DC MOTOR SPEED CONTROL DESIGN USING PI CONTROLLER

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Abstract The speed of the separately excited DC motor can be controlled from below and above the rated speed by using buck converter. This paper presents the speed control methodology by varying armature voltage of the DC motor. The chopper gives variable voltage to the armature of the motor for achieving desired speed using Proportional Integral (PI) controller. The reason behind using PI controller is it removes the delay and provides fast control. The modeling of separately excited DC motor is done and the complete layout of DC drive mechanism is obtained. The reference signal is compared with triangular carrier signal and to produce the PWM pulses for chopper switch. The simulation model is constructed in the MATLAB/SIMULINK. The simulated output parameters of the DC motor such as; armature current, voltage, speed, torque, and field current are analyzed.

Keyword. Abstract; Biodata; Conclusion; Data Analysis; etc.,

INTRODUCTION

An electrical drive consists of electric motors, power controller and energy transmitting shaft. In modern electric drive system power electronic converters are used as power controller. Electric drives are mainly of two types: DC drives and AC drives. They differ from each other in this way that the power supply in DC drives is provided by DC motor and power supply in AC drives is provided by AC motor. DC drives are widely used in applications requiring adjustable speed control, frequent starting, and good speed regulation, braking and reversing. Some important applications are paper mills, rolling mills, mine winders, hoists, printing presses, machine tools, traction, textile mills, excavators and cranes. For industrial applications development of high performance motor drives are very essential. DC drives are less costly and less complex than AC drives. DC motors are used extensively in adjustable speed drives and position control system. The speed of DC motors can be adjusted above or below rated speed [1]. Their speed above rated speed is controlled by field flux control and speed below rated speed is controlled by armature voltage. DC motors are widely used in industry because of its low cost, less complex control structure and wide range of speed and torque.

There are various methods of speed control of DC drives – armature voltage control, field flux control and armature resistance control. In this work, the motor speed under and up to the rated speed can be achieved by Changing the Armature voltage. The Armature voltage can be controlled by Using IGBT based chopper. Chopper as power converter and PI as speed and current controller, controlling of DC motor speed is examined. The use of controller is to decrease the error and the error is calculated by Equating output value with the set point.

A chopper is a static power electronic device used to converts stable dc input voltage to a adjustable dc voltage as output. Here we use IGBT Chopper systems which have fast in response, smooth control capability and are very efficient. A IGBT chopper is used to step down or step up the stable dc input voltage. [2][3].

MATHEMATICAL ANALYSIS OF SEPARATELY EXCITED DC MOTOR

When a separately excited dc motor is excited by a field current of If and an armature current of Ia flows in the circuit, the motor develops a back EMF and a torque to balance the load torque at a particular speed. The field current If is independent of the armature current Ia. Each winding is supplied separately. Any change in the armature current has no effect on the field current. The If is generally much less than the Ia.

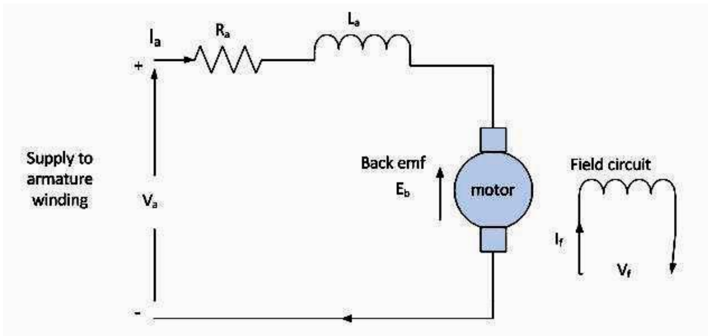

Figure 1. Separately excited DC Motor.

In the above figure 1, suppose Va is the armature voltage in volt, Ia is the armature current in ampere, Eg is the motor back emf in volt, La is the armature inductance in Henry, Ra is the armature resistance in ohm.The armature equation is shown below:

$$Va = E_g + I_a R_a + L_a \frac{dIa}{dt}$$

Now the torque equation will be given by:

$$T_{d=J\frac{dw}{dt}} + B_{w+T_i}$$

Where, T_i is load torque in Nm, is the torque developed in Nm, J is moment of inertia in kg/m², B is friction coefficient of the motor and ω is angular velocity in rad/sec. Assuming absence (negligible) of friction in rotor of motor, it will yield B=0. Therefore, new torque equation will be given by:

$$T_{d=J}{}^{dw}/_{dt} + Ti$$

Equation for back emf of motor will be:

E_g=K ϕ W

Also, T_d=K ϕ I_a

W= (V_a - $I_a R_a$)/K ϕ

Now, from the above equation it is clear that speed of DC motor depends on applied voltage, armature current, armature resistance and field flux. So, there are three ways of controlling speed of DC motor – armature voltage control, armature resistance control and field flux control [4].

SIMULINK MODEL OF DC MOTOR WITH IGBT

The MATLAB simulation model is shown in Figure.2. In that model the IGBT is used as a switch for the best performance of speed control, fast switching and low losses. Here 5HP, 240V, 1750 rpm separately excited DC motor and additionally 300V DC supply is given to the field. To take the constant load of the circuit consider its load 20Kg at constantly. In that simulation, there are four motor parameters are monitored by using displays, such as armature voltage, armature current, torque and speed of the DC Motor. Here the freewheeling diode is to maintain continuous current path in the armature. The discrete PI controller gain is chosen by the trial and error method. In that PI controller output is act as the modulation index of the converter. The relational operator can be comparing the reference signal to the carrier signal.

When the carrier signal voltage is more than reference voltage, that time IGBT go to OFF or 0 state. Otherwise the IGBT maintain the ON or 1 state.

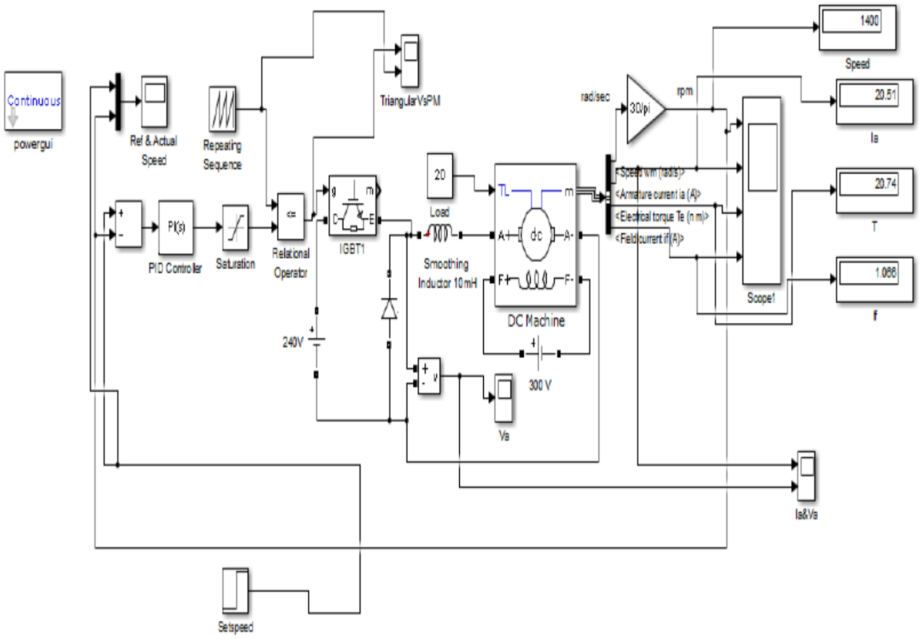

Figure 2 Simulink model of DC motor with IGBT

The Fig.3 shows the PWM Pulse generation for the converter. The outputs of the simulation results are show in Fig 4 .

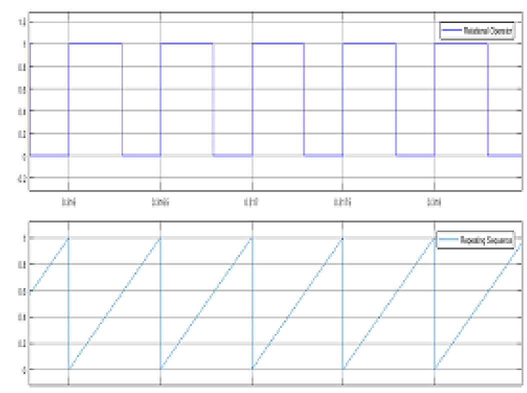

Figure 3 (a) PWM Pulses & Triangular Wave   Figure 4 Speed , Armature current , Torque &Current

The Comparison of Reference speed with the motor speed is shown in figure 5 and the Armature voltage waveform and current wave waveform is shown in figure 6.

Figure 5 Reference speed &Motor Speed

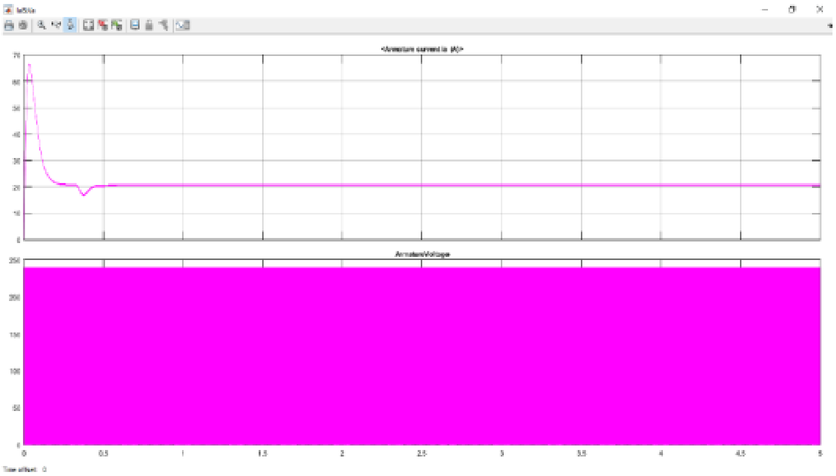

Figure 6 Armature Current &Armature Voltage

SETPOINT TRACKING PERFORMANCE

The Simulink model is tested with various speed for checking the performance. The Simulink model with various speed is shown in figure 7. The Comparison of Reference speed with the motor speed is shown in figure 8.

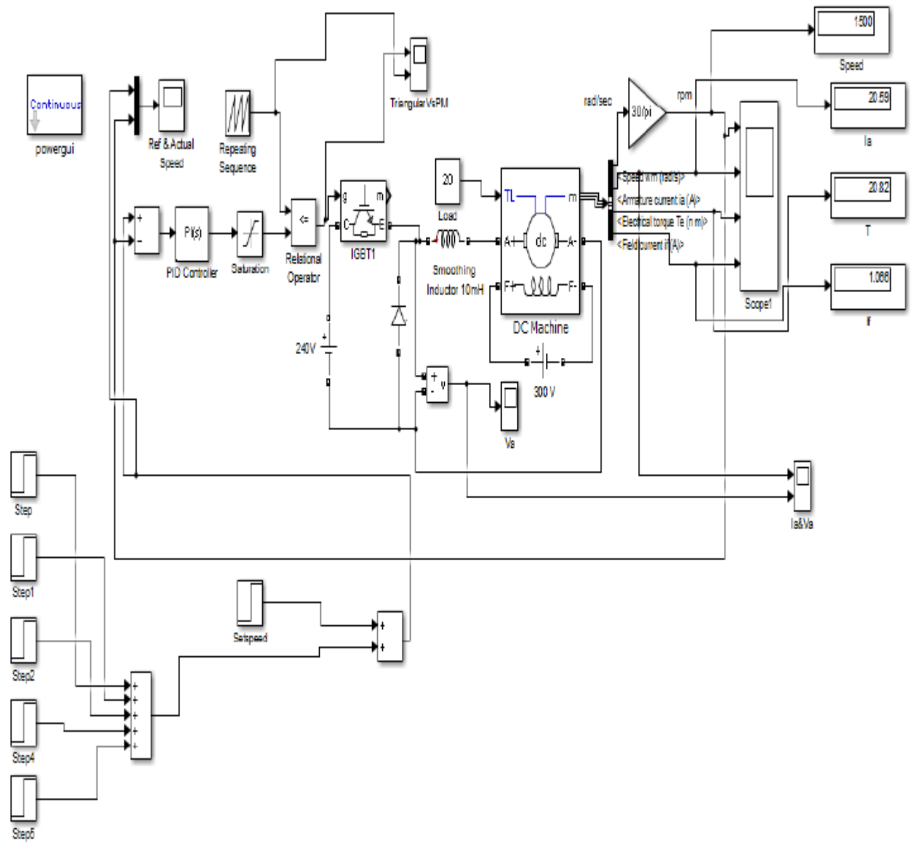

Figure 7 Simulink model with varying speed

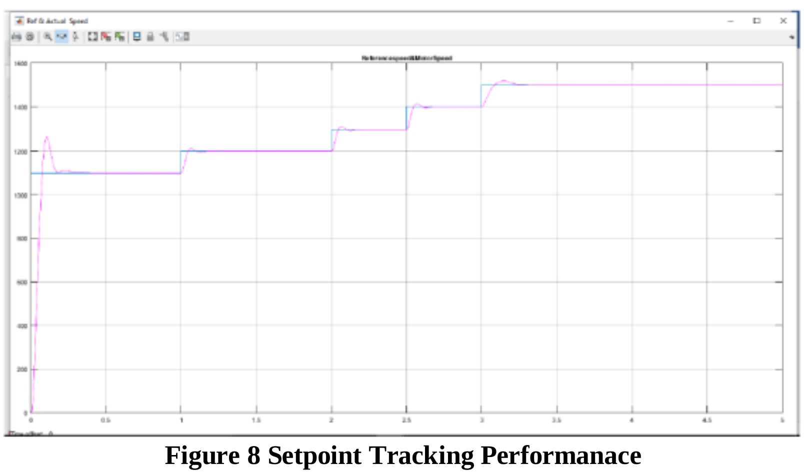

Figure 8 Setpoint Tracking Performanace

From the graph we can understand that the Simulink model is tracking the set point changes and the speed is controlled at the given set point. The outputs of the simulation results are shown in the below figures 9 and the Armature voltage waveform and current wave waveform is shown in figure 10.

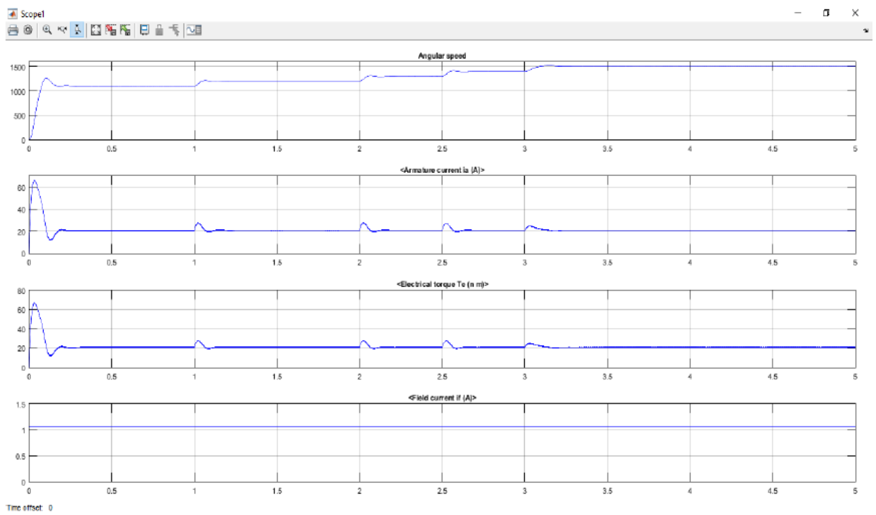

Figure 9 a) Speed (b) Armature current (c)Electrical Torque (d)Field Current for varying set points

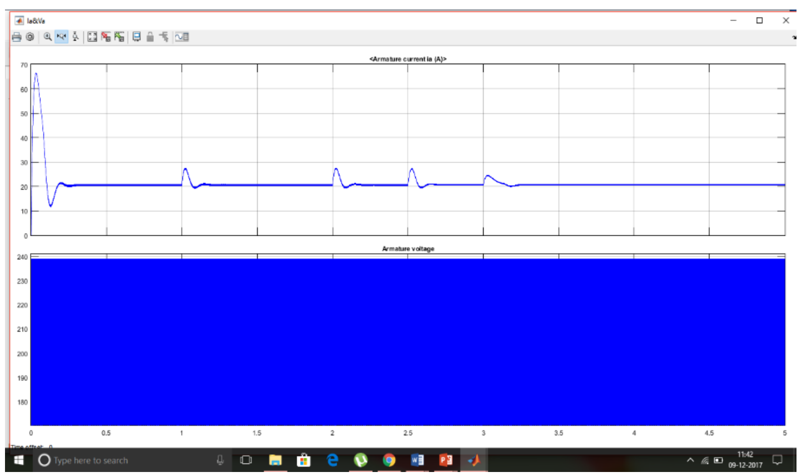

Figure 10Armature Curent &Armature Voltage

We ran the Simulink model for various speed values and we tabulated the results in Table 1.

Table 1 Result Analysis

load	Ref speed	Speed in rpm	Armature current in A	Electrical torque in N-m	Filed current in A
20	1400	1400	20.51	20.74	1.066
20	1200	1200	20.36	20.59	1.066
20	1000	1000	20.24	20.47	1.066
20	800	800	20.14	20.37	1.066
20	600	600	20.07	20.3	1.066

The simulation output creates the constant armature voltage and constant field current that time speed and torque of DC motor also produced constant output.

CONCLUSION

The speed of a dc motor has been successfully controlled by using Chopper as a converter and Proportional-Integral type Speed and Current controller based on the closed loop model of DC motor. Initially a simplified closed loop model for speed control of DC motor is considered and requirement of current controller is studied. Then a generalized modelling of dc motor is done. After that a complete layout of DC drive system is obtained. Then designing of current and speed controller is done. Now the simulation is done in MATLAB under constant load, varying reference speed condition and varying input voltage. The results are also studied and analyzed under above mentioned conditions. The model shows good results under all conditions employed during simulation.

REFERENCES

[1] F Varun ,Ravisekar,David,Avinash, "Speed Control of D.C. MOTOR Using Chopper", International Journal of Electrical and Electronics Research ISSN 2348-6988 (online) Vol. 3, Issue 1, pp: (289-295), Month: January - March 2015.

[2] Kaustubh S. Deshmukh1, Rutuja S Hiware, " Speed Control of DC Motor Using Chopper", International Journal of Science and Research (IJSR),ISSN (Online): 2319-7064, Volume 6 Issue 3, March 2017.

[3] R.Nagarajan, S.Sathishkumar S.Deepika, G.Keerthana, J.K.Kiruthika, R.Nandhini "Implementation of Chopper Fed Speed Control of Separately Excited DC Motor Using PI Controller", International Journal Of Engineering And Computer Science, ISSN:2319 7242,Volume 6 Issue 3, Page No. 20631-20633 ,March 2017

[4] Shivanand Killedar, " Speed Control of DC Motor using Chopper (MATLAB Simulation)", International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE), Volume: 3 Issue: 5,pp:(25-28), ISSN: 2349-7947, May 2016.

[5] Amir faizy,shailendra kumar,Dc motor control using chopper,NIT Rourkela 2011.