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Speed Control of DC Motor Using Chopper Based on Fuzzy Logic

Speed Control of DC Motor Using Chopper Based on Fuzzy Logic

Arunesh kumar Singh[1], Abhinav Saxena[1], Parveen Poon Terang[2], Palak Tulsyan[2] and M Waris[2]

[1]Department of Electrical Engineering , Jamia Millia Islamia, India
[2]Department of Electrical Engineering , JSSATE Noida, India

Email: abhinaviitroorkee@gmail.com

Abstract- This paper present the speed control of DC Motor based on boost converter under the controlling of fuzzy logic. The DC motor has armature and field winding in which armature winding is controlled by using boost converter which is triggered by fuzzy logic controller which consist of 7x7 rule and the input are change in error and rate of change of error and output is firing angle. The fuzzy logic controller gives smooth, reliable, efficient speed controlling of DC motor. Further the compative analysis between fuzzy logy and PID controller is assessed. The complete system is designed with SIMULINK/MATLAB for perfect analysis between two methods mentioned.

Keywords: fuzzy logic, DC Motor, PID,speed

1. Introduction

DC motor is commercially used for speed control at industrial and residential purposes. There were 2 methods used for speed control mainly field flux control and armature voltage control. Involvement of Field flux for assessing the performance of DC motor is at the above the base speed and armature voltage is kept constant in this process[1]. The armature voltage control method is used for the speed less than base speed keeping the flux constant, still DC motor is preferred for speed control over AC machines because speed and torque can be controlled independently. In this paper DC motor armature winding is controlled by the boost converter in which switching of IGBT switch is done by fuzzy logic controller.
The boost converter is nothing just step up chopper. DC motor has wide application in different home appliances for medium speed controller[5]. Here the complete is analyzed in d-q theory to avoid the decoupling theory. The chopper converts fixed dc input to variable dc output and the output voltage is controlled by firing angle. The switching of IGBT is analyzed by fuzzy set of Rule(3x3) which consist of change in the error and rate of change in the error and the output is the firing angle which triggered the IGBT switches[9]. The error produced is difference between reference value and measured value. The measured value is the d and q component of the current which is obtained by the passing the armature currents through the PID controller[12]. This measured value is further compared to reference value and error is produced , change in the error is produced by the delaying in the input signal by unity.
Average Voltage of the step up chopper

$$V_o = (T/T_{off})V_s \tag{1}$$
$$= (T/T\text{-}T_{on})V_s$$

$$V_o = \frac{V_s}{1-\alpha} \tag{2}$$

α =T_{on}/T.=firing angle

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The complete system of DC motor is incorporate with the fuzzy logic controller because traditionally speed control was analysed in conventional method like PID controller which was giving non satisfactory results after implementation of fuzzy logic controller system performance parameter like torque, speed gives better performance in comparison to conventional method.

2. Separately excited DC Motor

Machine has field and armature winding and field winding excited separately as shown in Fig.1. While in this case armature winding[21] is excited by using fuzzy logic logical through step up chopper as shown in Fig.2

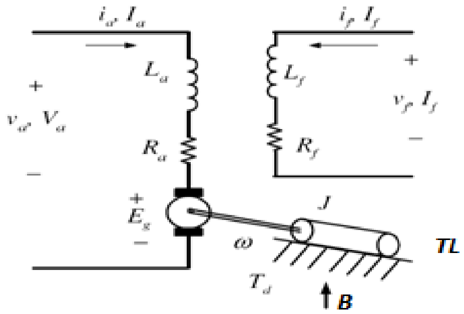

Fig.1 Separately Excited DC Motor

DC motor has equation

$$V_s = E_g + I_a R_a \tag{3}$$

Torque is

$$T_d = J\frac{d\omega}{dt} + B\omega + T_L \tag{4}$$

Excitation induced EMF will be

$$E_g = k\omega \; E_g = k\omega \tag{5}$$

$$T_d = k_1 I_a \tag{6}$$

3. Mathematical modelling of DC Motor using Fuzzy logic:

3.1 Design of PID Controller:

From the equation.3 the output voltage V_s is converted into the d-q component (V_{qs} & V_{ds})which is passing to the PID controller which gives the current Io in the component of d-q as which is I_d and I_q

$$I_{ds} = (K_{p1} + \frac{K_{i1}}{s} + sK_{s1})V_{ds}$$
$$I_{qs} = (K_{p2} + \frac{K_{i2}}{s} + sK_{s2})V_{qs} \tag{7}$$

Further this measured value (I_{ds} & I_{qs}) is compared with the reference value(I^*_{ds} & I^*_{qs}) and gives error E_1 and E_2

$$E_1 = I_{ds} - I^*_{ds} \tag{8}$$

$$E_2 = I_{qs} - I^*_{qs} \tag{9}$$

Further the error is passed through E_1 & E_2.

This error E_1 & E_2 is passing through PID controllers gives

$$V_{do} = (K_{p3} + \frac{K_{i3}}{s} + sK_{s3})E_1$$

$$V_{qo} = (K_{p4} + \frac{K_{i4}}{s} + sK_{s4})E_2 \quad (10)$$

Further the output shown in the Fig.10 is compared with V^*_{do} and V^*_{qo} and output of the above comparison gives the carrier voltage for pulse generator.

3.2 Design of fuzzy logic controller:

Error produced is given by

$$E = E_1 - E_2 \quad (11)$$

Change in error is given by

$$\Delta E = E(t) - E(t-1) \quad (12)$$

Rate of change of error is given by $\frac{d(\Delta E)}{dt}$

ΔE and $\frac{d(\Delta E)}{dt}$ are the change in the error

And the output corresponding is firing angle

ΔE / $\frac{d(\Delta E)}{dt}$	NB	NM	NS	HB	HM	HS	HL
NB	NM	NS	HB	HL	HS	NB	NM
NM	HM	HS	HL	NB	NS	NM	HB
NS	NB	NM	NS	HB	HM	HS	HL
HB	HL	HB	HM	HL	NB	NM	NS
HM	NM	NB	HB	HS	HM	HL	NM
HS	NB	NM	NS	HB	HM	HS	HL
HL	HL	HS	HM	HB	NS	NM	NB

Fig.2 Fuzzy Rules

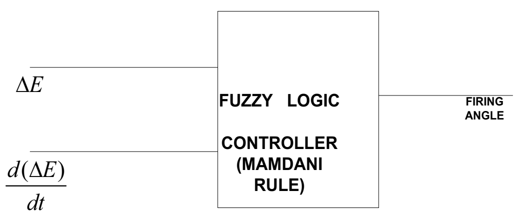

Fig.3 Fuzzy Model

Appendix:

K_{p1}= 12.5, K_{i1}=36.8, K_{s1}= 26.7
K_{p2}= 22.6, K_{i2}=45.98, K_{s2}= 56.9
K_{p3}= 45.6, K_{i3}=98.65, K_{s3}= 69.56
K_{p4}= 47.65, K_{i4}=95.65, K_{s4}= 79.65

2KW DC Motor

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Ra= 0.5ohmRf=220 ohmV= 220 V

Output : Firing angle =0.5,output Voltage is 440 V

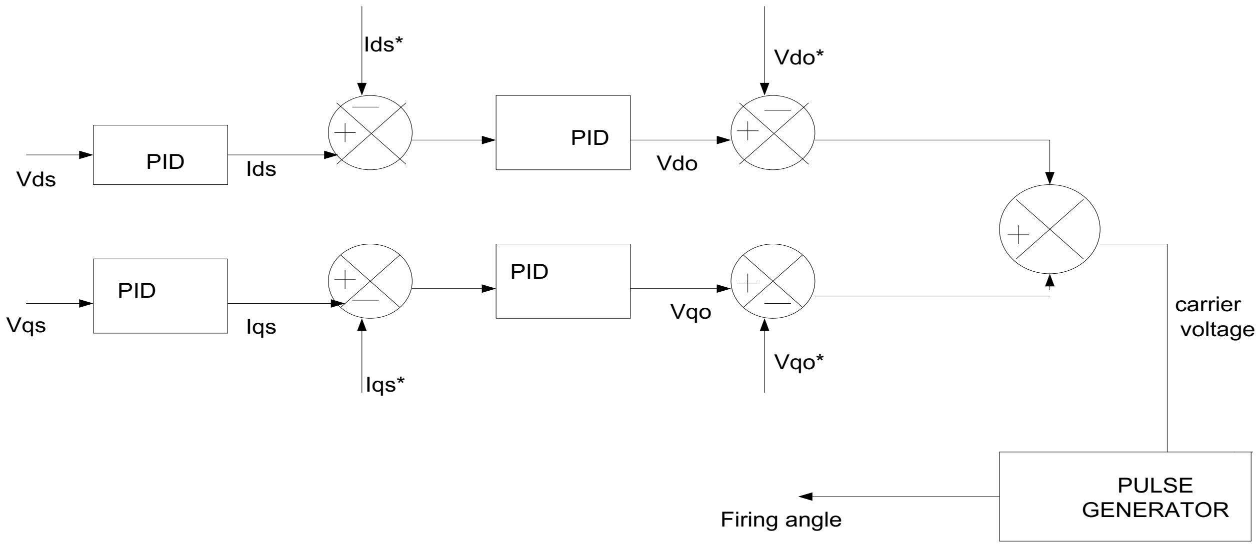

Fig.4 PID Controller structure for speed control of DC Motor

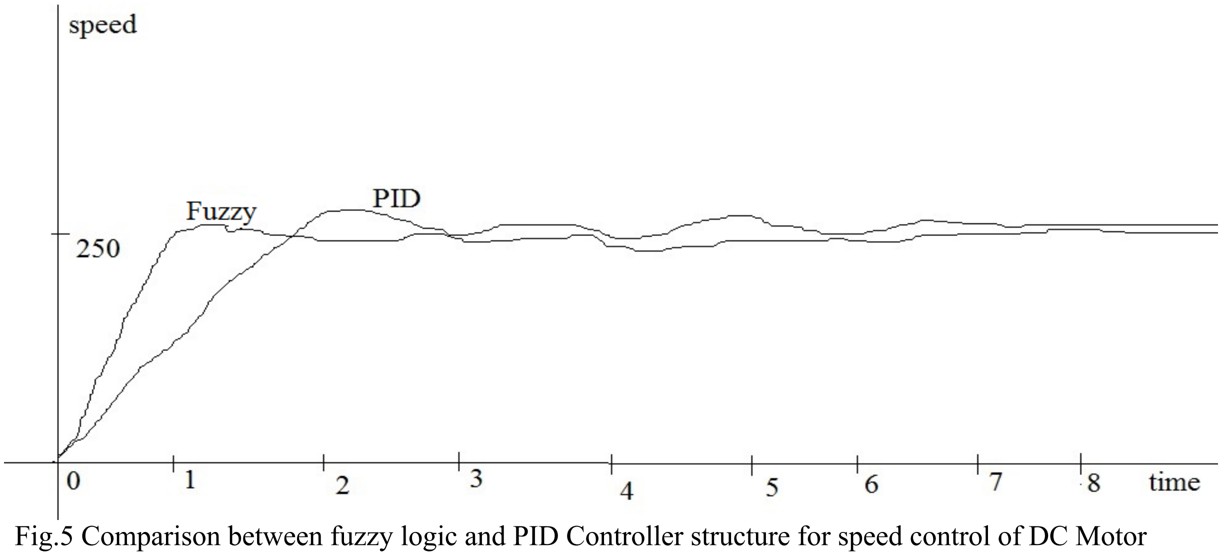

Fig.5 Comparison between fuzzy logic and PID Controller structure for speed control of DC Motor

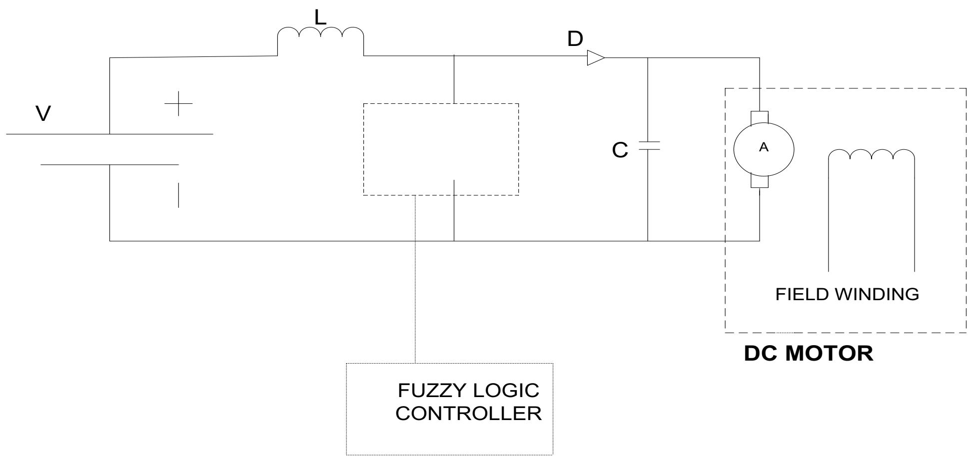

Fig.6.Fuzzy Logic Control of DC Motor

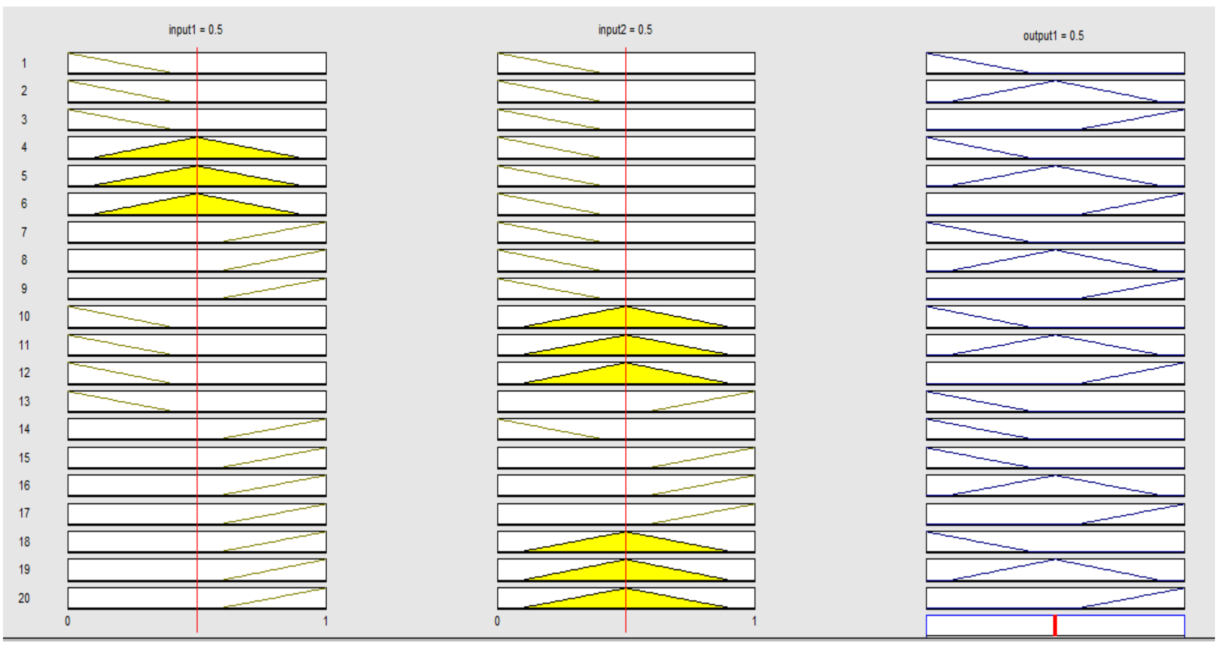

Fig.7.Fuzzy Set Rules of DC Motor

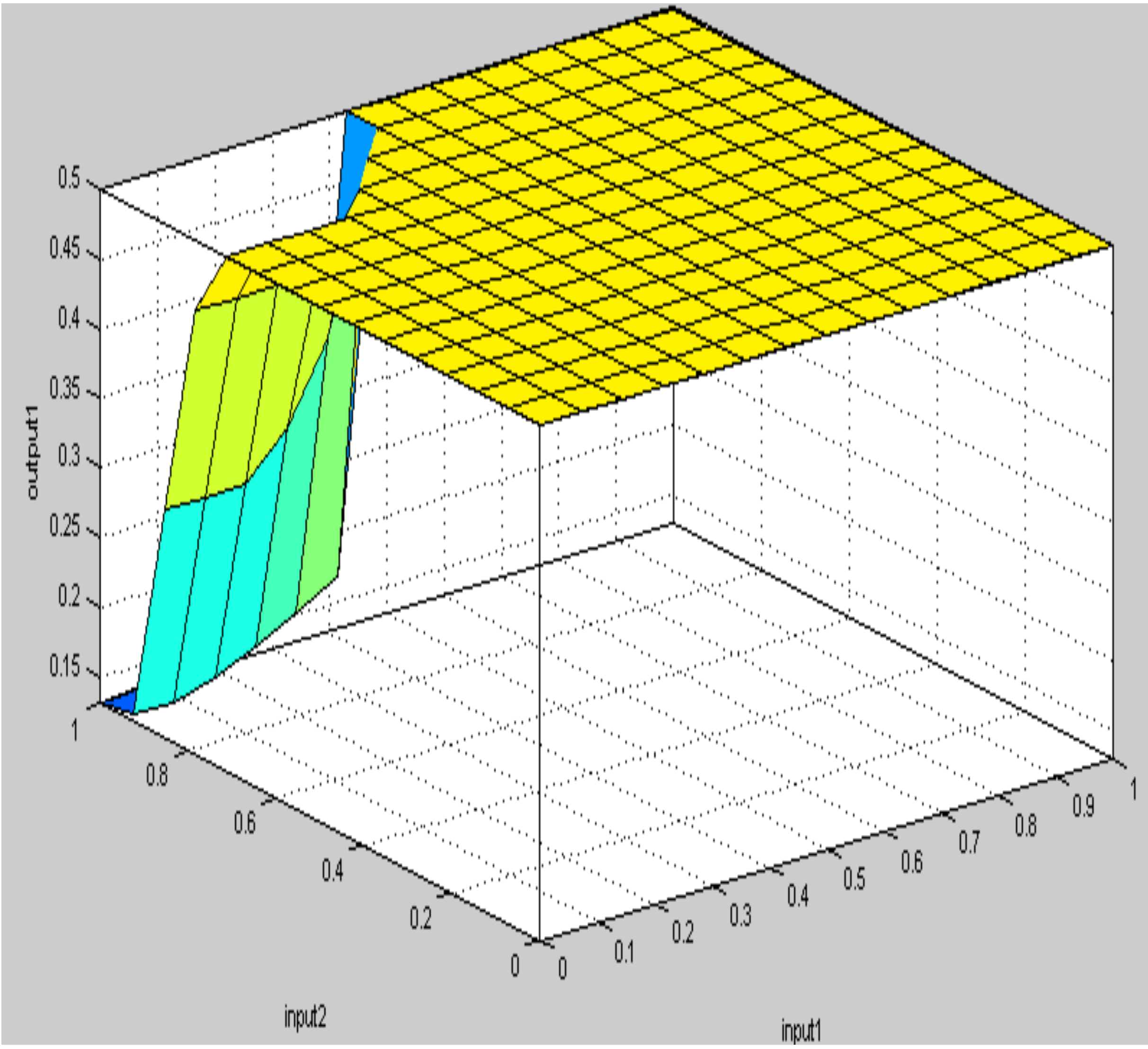

Fig.8 Fuzzy Logic Surface of DC Motor

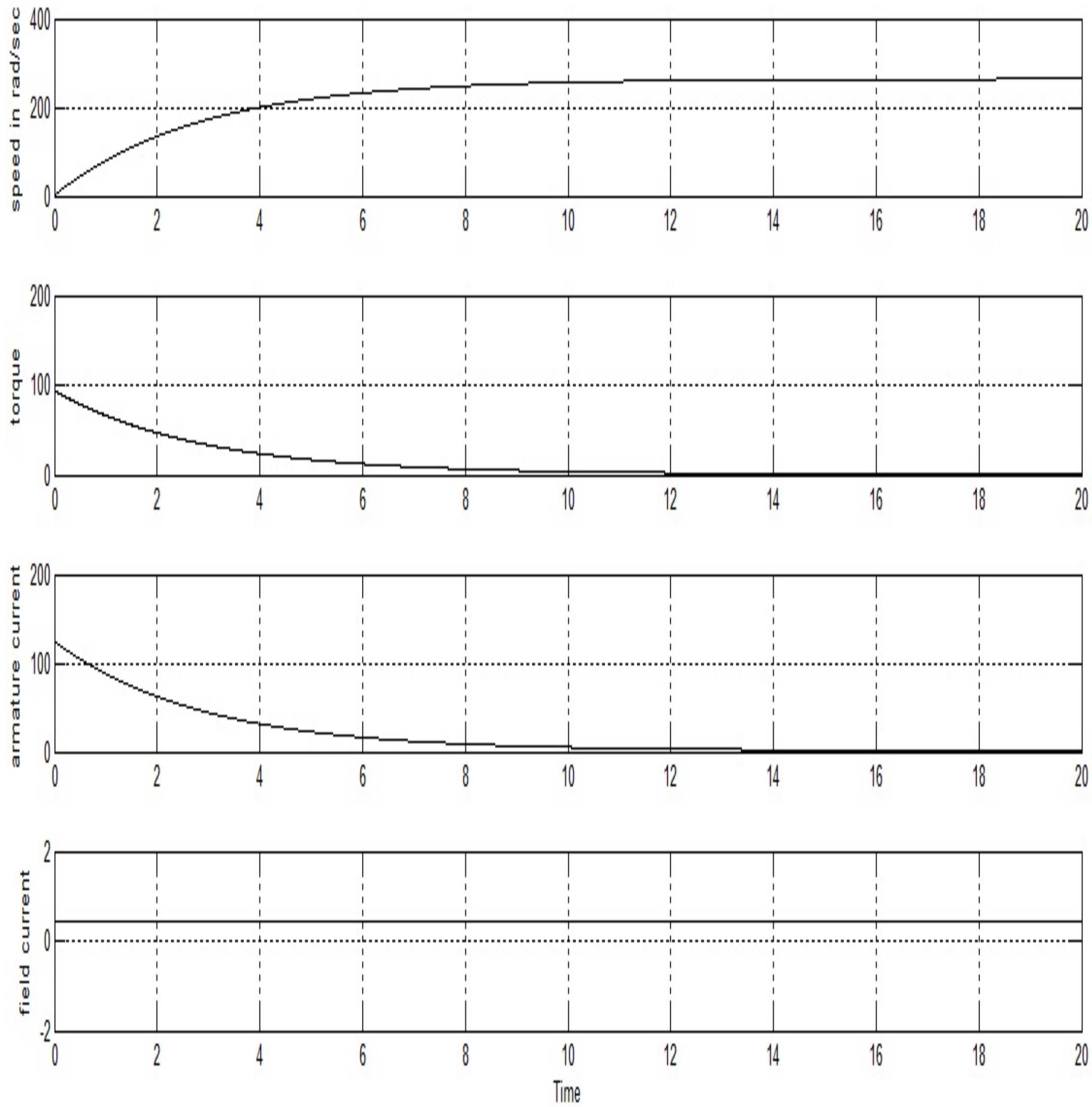

Fig.9. Performance Characteristics of DC Motor

4. Conclusion:

This paper shows the speed control of DC motor under fuzzy logic and it is found that performance parameter of system shows better transient and steady state performance by using fuzzy logic controller. The complete system using fuzzy logic controller gives satisfactory output in terms of speed and torque. from analysis It can conclude that usage of Fuzzy in system gives better performance in comparison to PID controller because Fuzzy logic controller application allows the system to take less settling time, lesser overshoot for achieving the output.

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