PROBLEMA 1

(1)

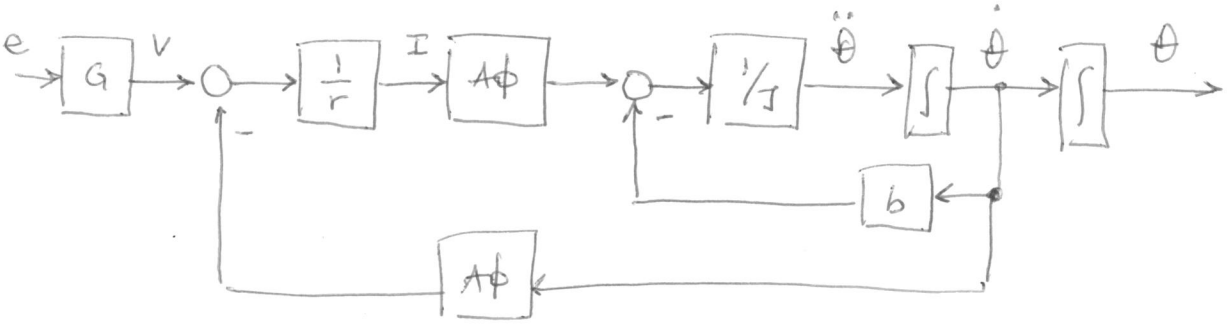
a) $V = rI + A\phi\,\dot{\theta}$

$(J_1 + J_2)\ddot{\theta} = A\phi I - (b_1 + b_2)\dot{\theta}$

$V = Ge$

$\Rightarrow \quad J\ddot{\theta} = \frac{A\phi}{r} Ge - \left[b + \frac{A\phi^2}{r} \right] \dot{\theta}$

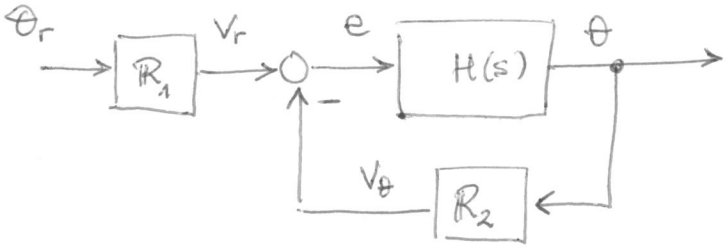
$J = J_1 + J_2 \;, \quad b = b_1 + b_2$



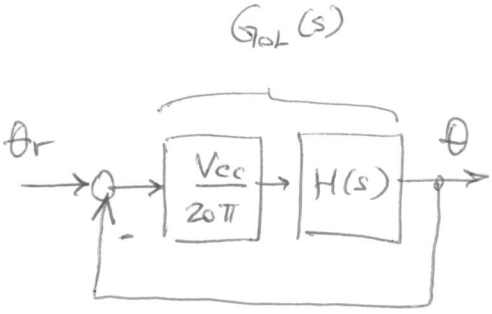
b) $\frac{\theta(s)}{E(s)} = \frac{G A\phi / r / J}{s\left(s + \frac{b}{J} + \frac{A\phi^2}{Jr}\right)} \rightarrow \frac{\theta(s)}{E(s)} = \frac{0.125\,G}{s(s+1.12)} = H(s)$

(2)

a)



$\Rightarrow$



$V_r = \frac{Vcc}{10 \cdot 2\pi}\,\theta_r$

$V_\theta = \frac{Vcc}{10 \cdot 2\pi}\,\theta$

$\Rightarrow \quad R_1 = R_2 = \frac{Vcc}{20\pi}$

b) $G_{OL}(s) = \frac{0.06\,G}{s(s+1.12)}$

entrada = rampa $\Rightarrow \quad e_{ss} = \frac{1}{K_V} = 0.05 \;;\quad K_V = \lim_{s \to 0} s\,G_{OL}(s) = \frac{0.06\,G}{1.12} \Rightarrow \boxed{G = 373.3}$

entrada = escalón $\Rightarrow \quad e_{ss} = 0$ (sistema tipo 1)

c) $G_{OL}(s) = \dfrac{22.4}{s(s+1.12)}$

$\boxed{MG = \infty}$

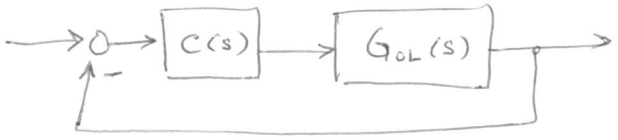
$Mf = 180° + \arctg\left(G_{OL}(j\omega_c)\right)$; $\omega_c /\ |G_{OL}(j\omega_c)| = 1$

$\Rightarrow \omega_c = 4.67$ rad/s $\Rightarrow$ $\boxed{Mf = 13.49°}$

d) $G_{CL}(s) = \dfrac{22.4}{s^2 + 1.12s + 22.4}$ $\Rightarrow$ $\omega_n = 4.73$ rad/s, $\zeta = 0.1184$

$M_p = e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}}$ $\Rightarrow$ $\boxed{M_p = 0.6876 = 68.8\%}$

3)



$C(s) = \dfrac{1+aTs}{1+Ts}$ $a<1$

C(s): compensador por atraso.

a) Estabilidad: $Ts^3 + s^2(1+1.12T) + (1.12 + aT\,22.4)s + 22.4 = 0$

RH $\Rightarrow$ $\boxed{T>0}$, $\boxed{1+22.4aT > \dfrac{22.4T}{1+T,1.12}}$

b) $Mf_d = 60° \pm 1°$

$\Delta\phi = 6°$ $\Rightarrow$ ω_c^* / $180 + \arctg\left(G_{OL}(j\omega_c^*)\right) = 66°$ $\Rightarrow \omega_c^* = 0.4987$ rad/s

$|G_{OL}(j\omega_c^*)| = 36.63 = \dfrac{1}{a}$ $\Rightarrow$ $\boxed{a = 0.0273}$

$T \gg \dfrac{1}{a\omega_c^*}$ $\Rightarrow$ $\boxed{T = 735\ s}$

Verif: $\arg\left(C(j\omega_c^*)\right) = \arctg aT\omega_c^* - \arctg aT\omega_c^* = 5.5° \in 5° \pm 1°$ ✓