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MATLAB SIMULATION ON CHOPPER BASED SPEED CONTROL OF DC MOTOR: A REVIEW

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Abstract - *This paper presents an overview MATLAB simulation of chopper based speed control of DC motor. The speed control of DC motor for different applications is very important. The speed control strategies of DC motor plays an important role in the drive performance. The use of speed controller is to take an signal sample of speed and to bring the motor to that desired speed. The base line objective of dc drive is to maintain the stable speed of the system irrespective of load condition. In a particular requirement, setting a speed of DC motor as the driving equipment must be performed remotely. Electric drives have number of applications in diverse areas such agriculture, transport, industry and domestic purpose. The operation of electric drives are selectively regulated and made partly or fully automatic to increase the productivity and efficiency of the industry. The dc drives play a significant role in modern industrial drives due to its higher performance, reliability, adjustable speed control etc. This paper presents the speed control method of dc motor by varying armature voltage using chopper as a converter. The proportional-integral type controller is used for controlling. Now, to get stable and high speed control of dc motor, the overall chopper Simulink model is done and analyzed in MATLAB (SIMULINK) and also comparing with different types of controllers (P, PI, PID and PD), the speed and performance of the dc machine is measured.*

Key Words: MATLAB, Speed, PI controller, Chopper, DC motor.

1. INTRODUCTION

In recent years, with the progress of science and technology, power electronic technology has been developed rapidly; the application of DC motor is more and more widely. It has good characteristics of speed control, speed smooth, convenient, and wide range of speed regulation. In order to meet the operating requirements of various special production process automation systems, the DC motor speed regulation is put forward higher request. The power electronics devices such as IGBT, MOSFET, SCR are used as switches. They can handle large amount of power obtained at higher voltage and high magnitude of current. Due to simplicity, ease of application, reliability and low cost DC drives are tremendously used for industrial purpose. DC motors are capable of providing starting and accelerating torques in excess of 400% of rated. The torque/speed characteristics of DC motors are compatible with many of mechanical loads. Hence they are less complex than those of AC drive. Hence by adjusting the terminal voltage speed of the Dc motor can be controlled. To convert the fixed AC voltage to variable DC voltage, the controlled rectifiers are used. Where as to convert the fixed DC voltage to variable DC voltage the choppers are used. The controlled rectifiers and choppers are widely used for the speed control of DC motors. Both series and separately excited DC motors are normally used in variable speed drives.

1.1 DC Chopper

A chopper is a static power electronic device that converts fixed dc input voltage to a variable dc output voltage .It is basically the dc-dc converter. A Chopper may be considered as dc equivalent of an ac transformer since they behave in an identical manner. As chopper involves one stage conversion, these are more efficient. Choppers are widely used all over the world. These are also used in trolley cars, marine hoist, forklift trucks and mine haulers. 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, power BJT, MOSFET and IGBT,GTO based chopper are also used. These devices are generally represented by a switch. Chopper is "on" or "off" semiconductor switch having high speed. When Switch is "off" no current flows through it. When the switch is "On" current flows through the circuit.

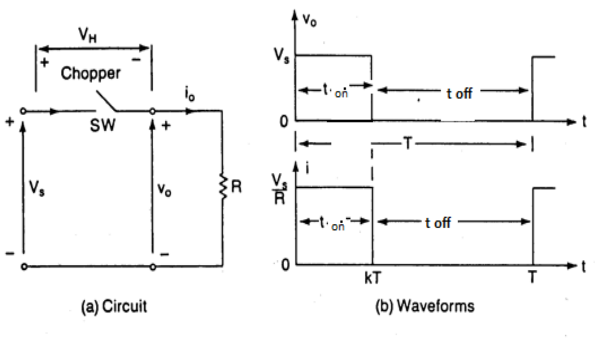

Fig-1: DC Chopper Circuit And Waveforms

1.2 PRINCIPLE OF CHOPPER OPERATION

Chopper is a high speed "on" or "off" semiconductor switch. It connects source to load and load and disconnect the load from source at a fast speed. In this manner, a chopped load voltage as shown in Fig.1(b) is obtained from a constant dc supply of magnitude Vs. During the period Ton, chopper is on and load voltage is equal to source voltage Vs. During the period Toff, chopper is off, load voltage is zero. In this manner, a chopped dc voltage is produced at the load terminals.

1.1 CLASSIFICATIONS OF CHOPPER

Based on input/output voltage levels, Chopper can be classified into two types.

- Step down Choppers
- Step up Choppers

Based on the directions of current and voltage, the choppers can be classified into five types.

- Class A Chopper
- Class B Chopper
- Class C Chopper
- Class D Chopper
- Class E Chopper

2. SEPARATELY EXCITED D.C. MOTOR

Separately Excited DC motor has field and armature winding with separate supply. The field windings of the dc motor are used to excite the field flux. Current in armature circuit is supplied to the rotor via brush and commutator segment for the mechanical work. The rotor torque is produced by interaction of field flux and armature current. 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*.

The armature equation is shown below:

Va= Eg + Ia Ra + La dIa/dt

The torque equation is given by :

$$Td = \frac{jdw}{dt} + \mathrm{Bw} + \mathrm{Tl}$$

Equation for back emf of motor will be:

$$\mathrm{Eg} = \mathrm{K\emptyset W}$$

Also we know, $Td = K\emptyset Ia$

$$W = (Va - IaRa)/K\emptyset$$

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. Here armature voltage control method is used.

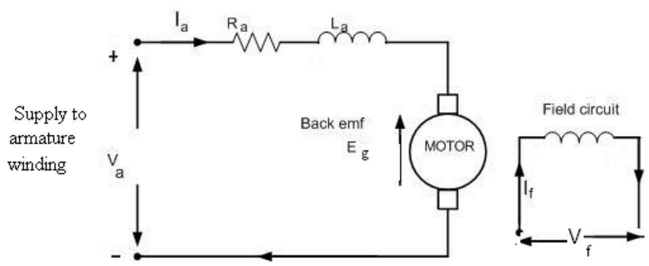

Fig-2: Separately Excited DC Motor

3. D.C. MOTOR MODELLING FOR DRIVE SYSTEM

The basic principle behind DC motor speed control is that the output speed of DC motor can be varied by controlling armature voltage for speed below and up to rated speed keeping field voltage constant. The output speed is compared with the reference speed and error signal is fed to speed controller. Controller output will vary whenever there is a difference in the reference speed and the speed feedback.

The output of the speed controller is the control voltage that controls the operation duty cycle of (here the converter used is a **Chopper**) converter. The converter output give the required armature voltage to bring motor back to the desired speed.

The Reference speed is provided through a potential divider because the voltage from potential divider is linearly related to the speed of the DC motor. If the error speed is negative, this means the motor is running slow so that the controller output should be increased and vice-versa The output speed of motor is measured by Tacho-generator and since Tacho voltage will not be perfectly dc and will have some ripple. So, we require a filter with a gain to bring Tacho output back to controller level The basic block diagram for DC motor speed control is shown below:

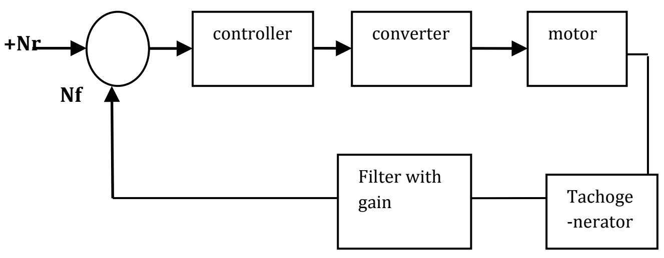

Fig-3: Block Diagram

The controller used in a closed loop model of DC motor provides a very easy and common technique of keeping motor speed at any desired set-point speed under changing load conditions. In this closed loop speed controller, a voltage signal is obtained from the Tacho-generator attached to the rotor which is proportional to the motor speed is fed back to the input where signal is subtracted from the set-point speed to produce an error signal. This error signal is then fed to controller to make the motor run at the desired set-point speed. If the error speed is negative, this means the motor is running slow so that the controller output should be increased and vice-versa.

Here, PI controller is used for the controlling purpose. Since PI controller is more efficient as compared to the Proportional controller. Proportional controller has the limited use and it never force the motor to run at exactly set speed. In case of PID controller it is very difficult to obtain derivative term in output which causes significant effect on the motor speed. It generates noise in main signal so PI type controller is best suited for the speed control purpose. In PI controller proportional term allows job of fast correction and integral term takes finite time to act and makes steady state error zero.

4. MATLAB SIMULATION MODEL

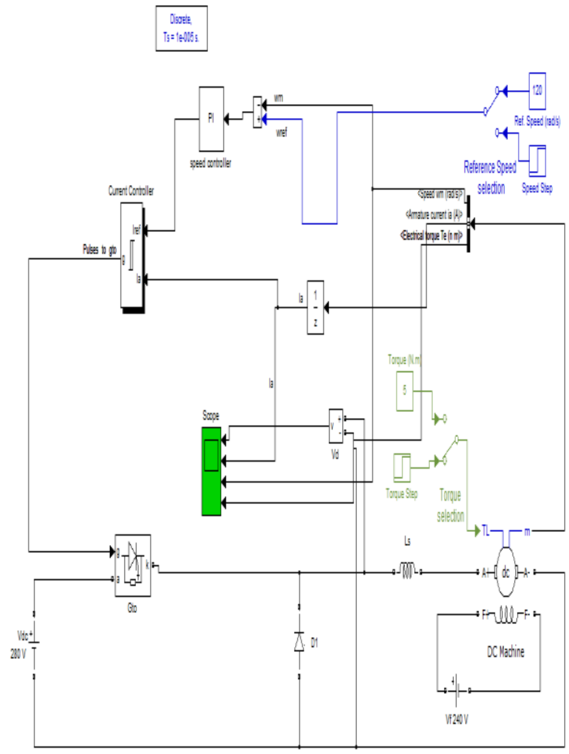

Fig. 4: MATLAB Simulation Model

By using closed loop model, the speed control of DC motor is done successfully.

5. CONCLUSIONS

This paper presents the literature review on MATLAB simulation of speed control of DC motor using Chopper. The speed below rated speed is controlled by using armature voltage control method. The closed loop control system is used for speed control. The PI controller and current controller are studied as well. Similarly by using field flux control the speed above rated speed can be controlled.

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