Speed Control of DC Motor Using MOSFET Based Chopper

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***Abstract*-The dc motor is the backbone of industrial applications. The dc motors are used as an adjustable speed machine for this wide range of option is evolved. The four main reasons for the usage of dc motors are reliability, simplicity and favorable cost. At the same time the dc motor drive is less complex compare to ac motor drives. In this project the mathematical model for the speed control of dc motor using mosfet based chopper is designed and tested through the MATLAB/Simulink software.**

***Keywords*-DC motor, Speed control, DC chopper, separately excited DC motor and current limit control.**

I.INTRODUCTION

A static device which converts fixed dc to variable dc voltage is known as dc chopper. Because of low price, less weight and more efficiency the single step static devices are used. In modern dc application the dc chopper has become a key component. The efficiency of the dc machine has increased due to the usage of dc chopper and also it has become the essential component of rapid transit systems. In the overall dc chopper circuit the power semiconductor devices like MOSFET or IGBT or GTO are used. The current limit control and time ratio control are the two modes exist in dc chopper. These two modes help in varying duty cycle of the system in order to get the required output voltage. Here current limit control method is used for dc chopper. The previous set value of the load current is used to operate {on/off} the chopper circuit. The minimum and maximum values of load current are set. The load current goes below the limit. Then the dc chopper is switched on. Whenever the load current gets the maximum limit current then dc chopper is switched off. At the same time by setting the value of current {maximum/minimum} it is possible to control the frequency of chopper. In general on the basis of dc motor excitation the dc motor are classified into two types. They are separately excited and self excited dc motor. In this project we used separately excited dc motor. Hence its field winding and armature are excited from two different sources. The fundamental of electric drives, power electronic circuits, devices and application are explained in detail [1-3].

II.WORKING PRINCIPLE OF DC CHOPPER

The dc chopper is a high speed on and off switching devices. Therefore basic operation of dc chopper is to connect and disconnect the load from source at a great speed. Hence we obtained a chopped dc voltage from a constant dc voltage.

In dc chopper operation we can observe two time period. They are ton and toff. During ton we get constant source voltage {Vs} across load during toff we get zero voltage across load. Likewise we obtain dc voltage in the dc chopper load terminal. DC motor speed control and dc chopper are presented in detail by s.n.singh, a.k.dewangan and n.afrasiabi [4-6].

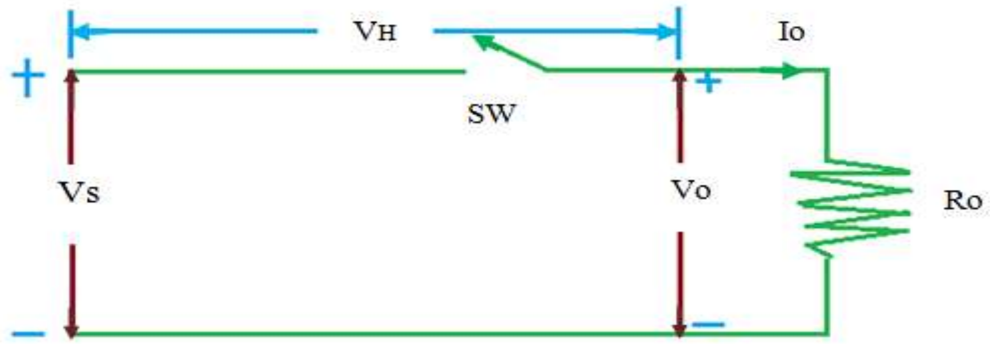

Figure {1} Basic Chopper Circuit

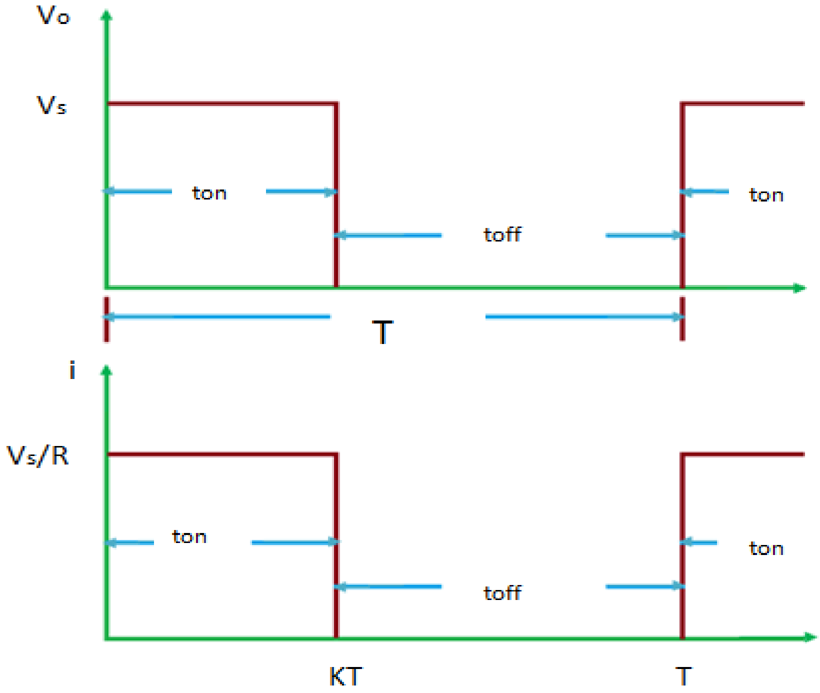

Figure {2} Voltage Waveform

V_0 = Circuits average output voltage

V_s = Circuits source voltage

$$V_0 = \frac{t_{on}}{\{t_{on} + t_{off}\}} * t_{on} \rightarrow Equation\{1\}$$

$\frac{t_{on}}{\{t_{on} + t_{off}\}}$ =Duty cycle denoted by α

Hence by varying the value of α the average output value is controlled.

III. SEPERATELY EXCITED DC MOTOR

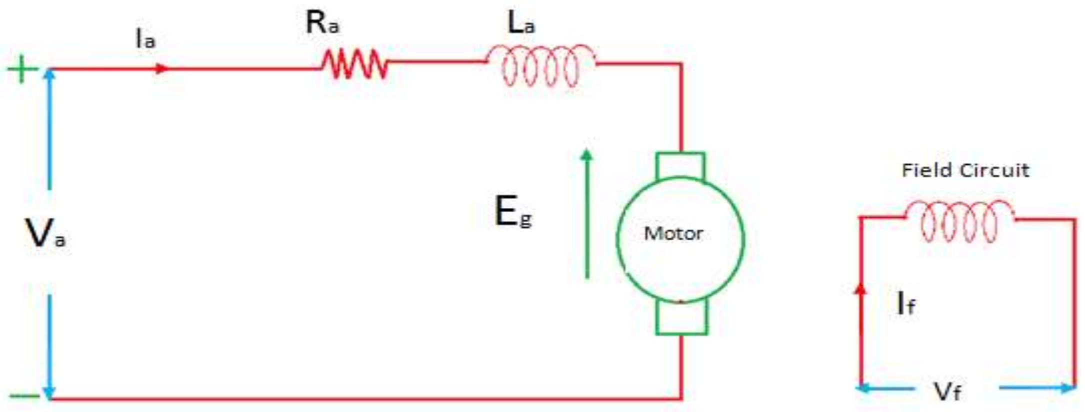

Figure {3} Separately excited DC motor

In the figure {3} with separate supply the separately excited dc motor has field and armature winding. To excite the field flux the field winding of the dc motor is used. For mechanical work current in armature circuit is supplied to the rotor through brush and commutator. The field flux and armature current interaction produces rotor torque. The working principle of separately excited dc motor is listed in points below. Okbuka and raju Singh has explained about the performance characteristics of controlled separately excited dc motor and stability analysis of separately excited dc motor respectively [7-8].

Point 1: The field current {if} excites the separately excited dc motor.
Point 2: In the circuit armature current {ia} flows.
Point 3: To balance load torque at particular speed. The motor develops a back emf and torque.
Point 4: Any change in armature current has no effect on the field current {if independent of ia}.
Point 5: The field current {if} is much less than the armature current {ia}.

IV.MATHEMATICAL EQUATIONS OF SEPERATELY EXCITED DC MOTOR

Armature equation,

$$V_a = E_g + I_a R_a + L_a \left\{ \frac{dI_a}{dt} \right\} \rightarrow Equation.2$$

Armature resistance in ohms {Ra}
Armature inductance in Henry {La}
Armature voltage in volts {Va}
Armature current in amps {Ia}
Motor back emf in volts {Eb}
Torque equation,

$$T_d = J\frac{d\omega}{dt} + B\omega + T_L \rightarrow Equation.3$$

Load torque in Newton-Meter {T_L}
Friction co-efficient of the motor {B}
Moment of inertia in Kg/m^2 {J}
Torque developed in Newton-Meter {T_d}
Angular velocity in rad/sec {w}
Assume {B=0}
New torque equation,

$$T_d = J\frac{d\omega}{dt} + T_L \rightarrow Equation.4$$

Taking field flux as phi, Back emf constant {KV} as K
Back emf of motor equation,

$$E_g = K\phi\omega \rightarrow Equation.5$$

$$T_d = K\phi I_a \rightarrow Equation.6$$

After taking Laplace transformation on both side {Basic motor armature equation}

$$I_a\{s\} = \frac{\{V_a - E_g\}}{R_a + L_a s} \rightarrow Equation.7$$

$$I_a\{s\} = \frac{\{V_a - K\phi\omega\}}{R_a\left\{1 + \frac{L_a s}{R_a}\right\}} \rightarrow Equation.8$$

$$\omega\{s\} = \frac{\{T_d - T_L\}}{Js} = \frac{\{K\phi I_a - T_L)}{Js} \rightarrow Equation.9$$

Armature time constant,

$$T_a = \frac{L_a}{R_a} \rightarrow Equation.10$$

V. SIMULATION MODEL OF DC MOTOR USING MOSFET BASED CHOPPER

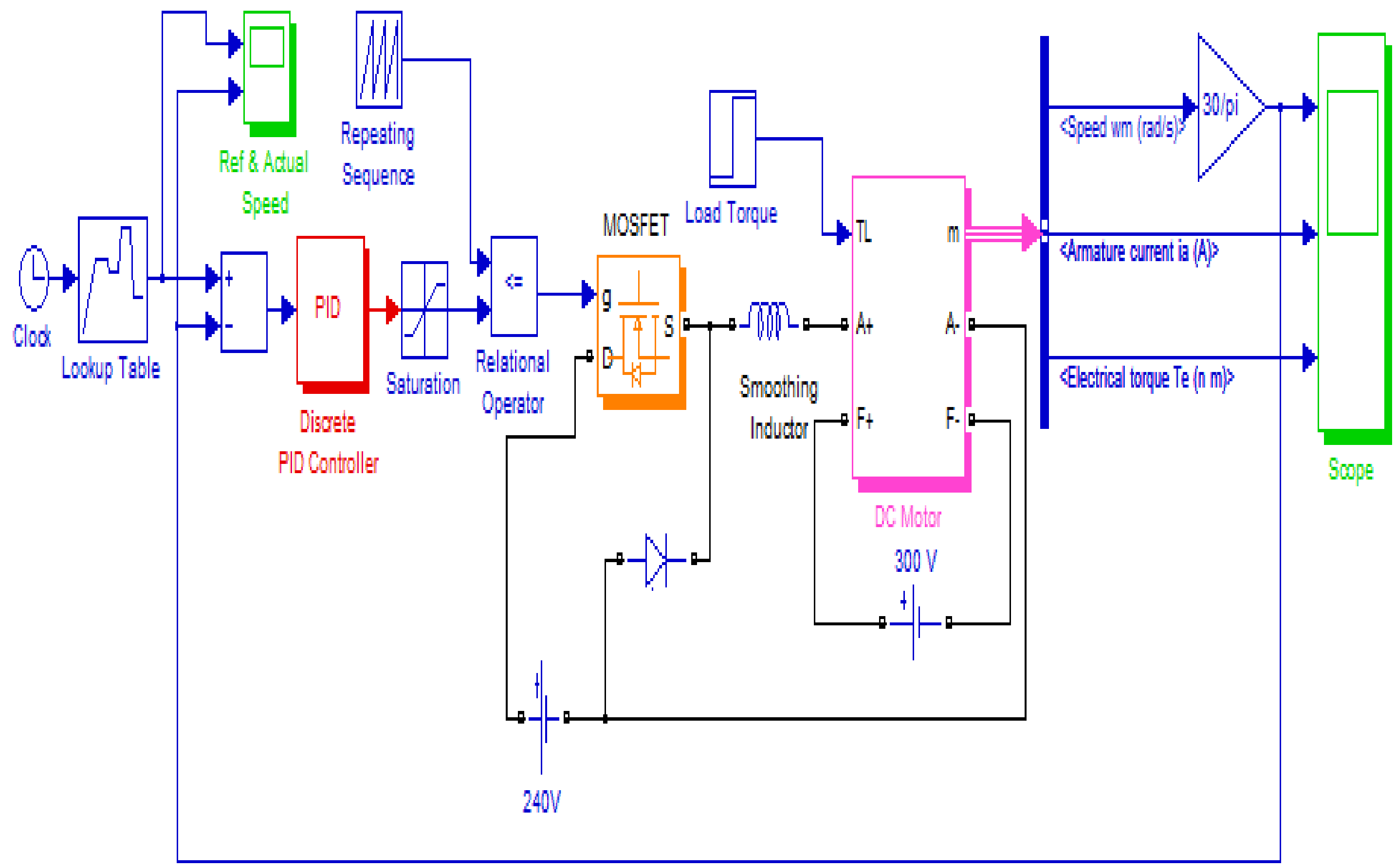

Figure {4} Simulation model of dc motor with MOSFET based chopper

VI.SIMULATION RESULTS

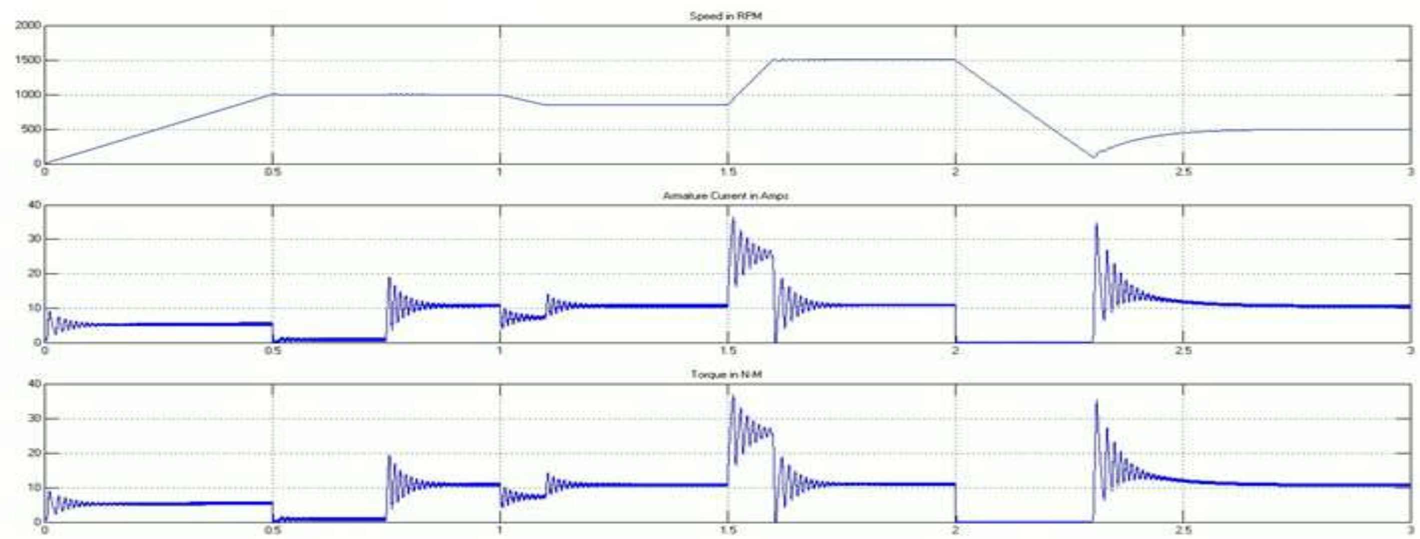

Figure {5} Speed in rpm, Armature current in amps and Torque in n-m

VII.CONCLUSION

The industrial application needs high performance motor drives. In general the high performance motor drive is nothing but a motor drive in which a drive system should have good load regulating response and dynamic speed command tracking. Therefore in acceleration and deceleration the dc motor provides excellent control in speed.

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IX.BIOGRAPHY

Mr.J.Vikramarajan received his Master degree in Power Electronics and Drives and Bachelor degree in Electrical and Electronics Engineering from VIT University, India. He has published several international research books and journals. His research interests are electrical machines, power electronic applications, power quality, power electronic converters and power electronic controllers for renewable energy systems.