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Speed Control of DC Motor Using Chopper

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Abstract: ***The Objective of the paper is to control the separately excited dc motor by using the IGBT based chopper. The speed of separately excited dc motor can be control by varying the armature voltage and varying field flux. Thus the speed can be controlled for under rated speed and speed beyond the rated speed, respectively. In this paper, the motor speed under and up to the rated speed can be achieved by varying the Armature voltage. IGBT based chopper Controls the Armature voltage. The IGBT chopper takes signal from controller and Adjustable voltage is given to the armature of dc motor as per the wanted speed. The advantages to employee this technique is that the Speed varies equivalently with armature voltage and varies inversely with field voltage by keeping field and armature voltage persistent respectively. The IGBT employed chopper i.e. power module gives smoother control as compared with the SCR based circuit. By using this system, we can chop the frequency and speed of DC motor can be control***

Keywords:

1. Introduction

Variable speed applications are gradually increases in industrial sector. Therefore it is important to create high performance, high flexible electrical drives. Electrical motor, Power controller and energy transmitting medium are the main Parts of Electrical drives. Nowadays, power electronics converter are cast instates of power controller. High performance motor drive system has special features such as good dynamic speed command and load regulating reaction. Electric drives are groups as: DC drives system and AC drives system. DC drives are usually used than AC drives, in applications such as, good speed regulation adjustable speed control, braking and reversing frequent starting. Some important applications are mine winders, paper mills, hoists, rolling mills, printing presses, traction, machine tools, textile mills, cranes, excavators. DC motors are used widely in position control system and variable speed drives.

There are number of methods of speed control of DC drives – armature voltage control, armature resistance control and field flux control. In this paper, 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 Equaling 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. DC Motor

When the wide speed range of control is needed, the DC motors are employed.The major use of DC motors are in position control and variable-speed applications. The techniques of speed control for DC motors are less expensive and simpler than the AC motors. Separately excited dc motor has armature and field winding. It requires separate supply voltage. Field flux is supplied by field winding to armature. The current immediately flows to the armature winding, when the supply is applied to the motor, through the brushes and commutator. The rotor is positioned in magnetic field and it is also carrying current. The back EMF and a torque are produced by motor, a torque stabilizes the load torque at specific speed. When the field current and armature current flows in circuit, it excites the DC motor, thus develops the back EMF and torque. The armature current is independent of The field current. The field and armature winding are supplied separately. Any variation in the armature current has no influence on the field current. The field current are generally minimum than armature current. Suppose, Ia is the armature current in ampere, Va is the armature voltage in volt, Eg is the motor back emf in volt, Ra is the armature resistance in ohm, La is the armature inductance in Henry.

The armature voltage equation is shown below:

$$V_a = E_g + I_a R_a + L_a \frac{dI_a}{dt}$$

The Torque equation is given as,

$$T_d = J\frac{dw}{dt} + B_w + T_l.$$

Equation for back EMF of motor is given as,

$$E_g = K \Phi W$$

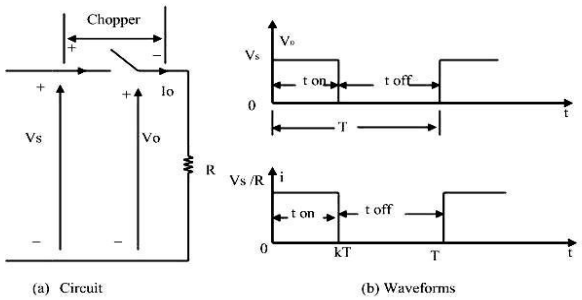
$$\text{Also, } T_d = K \Phi I_a$$

$$w = (V_a - I_a R_a)/ K \Phi$$

Thus from the above equations, we observe that the speed of DC motor be influenced by armature current, applied voltage, field flux, and armature resistance. So we can control the speed of motor by- armature resistance control, armature voltage control, and field flux control.

3. Chopper

A chopper is a static power electronic device which changes stable dc input voltage to a adjustable dc voltage. chopper is used to step down or step up the stable dc input voltage. Chopper systems offer high efficiency, regeneration facility, smooth control, and faster response. There are some power semiconductor devices used in a chopper circuit. They are force commutated thyristor, MOSFET, BJT, GTO and IGBT But from the above switching devices, GTO and IGBT are broadly used. These semiconductor devices are generally denoted by a switch. No current will flow, when the switch is OFF, and when switch is ON, the Current will flows through the load. In this paper, we cast the IGBT as switch in chopper circuit. IGBT employed chopper gives fast Switching, more efficiency, less switching losses. The ON and OFF state of semiconductor switch i.e. IGBT switch which is high in speed. It connects and disconnect, the source to load and the load from source respectively, at a fast speed. As shown in Fig1. When the switch is turning ON state i.e. Ton, chopper is turn ON and Output voltage and source voltage are equal. When the switch is turn OFF i.e. Toff, chopper is off and load voltage is zero. In this way, we obtaind the chopped dc voltage at the load terminals.



3.1 Chopper circuit diagram and its voltage and current waveform

Also, $V_0 = f * T_{on} * V_s$

$T_{on} = on\ time \quad T_{off} =$ off-time.

$T = T_{on} + T_{off} =$ Chopping period.

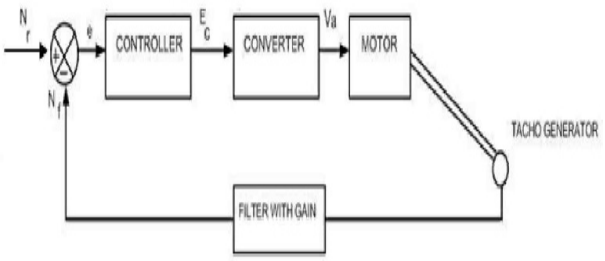
$\alpha = T_{on}/T_{off}$, $f = 1/T$ = chopping frequency.

Thus the voltage can be controlled by varying duty cycle α

$V_0 = f^* T_{on} * V_s$

4. Modeling Of DC Motor

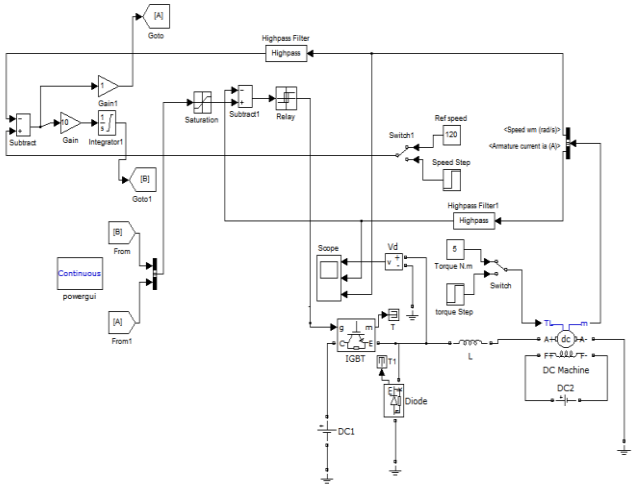
The basic principle of speed control of DC motor is that the output speed of DC motor can be change by changing the armature voltage for speed under and upto the rated speed. The field voltage is kept stable. The output speed is matched with the reference speed and if error is occurred than error signal is fed to speed controller. Controller will compare the result, and thus output will Vary whenever there is a change in the base speed and the speed feedback. The control voltage that controls the operation duty cycle of converter, which is control by speed controller. The converter output provides the variable voltage essential to bring motor back to the desired speed. The Reference speed is delivered through a potential divider. The voltage from potential divider is linearly linked to the speed of the DC motor. The output speed of motor is shown by Tachogenerator. Result of Tacho will not be perfectly dc and contains some ripple. So, we employed a filter to bring Tacho output controller level. The block diagram for DC motor speed control is show below:



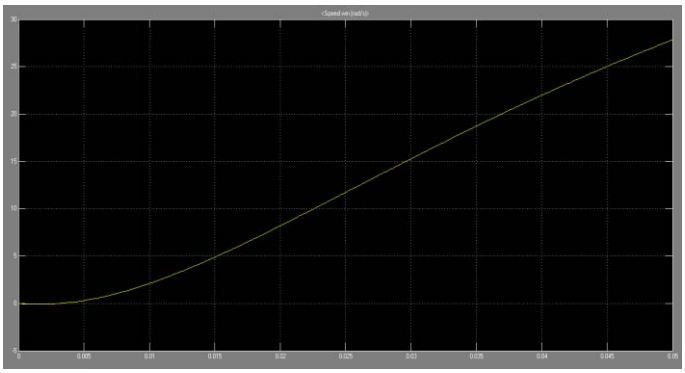
5. MATLAB Simulation and Results

In this paper, we analyzed the speed control of D.C.MOTOR by using current and speed controller

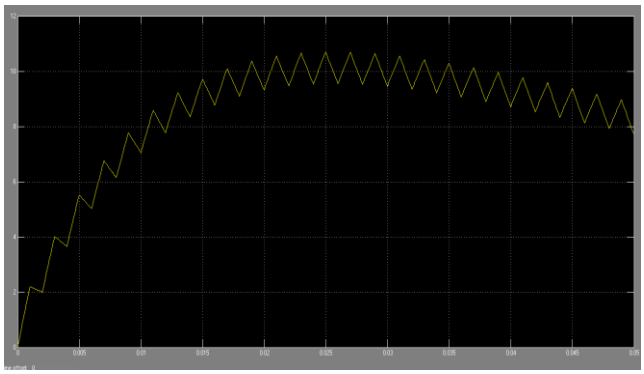
5.1 Simulation of closed loop model of chopper with dc machine



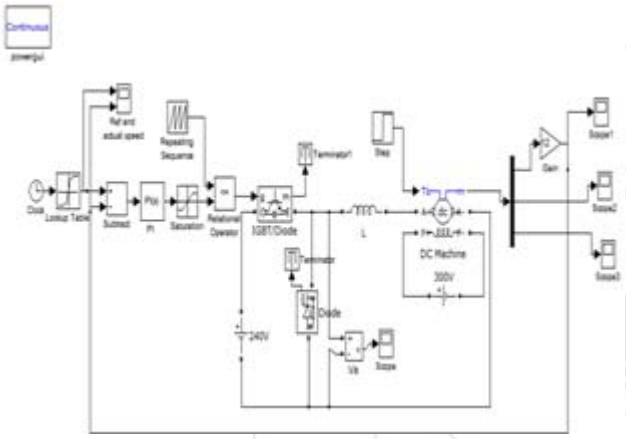
5.1.1 Result for Speed



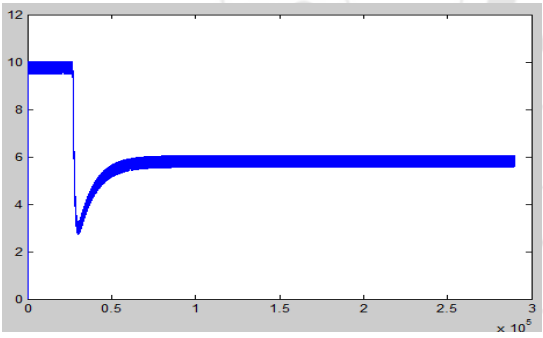
5.1.2 Result for Current



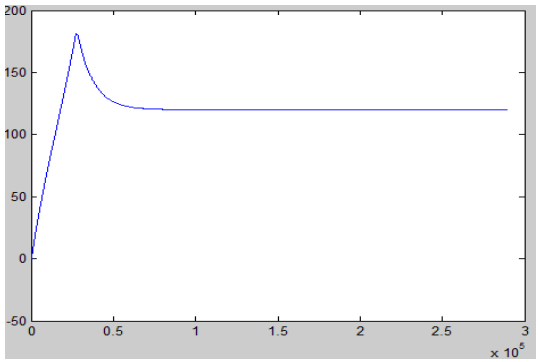
5.2 Simulation of Generalized Model For Speed Control OF DC MOTOR



5.2.1 Armature current waveform



5.2.2 Speed waveform



6. Conclusion

The DC motor speed control has been successfully analyzed using chopper as a power controller and Speed and Current controller (Proportional-Integral type) based on the closed loop model of DC motor. Initially a simplified open loop model for DC motor is studied and then closed loop model is considered and required of current controller is studied. Then a generalized modelling for speed control of dc motor is done and analyzed. The simulation is done in MATLAB under changing load condition, changing reference speed condition and changing input voltage. The results obtained are analyzed. The DC motor speed control is completed, for rated and under rated speed by changing the armature voltage.

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