ELEC 343, Home Work Assignment # 3:

Part 1:

Follow through Examples 3A, 3B and 3C. Do Study Problems: SP3.4-1, SP3.4-2, SP3.6-2

SP3.4-1. $V_a = I_a r_a + k_v \omega_r$. Solving for I_a yields

$$I_a = \frac{V_a - k_v \omega_r}{r_a} = \frac{12 - (0.01)(0)}{12} = 1 \text{ A}$$

$$T_e = k_v I_a = (0.01)(1) = 0.01 \text{ N·m}$$

SP3.4-2.
$$\begin{aligned} T_e &= T_L + B_m \omega_r \\ &= 3.53 \times 10^{-3} + (6.04 \times 10^{-6})(249) = 5.03 \times 10^{-3} \text{ N·m} \\ &= (5.03 \times 10^{-3})(16)(0.225)(39.37) = 0.713 \text{ oz·in} \end{aligned}$$

SP3.6-2

Observing eq. (3.6-3) we can see that if the field current (or the machine flux) is reduced, the machine's speed will have to increase in order to compensate for the unbalance between the applied voltage and the back emf. In a case of a practical machine, there will be some residual flux due to residual magnetization of the field winding (and the magnetic poles of the machine). However, because this residual flux is typically very small, if the field winding is disconnected, the machine will start to accelerate beyond its rated speed and may cause mechanical destruction.

Textbook Chapter Problem(s): 1, 2, 7.

1. $V_a = r_a I_a + \omega_r k_v$, $T_e = k_v I_a$, and $T_L = K\omega_r$. With $T_e = T_L$, $k_v I_a = K\omega_r$. Solving for I_a yields $I_a = \frac{K\omega_r}{k_v}$. Substitution into the voltage equation gives $V_a = \frac{K\omega_r}{k_v} r_a + \omega_r k_v$. Solving for ω_r yields

$$\omega_r = \frac{V_a k_v}{K r_a + k_v^2} = \frac{(6)(0.01)}{(5\times10^{-6})(8) + (0.01)^2} = 428.6 \text{ rad/s}$$

2. $V_a = r_a I_a + k_v \omega_r$, with $I_a = 0$

$$k_v = \frac{V_a}{\omega_r} = \frac{(7)(60)}{(3820)(2\pi)} = 0.0175 \text{ V·s/rad}$$

During steady-state operation, $T_e = B_m \omega_r + T_L$ where $T_e = k_v I_a$. With $T_L = 0$, $I_a = 0.1$ A and $\omega_r = 650$ rad/s

$$B_m = \frac{k_v I_a}{\omega_r} = \frac{(0.0175)(0.1)}{650} = 2.69 \times 10^{-6} \text{ N·m·s}$$

$$r_a = \frac{V_a - k_v \omega_r}{I_a} = \frac{12 - (0.0175)(650)}{0.1} = 6.25 \ \Omega$$

7. (a)
$$T_{eR} = \frac{P_{oR}}{\omega_{rR}} = \frac{5\times746}{127.7} = 29.21 \text{Nm}$$
$$I_{fR} = 1\text{A}$$
$$I_{aR} = \frac{T_{eR}}{L_{AF} I_{fR}} = 16.23\text{A}$$

(b)
$$I_f = \frac{P_{oR}}{L_{AF}\omega_r I_{ar}} = \frac{5\times746}{1.8\times4\times127.7\times16.23} = 0.25\text{A}$$

(c)
$$T_e = L_{AF} I_{aR} I_f = 1.8\times16.23\times0.25 = 7.30 \text{ N}\cdot\text{m}$$

Additional Problems:

Problem A: Consider a 100V series DC motor. The motor consumes 100W at full load while operating at speed of 2000rpm when it is supplied from nominal voltage of 100V.

The armature and field winding resistances are: Ra = 2 Ohms and Rf = 1 Ohms, respectively. Calculate the stall torque (or the maximum starting torque) of this motor.

$P_{in} = V_a I_a$. Solving for I_a yields $I_a = \dfrac{P_{in}}{V_a} = \dfrac{100}{100} = 1$ A

$V_a = (r_a + r_{fs}) I_a + \omega_r L_{AFs} I_a$. Solving for L_{AFs} yields

$$L_{AFs} = \frac{V_a - (r_a + r_{fs}) I_a}{\omega_r I_a} = \frac{100 - (2+1)(1)}{\frac{(2000)(2\pi)}{60}(1)} = 0.463 \text{ H}$$

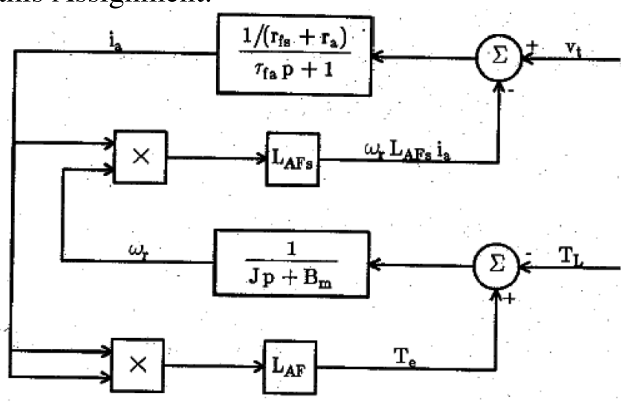
At stall, $\omega_r = 0$

$$I_a = \frac{V_a}{r_a + r_{fs}} = \frac{100}{2+1} = \frac{100}{3} \text{ A}$$

$$T_e = L_{AFs} I_a^2 = (0.463)\left(\frac{100}{3}\right)^2 = 514.6 \text{ N·m}$$

Problem B:

Develop the time-domain block diagram for a series-connected dc machine. You will also need this for Part 2 of this Assignment.



Part 2: Use the Matlab/Simulink and develop models of the PM and Series DC motors.

Implement the following study: Start both motors with zero initial conditions. At time t = 0.5 sec, apply the constant nominal torque to each of the motor. Use the step function **Step** that can be found under the **Sources** in the **Simulink Library**. Plot and compare the armature current Ia, rotor speed wr, and electromagnetic torque Te.

You should observe the start-up transient followed by the response to the applied load. The result should look similar to: The series motor develops higher starting torque and takes less starting current!