Inl ①

Uppgift 1 a)

konstant

$$T_d(s) = G_e(s)(U(s) - K_u\Omega(s))$$ identifiera $G_e(s)$.

$u_m(t) = K_u\omega(t)$

$T_d(t) = K_m i_a(t)$

$\mathcal{L}\{\omega(t)\} = \Omega(s)$

$$G_e(s) = \frac{T_d(s)}{(U(s) - K_u\Omega(s))} =$$

$$\Rightarrow G_e(s) = \frac{K_m i_a(s)}{(U(s) - K_u\Omega(s))}$$

Kirchoffs law

$$R_a i_a(t) + L_a \frac{d}{dt} i_a(t) + u_m(t) = u(t)$$

$$R_a i_a(s) \quad s \cdot L_a \cdot i_a(s) \quad K_u\Omega(s) \quad u(s)$$

$$L_a \frac{d}{dt} i_a(t) = L_a i_a'(t)$$

$$\Rightarrow u(s) = K_u\Omega(s) + s\cdot L_a i_a(s) + R_a i_a(s)$$

$$u(s) - K_u\Omega(s) = s\cdot L_a i_a(s) + R_a i_a(s) \Rightarrow$$

$$\Rightarrow T_d(s) = G_e(s)(s\cdot L_a i_a(s) + R_a i_a(s)) \Rightarrow$$

$$\Rightarrow G_e(s) = \frac{T_d(s)}{(s\cdot L_a i_a(s) + R_a i_a(s))} = \frac{K_m i_a(s)}{s\cdot L_a i_a(s) + R_a i_a(s)} =$$

$$= \frac{K_m i_a(s)}{i_a(s)(s\cdot L_a + R_a)} = \frac{K_m}{(s\cdot L_a) + R_a} \leftarrow \text{SVAR}$$

Uppgift 1 b)

Newtons lag för roterande system

$G_m(s)$

$\Omega(s) = G_m(s)T_d(s)$

$$\Rightarrow G_m(s) = \frac{\Omega(s)}{T_d(s)}$$

$$J\omega'(t) = T_d(t) - b\cdot\omega(t) \Rightarrow$$

$$\Rightarrow T_d(t) = J\omega'(t) + b\omega(t)$$

$$T_d(s) = Js\Omega(s) + b\Omega(s)$$

$$G_m(s) = \frac{\Omega(s)}{\Omega(s)(Js+b)} = \frac{1}{Js+b} \leftarrow \text{SVAR}$$

Scanned by CamScanner

Uppgift 1c)

$[J = J_n + J_m]$

$$G_e(s) = \frac{K_m}{(s \cdot L_A) + R_a} = \frac{0.155\,Nm/A}{(s \cdot 0.25\,mH) + 2{,}4} = \frac{0.155}{s \cdot 0.25 \cdot 10^{-3} + 2{,}4} \approx$$

≈ 0.0645 (utan s)

$$G_m(s) = \frac{1}{Js + b} = \frac{1}{s \cdot 11{,}5 \cdot 10^{-4} + 0.0025} \approx$$

≈ 71.42 utan s

$\Rightarrow$ Vilket gör $G_m(s)$ snabbast?

Uppgift 1d)

$$G_{uw} = \frac{\omega(s)}{U(s)}$$, hmm...

1c) $$G_e(s) = \frac{K_m/R_a}{1 + s\underbrace{\frac{L_A}{R_A}}_{T?}} \quad ; \quad G_m(s) = \frac{1/b}{1 + s\frac{J}{b}}$$

↑ snabbare då ① < ②

$$\frac{0.25 \cdot 10^{-3}}{2{,}4} = \underbrace{\frac{25}{2{,}4} \cdot 10^{-4}}_{①} \qquad \frac{11{,}5 \cdot 10^{-4}}{0.0025} = \underbrace{\frac{11{,}5}{2{,}5} \cdot 10^{-1}}_{②}$$

1d) $$G_{uw} = \frac{G_m(s)\cancel{T_a(s)}}{\frac{\cancel{T_a(s)}}{G_e(s)} + K_u(G_m(s) \cdot \cancel{T_a(s)})} =$$

$$= \frac{G_m(s)}{\frac{1}{G_e(s)} + K_u G_m(s)} = \frac{1}{\frac{1}{G_e(s)\,G_m(s)} + K_u}$$

$$\frac{1}{\frac{1/b}{1 + s\frac{J}{b}} \cdot \frac{K_m/R_A}{1 + s\frac{L_A}{R_A}}} = \frac{1}{\frac{\frac{1}{b} \cdot \frac{K_m}{R_A}}{1 + s\left(\frac{L_A}{R_a} + \frac{J}{b}\right) + \frac{L_A J}{R_A b}s^2}} = \frac{\frac{L_A J}{R_A b}s^2 + s\left(\frac{L_A}{R_a} + \frac{J}{b}\right) + 1}{\frac{1}{b} \cdot \frac{K_m}{R_A}}$$

Scanned by CamScanner

$$U(s) = k_u \Omega(s) + sL_A i_A(s) + R_A i_A(s)$$

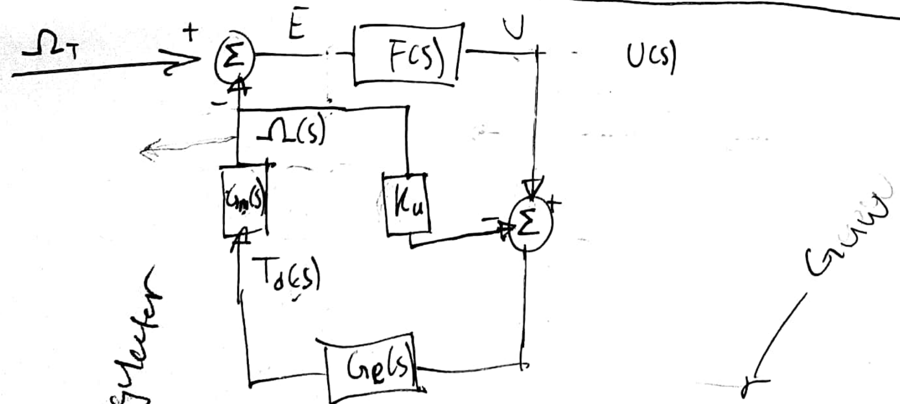
$$\frac{G_m(s) T_d(s)}{k_u G_m(s) T_d(s) + sL_A \frac{T_d(s)}{k_m} + R_A \frac{T_d(s)}{k_m}} = \frac{G_m(s)}{k_u \cdot G_m(s) + sL_A \frac{1}{k_m} + R_A \frac{1}{k_m}}$$

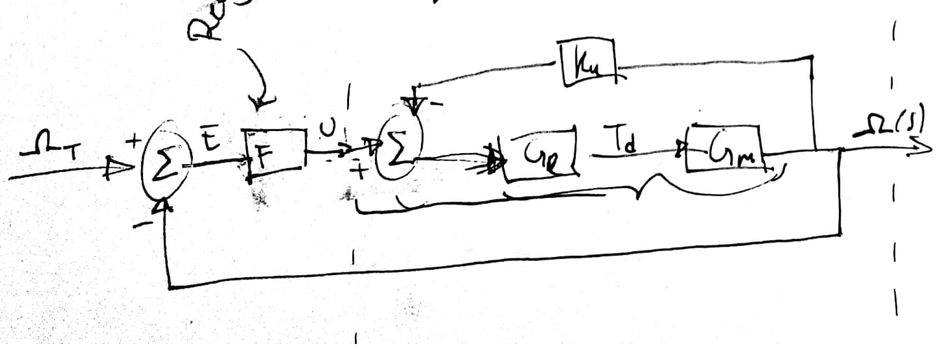
$$\frac{\dfrac{1/1}{\frac{L_A J}{R_A b} s^2 + s\left(\frac{L_A}{R_a} + \frac{J}{b}\right) + 1 + K_u \frac{k_m}{bR_A}}}{\frac{k_m}{R_A b}} = \frac{k_m / R_A b}{s^2 \frac{L_A J}{R_A b} + s\underbrace{\left(\frac{L_A}{R_A} + \frac{J}{b}\right)}_{\frac{L_A b + J R_A}{R_A b}} + bR_A + \frac{k_u k_m}{bR_A}}$$

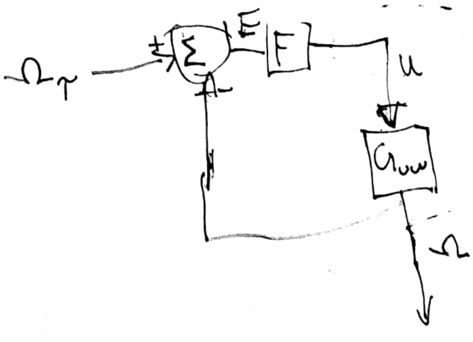
2a)

$$= G_{uw}(s) = \frac{k_m}{s^2 L_A J + s(L_A b + J R_A) + bR_A + k_u k_m}$$

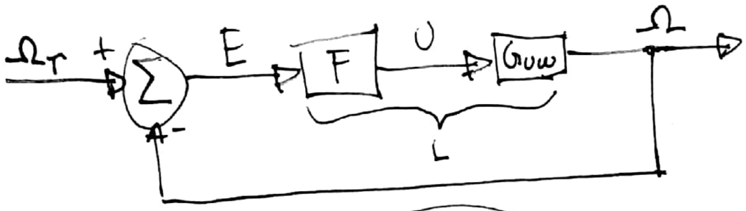
$$= \frac{0.155}{2.875 \cdot 10^{-7} s^2 + 6.25 \cdot 10^{-7} s + 5.3709 \cdot 10^{-2}}$$







2b)



kvarstående fel

$E = \Omega_T - \Omega$

$\Omega = U G_{UW} = EL$

$U = EF$

$U = (\Omega_T - \Omega)F \Rightarrow$

$\Omega = F G_{UW}(\Omega_T - \Omega) = F G_{UW}\Omega_T - F G_{UW}\Omega$

$\Omega(1 + F G_{UW}) = F G_{UW}\Omega_T \Rightarrow$

$\Omega = \frac{F G_{UW}}{1 + F G_{UW}}\Omega_T = \{L = F G_{UW}\} = \frac{L}{1+L}\Omega_T$

$E(s) = \Omega_T - \Omega = \left(1 - \frac{L}{1+L}\right)\Omega_T$

$= \left(\frac{1}{1+L}\right)\Omega_T$

$\rightsquigarrow \Omega_T = \mathcal{L}\{\omega_0 \sigma(t)\} =$

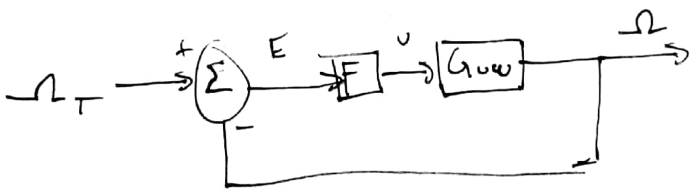
$= \frac{\omega_0}{s} \Rightarrow$

$\lim_{s\to 0} sE(s) = \lim_{s\to 0} \cancel{s}\frac{1}{1+L}\cdot\frac{\omega_0}{\cancel{s}} = \lim_{s\to 0}\frac{\omega_0}{1+L} = \left\{L = F G_{UW} = F\cdot\underbrace{\frac{k_m}{bR_A + k_0 k_m}}_{G_{UW}(0)},\ F = \begin{cases} k_p & (P) \\ \frac{k_p s + k_i}{s} & (PI)\end{cases}\right.$

P: $\lim_{s\to 0}\frac{\omega_0}{1 + k_p \cdot G_{UW}(0)}$ – exist

PI: $\lim_{s\to 0}\frac{\omega_0}{1 + \left(\underbrace{\frac{k_p \cancel{s}}{\cancel{s}}}_{=k_p} + \underbrace{\frac{k_i}{s}}_{\to\infty}\right)G_{UW}(0)} = 0$

2c) $\Omega =$



$\Omega = \underbrace{\frac{F G_{UW}}{1 + F G_{UW}}}_{H}\Omega_T$

$\Omega = GU$

$U = EF$

$E = \Omega_T - \Omega$

Scanned by CamScanner