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A Fuzzy Based Separately Excited DC Motor

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ABSTRACT

This paper proposes the importance of a Fuzzy over conventional PID method. The controller is designed based on the expert knowledge of the system. The output response of the system is obtained by using different types of controllers, namely PID and fuzzy logic controller. In this, paper the performance of DC Motor is verified using PID Fuzzy controllers. Finally, the result shows that the Fuzzy approach has minimum overshoot, minimum transient and steady state parameters, which shows more effectiveness and efficiency of Fuzzy than conventional PID.

Keywords: DC Motor, Fuzzy Control, & PID

I.INTRODUCTION

The development of high performance motor drives is very important in industrial as well as other purpose applications such as steel rolling mills, electric trains and robotics. Generally, a high performance motor drive system must have good dynamic speed command tracking and load regulating response to perform task. DC drives, because of their simplicity, ease of application, high reliabilities, flexibilities and favourable cost have long been a backbone of industrial applications, robot manipulators and home appliances where speed and position control of motor are required. DC drives are less complex with a single power conversion from AC to DC. Again the speed torque characteristics of DC motors are much more superior to that of AC motors. A DC motors provide excellent control of speed for acceleration and deceleration. DC drives are normally less expensive for most horsepower ratings. DC motors have a long tradition of use as adjustable speed machines and a wide range of options have evolved for this purpose. In these applications, the motor should be precisely controlled to give the desired performance. The controllers of the speed that are conceived for goal to control the speed of DC motor to execute one variety of tasks, is of several conventional and numeric controller types, the controllers can be: proportional integral (PI), proportional integral derivative (PID) Fuzzy Logic Controller (FLC) or the combination between them The proportional – integral – derivative (PID) controller operates the majority of the control system in the world. It has been reported that more than 95% of the controllers in the industrial process control applications are of PID type as no other controller match the simplicity, clear functionality, applicability and ease of use offered by the PID controller [3], [4]. PID controllers provide robust and reliable performance for most systems if the PID parameters are tuned properly.

II. SYSTEM MODELING OF SEPARATELY EXCITED DC MOTOR:

The equivalent circuit for a separately excited dc motor is shown in Figure 1. When a separately excited motor is excited by a field current if and armature current ia flows in the armature circuit, the motor develops a back emf and a torque to balance the load torque at a particular speed. The field current of a separately excited motor is independent of the armature current ia and any change in the armature current has no effect on the field current. The field current is normally much less than the armature current.

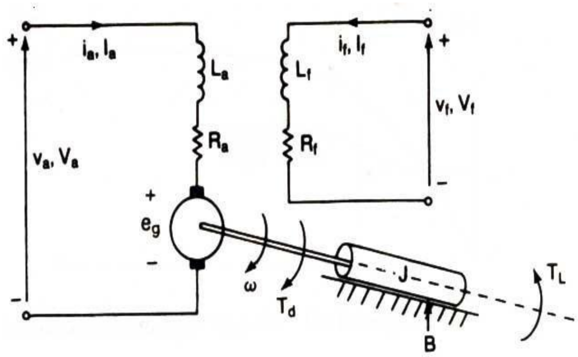


Figure 1: DC Motor Equivalent Circuit

III. MODELING OF SEPARATELY EXCITED DC MOTOR:

From figure 1:

The armature voltage equation is given by:

$$Va = Eb + IaRa + La\,(dIa/dt)$$

Now the torque balance equation will be given by:

$$Tm = Jm(d\omega/dt) + Bm(\omega) + TL$$

Where:

TL is load torque in Nm.

Friction in rotor of motor is very small (can be neglected), so Bm= 0 Therefore, new torque balance equation will be given by:

$$Tm = Jm(d\omega/dt) + TL \text{----------------(i)}$$

Taking field flux as Φ and Back EMF Constant as K. Equation for back emf of motor will be:

$$Eb = K\,\Phi\,\omega \text{-------- (ii)}$$

Also, $Tm = K\,\Phi\,Ia$ -------- (iii)

Taking laplace transform of the motor" s armature voltage equation we get

$Ia(S) = (Va – Eb)/ (Ra + LaS)$

Now, taking equation (ii) into consideration, we have:

$Ia(s) = (Va – K\Phi\omega)/ Ra\,(1+ LaS/Ra)$

And $\omega(s) = (Tm - TL) /JS = (K\Phi Ia - TL) /JmS$

(Armature Time Constant) $Ta= La/Ra$

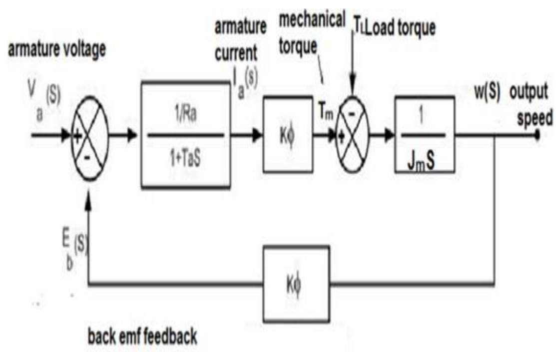


Figure 2: DC Motor Equivalent Circuit

After simplifying the above motor model, the overall transfer function will be

$\omega (s) / Va(s) = [K\Phi /Ra] /JmS(1+TaS) /[1 +(K^2\Phi^2 /Ra) /JmS(1+TaS)]$

PI Controller

A PI Controller (proportional-integral controller) is a combination of proportional and integral controller which is used for eliminating steady state error and peak overshoots [10-11]. The absence of derivative controller shows more stability under noise conditions. This is because the derivative controller is more sensitive under high frequency systems.

The general expression for PI controller is expressed as,

$$K_P\Delta + K_I \int \Delta dt$$

E. Fuzzy Logic Controller

In the previous section, control strategy based on PI controller is discussed. But in case of PI controller, it has high settling time and has large steady state error. In order to rectify this problem, this paper proposes the application of a fuzzy controller shown in Figure 3. Generally, the FLC [12] is one of the most important software based technique in adaptive methods.

As compared with previous controllers, the FLC has low settling time, low steady state errors. The operation of fuzzy controller can be explained in four steps [13].

1. Fuzzification
2. Membership function
3. Rule-base formation
4. Defuzzification

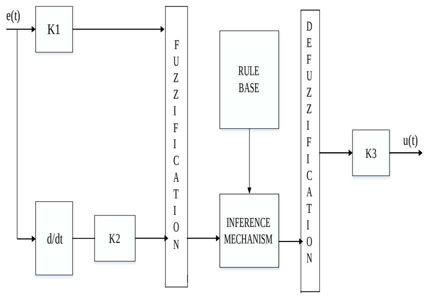


Figure 3: basic structure of fuzzy logic controller

In this paper, the membership function is considered as a type in triangular membership function and method for defuzzification is considered as centroid. The error which is obtained from the comparison of reference and actual values is given to fuzzy inference engine. The input variables such as error and error rate are expressed in terms of fuzzy set with the linguistic terms {el, em, eh} and Pin this type of mamdani fuzzy inference system the linguistic terms are expressed paper, two inputs and single output fuzzy inference system is considered. The second input is chosen as rate using triangular membership functions. In this of change of error. The number of linguistic variables for input and output is assumed as 3 The numbers of rules are formed as 9.

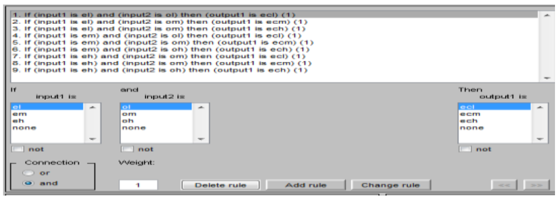


Figure 4: Rule-Base formation FIS system

IV. SIMULATION RESULTS

The results of the system with using different type of controllers are shown here. The responses of the system with several controllers such as PID, Fuzzy Logic Controller are being applied. In this section transfer function of the separately excited dc motor is used as a system and find out the response of the system applying the step function as an input.

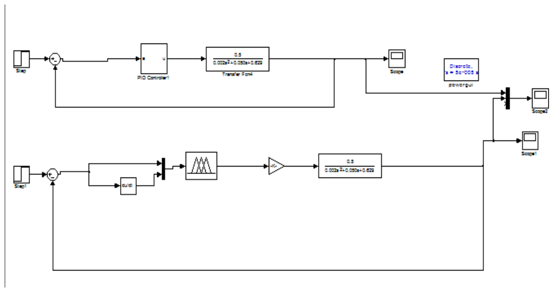


Figure 5: Simulation Diagram for DC Motor with PID & Fuzzy Controller

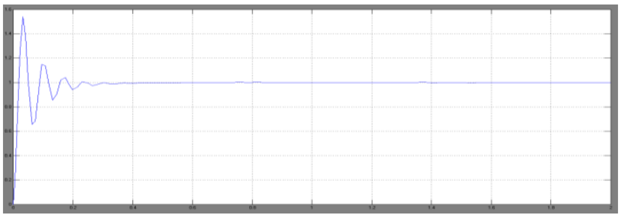


Figure 6: Simulation Result for Speed of DC Motor

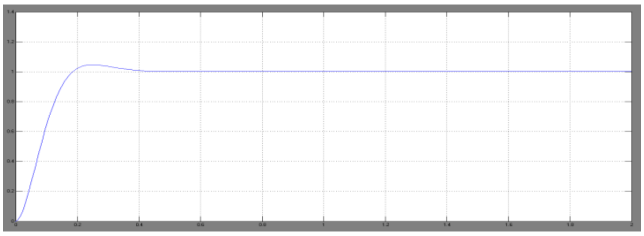
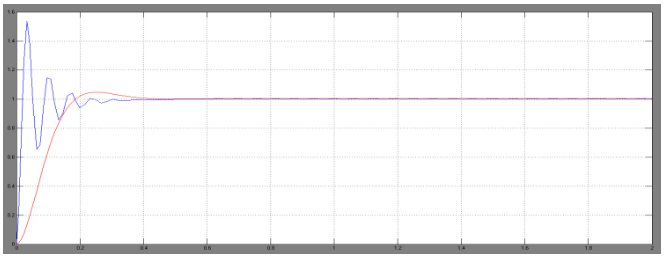


Figure 7: Simulation Result for Speed with Fuzzycontroller



Time	PID	FUZZY
Peak Time	0.03	0.25
Rise Time	0.027	0.225
Delay Time	0.015	0.125

Settling Time	4	0.44
Peak Overshoot	46	5

Table 1: Comparison of Time domain specifications Between PID & Fuzzy Controllers

VI.CONCLUSION

In this paper the speed of a DC motor is controlled using fuzzy logic and PID controller. The simulation results are obtained using MATLAB/SIMULINK. The Fuzzy response is compared with that of conventional PID controller. The results show that the overshoot, settling time, peak time and control performance has been improved greatly by using Fuzzy controller. The proposed Fuzzy controller has more advantages, such as higher flexibility, control, better dynamic and static performance compared with conventional controller.

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