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SPEED CONTROL OF SEPARATELY EXCITED DC MOTOR USING POWER ELECTRONIC CONVERTER

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ABSTRACT

In a modern technology the use of power electronic devices in the control strategies of electrical drives is increasing. The speed of a DC motor can be varied by controlling the field flux, the armature resistance or the terminal voltage applied to the armature circuit. The three most common speed control methods are field resistance control, armature voltage control, and armature resistance control. But here a technique of drive has been used for DC motor's speed control is chopper and some power electronics devices. It has been shown here the use of chopper and power electronics devices which paves the way of controlling also torque and speed characteristics of DC motor. Now the simulation of model is done and analysed in MATLAB (Simulink) under varying speed and torque condition

KEYWORDS- *Separately excited DC motor, Buck converter, snubber Circuit MATLAB(Simulink)*

INTRODUCTION

As there are two methods of speed control of DC Motor these are Field control method and Armature control method. Smooth Control of speed may not be obtained by using these methods. But in the modern technologies there is much advancement in Power electronics devices. A chopper is a static power electronic device which converts fixed dc input voltage to a variable dc output voltage. It can be step up or step down. It is also considered as a dc equivalent of an ac transformer since they behave in an identical manner. Chopper systems offer smooth control, high efficiency, faster response and regeneration facility. The power semiconductor devices used for a chopper circuit can be force commutated thyristor, BJT, MOSFET, IGBT and GTO. Among above switches IGBT MOSFET and GTO are widely used. These devices are generally represented by a switch.

A. Separately excited dc motor

Separately excited dc motor has field and armature winding with separate supply voltage. Field winding supplies field flux to armature. When DC voltage is applied to motor, current is fed to the armature winding through brushes and commutator. Since rotor is placed in magnetic field and it is carrying current also. So motor will develops a back emf and a torque to balance load torque at particular speed.

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*.

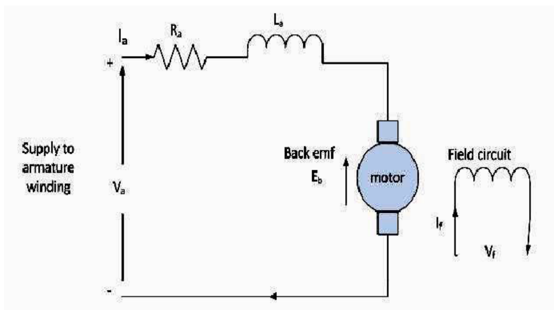

Figure 1: Schematic Diagram of a separately excited DC Motor

Table1: Specifications of Separately excited DC motor

Parameter	**Value**
Nominal Armature Voltage	220V
Nominal Field Voltage	120 V
Nominal Armature Current	3.5 A
Nominal Field Current	0.4473 A
Armature Resistance	8.415 Ω
Armature Inductance	0.08717 H
Field Resistance	286.2 Ω
Field Inductance	5.91 H
Mutual Inductance	1.534 H
Nominal Angular Speed	280 rad/sec
Nominal Torque	2.26 N.m

B. Buck chopper

A chopper is a static power electronic device which converts fixed dc input voltage to a variable dc output voltage. It can be step up or step down. It is also considered as a dc equivalent of an ac transformer since they behave in an identical manner. Due to its one stage conversion, choppers are more efficient and are now being used all over the world for rapid transit systems, in marine hoist, in trolley cars, in mine haulers and in forklift trucks etc. The future electric automobiles are likely to use choppers for their speed control and braking. Chopper systems offer smooth control, high efficiency, faster response and regeneration facility.

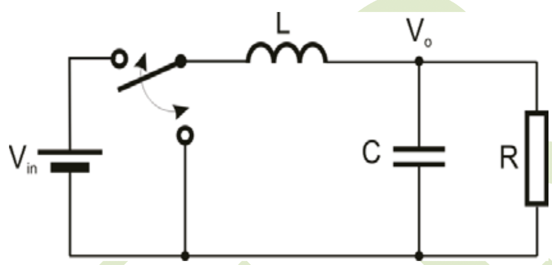

Figure 2: Buck chopper

The power semiconductor devices used for a chopper circuit can be force commutated thyristor, BJT, MOSFET, IGBT and GTO. These devices are generally represented by a switch. When the switch is OFF, no current will flow. Current flows through the load when switch is ON. The power semiconductor devices have on-state voltage drop of 0.5V to 2.5V across them. For the sake of simplicity, this voltage drop across these devices is generally neglected. During Period Ton, Chopper is ON and load voltage is equal to source voltage Vs. During the interval Toff ,chopper is OFF, load current flows through the freewheeling diode FD. As a result, load terminals are short circuited by FD and load voltage is therefore, zero during Toff. During Ton, load current rises whereas during Toff load current decays.

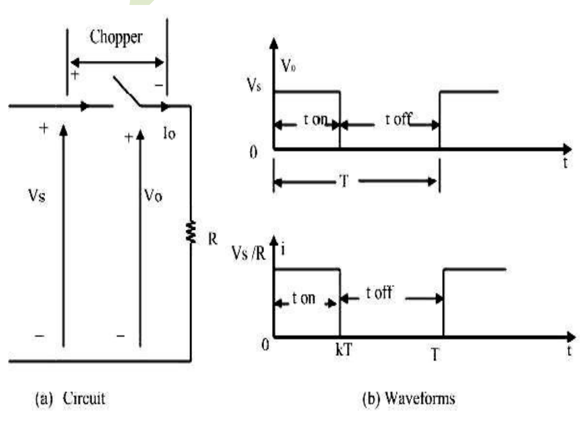

Figure 3: Operation of chopper and its waveforms

Average load voltage Vo is given by

$$V_o=V_s*(T_{on}/T)$$

$$\alpha= T_{on}/T$$

$$T=T_{on} +T_{off}$$

Where, α=duty cycle

Thus load voltage can be controlled by varying duty cycle.

$$V_{o=}\ V_{s*}\ F*T_{on}$$

Where F = chopping frequency

B. RC snubber

Snubbers are energy absorbing circuits used to suppress the voltage spikes caused by the circuit's inductance when a switch, electrical or mechanical , opens. The most common snubber circuit is a capacitor and resistor connected in series across the switch(transistor).The amount of energy the snubber resistance is to dissipate is the amount of energy stored in the snubber capacitor. The snubber capacitance has to met two requirements. First the energy stored in the snubber capacitor must be greater than the energy in circuit's inductance.

$$1/2 *C(V_o)^2>1/2*LI^2$$

$$C > LI^2 /(V_o)^2$$

where,

V_o= open circuit voltage

I=closed loop circuit current

V=Circuit Impedance

Secondly, the time constant of the snubber circuit should be small compared to the shortest ON time expected, usually 10% of the on time.

C. MATLAB Simulation and Results

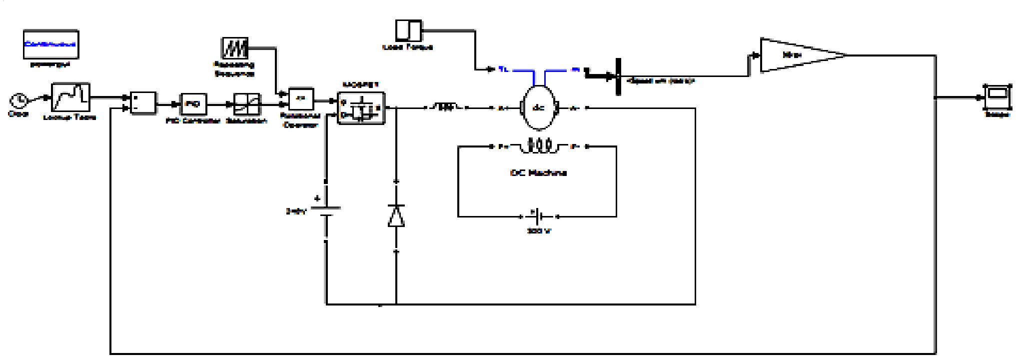

Figure 4: Simulation of speed control of dc motor using chopper

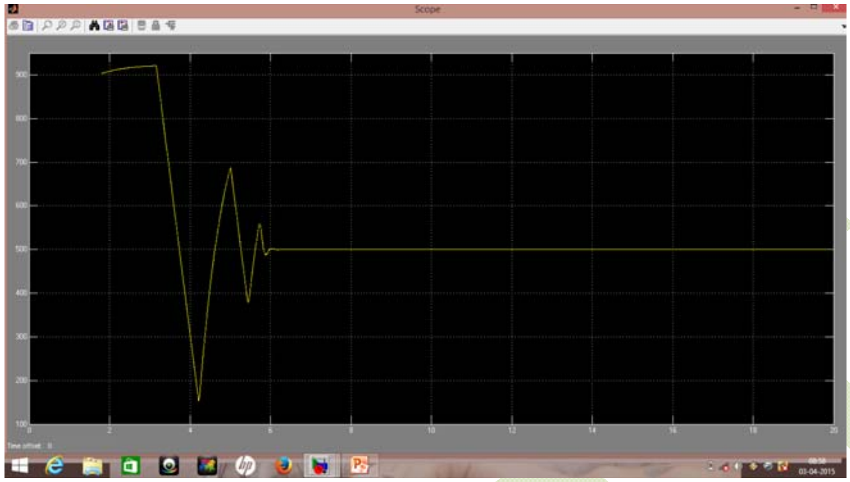

Figure 5: Waveform of speed Vs time

CONCLUSION

The armature voltage is controlled by varying time period of MOSFET. The speed below rated is thus controlled by varying armature voltage. Chopper systems offer smooth control, high efficiency, faster response and regeneration facility.

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