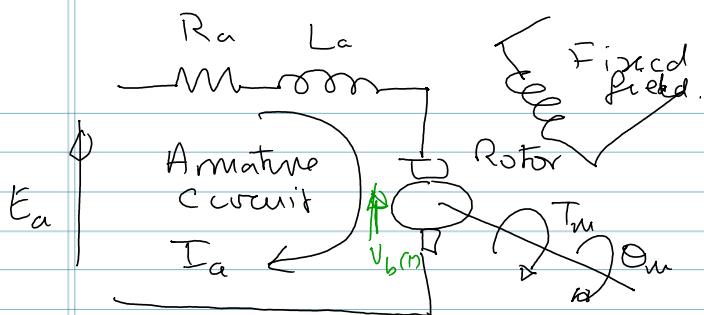


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$$E_a(s) \rightarrow [G(s)] \rightarrow \Theta_m(s)$$

$$V_b(t) = k_b \frac{d\Theta_m(t)}{dt}$$

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

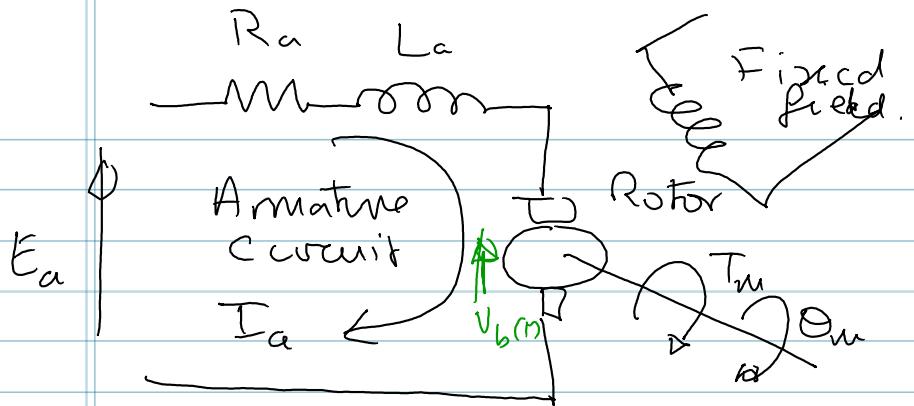
$$\begin{aligned} E_a(s) &= R_a I_a(s) + s L_a I_a(s) + V_b(s) \\ &= R_a I_a(s) + s L_a I_a(s) + k_b s \Theta_m(s) \quad (1) \end{aligned}$$

$$T_m(s) = k_t I_a(s)$$

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

$$E_a(s) - \underbrace{(R_a + s L_a) T_m}_{k_t} + k_1 s \Theta_m(s) \quad (2)$$

$$\begin{array}{c} \frac{T_m}{\Theta_m} \quad \frac{k_t}{k_1} \\ \overline{\Theta_m} \quad \overline{T_m} \\ \boxed{\Theta_m} \quad \boxed{T_m} \end{array} \quad T_m(s) - (J_m s^2 + D_m s) \Theta_m(s) \quad (3)$$



$$E_a(s) \rightarrow G(s) \rightarrow \Theta_m(s)$$

$$V_b(s) = -k_b \frac{d\Theta_m(s)}{dt}$$

$$V_b(s) = -T_m s \Theta_m(s)$$

$$\begin{aligned} E_a(s) &= R_a I_a(s) + sL_a I_a(s) + V_b(s) \\ &= R_a I_a(s) + sL_a I_a(s) + k_b s \Theta_m(s) \quad (1) \end{aligned}$$

$$T_m(s) = k_t I_a(s)$$

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

$$E_a(s) - \frac{(R_a + sL_a) T_m}{k_t} + k_y s \Theta_m(s) \quad (2)$$

$$\frac{T_m}{\Theta_m} = \frac{E_a}{J_m} - D_m \quad (3)$$

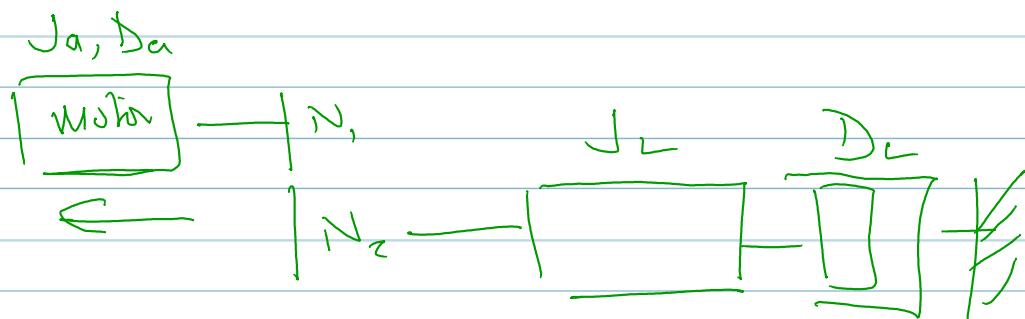
$$\frac{(R_a + sL_a)(J_m s^2 + D_m s) \Theta_m(s)}{k_t} + k_b s \Theta_m(s) = E_a(s).$$

Ignore  $L_a$

$$\frac{R_a}{k_t} (J_m s + D_m + k_b) s \Theta_m(s) = E_a(s)$$

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

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



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

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

$$\frac{R_a}{K_t} T_m + k_b \sin \theta_m = \dot{\theta}_c$$

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

$$t_m = \frac{k_b K_t}{R_a} \omega_m + \frac{K_t \varrho_a}{R_a}$$



$$\frac{K_t}{R_a} = \frac{T_{\text{stall}}}{\varrho_a}$$

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