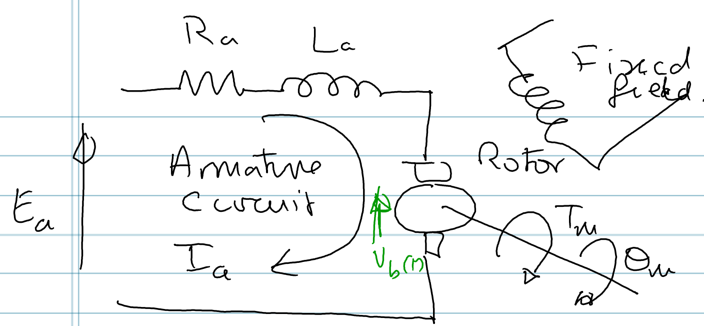


$$E_a(s) \longrightarrow \boxed{G(s)} \longrightarrow \Theta_m(s)$$

$$V_b(t) = K_b \frac{d\theta_m(t)}{dt}$$

$$V_b(s) = K_b s \Theta_m(s)$$

$$E_a(s) = R_a I_a(s) + sL_a I_a(s) + V_b(s)$$

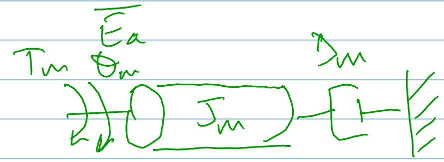
$$= R_a I_a(s) + sL_a I_a(s) + K_b s \Theta_m(s) \qquad (1)$$

$$T_m(s) = K_t I_a(s)$$

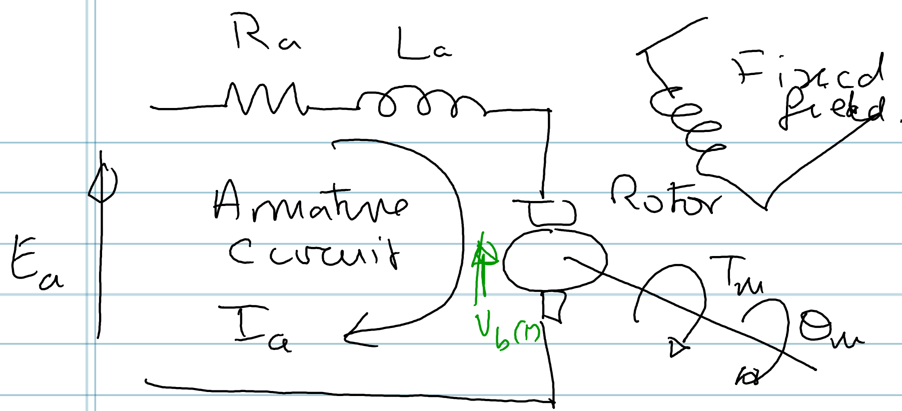
$$I_a(s) = \frac{1}{K_t} T_m(s)$$

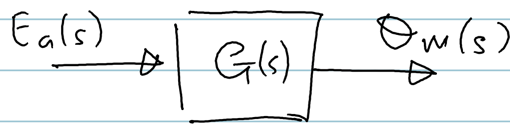
$$E_a(s) = \frac{(R_a + sL_a) T_m}{K_t} + K_b s \Theta_m(s) \qquad (2)$$

$$\frac{\theta_m}{E_a}$$



$$T_m(s) = (J_m s^2 + D_m s)\Theta_m(s) \qquad (3)$$





$$V_b(t) = K_b \frac{d\theta_m(t)}{dt}$$

$$V_b(s) = K_b\, s\, \theta_m(s)$$

$$E_a(s) = R_a I_a(s) + sL_a I_a(s) + V_b(s)$$

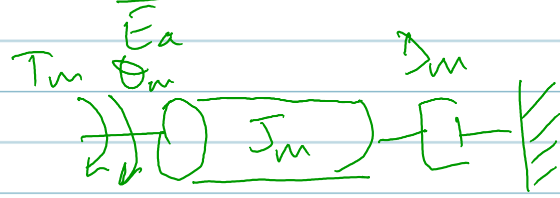
$$= R_a I_a(s) + sL_a I_a(s) + K_b s \theta_m(s) \qquad (1)$$

$$T_m(s) = K_t I_a(s)$$

$$I_a(s) = \frac{1}{K_t} T_m(s)$$

$$E_a(s) = \frac{(R_a + sL_a) T_m}{K_t} + K_b s \theta_m(s) \qquad (2)$$

$$\frac{\theta_m}{E_a}$$



$$T_m(s) = (J_m s^2 + D_m s)\theta_m(s)$$

(3)

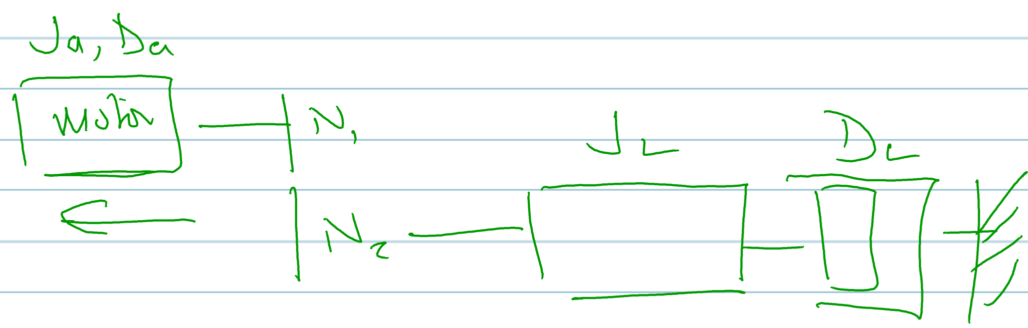
$$\frac{(R_a + sL_a)(J_m s^2 + D_m s)\Theta_m(s)}{K_t} + K_b s\Theta_m(s) = E_a(s).$$

Ignore L_a

$$\frac{R_a}{K_t}\left(J_m s + D_m + K_b\right) s\,\Theta_m(s) = E_a(s)$$

$$\frac{\Theta_m}{E_a} = \frac{K_t/(R_a J_m)}{s\left[s + \frac{1}{J_m}\left(D_m + \frac{K_t K_b}{R_a}\right)\right]}$$

$$= \frac{K}{s(s+\alpha)}$$



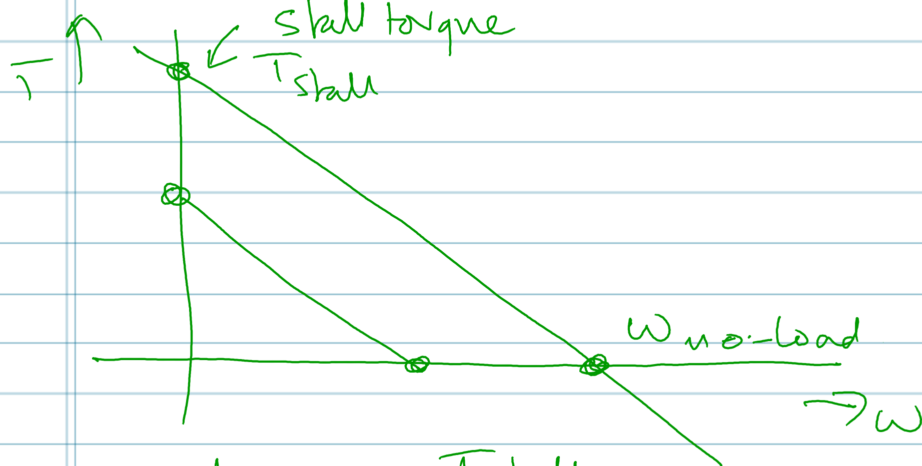
$$J_m = J_a + \left(\frac{N_1}{N_2}\right)^2 J_L$$

$$D_m = D_a + \left(\frac{N_1}{N_2}\right)^2 D_L$$

$$\frac{R_a}{K_t} T_m + k_b s \theta_m = E_a$$

$$\frac{R_a}{K_t} t_m(t) \cancel{+} k_b \omega_m(t) = e_a(t)$$

$$t_m = \frac{k_b k_t}{R_a} \omega_m + \frac{k_t e_a}{R_a}$$



$$\frac{k_t}{R_a} = \frac{T_{stall}}{e_a}$$

$$k_b = \frac{e_a}{\omega_{no\text{-}load}}$$