

Speed Control of DC Motor using Chopper (MATLAB Simulation)

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Abstract — Electric drives have numerous applications in diverse areas such as industry, transport, agriculture and domestic. 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. The speed control of separately excited dc motor is carried out by varying the armature voltage for below rated speed and by varying field flux to achieve the speed at above the rated speed. This paper presents the speed control methodology by varying armature voltage using chopper as a converter. The controller used is proportional-integral type. Using this controller the fast correction is done by proportional term and the integral term takes finite time to act and makes the steady state zero. 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.

Keywords— PID, MATLAB (SIMULINK) etc.

I. INTRODUCTION

Over the past decade, the DC machine have gained high popularity in the industry, especially where high performance is required owing to higher efficiency, adjustable speed control etc. the DC motors have variable characteristics and they are used extensively in variable speed drives. The DC motors are used to provide the frequent starting, good speed regulation, breaking and reversing. The speed control methods of DC motors are very simpler and less complex than the AC motors. The DC motors play a significant role in modern industrial drives. With recent advancement in power conversions, control techniques and microcomputers, the AC motors drives are becoming high competitive with DC motor drives. Although the future trend is toward DC drives, the AC drives completely replaced by DC drives. 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.

A very few paper published on concept of SPEED CONTROL OF DC MOTOR USING CHOPPER but the combination of various papers clearing the concept about speed control methods of a DC machine. Considerable papers have persecuted reviews and adopted microcontroller based controlling method, PC based speed controlling method and pulse width modulation method etc. but non for using PI type

Chopper based speed controlling method. The goal of this paper is to design and implementation of chopper based DC motor drive model in MATLAB (Simulink). And comparing with different types of controllers (P, PI, PID, and PD), the speed and performance of the DC machine is measured.

This paper organized as follows. In section II, The brief review of dc choppers, in section III, separately excited dc motors are discussed and in section IV, modelling of dc motor for drive systems are presented. The summary and conclusions are presented in section V.

II. DC CHOPPERS

Chopper drives are widely used in traction applications all over the world. A DC Chopper is used to convert the fixed DC voltage to variable DC voltage and it is connected between a fixed voltage DC source and a DC motor to vary the armature voltage. In addition to armature voltage control, a DC Chopper can provide regenerative braking of the motors and can return energy back to the supply. Chopper drives are also used in battery electric vehicles (BEVs), marine hoists, trolley cars, forklift trucks and mine haulers etc.

Chopper is act as a switch. The Chopper switch can be BJT, IGBT, MOSFET, SCR, Power transistors etc. A DC Chopper can be used as a DC transformer to step up or step down a fixed DC voltage. The Choppers can also be used for switching-mode voltage regulators and for transferring energy between two DC sources. However, harmonics are generated at

the input and load side of the Chopper and these harmonics can be reduced by input and output filters. A Chopper can operate on either fixed frequency or variable frequency. A variable frequency Chopper circuit generates more harmonics and also filter design becomes complex hence commonly fixed frequency Chopper circuit is used. Due to smooth acceleration control, high efficiency, lower maintenance, faster response and smaller size the Choppers are more popular.

CLASSIFICATION OF CHOPPERS

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

METHODS OF OUTPUT VOLTAGE CONTROL

The output DC voltage of DC Choppers can be varied by the following methods:

- Time ratio control
 - Pulse width modulation control or constant frequency operation.
 - Variable frequency control.
- Current limit control

III. SEPARATELY EXCITED DC MOTORS

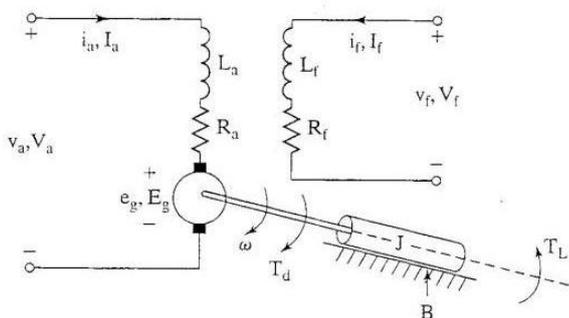


Fig. 1. Equivalent circuit diagram of separately excited dc motor

Separately excited DC motor consists of field and armature winding with separate supply. The equivalent circuit diagram of separately excited DC motor is shown in the fig. 1. When a separately excited DC motor is excited by a field

current of I_f and an armature current of I_a flows in the armature circuit. The back emf and torque will develop in the motor and that torque is used to balance the load torque at a particular speed. Both the currents that is armature current I_a and field current I_f are independent in separately excited DC motor. The field current is normally much lesser than the armature current. Hence, by the mathematical analysis the speed of the separately excited DC motor can be varied by

1. Controlling the armature voltage, V_a , known as voltage control.
2. Controlling the field current, I_f , known as field control.
3. Torque demand, which corresponds to an armature current, I_a , for a fixed field current I_f .

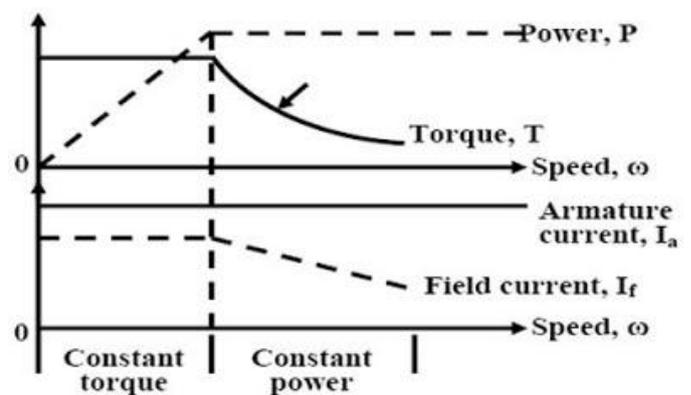


Fig. 2. Characteristic diagram

The speed which corresponds to the rated armature voltage, rated field current and rated armature current is called as base speed. In practice, for a speed of the motor less than the base speed, the armature current and field current are kept as constant to meet the torque demand and the armature voltage V_a , is varied to control the speed. For a speed of the motor higher than the base speed, the armature voltage is maintained at the rated value and the field current is varied to control the speed. However, the power developed by the motor ($=\text{torque} \times \text{speed}$) remains constant. Fig.2 shows the characteristics of power, torque, armature current, and field current against the speed.

IV. MODELLING OF DC MOTOR FOR DRIVE SYSTEMS (METHODOLOGY)

The speed of DC motors changes with the load torque. To maintain a constant speed, the armature (and or field) voltage should be varied continuously by varying the delay angle of ac-dc converters or duty cycle of dc choppers. In practical drive system it is required to operate the drive at a constant torque or constant power, in addition, controlled acceleration and deceleration are required. Most industrial drives operate as closed loop feed-back system. A closed loop control system has the advantage of improved accuracy, fast

dynamic response, and reduced effects of load disturbances and system non-linearity's.

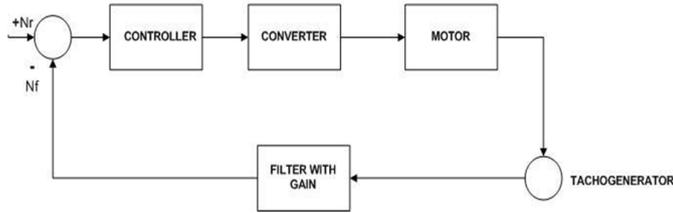


Fig. 3. Block diagram of closed loop model for speed control dc motor

The block diagram of closed loop converter model fed separately excited dc drive is shown in fig. 3. The basic principle of dc motor speed control is that keeping field voltage constant, the output speed of dc motor can be varied by controlling armature voltage the speed is controlled for below and up to rated speed. When the output speed of the motor is compared with the reference speed, there error will be generated. That error signal is fed to speed controller. If any difference occurred in the reference speed and the feed-back speed, the controller output will be vary. The output of the speed controller i.e. control voltage E_g fed to the converter and that controls the operation duty cycle of converter. In this paper chopper is used as a converter. The converter output generates the required voltage V to bring motor speed back to the specified speed. Tacho-generator is used to measure the output speed of the motor. The generated tacho voltage from tacho-generators contains some ripple and it will not be a perfect dc. Hence using a filter with gain to bring tacho output back to controller level.

The controller used in a closed loop model of dc motor is to control the speed of the dc motor as per desired set point values which are set in look up table. There are more number of controllers are available and its selection process is also an important role. The proportional controller, on-off controller, derivative controller, integral controller and PID controller etc are the most commonly used controllers in the control system. But PI controller is the some of better than the other controllers. Why because, in PI controller the fast correction is done by proportional term and the integral term takes finite time to act and makes the steady state zero. Hence the better suitable controller for speed control is PI type controller.

V. MATLAB SIMULATIONS, RESULTS AND ANALYSIS

5.1 SIMULATION OF CLOSED LOOP MODEL OF CHOPPER WITH DC MACHINE (USING MOSFET AS A SWITCH):

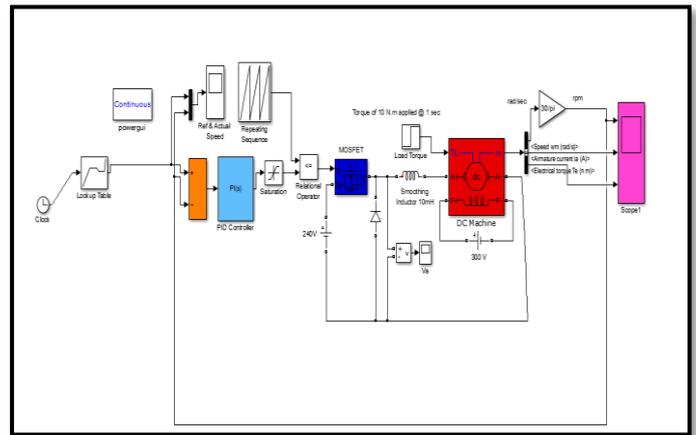


Fig.4: Simulink model of closed loop model of chopper with dc machine

LOOK UP TABLE

VECTOR OF INPUTS	SPEED IN RPM
0	0
0.5	1000
1	1000
1.1	850
1.5	850
1.6	1500

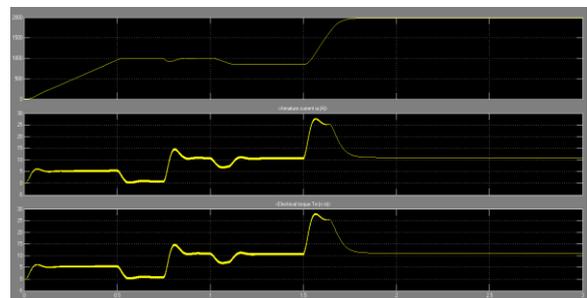


Figure 5: Simulation output of closed loop model of chopper with dc machine

VI. CONCLUSION

A brief review of dc drives, choppers, separately excited dc motors have been presented in this paper. The speed of separately excited dc motor has been successfully controlled by using chopper as a converter. In simulation the speed of dc motor is achieved by as per set-point values in the look up table. And the overall chopper simulink model for closed loop is done and analyzed in MATLAB simulink. The simulation results studied and analyzed also shown that the proposed PI controller gives better performance and less setting time under varying reference speed or load.

VII. REFERENCES

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