stability when going from one state to another state. In real world, systems are considered nonlinear whose better modeling is hard, costly and impossible. In certain cases conventional PID controllers do not provide good results for nonlinear systems. DC motor control is riper than other types of motors. Advanced control method is required to eliminate these problems and minimize the effect of noise. There are three basic methodology to intelligent control: Knowledge depend expert systems, fuzzy logic and neural networks. These three methods are very famous and promising aspect of research and growth. Our main research concern is Fuzzy Logic idea. Fuzzy Logic Controllers has successfully applied to huge no. of control actions. Control and analysis of systems like nonlinear, complex and time varying is a tough task using conventional methods due to uncertainties. The most common controller is the PID controller which needed a mathematical model for the system. A Fuzzy Logic Controller gives a solution to the PID controller.

Experimental Process
From Fig No.1 Block diagram, lets an error signal, i.e., the error between step input and motor output. This error signal along with its derivative are applied to the Fuzzy logic controller.

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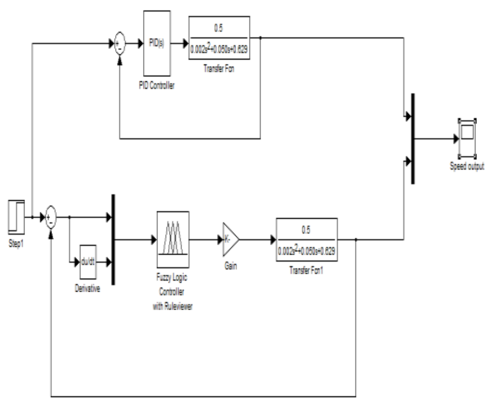

Fig 1: Block Diagram of DC Motor Using FLC

After solving the motor model, the overall transfer function will be obtained as:
$\phi(s)$ /Va(s)= Kψ/Lajms2 + Ra Jms + K2 ψ2
From the DC motor with constraints given in Appendix, overall transfer function of the system is obtained as:
$\phi(s)$ /Va(s)= 0.5/0.002s2 +0.050s +0.625

Fuzzy logic controller
A fuzzy logic model is considered as a logical-mathematical procedure depend on an "IF-THEN" rule system that mimics the human way if there is a thinking in computational form.
Generally, a fuzzy rule system has four types of modules.
1. Fuzzification
2. Fuzzy Inference
3. Rule base
4. Defuzzification

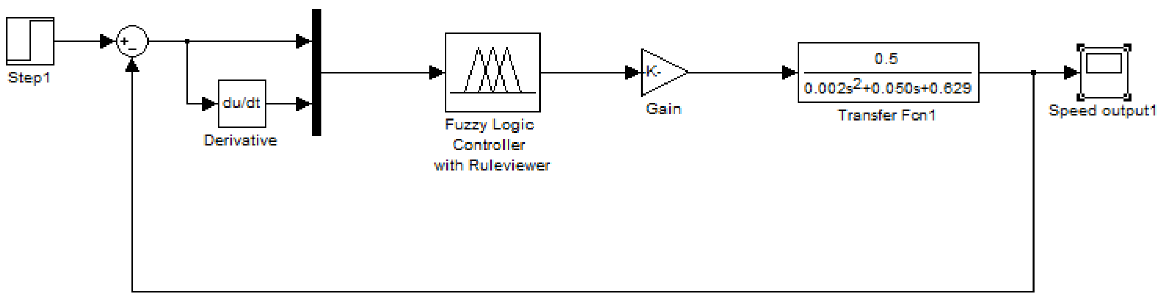

Fig. 2: Matlab /Simulink model of system using Fuzzy Logic controller

Fuzzification
Fuzzification converts crisp normalized input data into membership grades sets of fuzzy described on normalized UODs of input variables. Here we need fuzzy sets. We use triangular fuzzy sets for input variables, where input variables are considered as error and rate of change of error.

Fuzzy inference
After converting crisp values into sets of fuzzy inference is drawn on it. For this, we need a rule base consist of if-then rules. By using these rules, the controller deals the control action that has to be taken.

Under inference, the true value for the premise of each process is computed, and fed to the conclusion part of each process. This outcome in one fuzzy subset to be given to each output variable for each steps. Mostly MIN

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or PRODUCT is considered as inference rules. In MIN inference, the output membership function is clipped off at a height approaches to the rule premise's computed degree of truth (fuzzy logic AND). In PRODUCT inference, the output function membership is scaled by the rule computed degree of truth.

Defuzzification

Defuzzification converts fuzzy values back to values of crisp which control the actuators. For this, we again need fuzzy sets. We use triangular fuzzy sets for variable of output, i.e., control action that has to be taken over the motor actuators. There is a scaling of that output that denormalize it and bring it back to the operating range. This is then applied to the motor to serve our objective.

Designing procedure

The design of a Fuzzy Logic Controller needs the alternatives of Membership Functions. After the accurate membership functions are chosen, there is a creation of a rule base. The set of linguistic rules is the necessary aspect of a fuzzy controller. The many linguistic variables to implement rule base for output of the fuzzy logic controller are given in Table I. The response of the fuzzy logic controller is clculated using in MATLAB/SIMULINK. A two input which are Speed Error (e) & Change in Error (ec) and one – output Change in control, fuzzy controller is developed and the membership functions and fuzzy rules are obtained. The membership functions (MF) for inputs are given below in fig. 3(a), 3(b) and the MF for output is given in fig. 3(c).

1) Membership functions for inputs and output variables

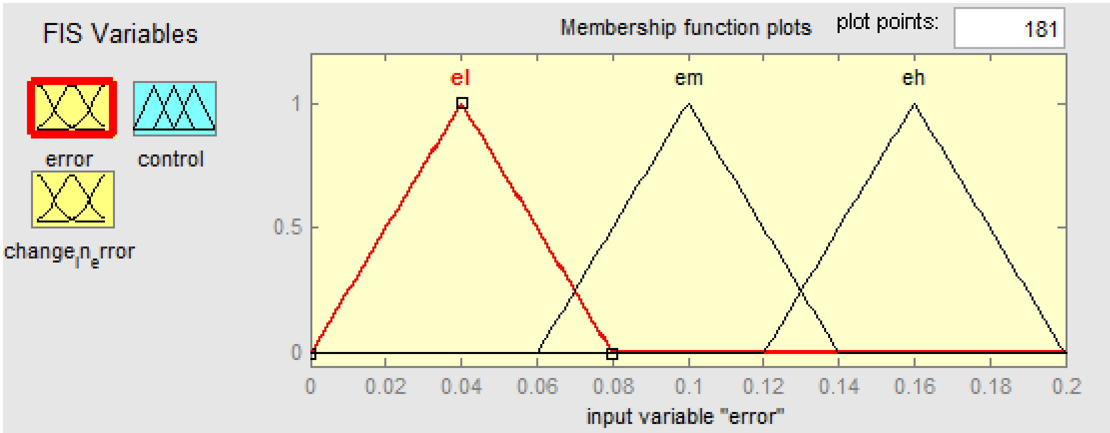

Fig 3(a) Fuzzy input variable "error"

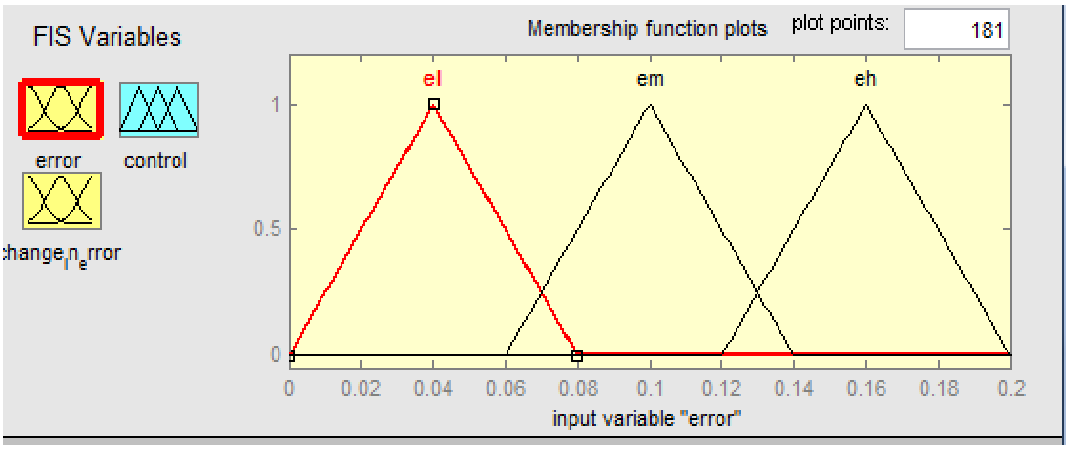

Fig 3(b) Fuzzy input variable "change in Error"

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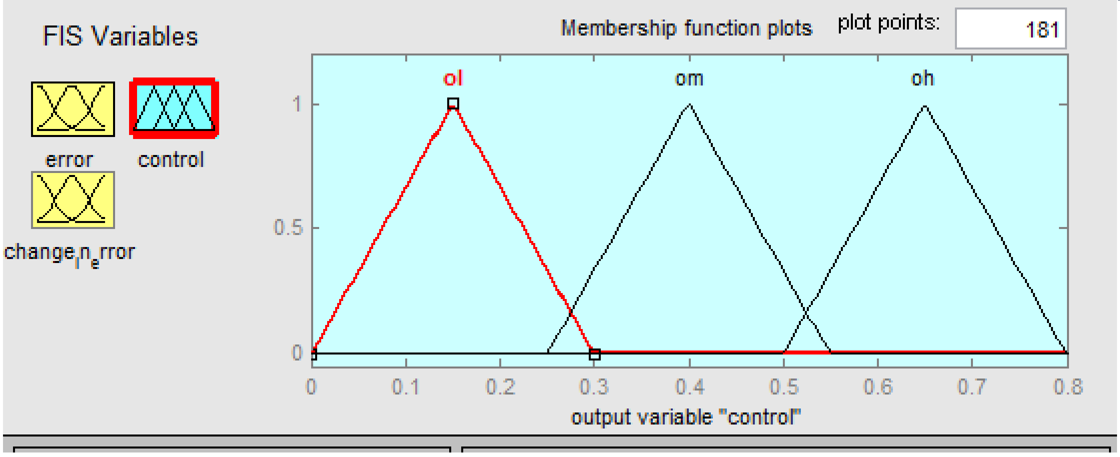

Fig *3(c)*

Fuzzy output variable “control”

Construction of rules and rule viewer

In figure 3.4(A) fuzzy if-then rules are given and in figure 3.4(B) Analysis of the two inputs (error and change in error) and output are given. There are total 9 rules output variable.

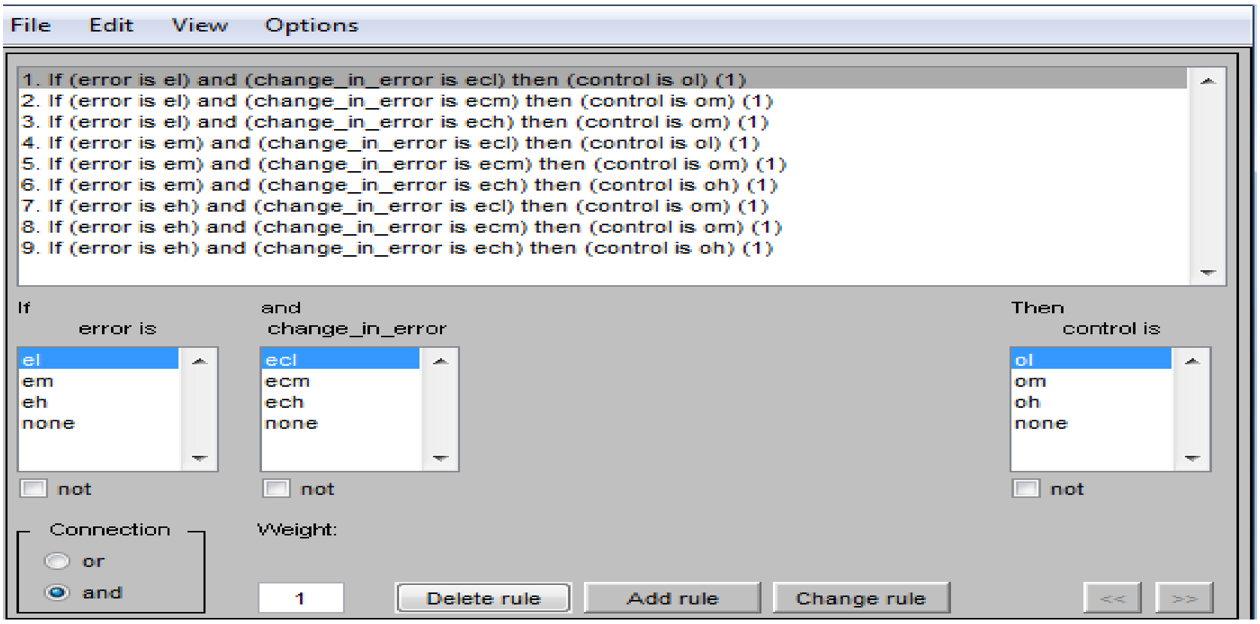

Fig 3.4(a): Fuzzy IF –Then rules

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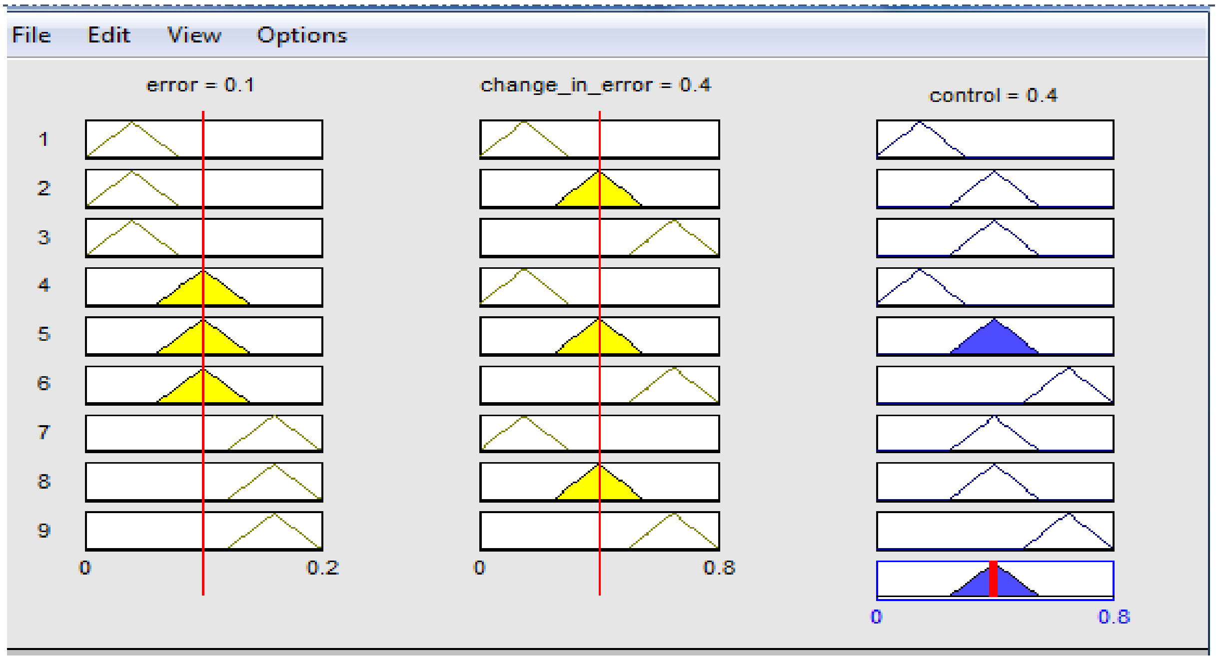

Fig 3.4(b): Analysis of both the inputs and output

Results

The conclusion of the system with using various type of controllers are given here. The results of the system with various controllers such as PID, Fuzzy Logic Controller are being approached. In this section separately excited dc motor transfer function is used as a system and to obtain the response of the system by applying the step function as an input.

A. PID controller

Figure 4 shows the PID control system implemented in MATLAB/Simulink where controller constraints are adjusted using (ZN) Method.

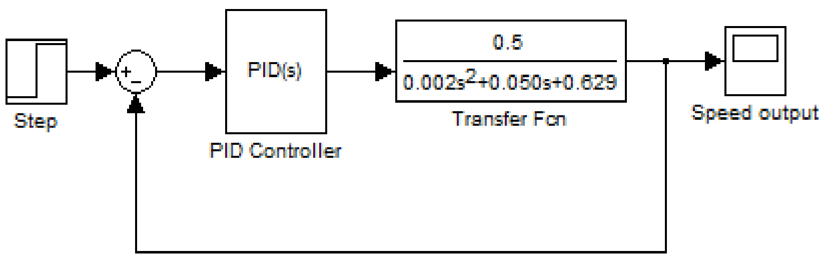

Fig 4: Matlab/Simulink model of system using PID controller

The simulation output of the PID Controller for 2ndorder system is shown in Figure 5

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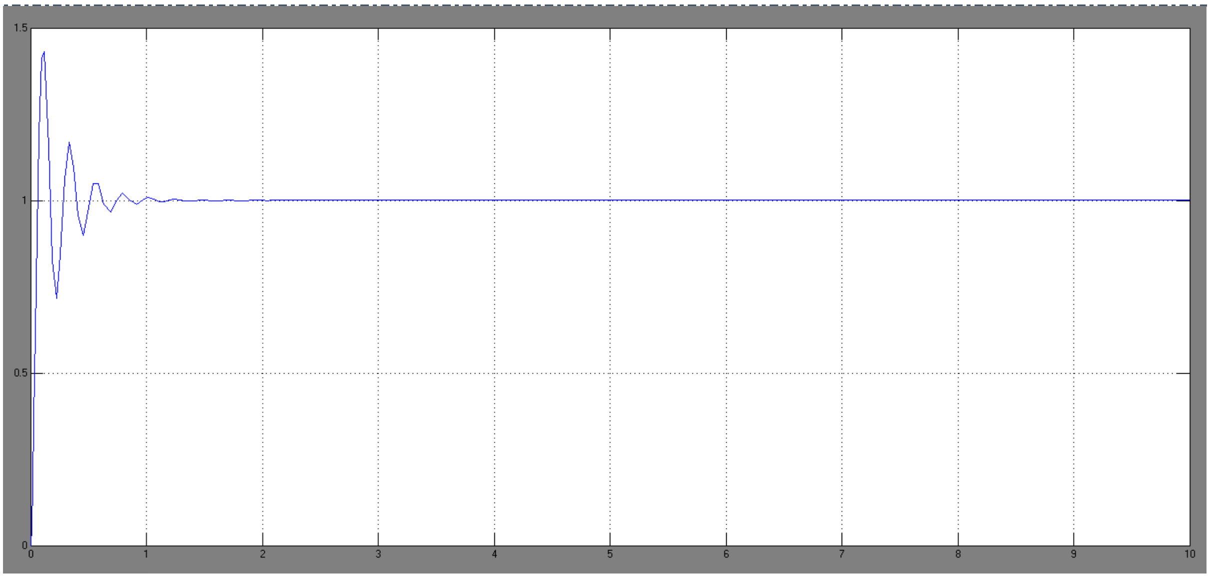

Fig 5 Step Response of the system with PID Controller

As from the analysis of figure, the PID controller response of the system has characteristics of high overshoot and longer settling time values. Hence, a practice is made to further increase the response of the system using fuzzy logic controller.

C. Step responses

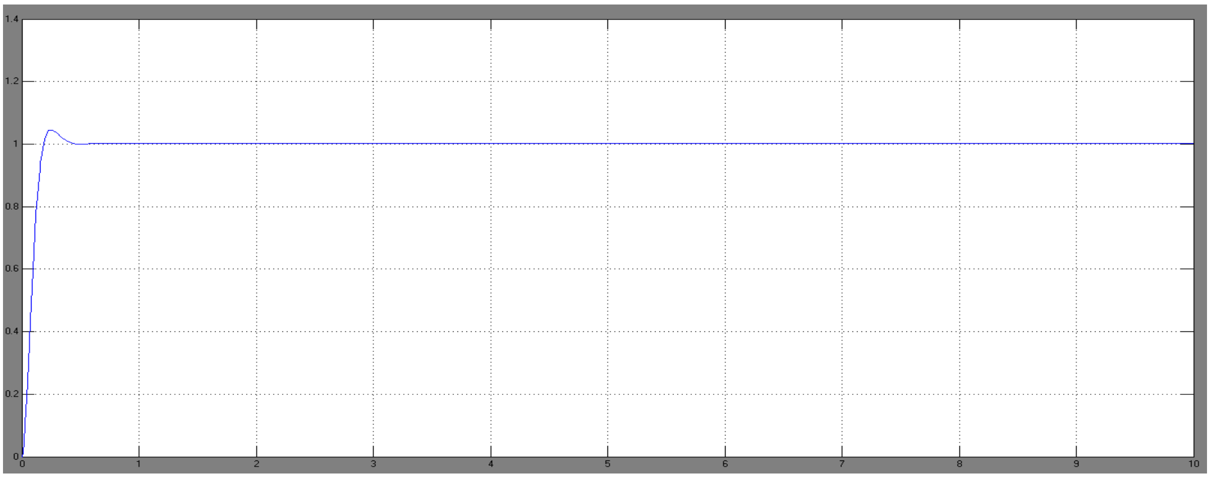

Fig 6 Step response of system using fuzzy logic controller

From above figure, it can seen easily that the overshoot has been considerably overcome with fuzzy logic controller as compared to the PID using classic ZN method. Comparative step response for PID regulated system and FLC controlled system is shown in figure 7.

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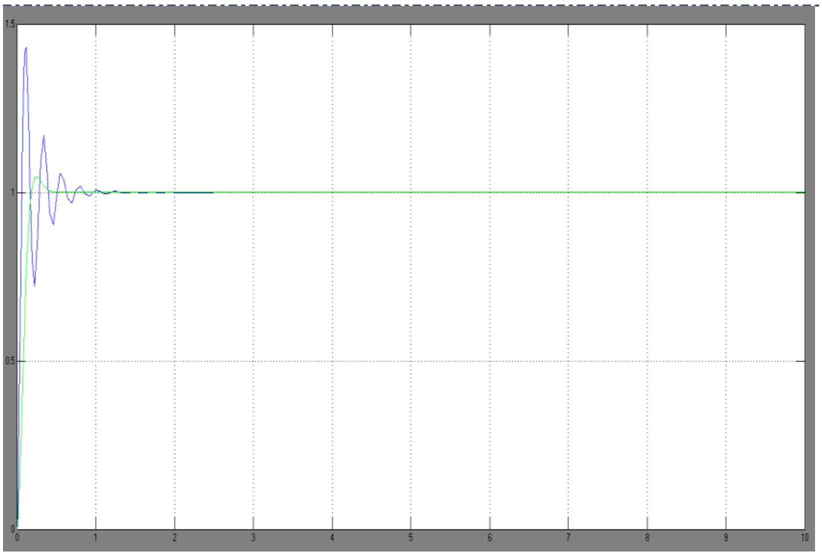

Fig 7 Step response of system using PID and fuzzy logic controller

Figure 7 shows that the response of the system has greatly improved on application of fuzzy logic controller (FLC). The overshoot of the system using FLC has been reduced, settling time, peak time of the system also shows appreciable reduction as analyzed in Table II.

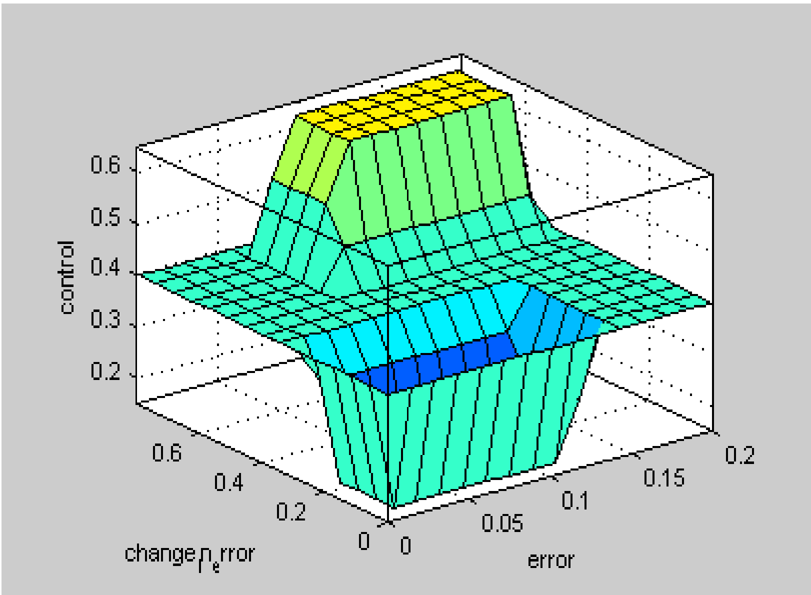

Fig 8: Three dimensional view of Fuzzy logic response

II. RESULT

Fig. 5 shows the response obtained by using PID controller for speed control of motor. Fig 6 shows the response obtained when PID controller was replaced by Fuzzy logic controller. Fig 7 shows a direct comparison between PID and Fuzzy controller for speed control of DC motor. A tabulated comparison is shown in the following table:

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Table 2 : Comparison between the output responses for controllers

Title	PID Controller	Fuzzy Logic controller
Rise time(sec)	1.35	0.3
Peak time(sec)	0.25	0.3
Settling time(sec)	0.75	0.3
% Overshoot	40%	10%
Steady State Error	0%	0%

III. CONCLUSION AND FUTURE SCOPE

In this paper, the speed of a DC motor has been controlled using PID and Fuzzy controller. The simulation results are obtained using MATLAB/SIMULINK. From the results , it is clear that Fuzzy logic controller gives accurate response than a PID controller. The proposed Fuzzy logic controller has several features like higher flexibility, control, better dynamic and static performance. Also, the results can be made better by tuning the parameters of Fuzzy controller like membership functions tuning, scaling factors tuning etc.

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