



# Positioning Control of Separately Excited Dc Motor Drive by Using Self-Tuning Fuzzy-PID Controllers

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**ABSTRACT:** This paper presents the implementation of a fuzzy logic controller and self-tuned proportional-integral-derivative (PID) controller on direct current (DC) motors positioning system. Simulation studies are carried out for self-tuned PID controller and FLC which are evaluated by using conventional rules & control knowledge base, for the armature-controlled with fixed field and field controlled with fixed armature current DC motors. The performance of the controllers is assessed on transient response and error integral criteria. The results presents that the FLC is superior in the rise time, speed fluctuations, and per cent overshoot as well as also much better in the controller output signal, which is much remarkable.

**KEYWORDS:** Fuzzy Logic Controller, DC Motor, Fuzzy PID Controller, MATLAB Toolbox, Designing of FLC, Simulation Results.

## I. INTRODUCTION

DC motors have a long tradition of use as adjustable speed machines and a wide range of options have evolved for this purpose due to less expensive and high power ratings. In these applications, the motor should be precisely controlled to give the desired performance. The speed controllers are designed for desired performance of DC motor to execute the tasks [1]. The various type of controllers are available worldwide i.e conventional PID, Fuzzy, FUZZY- PID etc.

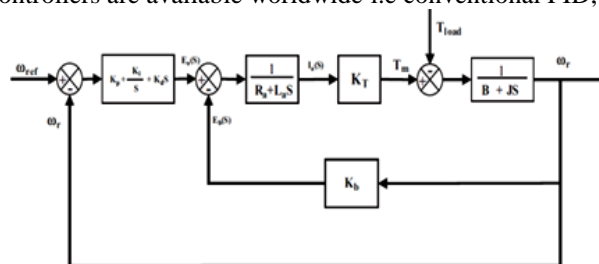


Fig: 1. Basic block diagram of speed control of DC motor using PID

## II. FUZZY LOGIC CONTROLLER (FLC)

The model is developed by using MATLAB/SIMULINK. MATLAB Fuzzy logic Toolbox is use to design FLC. Basically, the FLC consists of four basic components: fuzzification, knowledge base, inference engine, and a defuzzification interface. The addition of fuzziness to data in fuzzy logic is called the fuzzification. Fuzzy linguistic description is formal representation of system made through fuzzy IF-THEN rules. They determined knowledge about a system in statements of the form-IF (a set of conditions) are satisfied then (a set of consequents) can be inferred. [2] In many situations, for a system whose output is fuzzy, it is easier to take a crisp decision. The conversion of fuzzy set to single crisp value is called defuzzification [3].



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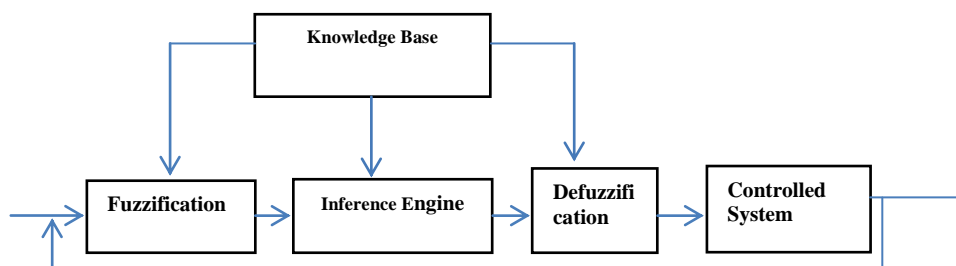


Fig.2.Basic configuration of fuzzy logic controller

### III. MODELLING OF MOTOR

The speed control stand for intentional speed variation carried out manually or automatically DC motors are most suitable for wide range speed control and there for many adjustable speed drives. Where

- $V_a$  is the armature voltage. (In volt)
- $E_b$  is back emf the motor (In volt)
- $I_a$  is the armature current (In ampere)
- $R_a$  is the armature resistance (In ohm)
- $L_a$  is the armature inductance (In henry)
- $T_m$  is the mechanical torque developed (In Nm)
- $J_m$  is moment of inertia (In kg/m<sup>2</sup>)
- $B_m$  is friction coefficient of the motor (In Nm/ (rad/sec))
- $\omega$  is angular velocity (In rad/sec)

For rotational speed  $\omega(V_a - I_a R_a)$   
 $\omega = (V_a - I_a R_a) / Ka\phi \dots \dots \dots (1)$

Where  $\phi$  = Field flux per pole

$Ka$  = Armature constant =  $PZ/2\pi a$

Where  $P$  = No. of pole

$Z$  = Total no. of armature conductor

$a$  = No. of parallel path

From (1) it is clear that for DC motor there are basically three method of speed control.

They are:-

- 1- Variation of resistance in armature circuit.
- 2- Variation of field flux.
- 3- Variation of armature terminal voltage.

### IV.DESIGNING OF FUZZY-PID

The designing of fuzzy PID controller have three input terms: error, integral error, derivative error, a rule base three inputs, such as fuzzy proportional controller reduce error response and disturbance, Derivative action helps to predict the error and the proportional –derivative controller uses the derivative action to improve closed loop stability. If there is a sustained error in steady state, integral action is necessary. The integral action will increase the control signal if there is a small positive error, no matter how small the error is: the integral action will decrease if error is negative. The input to the Self-tuning Fuzzy PID Controller is speed error "e (t)" and Change-in-speed error "de (t)". The input shown in figure is described by:

$$e(t) = \omega_r(t) - \omega_a(t) \dots \dots \dots (2)$$

$$de(t) = e(t) - e(t - 1) \dots \dots \dots (3)$$

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Using fuzzy control rules on-line, PID parameters “KP”, “KI”, “KD” are adjusted, which constitute a self-tuning fuzzy PID controller as shown in Figure 4. PID parameters fuzzy self-tuning is to find the fuzzy relationship between the three parameters of PID and “e” and “de”, and according to the principle of fuzzy control, to modify the parameters in order to meet different requirements for control parameters when “e” and “de” are different, and to make the control object a good dynamic and static performance.

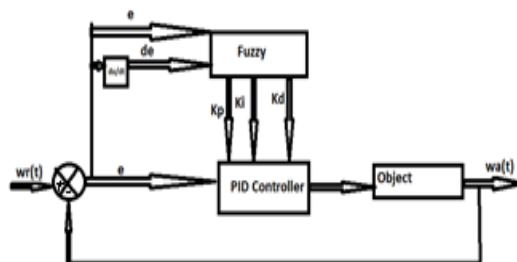


Fig.4. Structure of self- tuning Fuzzy PID Controller

## V. DESIGN OF FUZZY LOGIC CONTROLLER

Membership Function Plots Of Input Variable “Error”, Input Variable “Change Of Error” And Output Variable “Change of Control” Membership functions are defined off-line, and the values of the variables are selected according to the behaviour of the variables observed during simulations.

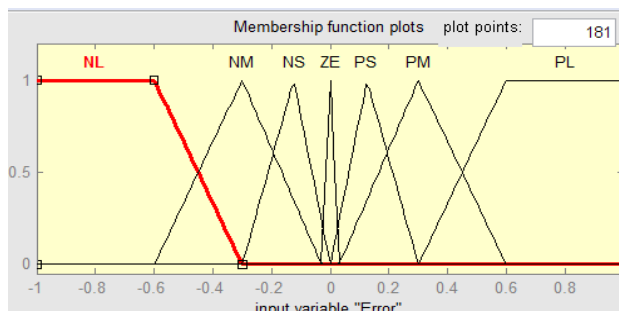


Fig. 5. Membership Function of “Input Error”

In figure 5 shows the membership function of input error. The parameter limit from -1 to 1. There are seven membership function are used.

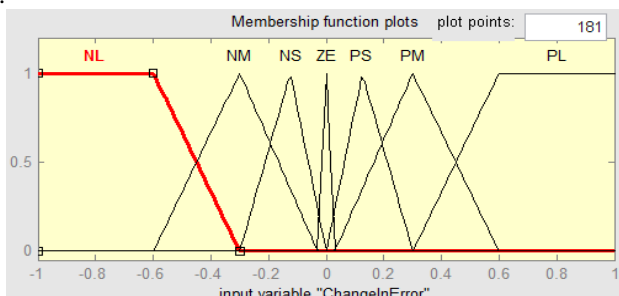


Fig. 6. Membership Function of “Input Change of Error”

In figure 6 shows the membership function of change of error. The parameter limit from -1 to 1. There are seven membership function are used.

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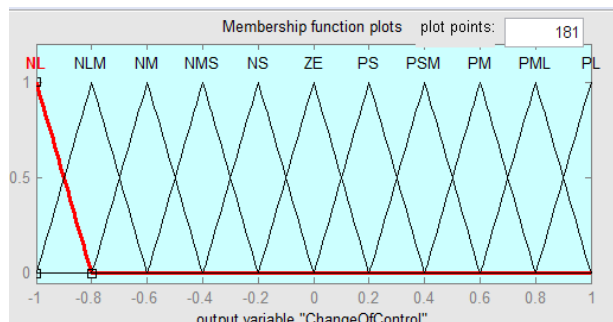


Fig: 7. Membership Function of “Output Change of Control”

In figure 6 shows the membership function of output variable for change speed control. The parameter limit from -1 to 1. There are seven membership function are used.

## V. RULES OF FUZZY LOGIC CONTROLLER

The rule base maps the fuzzy sets for the input to the fuzzy sets for the outputs and constitutes the core of a fuzzy controller. Table shows the rule base NL, NM, NS, PS, PM, are notations for fuzzy sets negative large, negative maximum, negative small, positive small positive maximum respectively. The entire rule base can be described in terms of such IF- THEN rules, which are AND and OR together. The designed control rules used in this work are given in table 1.

de/e	Negative Large	Negative Medium	Negative Small	Zero	Positive Small	Positive Medium	Positive Large
Negative Large	NL	NL	NLM	NM	NMS	NS	ZE
Negative Large	NL	NLM	NM	NMS	NS	ZE	PS
Negative Large	NLM	NM	NMS	NS	ZE	PS	PSM
Negative Large	NM	NMS	NS	ZE	PS	PSM	PM
Negative Large	NMS	NS	ZE	PS	PSM	PM	PML
Negative Large	NS	ZE	PS	PSM	PM	PML	PL
Negative Large	ZE	PS	PSM	PM	PML	PL	PL

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## VI. SIMULATION MODEL OF D.C. MOTOR POSITIONING CONTROL

Implementation of speed control of induction motor using fuzzy logic and self-tuned PID controller:

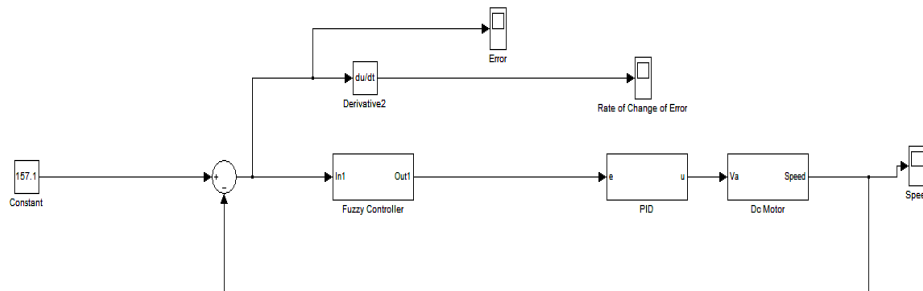


Fig: 7.Simulation Model for Speed Control of DC Motor.

## VII. SIMULATION RESULT

Using MATLAB simulation of the circuit we get the following result of speed, Input error and Change of error Characteristics of DC Motor are shown in figures. With the help of simulation we get precise result. In figure-9 we got speed variation in following time duration. The simulation was run with steady state and  $t = 5$  sec. speed reaches to its maximum value of 1.6 pu and the settling time  $t_s = 0.75$  sec.

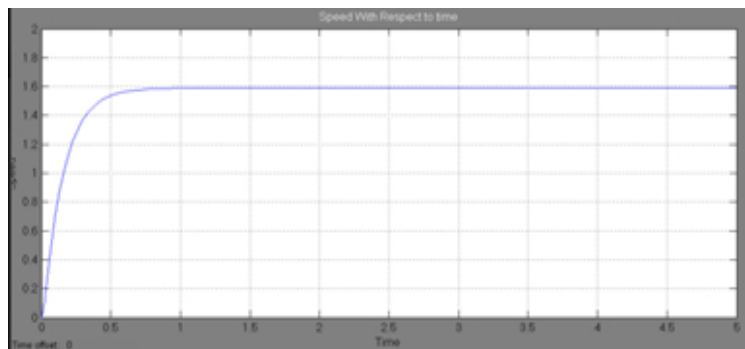


Fig 9: Plot Speed v/s Time Characteristics

In figure-10 shows the error variation with respect to time. In this figure we got maximum error, at starting time error is maximum up to 157.4 and by varying time error is reduced after 1 second error becomes constant.

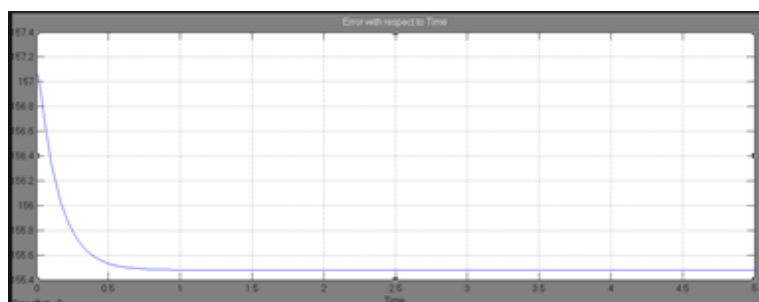


Fig10: Plot Input Error v/s Time Characteristics



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In figure-11 shows the change of error with respect to time. In this By using fuzzy logic controller we have to reduce the error in our simulation circuit. With the help of fuzzy logic controller reduce the error for desired speed. As shown in waveform that error reduces to zero at time  $t = 0.75$ sec by using fuzzy PID controller.

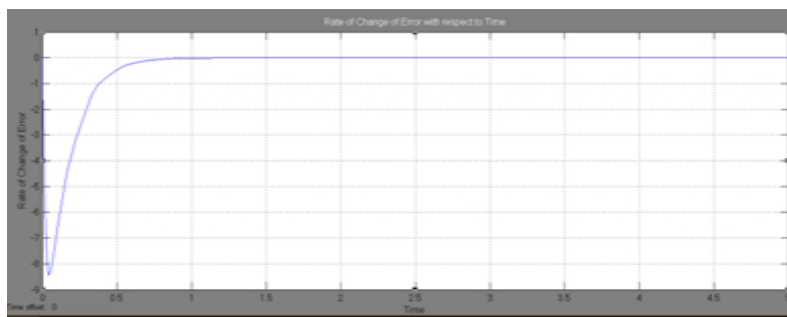


Fig11: Plot Change of Error v/s Time Characteristics

## VIII.CONCLUSION

An evaluation of fuzzy logic techniques applied to the control of DC motor was presented. Simulation results of the fuzzy logic approach are feasible. The implemented fuzzy logic controller presented a slightly superior and dynamic performance. The self-tuning FLC has better dynamic response curve, shorter response time, small overshoot, small steady state error (SSE), and high steady precision.

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