# Study On Speed Control of DC MOTOR Using Thyristor

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**Abstract -** *The DC motor is an main part of equipment in many industrial applications requiring variable speed and load characteristics due to its easy controllability. There are two different types of control loops, current controller and speed controller. This DC motors are widely used in the industries because of its versatile characteristics which have contributed in the extensive use of the DC motor in the industry. The DC motor can control by various method which are as field control, armature voltage control, armature resistance control. The Thyristor based DC drive with the analog and digital feedback control schemes are used for the speed control technique of DC motor. This drive also providing the functions like Start, Stop, Forward braking, reverse braking, increased and decreased speed of motor. This paper deal with the speed control of separately excited DC motor control in the better performance manner.*

***Key Words:*** *DC motor, speed control, Thyristor, etc…*

## 1.INTRODUCTION

An electrical drives consists of electrical motors, power controllable and energy transmitting shaft. This electrical drives are widely used in the industry because of its low cost, less complex control structure and wide range of speed and torque. In modern electrical drive system power electronics converter are used as power as power controller. Electrical drives are mainly of two types: DC drives and AC drives. They are different from each other in this way that the power supply in DC drives in provided by DC motor and power supply in AC drives provided by AC motor. Standard motors are classified as either constant speed or adjustable speed motors. Adjustable speed motors may be operated over a wide speed range by controlling armature voltage and field excitation. The speed below the base speed can be controlled by armature voltage control method and field control method is used for the above base speed.

In past, many researchers worked on various converter topologies of DC motor control for different industrial applications [5], but all of them are thyristor based. For simulation of various topologies MATLAB with its tool boxes like Simulink and Sim Power System are used [3].

### 1.1 Introduction to Thyristor

A thyristor is a solid-state semiconductor device with four of alternating N and P-type material. It acts as a bistable switch, conducting when gate receives a current trigger and continuing to conduct while the voltage acreoss the device is not received. A three-lead thyristor is designed to control the large current of its two leads by combining that current with the smaller current of its other lead, known as its control lead. Some sources defines silicon-controlled rectifier and thyristor as synonymous. Other sources define thyristor as a large set of device with at least four layers of alternating N and P-types material.

The first thyristor device was released commercially in 1956. Because thyristor can control a relatively large amount of power and voltage will a small device, they find wide application in control of electric power, rating from light dimmers and electric motor speed control to high-voltage direct current poer transmission. A thyristor unsuitable as an analog amplifier, but useful as a switch. A silicon controlled rectifier or semiconductor-controlled rectifier is a four-layer solid-state current controlling device.

## 2. MATHEMATICAL MODELING OF DC MOTOR

To analyse the torque speed characteristics, power factor and total harmonics distortion, the dynamics and steady state model of separately excited DC motor is required. Figure shows the schematic representation of the model of a separately excited DC motor, in which $E_a$ is the terminal voltage applied to the motor, $R_a$ and $L_a$ are the resistance and inductance of the armature circuits respectively. $R_f$ and $L_f$ are the resistance and inductance of the field circuit respectively, $E_b$ is generated back emf and $T_m$ is the electromagnetic torque developed by the motor. The related DC motor parameter are mentioned in appendix A. Due to the interaction of the field flux with current in armature conductors, the torque is produced which is given by Eq.(1)

$$T_m=k_t\Phi i_a \qquad (1)$$

Here $K_t$ is a constant depending on motor winding and geometry and Φ is the flux per torque produced. When armature rotates, the flux linking the armature winding will vary with time and therefore according to Faraday's law, an emf will be include across the winding. This generated emf, knows an the emf, depends on speed of rotation as well as on the flux produced by the field and given by Eq. (2)

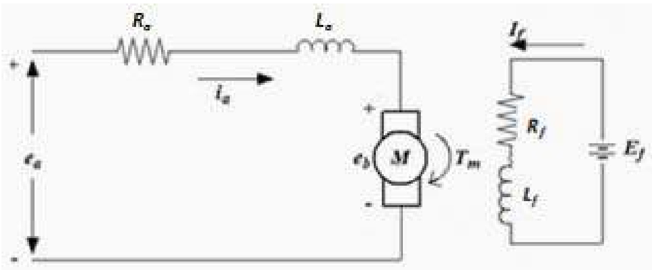


Fig1. Equivalent circuit of separately excited DC motor.

$$e_b = k_t \Phi \qquad (2)$$

By applying KVL at input side of in figure 1,

$$e_a = i_a R_a + L_a \frac{di_a}{dt} + e_b \qquad (3)$$

In steady state condition,

$$E_a = I_a R_a + E_b \qquad (4)$$

In terms of torque and speed, the steady state equation will be given by Eq. (5)

$$E_a = \frac{Tm}{Kt\emptyset} R_a + Kt\omega\Phi \qquad (5)$$

So,

$$\omega = \frac{Ea}{Kt\Phi} - \frac{Tm}{(Kt\Phi)^2} R_a \qquad (6)$$

Thus from the above equation it is clear that speed can be controlled by varying three parameters, namely, $E_a$, $R_a$ and $\Phi$. The three methods of speed control are following:

- Armature controlled ($E_a$).
- Armature resistance controlled ($R_a$).
- Fulx controlled ($\Phi$).

Adding external resistor to the DC drive to control the speed of DC motor is not a healthy practice as large part of energy get loosed in terms of heat due to the external resistor $R_{ext}$. Armature voltage controlled is preferred for speed up to rated speed (base speed), and flux control for speed beyond rated speed but at the same time the maximum torque capability of the motor is reduced since for a given maximum armature current, the flux is less than the rated value and so as the maximum torque produced is less than the maximum rated torque [4].Figure 2 illustrate the ideal torque speed characteristic which reflects equation (6), using armature voltage control method in which the voltage applied across the armature $e_a$ is varied keeping field voltage constant. Figure

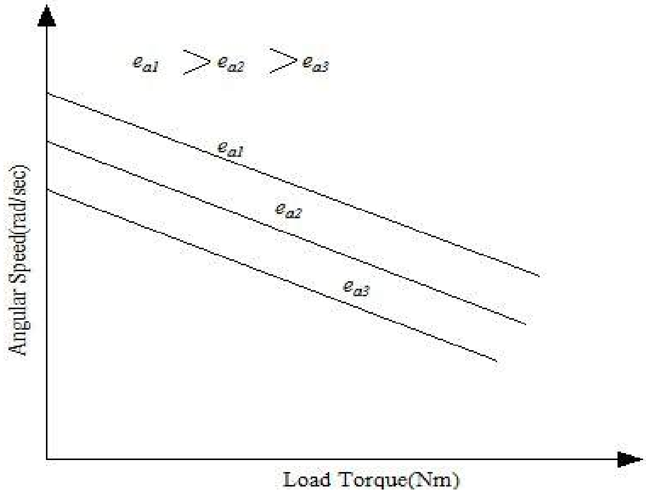


Fig 2. Torque speed characteristics of the separately excited DC motor at different armature voltages

## 3. The technique of DC motor speed control

Figure 3 shows a separately excited DC motor fed through single phase half wave converter. It offers only one quadrant drive. Such type of drives, are used up to about 0.5 kW DC motor

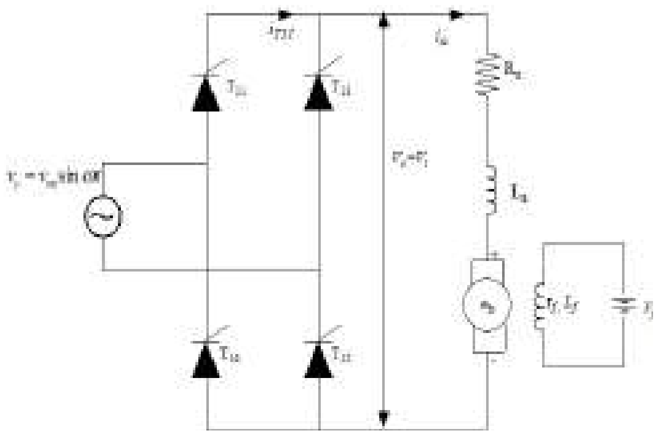

Fig 3. Single phase full wave converter drive

The average armature voltage in armature circuit for single phase full converter drive is given by Eq. (7)

$$V_0 = V_r = 2\,\frac{Vm}{\pi}(1+\cos\alpha), \text{for } 0 < \alpha < \pi \qquad (7)$$

A single phase full converter drive offers a two quadrant drive operation and is limited to applications up to 15kW, which is shown in figure 5. The armature converter gives $+V_o$ or $-V_o$ and allows operation in the first and fourth quadrant. The converter in the field circuit could be semi, full or even dual converter. The reversal of the armature or field voltage allows operation in the second and third quadrant.

The single phase full converter is a fully controlled bridge controlled rectifier using thyristor connected in the form of a full wave bridge configuration. All the thyristors are controlled switches which are tuned on at a appropriate times by applying suitable gate trigger signals. The single phase full converter is extensively used in industrial power applications where two quadrant operations is required.

## 4. SIMULATION MODEL

The simulink model used to get torque speed characteristic for a single phase full converter drive is shown n figure15. The effect of armature voltages on the torque speed characteristic is observed for six different firing angles, as the voltage applied to the field circuit is kept constant at 300V, and a constant 240V, 50 Hz AC is applied to input of single phase full converter. The average value of applied armature voltage is varied by varying the firing angle of full converter.

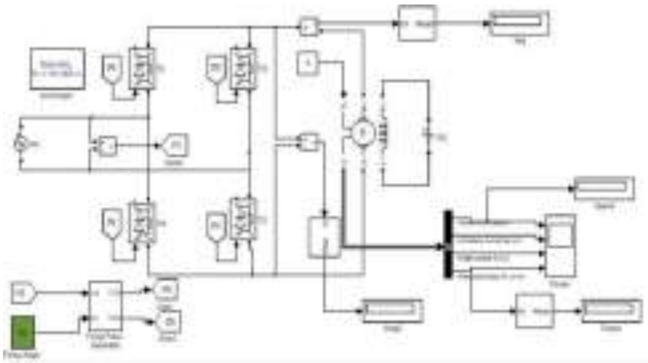

Fig4. Simulink realization of armature voltage speed control method using a single phase full converter drive.

## 3. CONCLUSION

In the above discussion, power factor improvement and their performance is compared on the basis of parameters such as power factor, input current distortion factor, input current harmonic factor, input displacement factor and total harmonic distortion, and it is found that the single phase diode rectifier circuit with improved parallel input resonant filter performs well. Thus the same parallel input resonant filter is applied with different types of DC drives systems which are single phase half wave converter drive, single phase semi converter drive, single phase full converter drive and single phase dual converter drive.

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