

E.2.27

The transfer function is:

$$\frac{V_o(s)}{V(s)} = \frac{R_2 R_4 C}{R_3} s + \frac{R_2 R_4}{R_1 R_3} = 24s + 144.$$

P2.13

The motor torque is given by:

$$\begin{aligned} T_m(s) &= (J_m s^2 + b_m s) \Theta_m(s) + (J_L s^2 + b_L s) n \Theta_L(s) \\ &= n \left((J_m s^2 + b_m s) / n^2 + J_L s^2 + b_L s \right) \Theta_L(s) \end{aligned}$$

Where: $n = \frac{\Theta_L(s)}{\Theta_m(s)} = \text{gear ratio}$

But:

$$T_m(s) = K_m I_g(s)$$

$$\neq \frac{I_g(s)}{V_g(s)} = \frac{1}{(L_g + L_f) s + R_g + R_f} V_g(s)$$

and $V_g(s) = K_g I_f(s) = \frac{K_g}{R_f + L_f s} V_f(s)$

Combining the above expressions yields:

$$\frac{\Theta_L(s)}{V_f(s)} = \frac{K_g K_m}{n \Delta_1(s) \Delta_2(s)}$$

Where: $\Delta_1(s) = J_L s^2 + b_L s + \frac{J_m s^2 + b_m s}{n^2}$ & $\Delta_2(s) = \frac{(L_g s + L_f s + R_g^2 + R_f^2) \times (R_f + L_f s)}{\text{Encl}}$

E2.19 The input-output relationship is:

$$\frac{V_o}{V} = \frac{A(K-1)}{1+AK}$$

Where:

$$K = \frac{z_1}{z_1 + z_2}$$

Assume $A \gg 1$. Then,

$$\frac{V_o}{V} = \frac{K-1}{K} = \frac{z_2}{z_1}$$

Where

$$z_1 = \frac{R_1}{R_1 C_1 s + 1} \text{ and } z_2 = \frac{R_2}{R_2 C_2 s + 1}$$

Therefore,

$$\frac{V_o(s)}{V(s)} = \frac{-R_2}{R_2 C_2 s + 1} \cdot \frac{R_1 C_1 s + 1}{R_1}$$

$$\therefore \frac{V_o(s)}{V(s)} = -\frac{2(s+1)}{s+2}$$

Solution

Additional Problem:

$$K_{Pot.} = \frac{10V - (-10V)}{10 \times 2\pi} = 0.318 \text{ v/rad.}$$

$$K = -$$

$$K_1 = 100$$

$$a = 100$$

$$V_2(s) = R I_a(s) + V_b(s) = R I_a(s) + K_b \cdot s \Theta_m(s)$$

$$I_a(s) = \frac{V_a(s)}{R} - \frac{K_b}{R} s \Theta_m(s)$$

$$T_m = K_t I_a(s) = \frac{K_t}{R} V_a(s) - \frac{K_t K_b}{R} s \Theta_m(s) = J_e s^2 \Theta_m(s) + D_e s \Theta_m(s)$$

where: $J_e = J_a + n^2 \cdot J_L$; $n = \frac{N_1}{N_2} = \frac{1}{10}$
 $D_e = D_a + n^2 D_L$

$$\frac{K_t}{R} V_a(s) = J_e s^2 \Theta_m(s) + \left(\frac{K_t K_b}{R} + D_e \right) s \Theta_m(s)$$

OR,

$$\frac{K_t}{J_e \cdot R} V_2(s) = s \left(s + \left(\frac{K_t K_b}{R J_e} + \frac{D_e}{J_e} \right) \right) \Theta_m(s)$$

$$\therefore \frac{\Theta_m(s)}{V_2(s)} = \frac{K_m}{s(s+a_m)}$$

where: $K_m = \frac{K_t}{J_e \cdot R} = 2.083$; $a_m = \frac{K_t K_b}{R J_e} + \frac{D_e}{J_e} = 1.71$

$$K_g = \frac{N_1}{N_2} = \frac{25}{250} = \frac{1}{10} = 0.1$$

