

MODELLING AND SIMULATION OF DC MOTOR DRIVEN GEARED SYSTEM USING SIMULINK

Bhushan Mahajan,
Assistant Professor, ICEM, Pune

ABSTRACT

Motors are quite popular for their use of drivers in Mechanical systems to be specific DC motors are used frequently due to ease of speed control and give desired performance characteristic under various conditions. The objective of this paper is to model a DC motor driven geared system and simulate it using Simulink. In addition to this PID controller is used to control the speed of motor. The evaluated equation is combination of motor and gear system. The study gives the transfer function for system under study and response of model for 240volt input with PID as a controller. This will be helpful in robotic arm actuation using motor with gear reduction.

KEYWORDS: DC Motor, Gear system, Simulink, step input, PID controller

I. INTRODUCTION

DC motor is used in various applications robotic manipulators, electric cranes, mills etc. In this paper whole driving system is divided in to two parts, first one is electric motor and second is geared system. Transfer function is formulated using both parts and then tested for no load to full load condition. Deb et al (2017) performed the model analysis of DC motor in MATLAB. This paper provided the frequency domain analysis of a system using bode plot. Aborisade (2014) provided the comparison of PID tuned with Cohen coon method, Ziegler Nicolas method and CHR method. Also dynamic characteristics of response are provided. Singh and Garg (2014) built the mathematical model for DC motor and provided the technique to control the speed of motor. Fuzzy logic controller was applied to the system to control the speed of motor. Results were compared for self-tuned fuzzy controller and GA tuned fuzzy controller. Gupta et al (2014) modelled the six speed hybrid gear box using CATIA and Simscape in MATLAB. Gear Pulley transmission and shift-shaft is developed according to Six speed gear box. Bandana and Gaur (2017) studied the transient behavior of DC motor using MATLAB. They provided the simulation results for armature voltage decrease and armature resistance increase. Rudra and Banerjee (2017) did the dc motor speed regulation using field current control. Field current vs. speed characteristic and torque vs. speed curve was studied by the authors.

II. SIMULINK MODEL OF A DC MOTOR SYSTEM

The modelling is a very important part especially in the engineering control field. In general, the researchers and engineers will create the equation of motion of the system model before focusing to the actual design production. Basically, the mathematical modelling is created in mathematical language to represent and describe the existing model or the model that is going to be constructed.

Main parts of DC motor are stator and rotor. Stator consists of motor housing, magnets, bearings etc. and rotor contains coil through which current flows with the help of commutator. The commutator used to supply current in proper direction. The electric circuit for DC motor is shown in below

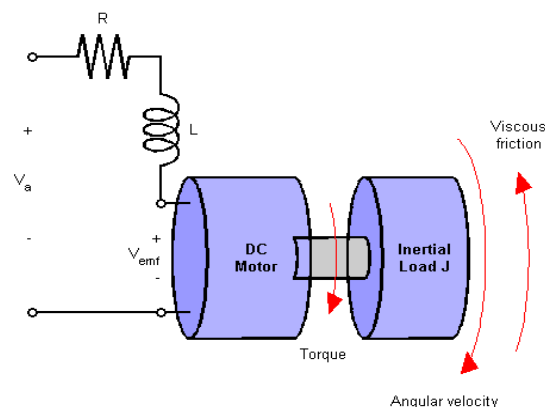


Figure.1 Motor driving the system

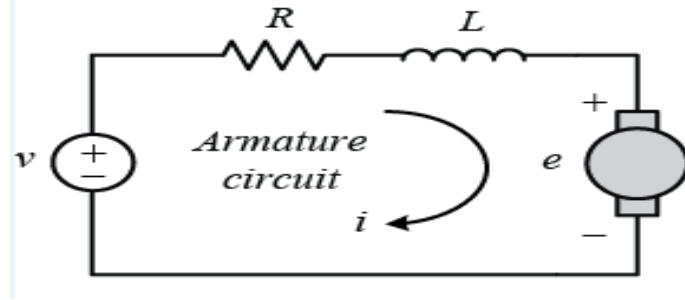


Figure.2 Circuit diagram for DC motor The equations of the DC motor,

$$T = k * i \quad 2.1$$

k = armature coil constant, i = armature current

Using Kirchhoff's law

$$v = L \left(\frac{di}{dt} \right) + R * i + e \quad 2.2$$

L = inductance, R = resistance, e = back emf

By applying Laplace transform,

$$i = (v - k_2 s \theta) / (Ls + R) \quad 2.3$$

Also,

$$T = J(\ddot{\theta}) + F(\dot{\theta}) = k * i \quad 2.4$$

J = inertial torque, F = coefficient of friction

J = Inertial torque, F = frictional coefficient

$$i = ((Js^2 \theta) + Fs \theta) / k_1$$

By combining 2.3 & 2.5,

$$\frac{\theta}{v} = k / ((Ls + R)(Js + F) + k_1 * k_2) s \quad 2.6$$

k_1 & k_2 = constants

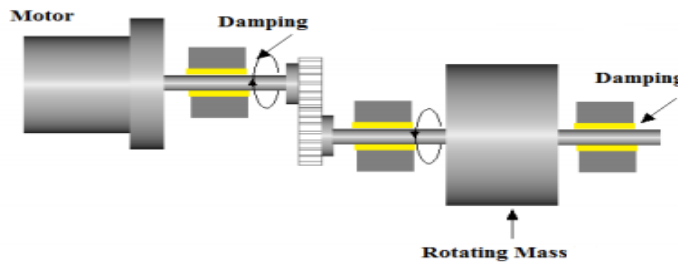


Figure.3 Geared system

The transfer function for gear system is,

$$\frac{\theta_l}{T_o} = \frac{G}{((J_1 + G^2 J_2)s + (F_1 + G^2 F_2))s} \quad 2.7$$

θ_l = load position

If,

$$J_e = (J_1 + G^2 J_2)$$

$$F_e = (F_1 + G^2 F_2)$$

Then,

$$\frac{\theta_l}{T_o} = \frac{G}{((J_e)s + (F_e))s} \quad 2.8$$

The overall transfer function is,

$$\frac{\theta_l}{v_1} = \frac{kG}{((J_e)s + (F_e)) + (Ls + R) + k_1 * k_2) s} \quad 2.9$$

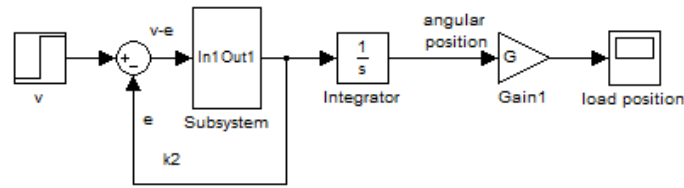


Figure.4 Simulink model

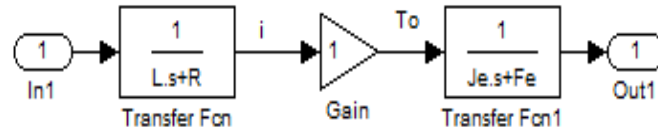
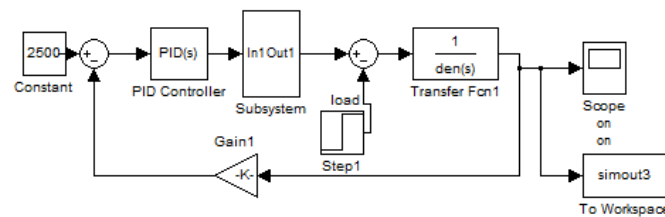


Figure.5 Subsystem



III. SIMULATION

This Simulink model of the system is tested for 240 v input voltage which is provided in the form of step input.

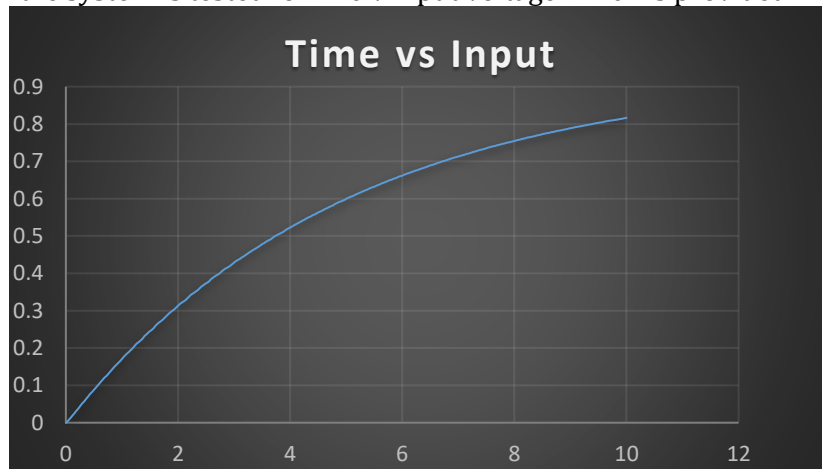


Figure.6 Open loop response

The response given by the model is unstable. Rise time and setting time values are too high. For application of PID controller reference speed is considered as 2500rpm

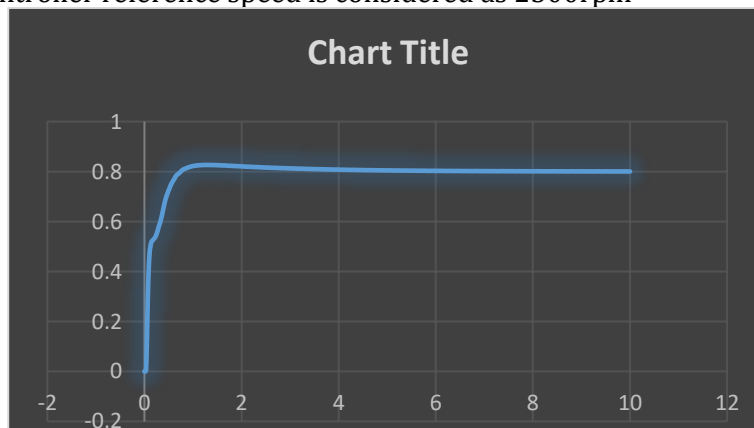


Figure.7 Closed loop response

Due to application of PID controller settling time & Rise time is decreased.

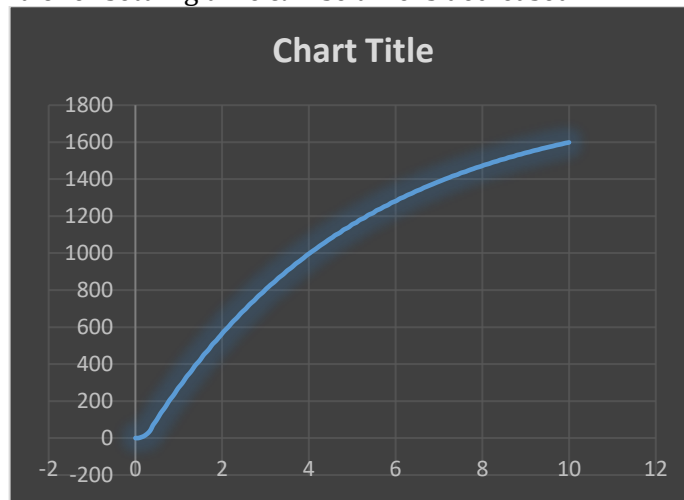


Figure.8 Uncontrolled response with load

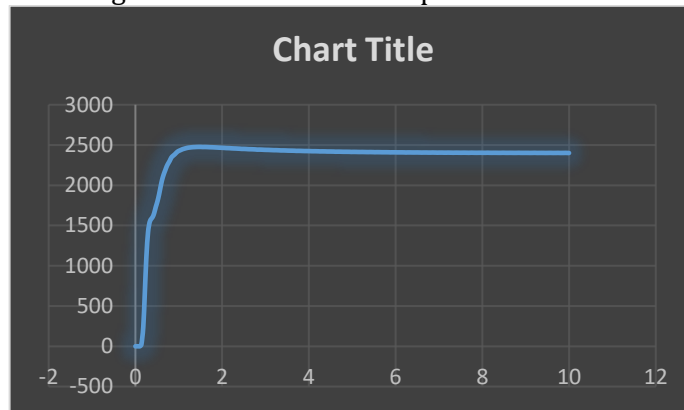


Figure.9 Response of system under load condition with PID

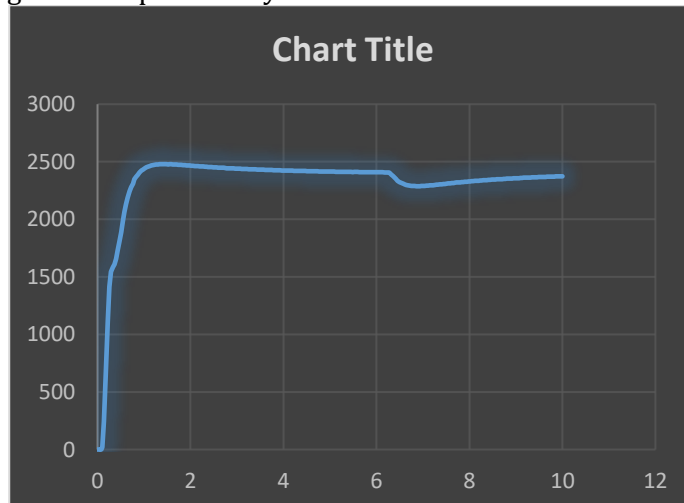


Figure.10 System from no load condition to full load condition

IV. CONCLUSION

- Analytical and Simulink model is constructed successfully.
- Simulation is done using Simulink for open and closed loop response. Settling time is reduced by 70%.
- Uncontrolled and controlled simulation using PID is performed under load conditions.
- System is simulated for no load to full load condition. From no load to full load step, speed is decreased by 200rpm and then again settles.
- As a part of future scope, we can use this system for simulation of robotic gripper actuation or drive system of electric vehicle.

REFERENCES

- 1) Pratyusha Biswas Deb, Oindrila Saha, Sajan Saha, Shaon Paul (2017), "Dynamic Model Analysis of a DC Motor", International Journal of Scientific & Engineering Research, Volume 8, Issue 3.
- 2) Aborisade, David O(2014), "DC Motor with Load Coupled by Gears Speed Control using Modified Ziegler-Nichols Based PID Tunings", Control Theory and Informatics IISTE, Volume 4, Issue 5.
- 3) Vijay Singh and Vijay Kumar Garg (2014), "A Comparative Study on Speed Control of D.C. Motor using Intelligence Techniques", International Journal of Electronic and Electrical Engineering, Volume 7, Issue 4.
- 4) Devesh Ramphal Upadhyay, SandeepSingh Mahesh, Kumar Gupta (2014), "Computational modelling of six speed hybrid gear box and its simulation using MATLAB", International Journal of Engineering Research and Applications, Volume 6, Issue 2.
- 5) Bandana, Sujata Gaur (2017), "Simulation of Transient Behavior of Dc Motor", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Volume 6, Issue 2.
- 6) Rinita Rudra, Rumrum Banerjee (2017), "Modeling and Simulation of DC Motor Speed Regulation by Field Current Control", International Journal of Computer Electrical Engineering, Volume 9, Issue 2.