International Journal of Research in Engineering, Science and Management
Volume-2, Issue-12, December-2019
www.ijresm.com | ISSN (Online): 2581-5792

Design and Simulation of Speed Control of DC Motor Using Chopper

D. Dinesh Kumar[1], V. Hari Krishna[2], P. Chandana[3], P. Vijaya[4], P. Maheswari[5]
[1]*Associate Professor, Department of Electrical and Electronics Engineering, Audisankara College of Engineering and Technology, Gudur, India*
[2,3,4,5]*UG Student, Department of Electrical and Electronics Engineering, Audisankara College of Engineering and Technology, Gudur, India*

***Abstract*: This projects deals with the speed control of separately excited DC motor with a high performance manner. There are four different quadrants operation of DC motor implement. In this project using chopper as a converter, the speed of a DC motor is to be controlled. We simulate the operation of DC motor in open loop as well as closed loop. As speed control is desired in order to get accurate performance of DC motor, the simulation of model will be done and analyzed in MATLAB under varying condition. A closed loop system brings the motor to the speed set by the user irrespective of load.**

***Keywords*: DC motor, Chopper, IGBT**

1. Introduction

An electrical drive which consists of electric motors. Now a day in modern electric drive system power electronic converters are used as power controller. In drives system it consists of two types: (a) AC drives and (b) DC drives. The speed of DC motors can be adjusted below or above rated speed, when their speed is above rated speed then it controlled by field flux control and when speeds below rated speed then it is controlled by armature voltage. So DC motors are widely used in industry because of its simple and robust control structure and wide range of speed and torque. For the control of DC drive, there are various methods available such as (a) Armature voltage control, (b) Field flux control, (c) Armature resistance control. In Armature voltage control if the supply is dc then speed can be control by chopper control method [1].

2. Chopper

A. *Introduction of Chopper*

A chopper is a power electronic device which is also called as dc-dc converter and it is a static device which converting fixed input dc voltage to variable output dc voltage. Earlier days the choppers were used for converting fixed dc variable dc but due to involvement of multistep conversion it was bulky and insufficient. So the dc choppers are only single step static devices and more efficient and also les bulky than the earlier choppers, and are also available in a lower price so it can be used for a speed control. Now a day's choppers have become very useful component and used in applications like EHV (electric hybrid vehicle), marine hoists, and other transit systems. Due to their regenerative braking facility it is used in the EHV. And also due to this braking facility it is used for the speed control of DC motor in the four quadrant operations. Choppers the efficiency of DC machine increased to a great extent so choppers become in power electronics essential component and modern dc application as a whole of industry employing dc power [2], [4].

B. *Classification of Chopper*

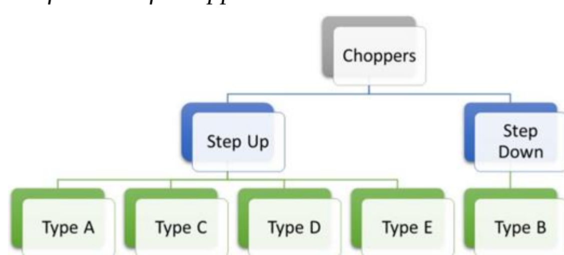

Fig. 1. Chopper

3. Control strategies

A. *Time ratio control*

In this method of control strategies time ratio or duty ratio is varied. And this is done by two different ways called a) Constant frequency system and b) Variable frequency system. We exp lain in details as follows:

1) Constant frequency system

In this scheme of control, on time T_{on} is varied but the chopping frequency id kept constant. So this scheme is called PWM scheme.

2) Variable frequency system

In this scheme of control, chopping frequency f is varied according to the input value and Ton is kept constant or T_{off} is also kept constant, in this method it is called FM scheme.

B. *Current Limit Control*

In this control strategies, the ON and OFF time of the chopper is determined by the value of the Output load current. The maximum and the minimum output load current is dependent on the ON and OFF time of the chopper. In this strategy the chopper is turned on when the output current equals to a present value. The chopper is kept on till output current equals to another present value. The chopping frequency and pulse width are dependent on the load parameters. The advantage of CLC is that the ripple in the load current can be regulated to a small, predetermined value for the wide range of loads. In short for the current limit control we say that when the load current reach upper limit, chopper is switched off and when load current falls below limit, chopper is switched on. Current limit control strategies are more complex due to feedback loop, trigger circuit so PWM technique is chosen for power control in chopper circuit [7].

4. Separately excited dc motor

A. Operation of Separately excited DC motor

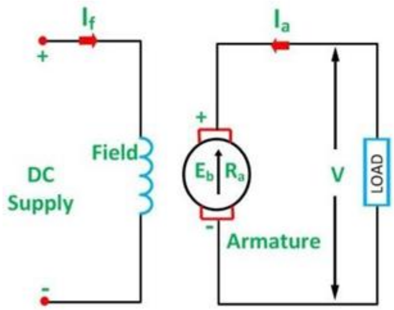

Fig. 3. Operation of separately excited DC motor

- Field and Armature winding with separate supply
- DC source is for the excitation of field winding
- Supply is given to the armature winding
- Rotor torque is produced due to the interaction of armature current and field flux

We see the construction of the separately excited DC motor as from the above circuit diagram, from it the supply is given to the armature and the excitation due to the field current which is given to the field so the armature and field current flows in the circuit, at a desired speed the motor develops back emf and torque to balance the load torque. The one important thing is the armature current and the fields current are independent because of the separate excitation. As name indicates the separately excited so in this dc motor has the armature and field has a separate supply voltage. In field winding the external dc excitation so the fields flux goes to the armature and in armature winding the current flows through brushes and commutators. so back emf and torque develop due to the motor [6].

B. Mathematical Analysis of separately excited DC motor

Field and Armature equations:

Instantaneous field current:

$$V_f = R_f I_f + L_f \frac{d_{if}}{d_t} \quad (1)$$

Instantaneous armature current:

$$V_a = R_a I_a + L_a \frac{d_{ia}}{d_t} + e_g \quad (2)$$

e_g =back emf, it is expressed as,

$$e_g = K_v \omega I_f \quad (3)$$

K_v = motor voltage constant

ω = motor speed

The torque equation will be given by:

$$T_d = J\frac{d_w}{d_t} + B_w + T_l \quad (4)$$

T_d = Torque developed in Nm

J= Moment of inertia Kg/m*m

T_l= Load torque in Nm

B= viscous friction coefficient

Assume negligible of friction so, B=0

$$T_d = J\frac{d_w}{d_t} + T_l \quad (5)$$

So, back emf equation will be:

$$E_g = K\emptyset W \quad (6)$$

Also,

$$T_d = K\emptyset I_a \quad (7)$$

$$\omega = (V_a - I_a R_a)/K\emptyset \quad (8)$$

So, From the above equation it is clear that the speed control of dc motor depends on armature current, armature resistance, field flux and the applied armature voltage. So after this equation as we describe and know that the different methods of speed control [11].

Steady State Torque and speed equations:

The motor speed,

$$\omega = \frac{(V_a - I_a R_a)}{K_v I_f} \quad (9)$$

Here is a small value and when motor is lightly loaded, is small,

$$\omega = \frac{(V_a)}{K_v I_f} \quad (10)$$

If the field current is kept constant,

The developed torque is:

$$T_d = K I_a I_f = B\omega + T_l \quad (11)$$

So the power required is:

$$P_d = \omega T_d \quad (12)$$

5. Application

For the Application purpose, DC drives are widely used for adjustable speed control, frequent starting, better speed regulation, braking and reversing. And the DC drives are also used for some important application such as paper mills, mine winders, hoists, elevators, printing presses, traction, textile mills, machine tools, cranes and rolling mills. For the industrial applications development of high performance motor drives are very essential. DC drives are less costly and less complex as compared to the AC drives, so it is widely used in industrial applications.

6. Conclusion

The speed of a separately excited DC motor can be controlled using two types of loop configuration such as open loop speed control and closed loop speed control technique. Here the speed of DC motor can is control in the forward motoring first quadrant open loop operation using ideal switch. The simulation results under varying the load armature current and voltage are also studied and analyzed.

Acknowledgment

First of all, I would like to thanks you to our Institute guides and advisor, Mr. Krunal Shah, Assistant professor, for their invaluable guidance and moral support, encouragement and patience throughout the UDP work. We also thanks to all faculty members and staff members for offering us all kind of support and help in this work.

References

[1] Muhammad H. Rashid, "Power Electronics- Circuits, Devices and Applications –Converters, Applications and Design", Prentice Hall of India, 3rd edition. 2009.
[2] Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics- Converters, Applications and Design", John Wiley's & sons, Inc., 3rd ed., 2003.
[3] Dubey G.K., fundamentals of Electrical Drives, New Delhi, Narosa Publishing House, 2009.
[4] Bose B.K., Power Electronics and motor drives recent technology advances, proceedings of the IEEE international symposium on industrial electronics, IEEE, 2002, pp. 22-25.
[5] Bimbhra. P.S., Power Electronics, New Delhi, Khanna Publishers, 2006.
[6] Rishabh Abhinav, Jaya Masand, Neha Gupta, "Separately Excited DC Motor speed control using four quadrant operation"., Volume 4, Issue 1, January 2013.
[7] Prajawal Reddy, javeed Kittur, Pavan Patil, "Open loop and Closed loop speed control of separately excited DC motor", MJRET, 2015.
[8] Nazanin Afrasiabi, Mohammadreza Yazdi, "DC motor control using chopper", GJSET, Issue 8, 2013, pp. 67-73.
[9] Moleykutty George, "Speed control of separately excited DC motor"., AJAS 5(3); 227-233, 2008.
[10] Varun Rohit Vadapalli, David Samson, N. Aninash, "Speed control of DC motor using chopper"., Vol. 3, Issue 1, pp. 289-295, January-March 2015.