Speed Control of DC Motor using fuzzy and PID Controller

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Abstract : In this paper Dc motor is three phase permanent magnet motor which is having the supply of Dc voltage. They are mainly use in electric vehicles because of high torque and efficiency. It is very difficult to apply in electrical vehicles because it works on dynamic load system. So in that PID controller not be applied here. So from that we have to overcome to bring PID-Fuzzy controller to achieve good performance. To keep up the relentless state of BLDC engine is differed set point and dynamic burden condition from that BLDC motor performance will improve.

IndexTerms - BLDC motor, fuzzy controller, PID controller, Fuzzy-PID controller.

I. INTRODUCTION

As we know that electric motors is widely used in all over the world and its very important to use.it is used in many things like vacuum cleaner, air conditioning, rolling machines etc. DC motor is the one which is used in electric vehicle because it is anything but difficult to control the speed and the variety of engine. It has high proficiency and high torque and simple to keep up. The use of BLDC motor is not optimal. IN that the conventional controllers is did not perform good in load condition. So its very important to control the speed.

There are lots of method to control the speed of dc motor but the few are the best like PID and Fuzzy. So in PID which has some parameter which has there own advantages. Only the PID can not generate the fast response.

The Fuzzy rationale controller is likewise used to control the speed of DC engine. Fuzzy designing need human reasoning to apply with the goal that it can without much of a stretch create dynamic reaction.

Fuzzy logic takes more time than PID because of the fuzzi and and defuzzi. In that PID became the main controller and the fuzzy is use to para of PID.

Application of fuzzy controller does not required a mathematical model. Fuzzy controller require a human reasoning to connected In the framework it can create dynamic reaction. Fluffy controller take has a more drawn out substitution time.

II. DC MOTOR

A. Modling of DC motor:

In DC engine which has lasting magnet engine that has trapezoidal back emf. In that the replacement on the dc engine utilizes six exchanging component specially three phase dc motor. So in that position of the rotor is obtained from three Hall effect sensor and which has 125 degree.

DC engine accept that the stator associated with the Y, obstruction may me equal. the eddy current loss are ignore.

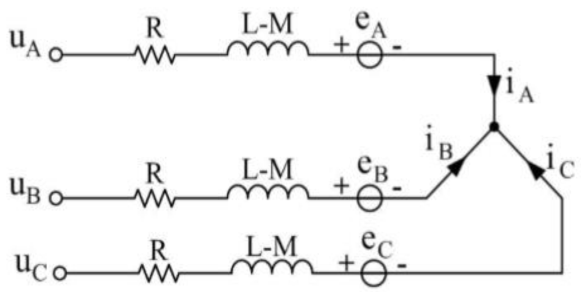

Fig. 1. Equivalent Circuit of Brushless DC Motor

The grid of the three stage voltage condition of dc engine.

$$\begin{bmatrix} u_A \\ u_B \\ u_C \end{bmatrix} = \begin{bmatrix} R & 0 & 0 \\ 0 & R & 0 \\ 0 & 0 & R \end{bmatrix} \begin{bmatrix} i_A \\ i_B \\ i_C \end{bmatrix} + \begin{bmatrix} L-M & 0 & 0 \\ 0 & L-M & 0 \\ 0 & 0 & L-M \end{bmatrix} \frac{d}{dt} \begin{bmatrix} i_A \\ i_B \\ i_C \end{bmatrix} + \begin{bmatrix} e_A \\ e_B \\ e_C \end{bmatrix} \quad (1)$$

Where, $u_{A,}\ u_B, u_C$ is phase voltage A, B, C. R is stator resistance, $i_A,\ \ i_{B,}\ i_{C,}$ is phae current.

The EM torque of DC motor is

$$T_{e} = \frac{e_A\, i_A + e_B\, i_B + e_C\, i_C}{\omega_m} \quad (2)$$

Where T_e is EM of dc engine and ω_m is angular velocity.

$$T_e - T_L = J\frac{d\omega_m}{dt} + B_v\omega_m \quad (3)$$

Where, T_L is load torqe , B_v is viscous friction.

The rotor and speed combined

$$\frac{d\theta_r}{dt} = \frac{P}{2}\omega_m \quad (4)$$

Where, θ_r is position rotor.

B. Speed control of DC motor:

DC engine depends on heartbeat plentifulness tweak. So in PAM the exchanging segments will be on or off in fast condition.

DC engine is worked by shifting the information voltage. So here the square outline is appearing underneath . In that there are two circles present there, the principal circle is for 6 stage inverter and other one is for control the dc engine.

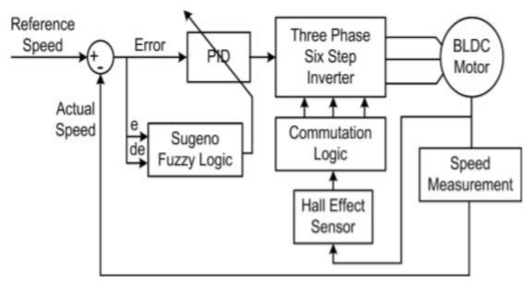

Fig. 2. Block Diagram Speed Control of Brushless DC Motor

In Corridor impact sensor on dc engine has essentially two capacity , first is position sensor and second one is speed sensor. When identifying the rotor position it is accustomed to exchanging replacement. Here when the loop is enerzised the attractive field will shape and after that rotor will pivot.

III. DESIGN OF CONTROLLER

The controller is utilized to restore set no. esteem reaction, even the set point esteem is a;so get change. The PID controller and Fuzzy logic plays very important role in speed control.

A. PID Controller:

PID controller have three par like P-prop.,I- Iintegral, and D-der. Any overabundance on para P,I,D can be parallel incorporated in to a PID controller.it can quicken the ascent time and diminishes the stedy state blunder in the framework and furthermore decreases the swaying.

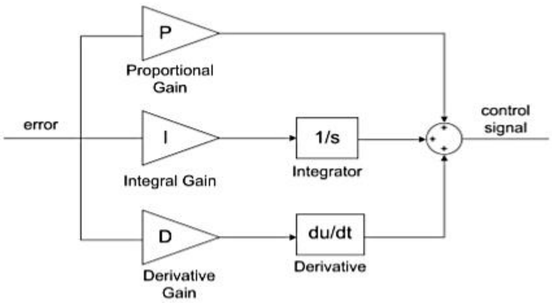

Fig. 3. Block Diagram of PID Controller

$$u(s) = \left[K_p + \frac{K_i}{s} + K_d s\right] E(s) \qquad (5)$$

The PID eq. in time domain is

$$u(t)= K_p e(t)+ K_i \int_i^t e(t)\, dt + K_d \frac{de}{dt} \qquad (6)$$

$$u(t)= K_p \left(e(t) + \frac{K_i}{K_p} \int_i^t e(t)\, dt + \frac{K_d}{K_p} \frac{de}{dt}\right) \qquad (7)$$

$$T_i = \frac{K_p}{K_i} \text{ and } T_d = \frac{K_d}{K_p} \qquad (8)$$

$$u(t)= K_p \left(e(t) + \frac{1}{T_i} \int_i^t e(t)\, dt + T_d \frac{de}{dt}\right) \qquad (9)$$

Where, K_p is proportional gain, K_d is derivative gain, T_i is constant integral time and K_i is integral gain.

B. PID-FUZZY:

If we make the combination of PID-FUZZY it will be very usefull and beneficial for dc motor. PID-FUZZY improve crafted by PID controller while having set point and dynamic burden. The fluffy rationale demonstrates the to decide kp, ki, kd parameters. PID-Fluffy have two things mistake and delta blunder & as we know that we have three output ki, kp and kd. The subsystem is shown in below diagram.

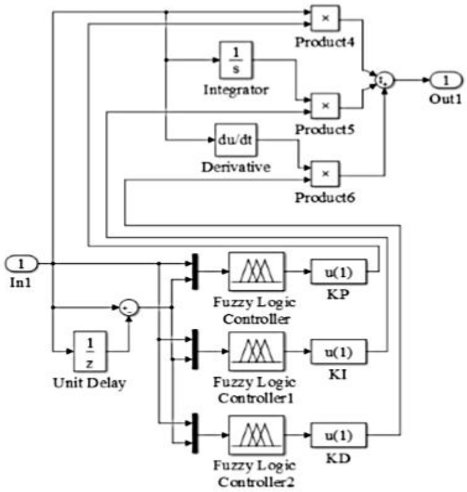

Fig. 4. Subsystem of PID-Fuzzy

IN fuzzy type the deffuzi process is greater easy than mamdni which is shown in below figure.

$$y=\frac{\sum c_n x_n}{\sum x_n} \qquad (10)$$

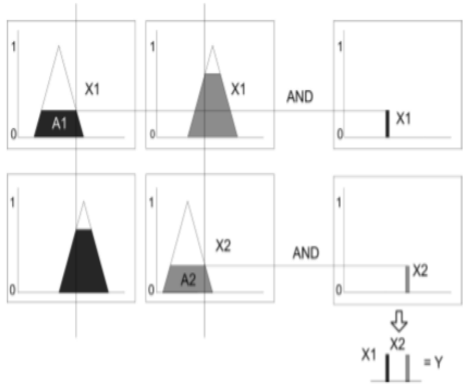

Fig. 5. Illustration of Sugeno Fuzzy Type Defuzzification Process

So, the overall process of PID-FUZZY control system is to control the DC motor. Motor speed and specification are shown in below terms . In that there are lots of things should be in negative big, negative small , zero, positive small and positive big respectively. There is functions ranging between -710 to 710, it means that 710 is maximum value.

C. Fuzzy Logic Controller:

Fuzzy systems are data based or rule based structures. The center of a cushy structure is a learning base including the implied If-Then guidelines. A fluffy If-Then clarification in which a couple of words are depicted by tenacious enlistment limits. In the wake of describing the feathery sets and doling out their support limits, rules must be made to depict the move to be made for each mix of control factors. These standards will relate the data components to the yield variable using If-Then enunciations which empower decisions to be made. The If is a forerunner to the Then (end) of every standard. Every standard when all is said in done.

SIMULATION DIAGRAM:

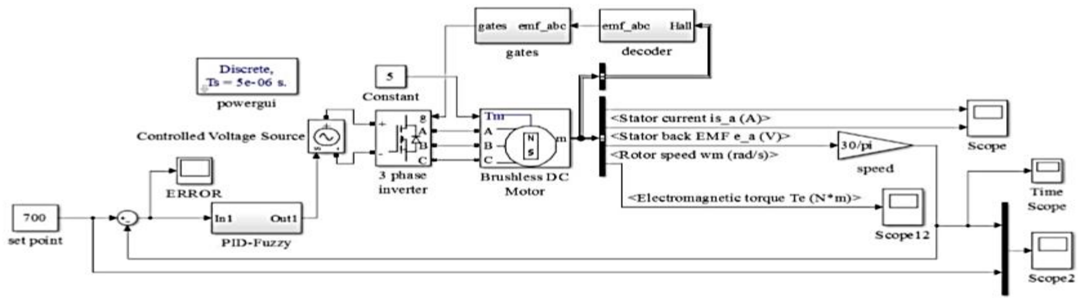

Fig. 6. Overall System of Speed Control Brushless DC Motor use PID-Fuzzy

TABLE II. BRUSHLESS DC MOTOR SPECIFICATION

Parameters	Value
Stator phase resistance Rs (ohm)	0.045
Stator phase inductance Ls (H)	6.85e-3
Voltage constant (V_peak L-L / krpm)	65.48
Back EMF flat area (degrees)	120
Inertia (J(kg.m^2))	0.0008
Viscous damping (F(N.m.s))	0.001
Pole pairs	13

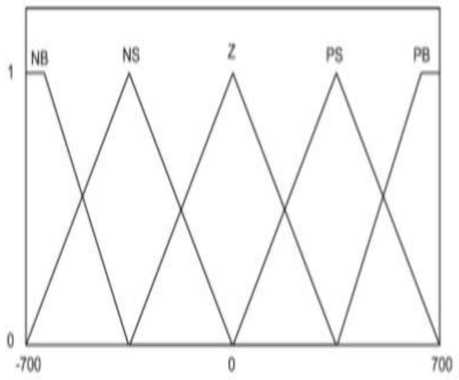

Fig. 7. Membership Function for error and delta error

While the fluffy yield comprises of three yield. Ther are yield of Kp, yield of Ki, and yield for Kd. enrollment work yield Kp,Ki,&Kd para is appeared below Fig.

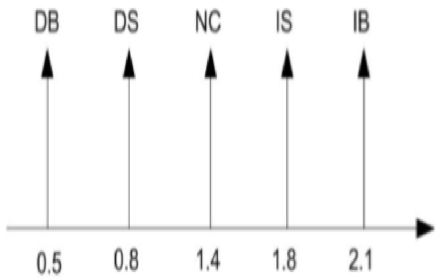

Fig. 8. Membership Function Output for Kp Parameter

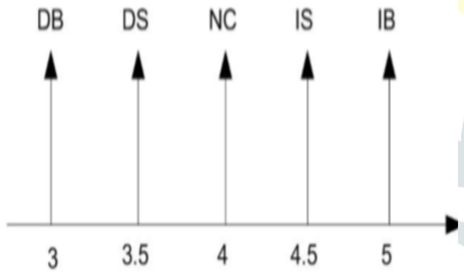

Fig. 9. Membership Function Output for Ki Parameter

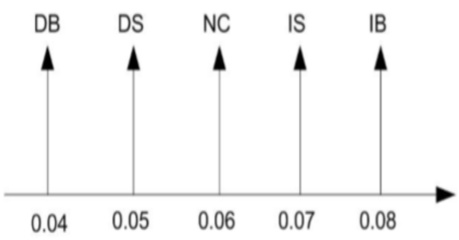

Fig. 10. Membership Function Output for Kd Parameter

Abatement Enormous, Reduction Little, Not Change, Increment Little, and Increment Huge independently. So estimation of Kp,Ki&Kd at each set point and each pile. The para regard is use to sort of point of view for fleecy yield.

TABLE III. RULE BASE SUGENO FUZZY TYPE FOR KP, KI, AND KD PARAMETERS

e \ de	NB	NS	Z	PS	PB
NB	DB	DB	DB	DS	NC
NS	DB	DB	DS	NC	IS
Z	DB	DS	NC	IS	IB
PS	DS	NC	IS	IB	IB
PB	NC	IS	IB	IB	IB

IV. SIMULATION RESULT

The proliferation is performe 47V; 2KW DC engine, with apparent of 710. below Fig. show yield response from PID-Fluffy & common PID at set value 102 & 710 no heap.

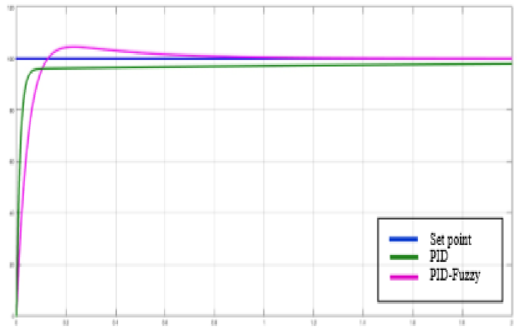

Fig. 11. Speed Response of 100 rpm with no load

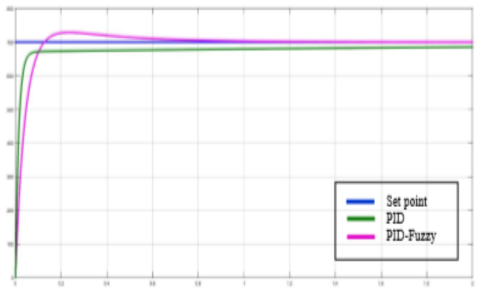

Fig. 12. Speed Response of 700 rpm with no load

PID reaction at set point 110rpm with no heap has an ascent value 31.143ms with overshoot of - 2.971%. At set value 710rpm. yet its reaction can achieve the relentless state condition with the set time of 0.343 s at set no. 110 and set value of 0.345 s set no. 710

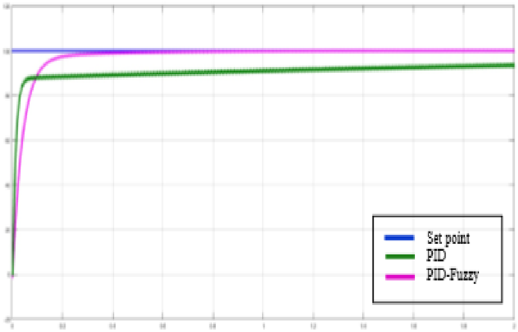

Fig. 13. Speed Response of 100 rpm with load

Fig.13&14 show response of the fuzzy&PID at the 110&710rpm.

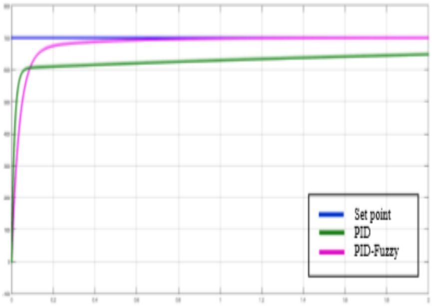

Fig. 14. Speed Response of 700 rpm with load

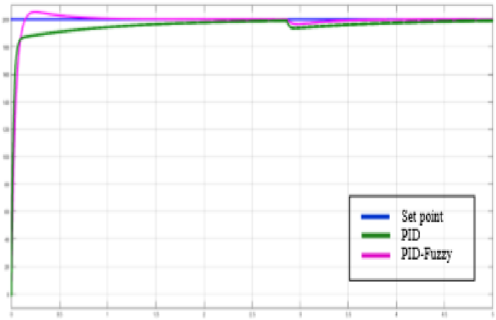

Fig. 15. Speed Response of 700 rpm with no load

Fig. 15 demonstrates the yield reaction PID-Fuzzy and regular PID at the set purpose of 210 rpm with unsettling influence. The unsettling influence was all of a sudden given at time of 1.7 sec. The outcome demonstrates that PID can achieve the unfaltering state cond. at the set vlue of 3.9 sec. In the interim, PID-Fuzzy can achieve the relentless state condition at the set value of 2.6 sec.

TABLE IV. PERFORMANCE RESULT BETWEEN CONVENTIONAL PID AND PID-FUZZY

Controller	Set point	No load			With load		
		tr	ts	Mp	tr	ts	Mp
PID	100	34.48	-	-1.75	36.44	-	-1.45
	200	34.53	-	-1.75	36.49	-	-1.45
	400	35.02	-	-1.74	36.80	-	-1.62
	600	35.12	-	-1.74	79.26	-	-1.68
	700	35.37	-	-1.74	80.68	-	-1.68
PID-Fuzzy	100	66	0.23	9.78	98.52	1.71	-0.32
	200	67	0.23	9.65	99.10	1.71	-0.31
	400	69.32	0.23	7.44	112.19	1.99	-0.23
	600	68.54	0.23	7.44	115.10	1.99	-0.21
	700	68.76	0.23	7.44	115.79	1.99	-0.21

V. CONCLUSION

The recreation of speed control brushless DC engine has been introduced. The recreation result demonstrate that the PID parameters tuned by fluffy rationale can improve the execution of brushless DC engine speed in changed set point and dynamic burden conditions. PID-Fuzzy creates preferred execution over customary PID.PID-Fuzzy demonstrates that the reaction can achieve consistent state condi. quicker than ordinary PID on unique burden and fluctuated set point in electric vehicle. This exploration is the initial step. Later on this examination will be reference to be proceeded in execution.

REFERENCES

[1] B.J. Chalmers, "Influence of saturation in brushless permanent magnet drives." IEE proc. B, Elect. Power Appl, vol.139, no.1, 1992.

[2] C.T. Johnson and R.D. Lorenz, "Experimental identification of friction and its compensation in precise, position controlled mechanism." IEEE Trans. Ind, Applicant, vol.28, no.6, 1992.

[3] Zhang, N. Wang and S. Wang, "A developed method of tuning PID controllers with fuzzy rules for integrating process," Proceedings of the American Control Conference, Boston, 2004, pp. 1109-1114.

[4] PavolFedor, Daniela Perduková, "A Simple Fuzzy Controller Structure,"ctaElectrotechnica ETInformatica No. 4, Vol. 5, 2005.

[5] Maher M.F. Algreer andYhyaR.M.Kuraz, "Design Fuzzy Self Tuning of PID Controller for Chopper-Fed DC Motor drive." Kuraz.

[6] Bomediene Alloua, Abdellah Laouf Brahim Gasbaoui and ABdessalamAbderrahamani, "NeuroFuzzy DC Motor speed Control Using Particle Swarm Optimization," Leonaro Electronic Journal of Practices and Technologies ISSN,1583-1078.

[7] ManafeddinNamazov and OnurBasturk, "DC motor position control using fuzzy proportionalderivative controllers with different defuzzification methods," Turkish Journal of Fuzzy Systems (eISSN: 1309–1190), Vol.1, No.1, pp. 36-54, 2010.

[8] K. Zdenko and B. Stjepan "Fuzzy Controller Design Theory and Applications," © 2006 by Taylor & Francis Group.

[9] J.X. Shen, Z.Q. Zhu, D. Howe, and J.M. Buckley, "Fuzzy Logic Speed Control and CurrentHarmonic Reduction in Permanent-Magnet Brushless AC Drives," IEEE Proc.-Electr. Power appl., vol. 152, no. 3, pp. 437-446, 2005.

[10] R. Krishnan, "Electric Motor Drives : Modeling, Analysis, and Control," Prentice Hall, 2001, pp. 577-580.

[11] Xia. Chang-liang, "Permanent Magnet Brushless DC Motor Drives and Controls," Wiley, 2012, pp. 33-39.

[12]Gaddam Mallesham and Akula Rajani, “AUTOMATIC TUNING OF PID CONTROLLER USING FUZZY LOGIC.” 8th International Conference on DEVELOPMENT AND APPLICATION SYSTEMS Suceava, Romania, May 25 – 27, 2006.

[13] M.Chow and A. Menozzi ,”on the comparison of emerging and conventional techniques for DC motor control” proc.IECON ,PP.1008-1013,1992.