

ECE 763

Homework #7

Problems:

1. The no-load speed at the output of a DC motor and gear unit ($n=50$) is 7.5 RPM for an input voltage of 3 volts. When the motor is stalled with a 3 volt input, it draws 1.0 amp of current and exerts a torque (at the output of the gear) of 2.5 nt-m. When the motor is turning with no load and the input voltage is removed (0 volts), the speed falls to 36.8% (which is e^{-1}) of the no-load speed in 160 ms. Find the following parameters for the motor: J_m , B_m , K_τ , K_b , R . Assume that L and τ_f are zero. Be sure to give the units on all quantities.

2. The continuity equation for a pump-controlled linear hydraulic actuator is given as follows:

$$Q_L = A_p \dot{x}_p + C_t P_L + (V_o/\beta_e)(dP_L/dt) \quad (1)$$

Give a description of the significance of each of the terms in the equation.

3. The basic equations that may be used to model a pump-controlled, linear hydraulic actuator (in addition to the continuity equation given above) are given as follows:

$$Q_L = K_p N_p \phi \quad (2)$$

$$A_p P_L = M_t \ddot{x}_p + B_p \dot{x}_p + F_L + F_f. \quad (3)$$

- (a) Derive the transfer function $X_p(s)/\Phi(s)$ assuming $F_L = 0$ (no load) and $|F_f| = 0$.
- (b) Using the following values for the actuator parameters, what are the poles of the system?

$$\begin{aligned} \beta_e &= 10^5 \text{ psi} \\ B_p &= 4.0 \text{ lb}/(\text{in}/\text{sec}) \\ C_t &= 0.01 \text{ (in}^3/\text{sec)}/\text{psi} \\ K_p &= 0.00243 \text{ in}^3/(\text{RPM}\cdot\text{deg}\cdot\text{sec}) \\ M_t &= 2.0 \text{ lb}/(\text{in}/\text{sec}^2) \\ A_p &= 2.356 \text{ in}^2 \\ V_o &= 35 \text{ in}^3 \\ N_p &= 3000 \text{ RPM} \end{aligned}$$

From the values for the poles of the actuator, what can you say about its general damping characteristics?