Abdelrahman Adel Abdelfattah **Sheet 2** 17012296 NOTES

① a) error detetor

$$E_e(s) = K_s(\theta_r(s) - \theta_r(s))$$

$$\theta_r(s) \xrightarrow{+} \bigcirc \xrightarrow{} \boxed{K_s} \rightarrow E_e(s), \quad \theta_c(s) \xrightarrow{-} \bigcirc$$

· Amplifier

$$E_f(s) = A\,E_e(s) \qquad E_e(s) \rightarrow \boxed{A} \rightarrow E_f(s)$$

· Motor

$$T_m = K_m \Phi I_m , \quad \Phi = K_f I_f$$

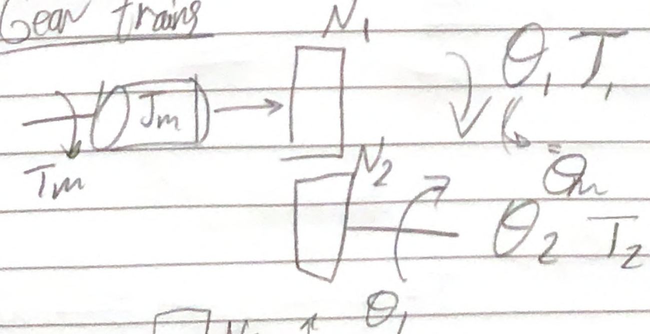
$$\therefore T_m = K_m K_f I_m I_f \qquad \because I_m \text{ is constant}$$

$$= K I_f$$

$$E_f = (R_f + L_f S) I_f , \quad I_m = (J s^2 + B S)\theta_m$$

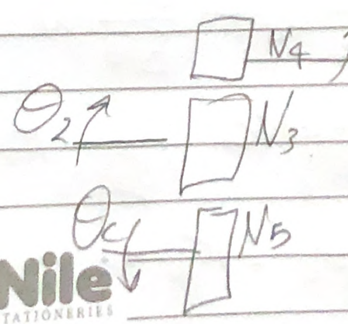
$$E_f(s) \rightarrow \boxed{\frac{1}{R_f + L_f s}} \xrightarrow{I_f} \boxed{K} \xrightarrow{T_m} \boxed{\frac{1}{Js^2 + BS}} \rightarrow \theta_m$$

· Gear trains



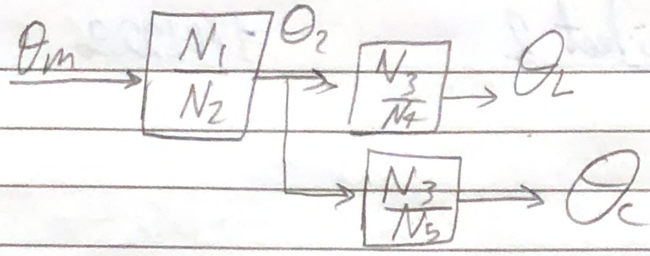
$$\frac{\theta_2}{\theta_m} = \frac{N_1}{N_2}$$

$$\theta_2 = \frac{N_1}{N_2}\theta_m$$

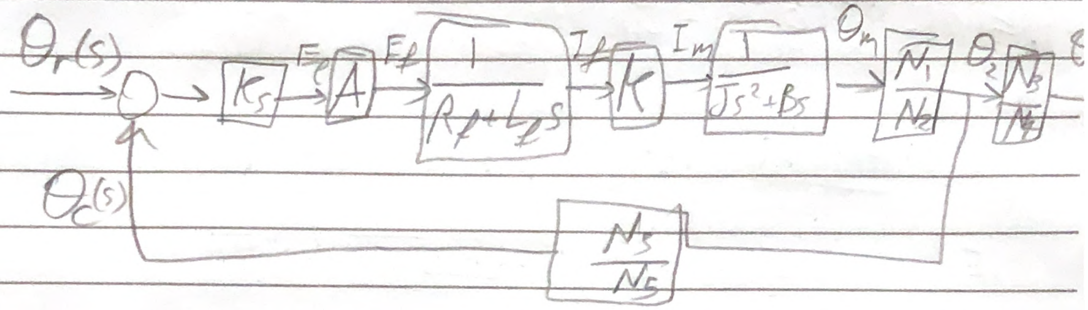


$$\frac{N_4}{N_3} = \frac{\theta_2}{\theta_L}$$

$$\frac{N_3}{N_5} = \frac{\theta_c}{\theta_2}$$



b)



. for the open Loop T.function $\frac{\theta_L}{E_e}$

$$\frac{\theta_L(s)}{E_e(s)} = \frac{AKN_1N_3}{(R_f+L_f s)(Js^2+Bs)N_2N_4}$$

. for the closed loop T.f

$$\text{let } G = \frac{AKN_1N_3}{(R_f+L_f s)(Js^2+Bs)N_2}, \quad \boxed{H = \frac{N_3}{N_5}}$$

$$\frac{\theta_L(S)}{\theta_r(S)} = \frac{G}{1+GH} \cdot \frac{N_3}{N_4} \quad \#$$

2 a) error detector

$$E_s = K_s(\theta_r - \theta_f)$$

Amplifier

$$\cdot\ E_L = A E_a$$

∘ Two phase motor

$$T = \frac{\delta T}{\delta e_c} e_c - \frac{\delta T}{\delta \omega} \omega$$

$$\text{Let } \frac{\delta T}{\delta e_c} = K_c, \quad \frac{\delta T}{\delta \omega} = K_w$$

$$T = K_c e_c - K_w \omega$$

$$T = K_c E_c - K_w S\theta \quad (1)$$

$$T = (Js^2 + Bs)\theta \quad (2)$$

from (1) & (2)

$$K_c E_c - K_w S\theta = (Js^2 + Bs)\theta$$

$$K_c E_c = [Js + (B + K_w)] S\theta$$

$$\underbrace{\frac{K_c}{B + K_w}}_{K_m} E_c = \left[\underbrace{\frac{J}{B + K_w}}_{\tau_m} S + 1\right] S\theta$$

$$K_m E_c = (\tau_m S + 1) S\theta \quad / \quad E_c \rightarrow \boxed{\frac{K_m}{S(\tau_m S + 1)}} \rightarrow \theta_m$$

- Tachometer

$$e_t \propto w_t$$

$$e_t = K_t w_t$$

$$\xrightarrow{L.T} E_t(s) = K_t S \theta_t$$

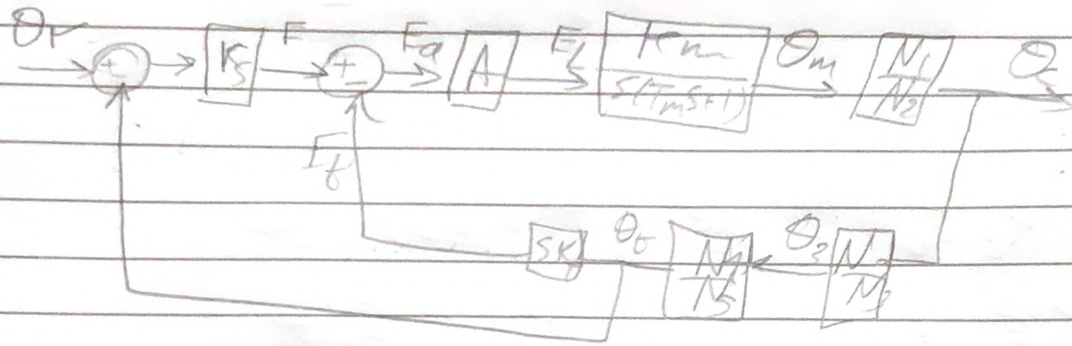
- Gear trains

$$\frac{\theta_c}{\theta_m} = \frac{N_1}{N_2}$$

$$\frac{\theta_3}{\theta_c} = \frac{N_2}{N_3}$$

$$\frac{\theta_t}{\theta_3} = \frac{N_4}{N_5}$$

b) $e = e_a + e_f \Rightarrow E_a = E - E_f$



Let $G_1 = \dfrac{AK_m N_1}{s(T_m s+1)N_2}$

$H_1 = \dfrac{N_2 N_4 sK_t}{N_3 N_5}$

$\dfrac{\theta_c(s)}{E(s)} = \dfrac{G_1}{1+G_1H_1} = G_2$

Let $G = K_s G_2$

$H = \dfrac{N_2 N_4}{N_3 N_5}$

$\dfrac{\theta_c(s)}{\theta_r(s)} = \dfrac{G}{1+GH}$

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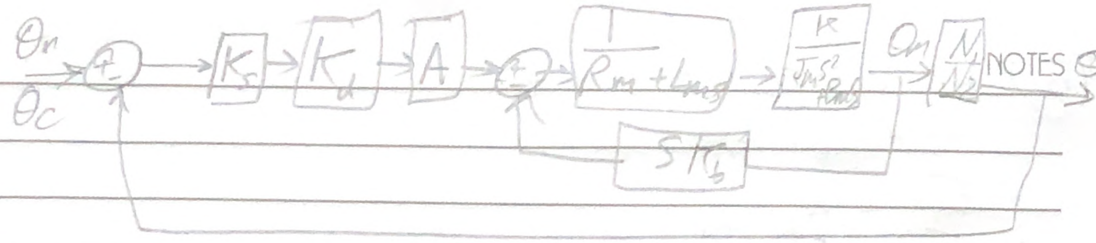

Let $G_1 = \dfrac{K}{(R_m + L_m S)(J_m S^2 + B_m S)}$, $H_1 = S K_b$

$$G_2 = \frac{G_1}{1 + G_1 H_1}$$

Let $G = K_s K_d A\, G \dfrac{N_1}{N_2}$

$$\frac{\theta_c(S)}{\theta_r(S)} = \frac{G}{1+G} \quad , H = 1$$

. for open loop

$$\frac{\theta_c(S)}{\theta_e(S)} = K_s K_d A\, G_2 \frac{N_1}{N_2}$$

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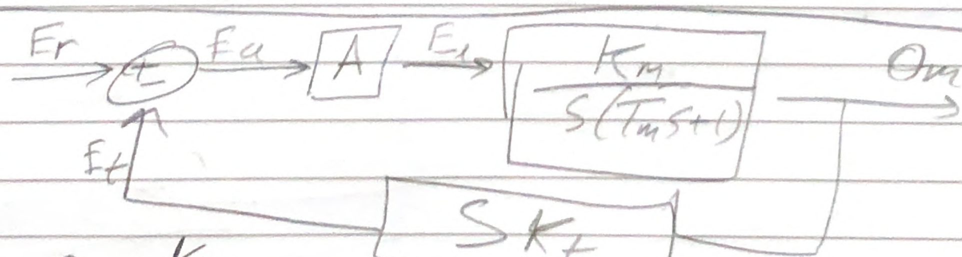


Let $G = \dfrac{A K_m}{S(T_m S+1)}$, $H = S K_t$

$$\frac{\theta_m}{E_r} = \frac{G}{1 + GH}$$

NOTES.

(5) $E_r = E_t + E_c$

$E_c = (R_c + L_c S) I_c$

$F_c = K_c I_c$

$F_c = K_s x$

$F_f = K_x x$

$E_f = I_f (R_f + L_f S)$

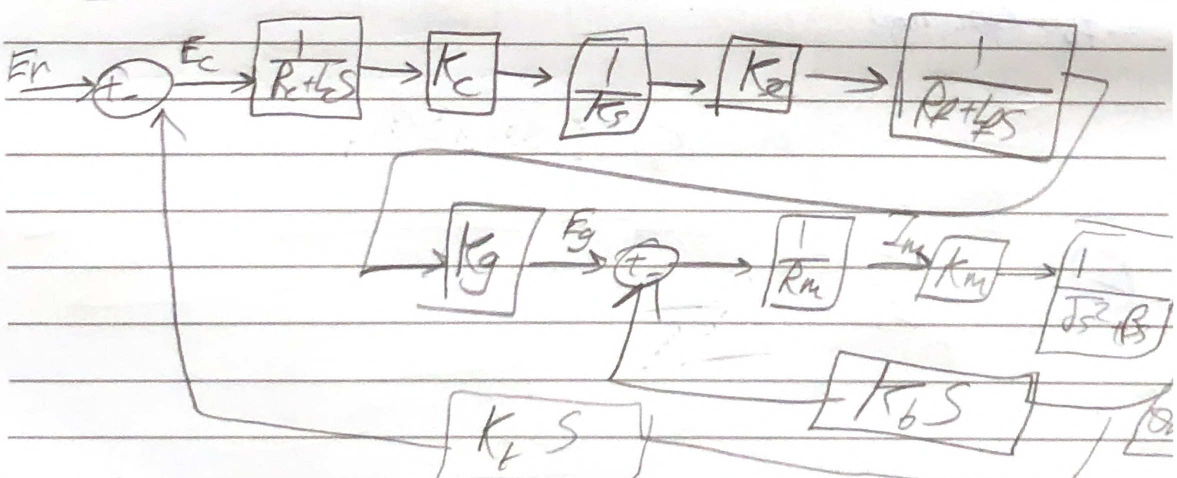
$E_g = K_g I_f$

$E_g - E_m = I_m R_m$

$T_m = K_m I_m$

$T_m = (J S^2 + B S)\theta_m$

$E_t = K_t S \theta_m$



let $L_1 = \frac{K_c K_x K_g}{K_s(R_c+L_cS)(R_f+L_fS)}$, $L_2 = \frac{K_m}{R_m(JS^2+BS)}$

$L_3 = \frac{L_2}{1+L_2 K_b S}$, $L_4 = K_t S$

$$\frac{\theta_m}{E_r} = \frac{L_1 L_3}{1+L_1 L_3 L_4}$$

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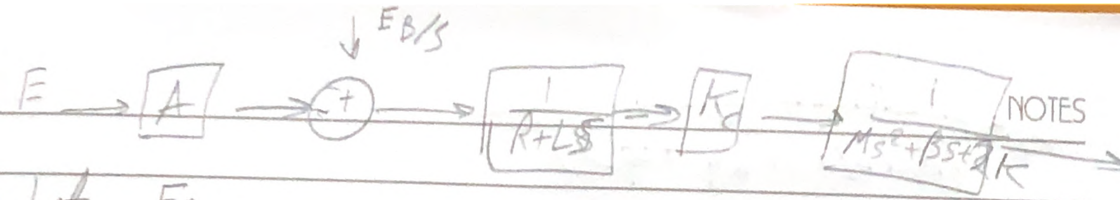

NOTES

1) Let $E_{B/s}=0$

$$T.F_1 = \frac{x}{E} = \frac{AK_c}{(R+LS)(Ms^2+Bs+2K)}$$

2) Let $E=0$

$$T.F_2 = \frac{x}{E_B/s} = \frac{K_c}{(R+LS)(Ms^2+Bs+2K)}$$

$$\frac{x}{E} = T.F_2 \cdot \frac{E_B}{SE}$$

$$TF = T.F_1 + T.F_2 \, \frac{E_B}{SE}$$

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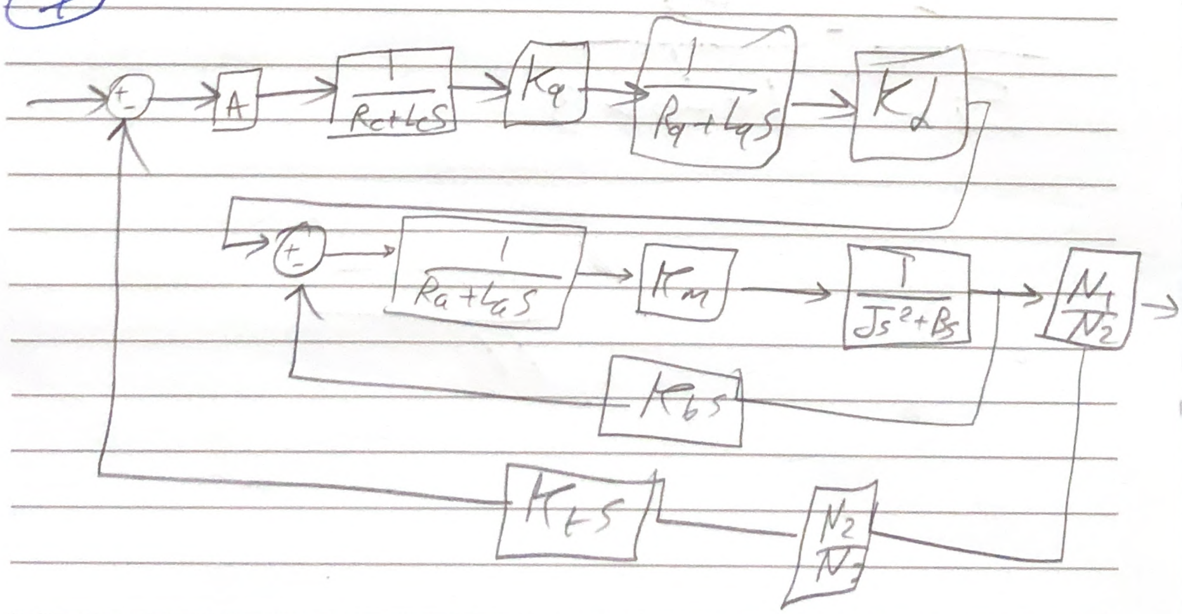

NOTES.

$$L_1 = \frac{A K_q K_d}{(R_c + L_c S)(R_q + L_q S)}$$

$$L_2 = \frac{K_m}{(R_a + L_a S)(J s^2 + B s)}$$

$$L_3 = \frac{K_t S N_2}{N_3}$$

$$L_4 = \frac{L_2}{1 + L_2 K_b S}$$

Let $L_5 = L_1 L_4 \dfrac{N_1}{N_2}$

$$\frac{\theta_L}{E_i} = \frac{L_5}{1 + L_5 L_3}$$

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Nile STATIONERIES

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