WIKIPEDIA

Armature Controlled DC Motor

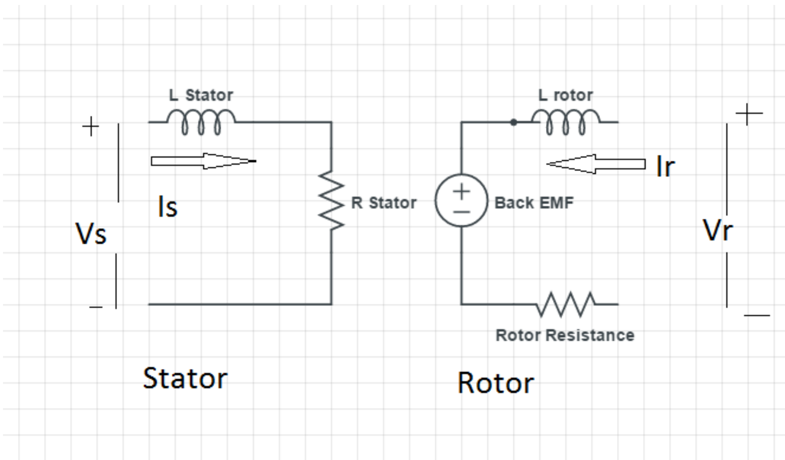
A motor is an actuator, converting electrical energy in to rotational mechanical energy. A motor requiring DC supply for operation is termed a DC motor. DC motors are widely used in control applications like robotics, tape drives, machines and many more. Separately excited DC motors are suitable for control applications because of separate field and armature circuit. Two ways to control DC separately excited motors are:

1. Armature Control.

2. Field Control.

Modelling of armature control DC motor is discussed in the article.

Basic operating mechanism of a DC motor[1]



It represents basic structure of separately excited DC motor.

DC motor consists of two parts i.e. rotor and stator. Stator consists of field winding while rotor (also called armature) consists of armature winding. When both armature and field are excited by DC supply, current flows through windings and magnetic flux proportional to the current is produced. When the flux of field interacts with the flux of armature, it results in motion of the rotor. Armature control is the most common control technique for DC motors. In order to implement this control, the flux is required to be kept constant. To this aim, either the stator voltage is constant or the stator coils are replaced by a permanent magnet. In the latter case, the motor is said to be a permanent magnet DC motor and is driven by means of the only armature coils.

As in armature control, field flux is constant; equations governing operation of motor become linear, that is

$T = K_{\phi}\Phi\mathrm{I}$ (1)

where T is motor torque, Φ is flux and I is armature current. When field flux is constant, equation (1) becomes

$T = K'\mathrm{I}$ (2)

where $K' = K_\phi \phi$ as Φ is constant.

In addition, the motor has an intrinsic negative feedback structure, hence at the steady state, the speed ω is proportional to the reference input Va.

These two facts, in addition to the cheaper price of a permanent magnet motor with respect to a standard DC motor (because only the rotor coils need to be wound), are the main reasons why armature controlled motors are widely used. However, several disadvantages arise from this control technique, of which major is the flow of large currents during transients. For example, when started speed ω is zero initially, hence back EMF (Electromotive Force) governed by the following relation, would be zero.

$E_b = K_\phi \phi \omega$ (3)

Also, armature current is given by $I = \left(\frac{V - E_b}{R_a}\right)$ (4)

which will be very high causing increase in heating of machine and it may damage the insulation.

Transfer Function[2]

Essential Equations [1]:

Electrical Equations:

$E_b = K_\phi \phi \omega$ in Laplace domain $E_b(s) = K_\phi \phi \omega(s)$ (5)

$I = \left(\frac{V - E_b}{R_a}\right)$ in Laplace domain $I(s) = \left(\frac{V(s) - E_b(s)}{R_a}\right)$ (6)

$T = K_\phi \Phi \mathrm{I}$ in Laplace domain $T(s) = K_\phi \Phi \mathrm{I}(s)$ (7)

$T - T_L = J\frac{d\omega}{dt} + F\omega$ in Laplace domain $T(s) - T_L(s) = J\frac{d\omega(s)}{dt} + F\omega(s)$ (8)

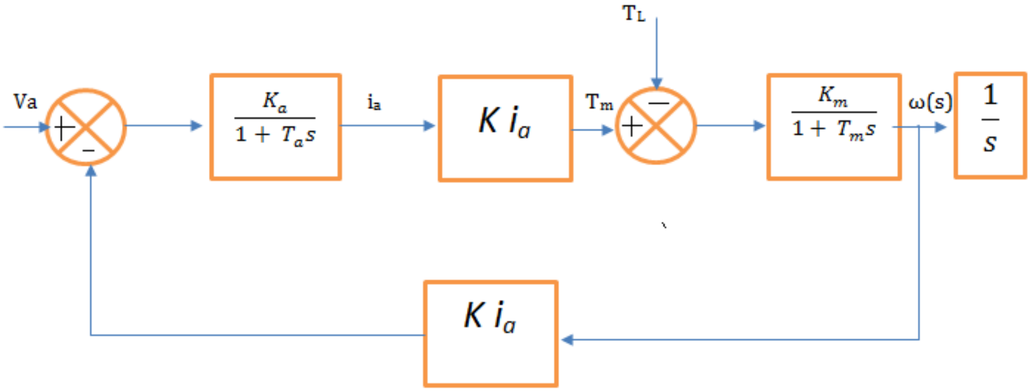
Block Diagram of Separately Excited DC Motor is given in Fig.2

Various parameters in figure are described as

- $K_a = \frac{1}{R_a}$ is the rotor gain.
- $\tau_a = \frac{L}{R_a}$ is the electrical time constant.
- T_m is the motor torque.
- K is a constant depending on field flux.

- $K_m = \frac{1}{F}$ is mechanical gain.
- F is viscous friction coefficient.
- $\tau_m = \frac{J}{F}$ is the mechanical time constant, where J is moment of inertia of the load.
- $\omega(s)$ is the resulting angular velocity.

The transfer matrix of the system may be written as



It represents a block diagram of separately excited DC motor with armature control.

$$\omega(s) = [\,W_1(s) \quad W_2(s)\,]\begin{bmatrix} V_a \\ T_L(s) \end{bmatrix} \text{ (9)}$$

where $W_1(s) = \dfrac{K_a K_\phi K_m \phi}{(1+\tau_a s)(1+\tau_m s) + K_a K_m (K_\phi \phi)^2}$ (10)

$$W_2(s) = \frac{K_m(1+\tau_a s)}{(1+\tau_a s)(1+\tau_m s) + K_a K_m (K_\phi \phi)^2} \text{ (11)}$$

References

1. Stephen J. Chapman, *Electric Machinery Fundamentals*.
2. Luca Zaccarian, *DC motors: dynamic model and control techniques*.

Retrieved from "https://en.wikipedia.org/w/index.php?title=Armature_Controlled_DC_Motor&oldid=910805562"

This page was last edited on 14 August 2019, at 15:36 (UTC).