International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072

DC MOTOR CONTROL USING PID CONTROLLER

Sagar J. Dahile

B. Tech Student, Dept. Of Electronics and Telecommunication, MITAOE, Maharashtra, India

---***---

Abstract - *This paper presents a comparative study of PID for speed analysis and controlling of PMDC motor. PID controller is one of most common type of feedback controller used in dynamic systems. PID and LQR design based on the optimal control theory. The main aim of these controllers is used to reduce the errors caused due to deviation of speed of PMDC motor. The performance of these controller has been verified through simulation results by using LABVIEW. The proportional-integral-derivative i.e. PID controller & LQR (linear Quadratic Regulator) both have great significance in controlling DC motor. Our project is an attempt to evaluate the performance PID Controller order to control DC motor which will further be used in robotic arm. An efficient PMDC motor was selected for this project. We have used a real time embedded evaluation board- MyRio for rotating motor with the help of National Instruments.*

***Key Words*: Proportional Integral Derivative (PID) Controller, PMDC Motor, Mathematical Modelling of PMDC motor, Speed Control**

1. INTRODUCTION

In industry most of the control algorithms PMDC motors are used. PMDC motors have linear and stable characteristics. There are many methods are available to control or vary the speed of DC motor. Desired performance is obtained by using different control algorithms. To control the speed of DC motor, we required the mathematical modeling of PMDC motor. Every control algorithm is got by using the proper mathematical modeling of PMDC motor. Motor can be modelled by using basic equations of voltage source, induced emf in armature, load torque and total torque delivered by motor. By using input and output function, we get the transfer function of PMDC motor. DC motors are used in industrial control systems. This paper includes PID and LQR control strategies. These controllers are used to determine the performance evaluation for speed control of DC motor. PID is the most used controller till the date because it is cost effective and easy to understand. For accurate tuning the accurate parameters are required. Optimal control provides better response of the system. The DC motor is popular in the industry control area for a long time, because they have many good characteristics, for Example: high start torque characteristics, high response performance and easier to be linear control [1]. DC motor has a good speed control respondence, wide speed control range. it is widely used in speed control systems which need high control requirements, such as rolling mill, high precision digital tools, etc. [4]

2. DC MOTOR MODELING

Mathematical modeling of permanent magnet DC motor is presented in this section. Torque and electrical equations described in [9, Chapter 2] have been considered for derivation of the model. The electrical circuit of the motor is shown in Fig. 1. It can be represented by a voltage source (ea) across the coil of the armature. The electrical equivalent of armature coil can be denoted by an inductance (La) in series with a resistance (Ra) in series with an induced voltage or back electromotive force (emf) (eb) which opposes the voltage source. Rotation of electrical coil through fixed flux lines of permanent magnets generates back emf. A differential equation for the electrical circuit shown in Fig. 1 can be derived by applying Kirchhoff's voltage law. Using Ohm's and Kirchhoff's law the sum of all voltages around a loop

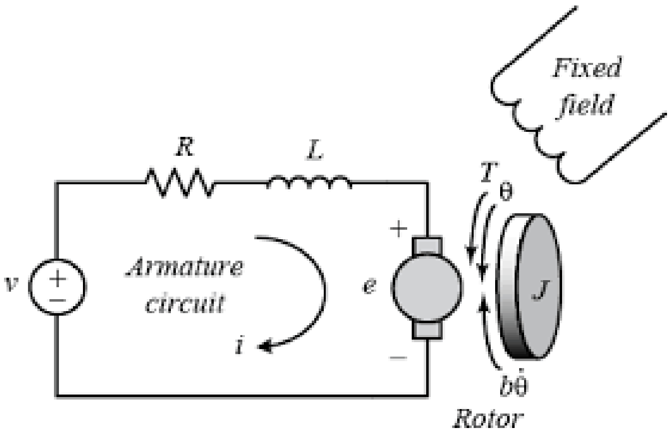

Fig 1: D Motor

The DC motors having parameter are as follows:

- Input Voltage 12V (V)
- DC Motor Electric Resistance (Rm)
- DC Motor Electric Inductance (Lm)
- Moment of Inertia of the Rotor (J)
- Damping ratio of the Mechanical System (B)
- Motor Constant (Km)

$$V\text{-}K_m\theta = R_m i + L_m \frac{di}{dt} \text{ .... } (1)$$

$$J\theta + b\theta = \dot{} K_m \imath - T_l \text{ . ... } (2)$$

Because the back EMF eb is proportional to speed ω directly, then we find the dc motor torque T_m is related to the armature current (I), by a constant factor K_t. The back emf (e_m) is related to the rotational speed by the following equations:

$$e_m = K_e\dot{\theta} \text{ .... } (3)$$

$$T_m = K_t I \text{.................... } (4)$$

Assuming that, (motor torque constant) = (electromotive force constant of dc motor),

Using Laplace Transforms,

$$S\,(J_s + b)\;\dot{\theta}\; K_m I(S) - T_L(s) \text{........... } (5)$$

$$(L_m(s) + R_m)I(S) = V(S) - K_m S\theta\,(S) \text{...... } (6)$$

By eliminating *I(S)* between the two above equations, where the rotational speed is considered the output and the Armature voltage is considered the input. Assuming (load torque) =0, even

Though it will not affect the transfer function.

$$\frac{\dot{\theta}(s)}{V(s)} = \frac{K_m}{(L_m S + R_m)(JS + b) + K_m^2} \text{......... } (7)$$

2.1 CONTROL STRATEGIES

In this section we will discuss closed-loop control of DC motor and design of PID, LQR and MPC controllers. Fig. 2 shows the closed-loop system of DC motor control. In the Fig. 2,

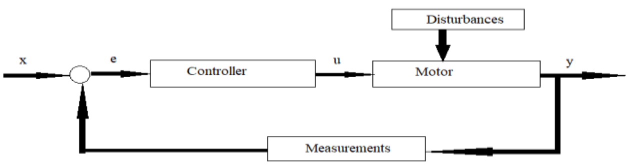

Fig. 2. DC motor control closed loop system block diagram.

3. PID CONTROLLER

The name PID controller stands for Proportional- Integral-Controller. PID controller contains basic algorithms i.e. Proportional mode, Integral mode and Derivative mode.The gain of proportional control is Kp. Proportion controller is directly proportional to error value i.e. difference between process variable and set point.This controller reduce the error but does not eliminate error value. To element the present error, we used Integral controller.In this controller we can adjust the integral time. In the Integral controller the output of controller is directly proportional to the integral of error of error with respect to time. The next mode is Derivative controller. Derivative controller decreases overshoot caused due to integral controllers fast response. Td is the derivative rate time which is used to control the derivative controller action. PID in continuous time form can be stated as

$$u_t = K_p(e_t + \frac{1}{T_1}\int e_t\,dt + T_D\frac{de_t}{dt})\text{....(8)}$$

In order to compare it with other strategies, we need to discretize above equation using a backward difference method to replace derivative term and rectangular integration method to replace the integration term.

4. RESULTS:

PID Controller Fig. 5 shows the response of discrete PID controller without saturation limits on input. It can be seen that the set point is tracked correctly. Also, the response of the system is fast. On the downside, the PID is demanding voltage which is way beyond the 24 V supply provided to the motor.

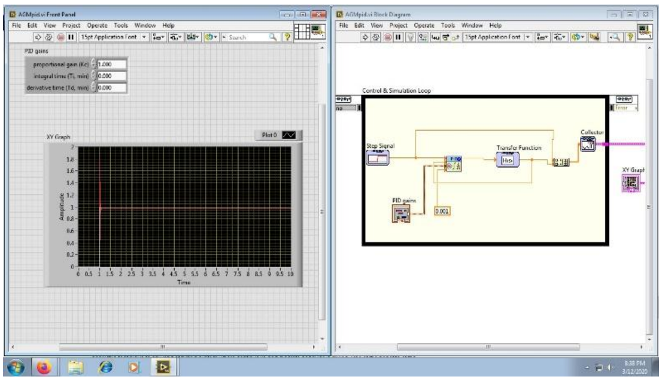

Fig 3: Closed loop response for different value kp

The above plot shows that the proportional controller reduced both the rise time and the steady-state error, increased the overshoot, and decreased the settling time by a small amount.

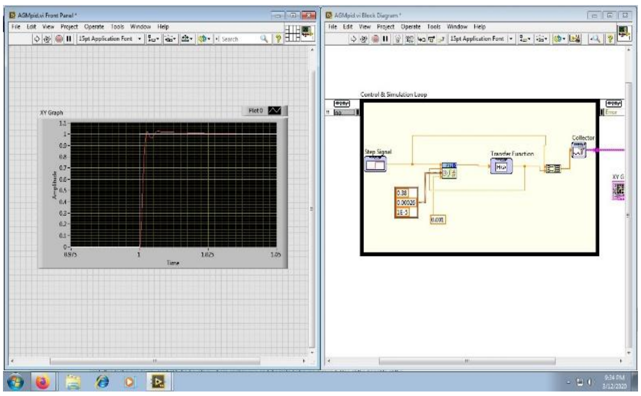

Fig 4: Closed loop response for different value kd

This plot shows that the addition of the derivative term reduced both the overshoot and the settling time, and had a negligible effect on the rise time and the steady-state error.

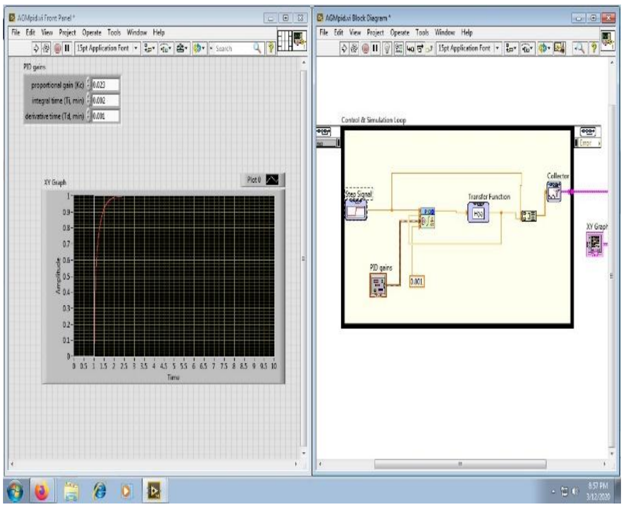

Fig 5: Closed loop response for PID control

Now, we have designed a closed-loop system with no overshoot, fast rise time, and no steady-state error.

5. CONCLUSIONS

In this project at initial state we have learned about the basic control system blocks. We studied about the open loop control system and close loop control system. We also learn about the transient response and steady state response. we have found out the different techniques to check the performance of dc motor control by using PID controller. We learned about the mathematical modelling of dc motor. We studied about the different parameters of dc motor. Mathematical modelling of dc motor includes the different parameters as well as the transfer function of angular speed and the transfer function of angular position. The transfer function of motor is given to the PID controller in the LABWIEW. Technically the Simulink model drawn from transfer function of DC motor and LABWIEW from state space equations are same. DC motor are the unique features possible with state space approach of DC Motor modeling. Manipulation in any of the parameters is also possible while solving differential equation which is useful for implementing.

6. AKNOWLEDGEMENT

Words do not prove to be sufficient to express our gratitude and appreciation to our guide Prashant K. Aher who devoted his time and intellect towards the successful completion of our project feel immense pleasure and heartfelt gratitude towards our guide Prashant Aher for offering us this project and under his prestigious guidance and giving us the opportunity for learning and technical skill development.

I would like to thank Prashant K. Aher and others faculties for giving their valuable time. I would also like to thanks for their constant guidance, suggestion and for imparting valuable knowledge throughout our major project tenure.

At last we must express our sincere heartfelt gratitude to all the staff members of School of electrical engineering who helped us directly or indirectly during this course of work.

REFERENCES

[1] Pratap Vikhe, Neelam Punjabi, Chandrakant Kadu, areal Time DC Motor Speed Control using PID Controller in LabVIEW, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3, Issue 9, September 2014.M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[2] Ramu Krishnan, ˆaElectric motor drives: modeling, analysis, and controlˆa, Prentice Hall, 2001.

[3] S. Khatoon, D. Gupta and L. K. Das, ˆaPID LQR control for a quadrotor: Modeling and simulation, a Advances in Computing, Communications and Informatics (ICACCI), 2014 Inter-national Conference on, New Delhi, pp. 796-802, 2014.

[4] Norman S. Nice, Control System Engineering, John Wiley Son, 2000.

[5] P. Chevrel, L. Sicot and S. Siala, ˆaSwitched LQ controllers for DC motor speed and currentcontrol: a comparison with cascade control,ˆa Power Electronics Specialists Conference, PESCˆa96 Record., 27th Annual IEEE, Baveno, pp. 906-912 vol.1, 1996

[6] Ramu Krishnan, "Electric motor drives: modeling, analysis, and control", Prentice Hall, 2001.

[7] Ermira Buzi, Petraq Marango, "A Comparison of conventional and nonconventional methods of DC motor speed control", IFAC Proceedings Volumes, Volume 46, Issue 8, pp. 50-53, 2013.

[8] P. Dhinakaran, D. Manamalli, "Novel strategies in the Model-based Optimization and Control of Permanent Magnet DC motors", Computers & Electrical Engineering, Volume 44, pp. 34-41, 2015.

[9] Anderson BD., Moore JB., "Optimal control: linear quadratic methods," Courier Corporation, 2007.