A NEW APPROACH TO IMPROVE THE PERFORMANCE OF POSITION CONTROL OF DC SERVO MOTOR BY USING FUZZY LOGIC CONTROLLER

BY

[1] **Abhishek Kumar Kashyap**, [2]**Binanda Kishore Mondal**, [3]**Souvik Chatterjee and** [4]**Sudipta Ghosh**

[1, 2, 3] Assistant Professor in ICE Department

[4] Associate Professor in ECE Department

Calcutta Institute of Engineering & Management, Kokata-700040

akpa83@gmail.com, , binanda36@gmail.com, souvikchatterjee657@yahoo.com ,ghoshsudipta12@yahoo.co.in

Abstract

The position control system is one of the interesting term in control system engineering. Now a days several control system algorithm have been applied in that application. PID controller is a well known controller and widely used in feedback control in industrial processes. For position control system sometime pid controller is not accurate for this application because of non linear properties. Therefore e in this research the fuzzy logic controller is proposed to overcome the problem of pid controller. Fuzzy logic controller has a ability to overcome the problem of pid controller. Fuzzy logic controller has ability to control the non linear systems also because the algorithm used is concentrated by emulating the expert and implemented in language based on the experimental result , the fuzzy logic controller designed, is able to improve the performance of the position control system compare to the pid controller, in terms of rise time (Tr) is 50%, settling time Ts is 80% and maximum overshoot (M%) is 98%, and that can be reduced.

Keywords- Fuzzy logic controller, PID controller, position control, DC servo motor.

1. INTRODUCTION.

The motor considered in the presented work is a field controlled with fixed armature current type D C motor. The transfer function between the output angular displacement of this motor shaft (t) and its input control action E_f (t) is given by eqn. (2.3), where K_m is motor gain constant; T_f is time constant of field circuit and T_m is time constant of

inertia-friction element. For simplicity, we assume that K_m=1radian/volt-sec,$T_f = 0.1$ sec and $T_m = 1$ sec. Hence the effective transfer function of the field controlled dc motor becomes:

$$Gm(s) = \frac{1}{0.1s^3 + 1.1s^2 + s} \tag{1}$$

The simulation of the above motor transfer function is done in SIMULINK/MATLAB with PI, PD, PID controllers and finally is compared to the response obtained with Fuzzy Logic Controller.

1.1 Simulation1:

Here, all the controllers are compared on the basis of Rise Time (t_r), Settling Time (t_s), Maximum Overshoot (M%) and their corresponding Performance Indices (PI) like Integral Square Error (ISE), Integral Time Square Error (ITSE), Integral Absolute Error (IAE), and Integral Time Absolute Error (ITAE).
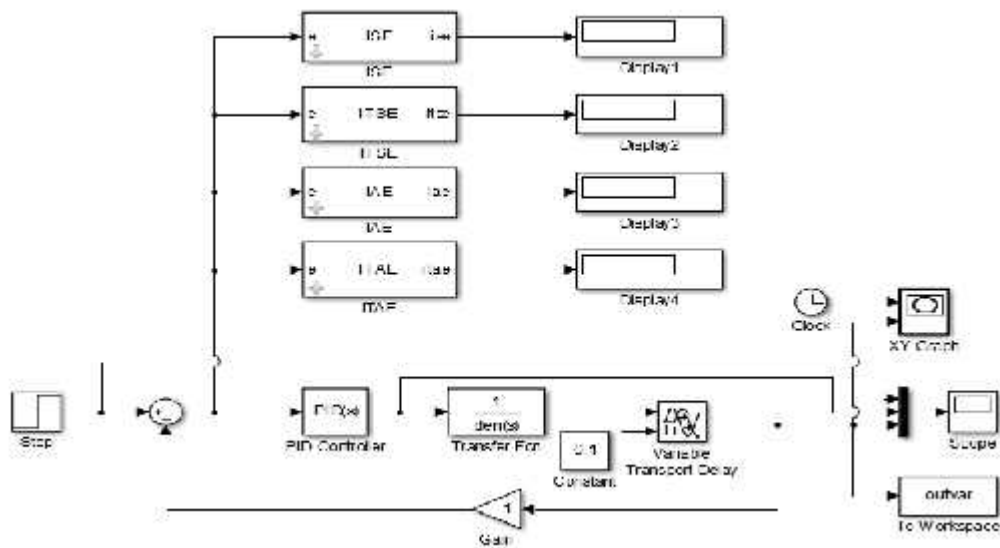

Fig. 1 Simulink Block Diagram with conventional controller for dc motor

The Ultimate Gain (Ku) and Ultimate Period (Pu) is obtained when sustained oscillation of the response in P only mode is achieved according to the Ziegler-Nichols Tuning Rule. Ultimate Gain (K_u) =5.34, Ultimate Period (P_u) =2.9

According to the Ziegler Nichols tuning table, controller parameters for PD and PID are found to be,

CONTROLLER TYPE	K_P	K_I	K_D
PI	2.4272	1.0043	0
PD	4.272	0	1.5486
PID	3.204	2.20965	1.16145

Table .1 Controller Parameters According to Ziegler-Nichols Method for dc motor

The corresponding Amplitude vs. Time Plot for PI, PD and PID are shown in Fig. 1, Fig. 2 and Fig. 3 respectively obtained for the controller parameters calculated in the above Table 1.
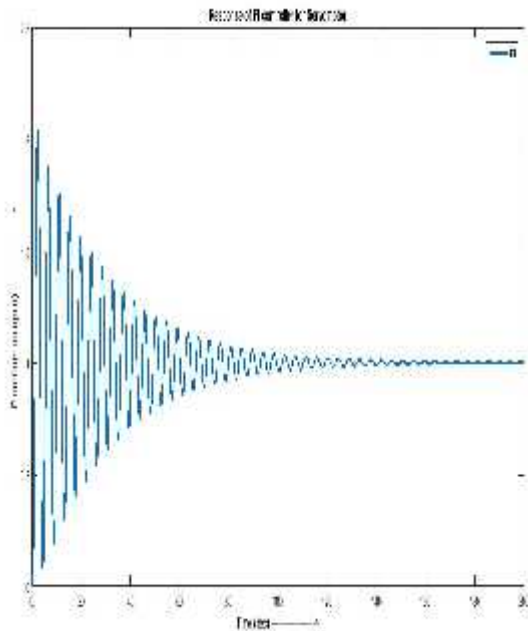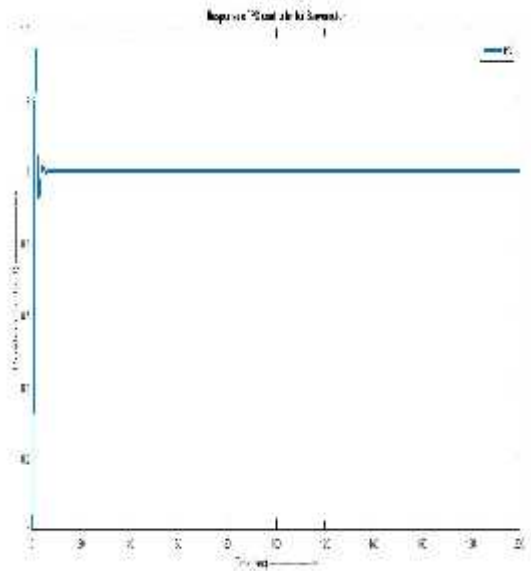

Fig. 1 Response of PI Controller   Fig. 2 Response of PD Controller

Fig. 3 Response of PID Controller

On running the same Transfer Function with Fuzzy Logic Controller having Rule Base defined earlier in Table 1. The Simulink block diagram for Fuzzy Logic based Controller is shown in Fig. 4.

Fig. 4 Simulink Block Diagram with fuzzy logic controller for dc motor.

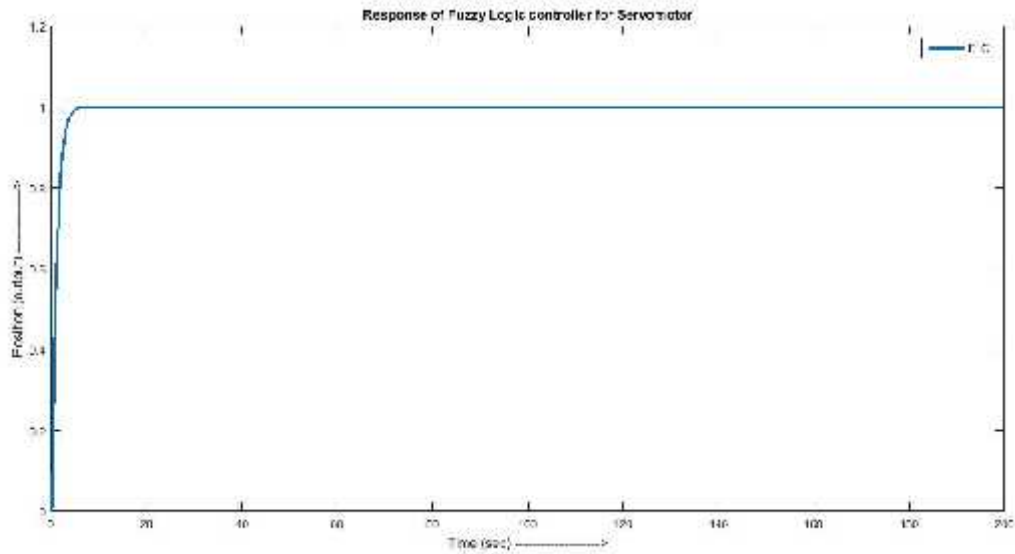The position vs. time plot is shown in Fig. 5.

Fig. 5 Response of Fuzzy Logic Controller

All the four responses obtained from four different controllers are plotted altogether, shown in Fig.7 for comparison of their performance with respect to time.
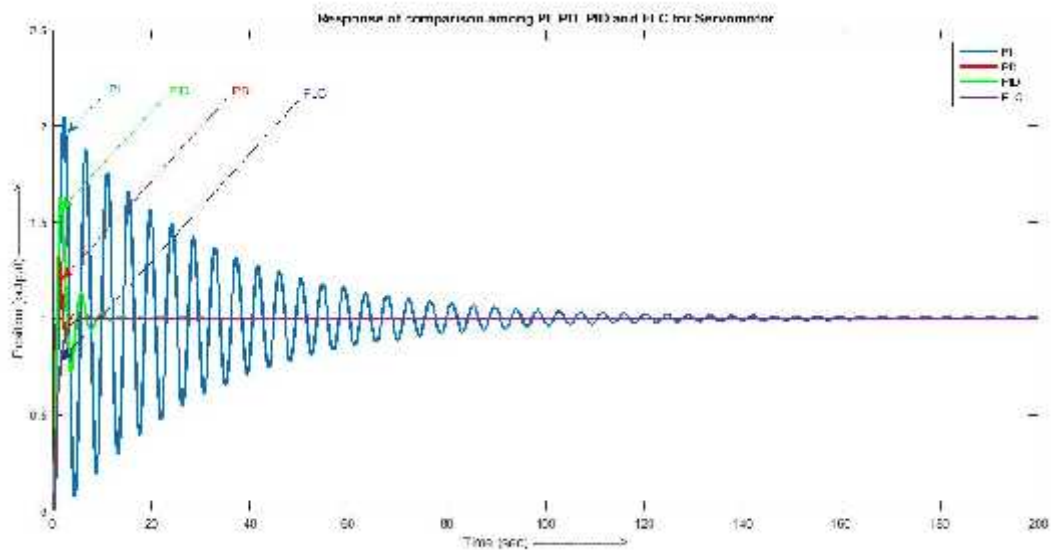

Fig. 6 Response for comparison of performance among PI, PD, PID and FLC for dc motor

Here performance of Fuzzy Logic Controller over conventional PD and PID is analysed. The results shows that the fuzzy logic control achieve better performance for tuning the controller gains than conventional tuning methods such as eliminating overshoot, rise time and steady state error. Performance Analysis data obtained from the simulation and responses has been tabulated in Table 2.

Transfer Function	Control Type	Rise Time in sec (tr)	Settling Time in sec (ts)	Maximum Overshoot (M%)	Integral Absolute Error (IAE)	Integral Time Absolute Error (ITAE)	Integral Square Error (ISE)	Integral Time Square Error (ITSE)
$G_M(S)$	PI	1.379	185.5	103.9%	20.03	571.9	8.627	123.5
	PD	0.795	7.717	33.7%	0.8569	0.8373	0.4577	0.1981
	PID	0.98	16.604	73.1%	1.991	5.222	0.9155	1.232
	FLC	7.2	7.2	0%	1.219	1.354	0.7077	0.3762

Table 2 Performance analysis for dc motor (Gm)

1.2 Conclusion:

The conventional PI,PD,PID vs. Fuzzy Logic Controller(FLC) is compared for the $G_1(s)$ and $G_2(s)$ transfer function and a separate servo transfer function $G_M(s)$for fuzzy logic based controller for a D.C. servomotor with a concern of speed control . The design of the Fuzzy Logic Controller has been explained and the performance was evaluated by simulation. The results show significant improvement in maintaining performance of approximate minimum stabilizing time.

Hence, a more heuristic approach is required for choice of the controller parameters which can be provided with the help of fuzzy logic, where we can define variables in a subjective way. Thus we can avoid the numerical complicacy involved in higher order systems. Fuzzy logic provides a certain level of artificial intelligence to the controllers since the try to imitate the human thought process. This facility is not available in the

conventional controllers. In this paper Our focus is to develop a Fuzzy Logic Based Controller so as to achieve precision in control. The controller attempts to attain a certain level of human intelligence by utilizing the linguistic variables instead of numerical ones. Its main advantage is that it completely avoids the mathematical computations, which relieves the designer from using complicated techniques.

References

1) Nagrath, I.J. and M. Gopal, *Control Systems Engineering*, 3rd edition, New Age Publishers, 2000

2 Driankov, D., H. Hellendoorn and M. Reinfrank,*An Introduction to Fuzzy Control*,2nd edition, Springer International Student Edition, 2001

3) Klir, G.J. and Bo Yuan, *Fuzzy Sets and Fuzzy Logic: Theory and Applications,* Prentice Hall International, 1995

4) Chen, G. and T.T. Pham, *Introduction to, Fuzzy Sets, Fuzzy Logic and Fuzzy] Control System,* CRC Press, 2001

5) Beucher, O. and M. Weeks, *INTRODUCTION TO MATLAB® & SIMULINK A Project Approach,* 3rd edition, Infinity Science Press LLC, 2008

6) Rajoriya, A. and H. Ahmed (2014) Performance Assessment of Tuning Methods for PID Controller Parameter used for Position Control of DC Motor, *International Journal , Electrical Engg.*, 9, 139-148

7) http://www.mathworks.com/matlabcentral