E.2.27

The transfer function is:

$$\frac{V_0(s)}{V(s)} = \frac{R_2 R_4 C}{R_3} s + \frac{R_2 R_4}{R_1 R_3} = 24s + 144.$$

P2.13 The motor torque is given by:

$$T_m(s) = (J_m s^2 + b_m s)\theta_m(s) + (J_L s^2 + b_L s) n \theta_L(s)$$
$$= n\left((J_m s^2 + b_m s)/n^2 + J_L s^2 + b_L s\right)\theta_L(s)$$

Where: $n = \frac{\theta_L(s)}{\theta_m(s)}$ = gear ratio

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

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

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

End

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 $A >> 1$. Then,

$$\frac{V_o}{V} = \frac{K-1}{K} = \frac{Z_2}{Z_1}$$

Where

$$Z_1 = \frac{R_1}{R_1C_1s+1} \quad \text{and} \quad Z_2 = \frac{R_2}{R_2C_2s+1}$$

Therefore,

$$\frac{V_o(s)}{V(s)} = \frac{-R_2}{R_2C_2s+1} \cdot \frac{R_1C_1s+1}{R_1}$$

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

Solution

Additional Problem:

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

$K = -$

$K_1 = 100$

$a = 100$

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

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

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

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

$D_e = D_a + n^2 D_L$

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

OR,

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

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

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

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