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Speed Control of DC motor Using Hybrid Fuzzy-PID Controller

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ABSTRACT: Proportional-integral-derivative controller is a generic control feedback mechanism widely used in industrial control system. A PID controller attempts to correct the error between the measured process variable and a desired set point by calculating and outputting a corrective action that can adjust the process accordingly. So by integrating the PID controller to the dc motor were able to correct the error made by the DC motor to the desired point or speed. By using fuzzy logic controller, the speed can be tuned until it get similar to the desired output that user need and can operate with noise and disturbance of a different nature. In this work, the modeling and simulation of DC motor was done by using MATLAB(SIMULINK) .From this work, the result performance of the PID controller studied in terms of response and this will give the motor flexibility of the speed control of motor.

KEYWORDS: Control loop feedback, DC motor, Efficiency lag, Fuzzy logic controller, PID controller.

I.INTRODUCTION

The evolution of good performance DC motor drive is most important in industrial sectors. Basically, a good performance DC motor drive system having good dynamic speed tracking and load regulating response. From various types of motors, DC motors are more advantageous because of their compactness, high starting torque. But any variation to either of the above parameters may lead to damage of equipments attached to DC motor. To avoid this two fold nature of DC motor we need to control speed and torque. Controlling motor speed means running the motor with desired speed for any variations at the input of motor.

DC series motor is used specially for its high starting torque and variable speed. DC series motors are not applicable where constant speed is required because the velocity of series motors are varying according to their varying loads. It is used for traction, electric locomotive and trolley system, cranes hoists and conveyors. DC shunt motors are much popular for their constant speed operations and it is remains constant from full load to no load. It is used for driving the constant speed shafts, centrifugal pumps, blower and pumps etc. DC motors are widely used because of their good performance in electrical drives and servo system.

Many types of DC motors are there and having good and bad features. Such bad features are lag of efficiency. To solve this problem a controller is introduced to the system i.e. PID controller. The summation of proportional-integral-derivative controller is called PID controller and it is a generic control loop feedback mechanism broadly used in industries. So by integrating the PID controller to the DC motor will able to correct the error made by the DC motor and control the speed or the position of the motor to the desired speed. The fuzzy logic is adequate to model unreliable or uncertain models. The fuzzy logic application attempts a easier, faster and extra predictable explanation that is clear improvement over accepted skills. It is absolutely distinct from other controllers, fuzzy logic's assumption is to understand like an biological living thing; human.

II. DC MOTOR MODEL

DC motors are widely used in industrial application because of their speed control techniques. The parameters used DC motor modeling are :

Moment of inertia (J) = 0.01 $kg.m^2$

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Viscous friction constant (B) = 0.1 N. m. s
Electromotive force constant (K_e) = 0.01 v/ rad. /sec
Motor torque constant (K_t) = 0.01 N. m / amp
Electrical resistance (R) = 1 ohm
Electrical inductance (L) = 0.5 H
Simplified DC motor modeling diagram is given by :-

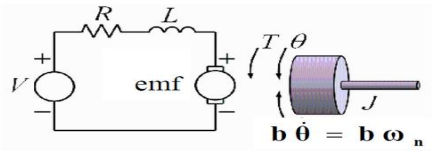

Fig 2.1 DC motor model

The torque generated by DC motor is proportional to the armature current and the strength of the magnetic field.

$$T = K_t i$$

The back e. m. f is proportional to the angular velocity of the shaft by a constant factor K_e

$$e = K_e \frac{d\theta}{dt}$$

where $\omega = \frac{d\theta}{dt}$

$$e = K_e \omega$$

Applying Newton's 2nd law to secondary side and Kirchoff's voltage law to armature side :-

$$\frac{d\omega}{dt} = \frac{Kt}{J} i - \frac{B}{J} \omega$$

$$\frac{di}{dt} = -\frac{R}{L} i - \frac{Ke}{L} \omega + \frac{V}{L}$$

The simulink diagram of a DC motor model is given by :-

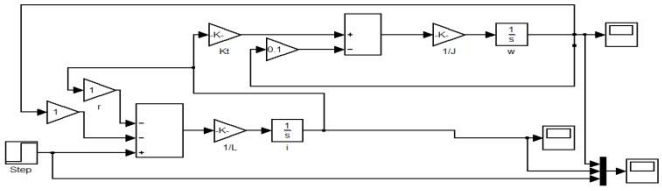

Fig 2.2 SIMULINK MODEL OF A DC MOTOR

The simulation result of this DC motor model is given by :-

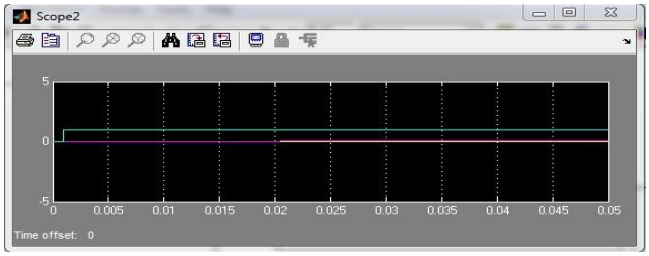

Fig. 1.3. SIMULATION RESULT OF DC MOTOR

III.DC MOTOR WITH DIFFERENT CONTROLLER

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1) MOTOR WITH PID CONTROLLER:

The main motive of constructing a PID controller is to regulate and control the speed performance of DC motor. In PID controller, the proportional action is used for the amplification with an adjustable gain , the integral control action is called as reset control and the derivative control action is called as rate control. When all the three control actions are merged then this controller is known as PID controller. The simulink diagram of speed response with PID controller is given below :-

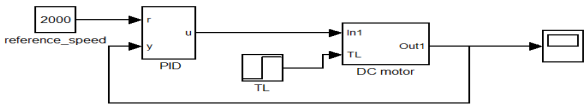

Fig1.4 DC MOTOR WITH PID CONTROLLER

2) MOTOR WITH FUZZY LOGIC CONTROLLER:

Fuzzy logic controller is a computational pattern based on how human feels. It is able form a logic from the behavior of system depending on the rules provided by user. Fuzzy logic is a multi-valued input logic, it allows the values between appropriate calculations like high-low, true-false, yes-no. Fuzzy logic is a path to create systems more sharp to logic in a fuzzy manner like humans. Fuzzy logic is based on IF-THEN rule system that means the human being is thinking in computational ways.

Normally, fuzzy logic consists of four modules:-

- **Fuzzification**
- **Fuzzy inference system**
- **Rule base**
- **Defuzzification**

A. FUZZIFICATION:

It is the first step in the fuzzy inference system. The process of converting real numbers to linguistic variables is called Fuzzification.

B. FUZZY INFERENCE SYSTEM:

In fuzzy inference system, the truth value of the each rule is evaluated and it is applied to the conclusion of the each rule. It is used to describing the logical rules saved in the rule base.

C. RULE BASE:

In rule base, the rules are designed for outputs. Normally, the rules are “If-Then” format. Here If is used for the conditions and Then is used for the conclusion. The fuzzy logic is simple to understand and easy to maintain.

D. DEFUZZIFICATION:

Defuzzification is the process of converting truth values to the outputs of the fuzzy logic system. Defuzzification is based on the two methods that is Mamdani-style inference and Sugeno-style inference. Mamdani method allows to

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describing the ability in more automatic, more human like manner. Whereas Sugeno method is computationally effective and works well with optimization and adaptive techniques, which makes it very attractive in control problems. The block diagram of fuzzy logic controller is given below :-

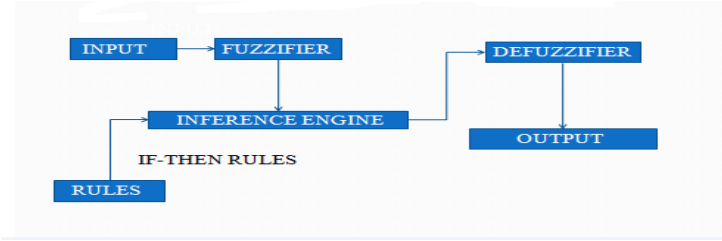

Fig 1.5 Fuzzy logic block diagram

The simulation diagram of fuzzy logic controller is given by :-

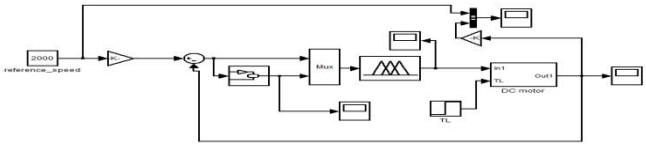

Fig1.6 DC MOTOR WITH FUZZY CONTROLLER

3) PROPOSED FUZZY LOGIC CONTROLLER:

Here in our proposed model we have combined the effect of PID as well as fuzzy for better controlling. The simulink diagram of fuzzy-PID controller is given by :-

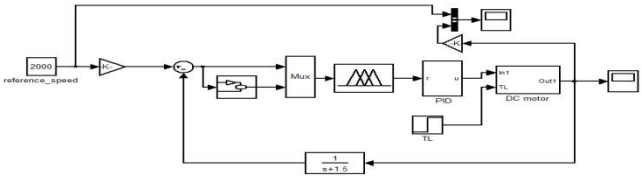

Fig1.7 DC MOTOR WITH FUZZY-PID CONTROLLER

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IV.RESULT AND DISCUSSION

The simulation result of DC motor with PID controller is given below :-

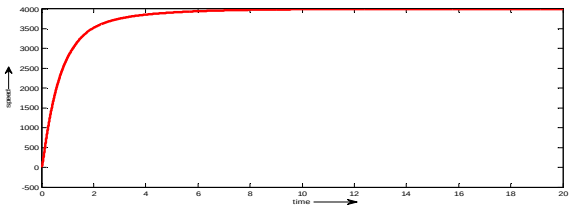

Fig. 1.8 SIMULATION RESULT WITH PID

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With high proportional gain, high integral gain and moderate derivative gain the rise time has been decreased with zero steady state error and no overshoot. The above figure shows the response of the PID controller with decreased rise time, decreased overshoot and zero steady state error.
Below figure describes output response while using fuzzy logic controller.

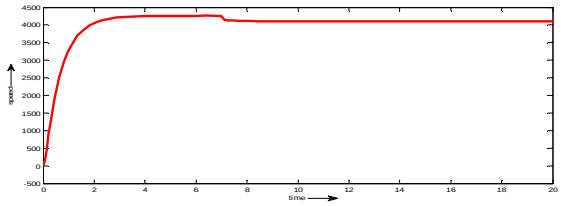

Fig.1.9 OUTPUT RESPONSE OF FUZZY LOGIC CONTROLLER

With the use of fuzzy logic controller it is possible to reduce rise time and settling time as shown in figure. But the response is having some steady state error. Which means if a marginal error will have no issue with the reference speed then we can use this controller. But if the reference speed is very important for some specific application. In that case we need a more advanced controlling technique that can solve the error.

The output response of fuzzy-PID controller is shown below

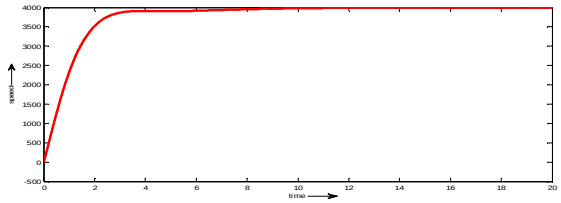

Fig.1.10 OUTPUT RESPONSE OF FUZZY-PID LOGIC CONTROLLER

Simulation result of fuzzy-PID controller shows improved time domain specifications like settling time, overshoot and steady state error.

V. CONCLUSION

Controlled system shows good results in terms of response time and precision when parameters are well adjusted. A little change in the system parameters leads to the change of PID parameters. Fuzzy logic controller can resolve the issue worth the cost of marginal steady state error. Once a fuzzy logic controller is given, the whole system can be considered as a deterministic system. From the output response of fuzzy logic controller, we obtained a fixed settling time and overshoot. With combined PID and fuzzy controller, which means system can be well controlled by PID which is supervised by a fuzzy system we can resolve the two fold nature of PID and fuzzy controller. So the proposed paper well describes the control of variance in speed of DC motor using PID which is supervised by a fuzzy system.
For better development in future, we can go for adding more rules but it will affect time specifications in the same time. So our next work will focus on achieving timing specifications with reduced rules.

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