2.1 Steady state analysis of single phase converter fed separately excited DC motor drive:

INTRODUCTION

Direct-current motors are extensively used in variable-speed drives and position-control systems where good dynamic response and steady-state performance are required. Examples are in robotic drives, printers, machine tools, process rolling mills, paper and textile industries, and many others. Control of a dc motor, especially of the separately excited type, is very straightforward, mainly because of the incorporation of the commutator within the motor. The commutator brush allows the motor-developed torque to be proportional to the armature current if the field current is held constant. Classical control theories are then easily applied to the design of the torque and other control loops of a drive system.

DC MOTORS AND ITS CHARACTERISTICS

When a DC supply is applied to the armature of the dc motor with its field excited by a dc supply, torque is developed in the armature due to interaction between the axial current carrying conductors on the rotor and the radial magnetic flux produced by the stator. If the voltage V is the voltage applied to the armature terminals, and E is the internally developed motional e.m.f. The resistance and inductance of the complete armature are represented by R_a and L_a in Figure 2.1(a). Under motoring conditions, the motional e.m.f. E always opposes the applied voltage V, and for this reason it is referred to as 'back e.m.f.' For current to be forced into the motor, V must be greater than E, thearmature circuit voltage equation being given by

$$V= E \quad I_a R_a L \, dI_a/dt$$

SinglePhase rectifierfed separatelyExcited DCmotor drive

The thyristor D.C. drive remains an important speed-controlled industrial drive, especially where the higher maintenance cost associated with the D.C. motor brushes is tolerable. The controlled (thyristor) rectifier provides a low-impedance adjustable 'D.C.' voltage for the motor armature, thereby providing speed control. For motors up to a few kilowatts the armature converter can be supplied from either single-phase or three-phase mains, but for larger motors three-phase is always used. A separate thyristor or diode rectifier is used to supply the field of the motor: the power is much less than the armature power, so the supply is often single-phase. Figure 2.9 shows the setup for single phase controlled rectifier fed separately excited dc motor drive. Field circuit is also excited by a dc source, which is not shown in the figure just for simplicity.

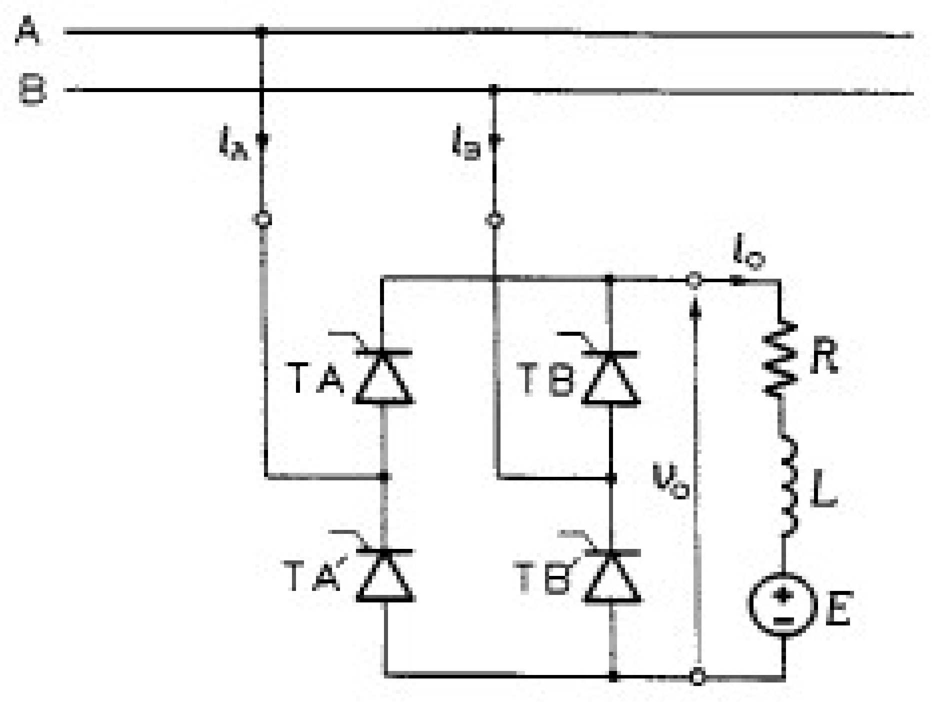

Figure 2.1.1 SinglePhase rectifierfed DCmotor drive

(Source:"Fundamentals of Electrical Drives" by G.K.Dubey,page-108)

The basic circuit for a single-phase separately excited dc motor drive is shown in Fig. The armature voltage is controlled by a semi-converter or full-converter and the field circuit is fed from the ac supply through a diode bridge. The motor current cannot reverse due to the thyristors in the converters. If semi-converters are used, the average output voltage (Ea)is always positive. Therefore power flow (Ea1a) is always positive, that is, from the ac supply to the dc load. In drive system semi-converters, regeneration or reverse power flow from motor to ac supply is not possible. In semi-converters free- wheel (i.e., dissipation of armature inductance energy through the free-wheeling path) takes place when the thyristor blocks.

Single-phase full-wave drives are used for low and medium-horsepower applications as indicated infig2.1.Suchdriveshavepoor speed regulation on open-loop firing angle control. However, with armature voltage or tachometer feedback, good regulation can be achieved.

Basic Equation I

The armature circuit of the de motor is represented by its back voltage e_g, armature resistance Ra, and armature inductance La as showninFig.

Back voltage:

$$e_g = K_a \Phi n$$

Average Back Voltage

$$E_g = K_a \Phi N$$

The armature circuit voltage equation is

$$e_a = R_a i_a + L_a \frac{di_a}{dt} + e_g$$

Interms of average values,

$$E_a = R_a I_a + E_g$$

Note that the inductance La does not absorb any average voltage. From equations 2 and 6, the average speed is

$$N = \frac{E_a - R_a I_a}{K_a \Phi}$$

In single-phase converters, the armature voltage e_a and current t, change with time. This is unlike the M-G set drive in which both e_a and t, are essentially constant. In phase-controlled converters, the armature current ia may not even be continuous. In fact, for most operating conditions, t, is discontinuous. This makes prediction of performance difficult. Analysis is simplified if continuity of armature current can be assumed.