IMPROVEMENT OF PMDC MOTOR PERFORMANCE OF SPEED CONTROL USING PID AND FUZZY TECHNIQUE

Jamshed ahmad\textsuperscript{1} and Rameshwar singh\textsuperscript{2}
\textsuperscript{1} M.Tech Student, Department of Electrical Engineering NITM Gwalior (India)
\textsuperscript{2} Assistant professor, Department of Electrical Engineering NITM Gwalior (India)

Abstract- The paper describes about the concept of PMDC motor and Speed control PMDC motor. Motor speed is controlled with PID Technique and first system is checked without controller on loaded condition then add PID controller and system is tuned using its existing tuning methods. This paper describes about the basic concepts of Fuzzy Logic, the speed control with the help of Fuzzy controller. Fuzzy controller provides better control strategies than other controllers. Optimization of Fuzzy controller with Simulink model describes in this paper and a new way for faster response and smooth output. The comparison of these two controllers’ results is also showed. So for the better performance, intelligent controller such as Fuzzy is used. Fuzzy has the ability to satisfied control characteristics and it is easy for computing. The case study results verify that Fuzzy has better control performance than the other controller or from the results it is proved that Fuzzy Controller is the best controller.

Keywords- Automatic Voltage Regulator, PI controller, PID controller and Fuzzy-PID controller

I. INTRODUCTION

Optimization in engineering design has always been of great importance and interest particularly in solving complex real-world design problems [1]. DC motors have long been the primary means of Electrical Traction. DC motor has at torque/speed characteristics compatible with most mechanical loads. The speed control methods of a dc motor are simpler and less expensive than those of A.C Motors and speed control over a large range both below and above rated speed can be easily achieved [2]. High performance permanent magnet dc (PMDC) motor drives (10-1000 KW) are currently used in a multitude of industrial applications such as in process control, traction, pulp and paper, steel mills, robotics, guided vehicles, mining and smelting plants. Precise, fast and dynamic speed reference tracking with minimum overshoot/ undershoot and small steady state tracking error are the main control objectives of such a drive system. In a typical electric drive controller, there are usually several nested control loops for the control of current/torque, speed and position, each of which may use a separate proportional-integral- Derivative (PID) controller. PMDC motors are commonly used in robotic application and industrial machinery. The beauty of this motor is it provide high torque load sustaining properties. It describes about the general DC motor and about its motion [3]. For this paper PMDC motor is selected after comparing with others wounding techniques. It discuss about the background work in this field. The remarkable work is presented in this section of some previous researchers on PMDC motor speed control. It discusses the suitable equations of PMDC motor and electrical equations and mechanical equations are developed to check the system using Matlab software. The objective of this paper is to show that by employing the fuzzy method, an optimization can be achieved. This can be seen by comparing the results of the PI, PID Controller optimized system against the fuzzy logic tuned system.

II. LITERATURE REVIEW

Muaz Abdel Rahman Ismail, “Speed Control of PMDC Motor using PID Controller” in this article the real parameters were used for speed control PMDC motor using PID controller. PMDC Motor and Mat lab/ Simulink were used to design the transfer function and simulate PMDC Motor.
with and without Load, a with PID controller. The also study was discussing the performance of PMDC Motor; it found that the PI have the best perform[4].

Aruna.K1, Pravin.M.R2,” Design and Implementation of PI Controller for the Speed Control of DC Motor in Cooling System” in this article In recent days power consumption is becoming one of the most important constraints. This paper presents the design and implementation of PI controller using FPGA for the speed control of DC motor in the cooling system. In many industrial applications like Transformer, diesel engine etc., there is need to maintain the temperature to prevent the system from damage. Here the PMDC (Permanent Magnet DC) motor is used to drive the cooling fan in cooling system because they offer several advantages like no field winding, small in size, increase in efficiency [5].

S. Z. Moussav, “Speed Control of Permanent Magnet DC Motor by using Combination of Adaptive Controller and Fuzzy Controller” in this article A novel controller based on adaptive controller and fuzzy controller for Permanent Magnet Direct Current motor is proposed in this paper. The proposed controller is compared with adaptive controller and fuzzy controller for PMDC motor. By means of simulation in MATLAB, we concluded that the proposed controller will be achieved the shorter settling time and also lower overshoot and steady state error[6].

Shatori Meadows1, Arbin Ebrahim2, “Speed and Torque Control of Mechanically Coupled Permanent Magnet Direct Current Motor” A new controller is designed for speed and torque control of a Permanent Magnet DC motor based on measurements of speed and current. This research work focuses on investigating the effects of control of the speed and torque of two brushless dc motors that are mechanically coupled. Two controller design methods: the Root Locus method and Bode Plot method as well as two controllers: Proportional-Integral-Derivative (PID) and Proportional-Integral (PI) are used to obtain the control objectives of speed control and torque control. The simulation is performed using MATLAB/SIMULINK software [7].

III. DETAILS AND DATA ANALYSIS PMDC

3.1 Mathematical model of PMDC motor

PMDC motor electrical equivalent model is used to obtain the PMDC motor mathematical model. This model consists of the connections between the electrical and mechanical parts of the motor [8]. The electrical

![Figure 1. The electrical model of PMDC motor](image)

Dynamic equations of electrical circuit with Kirchhoff Voltage Law (KVL) from the following equation

\[-V_a(t) + R_a i_a(t) + L_a \frac{d}{dt} i_a(t) + V_b(t) = 0 \quad \ldots \ldots (1)\]

\[\frac{d}{dt} i_a(t) = -\frac{R_a}{L_a} i_a(t) - \frac{K_e}{L_a} \omega_r(t) + \frac{1}{L_a} V_a(t) \quad \ldots \ldots (2)\]

From the moment equation of PMDC motor

\[T_m(t) = K_m i_a(t) \quad \ldots \ldots (3)\]

\[T_m(t) = J \frac{d}{dt} \omega_r(t) + b \omega_r(t) + T_L \quad \ldots \ldots (4)\]
Because there is no load on the motor in the initial condition, load moment was accepted TL = 0. Therefore, Eq. 4 was transformed Eq. 5.

3.2 System Modeling PMDC motor

The transfer function of the PMDC motor was obtained from the state space model is given in Eq. 10. The simulink model of PMDC motor was obtained by using Eq. 1 and Eq.5 and shown in Figure 2. and parameter show in PMDC motor in given in table 1.

\[
\frac{d}{dt} \omega_r(t) - \frac{k_m}{J} i_a(t) - \frac{b}{J} \omega(t) \ldots \ldots (5)
\]

Table 1 Parameters of the PMDC motor [8]

| s.no | Name of parameter          | PMDC motor values         |
|------|---------------------------|---------------------------|
| 1    | inertia moment            | J=0.0243 (kgm2/s2)        |
| 2    | viscous friction          | b= 0.02 (Nms)             |
| 3    | armature resistance       | Ra=3.54 (Ohm)            |
| 4    | armature inductance       | La=0.25 (H)              |
| 5    | back E.M.F. coefficient   | Kc=0.125 (Vs/rad)        |
| 6    | torque coefficient        | Km=0.125 (Vs/rad)        |

\[
\omega(s) = \frac{K_m}{((sL_a+R_a)(fS+b))+K_mK_c} * V_a(s) \ldots \ldots (10)
\]

IV. DESIGN OF CONTROLLER

4.1 PID Controller

A Proportional Integral Derivative controller is a generic controller widely used in industrial control system. The Proportional term responds instantaneously to the current error. The integral term responds to the accumulation of error providing a slow response that drives the steady state error towards zero. And derivative term responds to the rate at which the error is changing [9-10]
The PID controller is placed in the forward path, so that its output becomes the voltage applied to the motor’s armature. The feedback signal is a velocity, measured by a tachometer. The output velocity signal \( C(t) \) is summed with a reference or command signal \( R(t) \) to form the error signal \( e(t) \). Finally, the error signal is the input to the PID controller.

\[
u = k_p e + k_i \int e \, dt + k_d \frac{de}{dt}
\]

Obtaining any open loop response and determining what needs to be improved.

I. \( K_p \) to improve the rise time and faster control response
II. \( K_d \) to improve the overshoot.
III. \( K_i \) to eliminate the steady state error.

4.2 Fuzzy Controller Design

The traditional control design paradigm is to form a system model and develop control laws. The controller may be modified based on results of testing and experience. Due to difficulties of analysis, many such controllers are linear. The fuzzy controller approach should be reversed to some extent [11-12]. There are specific components characteristic of a fuzzy controller to support a design procedure. Figure 4 shows the controller between the pre-processing block and post-processing block.

![General structure of fuzzy inference system](image)

**Figure 4 General structure of fuzzy inference system**

In this paper FIS model show in fig 5 and This paper Mamdani has been used to implement FLC for the PMDC motor. FLC contains three basic parts: Fuzzification, Base rule, and Defuzzification.

![FIS fuzzy system](image)

**Figure 5 FIS fuzzy system**
**Fuzzification** - The Fuzzy set of the Error input which contains 5 memberships is shown in Figure 6. Figure 7 illustrates the Fuzzy set of the Change Error input which contains 5 Triangular memberships. Figure 8 illustrates the Fuzzy set of the output which contains 5 Triangular memberships.

**Figure 6 Membership function for error**

**Figure 7 Membership function for change of error**

**Figure 8 Membership function for output**

**Control Rules** - Figure 9 presents rule editor the knowledge base defining the rules for the desired relationship between the input and output.
Defuzzification - The center of gravity “centroid” method was used in this paper. Figure 11 shows the Simulink block diagram for the Fuzzy speed controller for PMDC motor. The controller has been tested using Simulink in Matlab. The result of Fuzzy controller is shown in Figure 12.

V. RESULTS AND DISCUSSION

In this paper Real parameters are used in Simulink model of PMDC motor, After that the various types of the PID controllers to the Simulink model of PMDC motor with same parameter and find out the Simulink responses for with PID and fuzzy controller. MATLAB Combined simulink model show in the given figure.
We simulate all the three Simulink models i.e. without using any controller, using PID controller and using fuzzy logic. Then we combine all the three responses in a single plot is 12. Comparative response given in table 2 the response obtained by the DC motor speed analysis is shown below.

**Table 2** Percentage of improvement of PID-like FLC over conventional PID controller

| Tuning Method                     | Settling (seconds) | Overshoot (%) |
|-----------------------------------|--------------------|---------------|
| without using any controller [8]  | 3.5                | 50            |
| Proportional integral Controller [8]| 4.0                | 20            |
| using PID controller [8]          | 1.0                | 5.9           |
| Using fuzzy Controller            | 1.44               | 0.0866        |

**VI. CONCLUSIONS**

In this paper speed controlling technique of PMDC motor by NO used controller, used PID controller and fuzzy controller used is presented. Obtained through simulation of PMDC motor, the results show that the proposed controller can perform an efficient result. It shows higher flexibility, control, better dynamic and static performance compared with conventional controller and PID controller. Moreover it satisfies the design parameters as mentioned above with conventional controller and PID controller. Moreover, it satisfies the design parameters as mentioned above. Thus Fuzzy Logic Controller is the preferred choice for the controlling the speed response of the DC Motor.

**REFERENCES**

[1] C.Agees Kumar, “Multi-Objective PI Controller Design with an Application to Speed Control of Permanent Magnet DC Motor Drives” IEEE Proceedings of 2011 International Conference on Signal Processing, Communication, Computing and Networking Technologies (ICSCCN 2011).

[2] Adel M. Sharaf, “Optimal Tuning of Tri-Loop Dynamic Error Driven Controller for Industrial PMDC Motor Drives Based on Particle Swarm Optimization-PSO” IEEE 2009.

[3] G.T.P.Naidu1, R.Vijaya Santhi2, I.Nikhil Kumar3, “Design of Fuzzy Pi Controller for the Speed Control of PMDC Motor” International Research Journal of Engineering and Technology (IRJET), Volume: 02 Issue: 06 | Sep-2015

[4] Muaz Abdel Rahman Ismail1, Eltahir Mohamed Heessain2, “Speed Control of PMDC Motor using PID Controller” International Journal of Science and Research (IJSR), Index Copernicus Value (2013).

[5] Purushotam Kumar, Prabhakar Kumar Prabhat, Mithun Kumar, Dr. S.D. Choudhary, “Speed Control of DC Motor Using PID & Smart Controller” International Journal of Scientific & Engineering Research, Volume 5, Issue 11, November-2014.

[6] S. Z. Moussavi, M. Alasvandi, “Speed Control of Permanent Magnet DC Motor by using Combination of Adaptive Controller and Fuzzy Controller” International Journal of Computer Applications (0975 – 8887), Volume 52– No.20, August 2012.
[7] Shatori Meadows1, “Speed and Torque Control of Mechanically Coupled Permanent Magnet Direct Current Motor” ACEEE Int. J. on Control System and Instrumentation, Vol. 4, No. 2, June 2013.

[8] Muhammed Reşit Corapsiz1,a) and Hakan Kahveci2, “The Speed Control of DC Motor under the Load Condition using PI and PID Controllers” Published by the American Institute of Physics, AIP Conference Proceedings 1833, 020116 (2017).

[9] Shikha Singh1, Miloni Ganatra2, Hansa Shingrakhia3, Zalak Patel4, “DC Motor Speed Control with PID Controller: A Review” International Journal of Innovative Research in Computer and Communication Engineering Vol. 5, Issue 5, May 2017.

[10] Oludayo John Oguntoyinbo, “PID Control of Brushless DC Motor and Robot Trajectory Planning and Simulation with MATLAB/SIMULINK,” Degree Program of IT, Vaasa University of Applied Sciences, Finland, December 2009.

[11] Laxmi Sahu1, Nivedita Singh2, “Comparison between Genetic Algorithm based PID Controller and Fuzzy Logic based PD Controller for Position Control of DC Motor in Simulink “International Journal of Science and Research (IJSR). Volume 3 Issue 4, April 2014.

[12] S. Z. Moussavi, M. Alasvandi, “Speed Control of Permanent Magnet DC Motor by using Combination of Adaptive Controller and Fuzzy Controller” International Journal of Computer Applications (0975 – 8887), Volume 52– No.20, August 2012.