Lecture Note Electrical Drives

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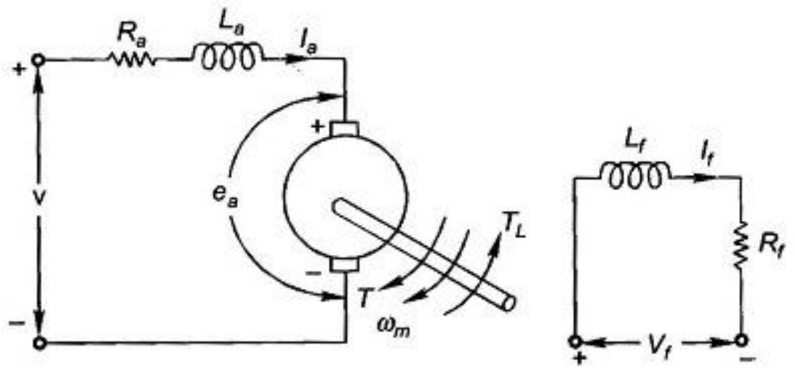
Q: Dynamic modelling of DC Machine



When supply V_a is given to stator winding, flux produced in stator winding linked to Rotor and Rotor starts rotating as a result back emf is generated. Applying KVL in armature circuit:

$$V_a = I_a R_a + L_a \frac{dI_a}{dt} + E_b \qquad (1)$$

Where,

V_a is the armature voltage in volts.
I_a is the armature current in ampere.
L_a is the armature inductance in Henry.
R_a is the armature resistance in ohms.
E_b is the back emf in volts.

By applying laplace transformation to (1):

$$V_a(s) = I_a(s) R_a + sL_a I_a(s) + E_b(s)$$

$$I_a(s) = \frac{V_a(s) - E_b(s)}{R_a + sL_a} \qquad (2)$$

Similarly for field winding if we apply KVL and transforming into laplace domain

$$I_f(s) = \frac{V_f(s)}{R_f + sL_f}$$

V_f is the Field Voltage in volts.
R_f is the field resistance in ohms.
I_f is the Field current in ampere.

Now back emf can be obtained as

$$E_b = \frac{ZP}{60A}\phi N$$

$$= \frac{ZP}{60A}\,\phi\frac{60\omega}{2\Pi}$$

$$= \frac{ZP}{A}\,\phi\frac{\omega}{2\Pi}$$

$$= \frac{ZP}{2\Pi A}\phi\omega$$

$$= \frac{ZP}{2\Pi A}KI_f\omega$$

$$= K_b I_f \omega$$

Where,

Z is the number of conductors.
P is the number of poles.
A is the number of Parallel Path.
φ is the flux in weber.
N is the number of turns in rpm.
ω is the Speed in rad/sec.

Motor torque equation can be written as

$$T = K_t I_a \phi$$

$$= \frac{ZP}{2\Pi A}\phi I_a$$

$$= K_t I_f I_a$$

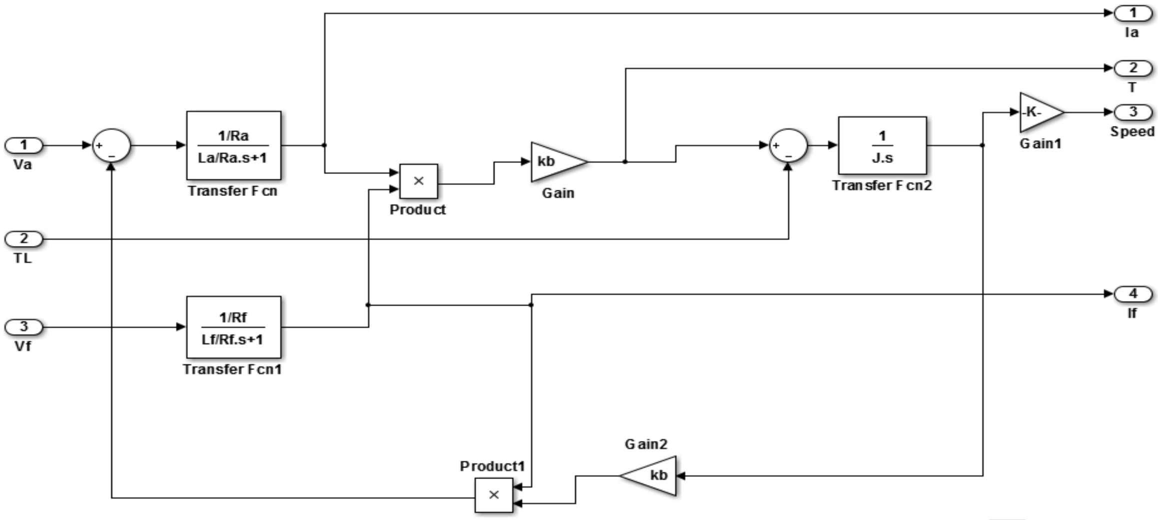
Finally Speed of the machine can be obtained as:

$$T_e = T_L + J\frac{d\omega}{dt}$$

$$T_e(s) = T_L(S) + sJ\omega$$

$$\omega = \frac{T_e - T_L}{Js}$$

T_e is the motor Torque in N.m
T_L is Load Torque in N.m
J is the inertia.



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Va
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1/Ra
La/Ra.s+1
Transfer Fcn
1/Rf
Lf/Rf.s+1
Transfer Fcn1
Product
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J.s
Transfer Fcn2
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1
Ia
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Product1