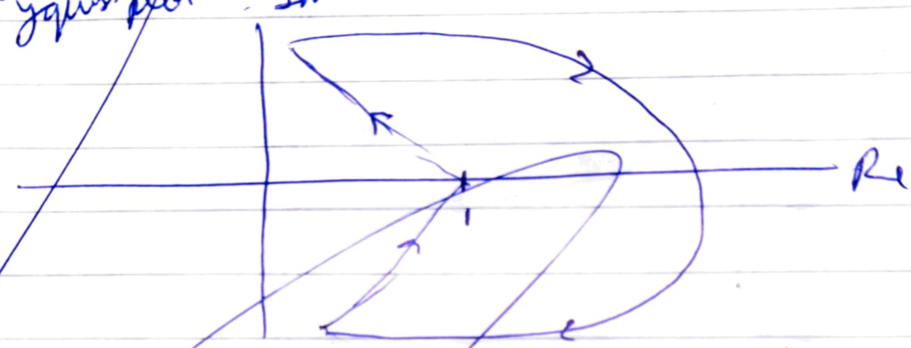
SHUBHAM GUPTA 180741

END SEM

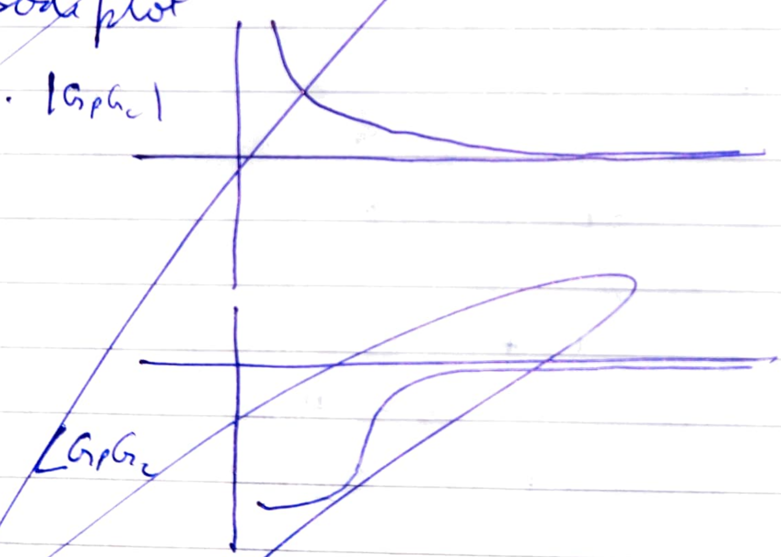
1\) a) $G_p = \dfrac{e^{-s}}{s}$ $G_c = \dfrac{k_c(z_I s+1)}{z_I s}$

$$G_p G_c = \frac{k_c e^{-s}(z_I s+1)}{z_I s^2}$$

Nyquist plot

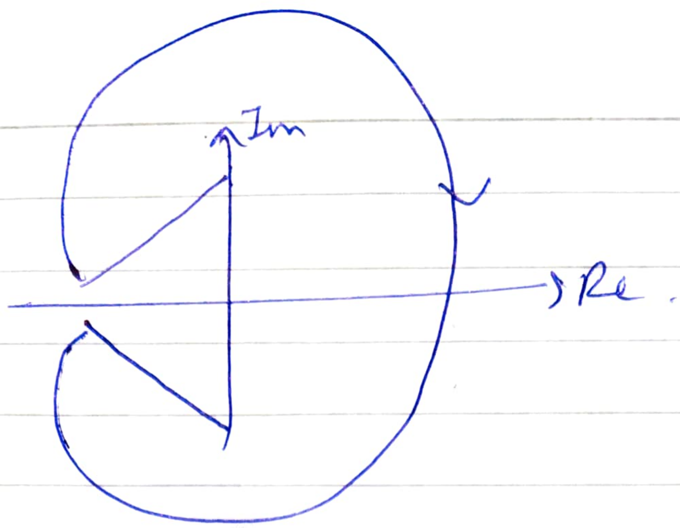


Bode plot



b) $-\omega + (\tan^{-1} z_I -$

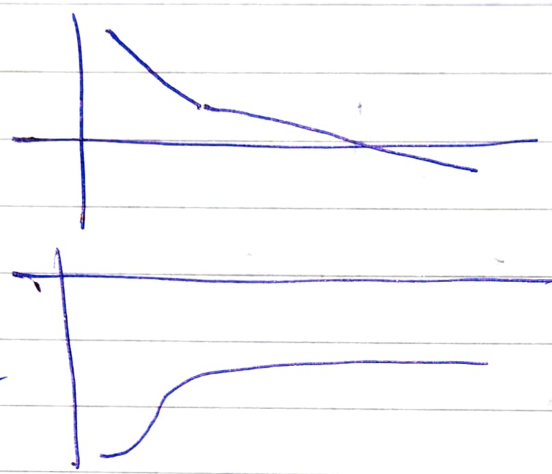
* Nyquist



* Bode

mag

∠G_pG_c



b) $-\omega + \tan^{-1}(\tau_I\omega) = -\pi = \angle G_{OL}$

$$\frac{d\angle G_{OL}}{d\omega} = -1 + \frac{\tau_I}{\tau_I^2\omega^2+1} = 0$$

$$\tau_I = \tau_I^2\omega^2 + 1$$

$$\cancel{\tau_I^2\omega^2 - \tau_I + 1 = 0}$$

$$\omega^2 = \frac{\tau_I - 1}{\tau_I^2}$$

$$\boxed{-\left(\frac{\tau_I-1}{\tau_I^2}\right) + \tan^{-1}\left(\frac{\tau_I-1}{\tau_I}\right) = -\pi}$$

c) $\dfrac{G_{OL}}{1+G_{OL}} = \dfrac{\dfrac{k e^{-s}(z_1 s+1)}{\cancel{z_1 s^2}}}{\dfrac{z_1 s^2 + k e^{-s}(z_1 s+1)}{\cancel{z_1 s^2}}}$

$$G_{CL} = \frac{k e^{-s}(z_I s+1)}{z_1 s^2 + k e^{-s}(z_1 s+1)}$$

$|G_{CL}| = 1.258$

d) $\cancel{1 + G_p G_c = 0}$

$\cancel{1 + \frac{e^{-s}}{s} \times \frac{k z_1 s+1}{z_1 s} = 0}$

$\cancel{z_1 s^2 + e^{-s} k z_1 s + e^{-s}}$

$$G_p G_c = \frac{k e^{-s}(z_1 s+1)}{z_1 s^2}$$

$\angle G_{OL} = -\omega + \tan^{-1}(z_1\omega) - \cancel{\pi/2} - \pi/2 = -\cancel{\pi}$ --- ①

$|G_{OL}| = \dfrac{k\sqrt{z_1^2\omega^2+1}}{z_I\omega^2} = 1$ --- ②

$+\tan^{-1}(z_1\omega) - \frac{\pi}{2} = +\frac{\pi}{10}$

--- ③

solving ① ③

$\boxed{\begin{aligned} z_1 &= 3.33 \\ \omega &= 1.35 \\ K_U &= 1.317 \end{aligned}}$

e.) $z_1 = 1.88$

$\angle G_{OL} = -\omega + \tan^{-1}(1.88\,\omega) = 0$

$\boxed{\omega = 1.13}$

$|G_{OL}| = \frac{1}{2} = \frac{k\sqrt{\omega^2 z_1^2 + 1}}{z_1 \omega^2}$

$\boxed{K = 0.511}$ Ans

f). $z_1 = 1.88$

$\angle G_{OL} = -\omega + \tan^{-1}(1.88\,\omega) = \frac{\pi}{4}$

$\boxed{\omega = 2.1}$

$|G_{OL}| = 1 = \frac{k\sqrt{\omega^2 z_1^2 + 1}}{z_1 \omega^2}$

$\boxed{K = 2.035}$ Ans

2.) $k_p = G_M(0) = \begin{bmatrix} 1 & 2 \\ 1.5 & 0.5 \end{bmatrix}$

a, b

$NI_1 = \dfrac{0.5 - 3}{0.5} = -5$

$RGA_1 = [K^{-1}]^T = \begin{bmatrix} -0.2 & 0.6 \\ 0.8 & -0.4 \end{bmatrix}$

$RGA_1 = \begin{bmatrix} -0.2 & 1.2 \\ 1.2 & -0.2 \end{bmatrix}.$

$k_p = \begin{pmatrix} 2 & 1 \\ 0.5 & 1.5 \end{pmatrix}.$

$NI_2 = \dfrac{3 - 0.5}{0.5} = 5$ preffered

$RGA_2 = (k^{-1})^T = \begin{pmatrix} 0.6 & -0.2 \\ -0.4 & 0.8 \end{pmatrix}$

$RGA_2 = \begin{bmatrix} 1.2 & -0.2 \\ -0.2 & 1.2 \end{bmatrix}$ preffered

Both RGAs are good
2nd NI is good.

c.) $G_p = \dfrac{2\, e^{-0.5s}}{3s+1}$ $\qquad G_c = \dfrac{k(\tau_I s + 1)}{\tau_I s}$

$\tau_I = 3 \text{ min}$.

$G_p G_c = \dfrac{2k\, e^{-0.5s}}{3s}$

$G_{OL}(\omega j) = \dfrac{2k\, e^{-0.5\omega j}}{3\omega j}$

$\angle G_{OL} = -0.5\omega_c - \pi/2 = -\pi$ $\qquad \boxed{\omega_c = \pi}$

$$|G_{OL}\,\omega j|_{\omega_c} = \frac{1}{G_m} = 1 = \frac{2k_c}{3\pi}$$

$$\boxed{k_c = \frac{3\pi}{2}} \approx \boxed{4.712}$$

$$P \approx \frac{2\pi}{\omega} = 2$$

$$k_u = \frac{3\pi}{2} \qquad P_u = 2$$

ZN settings

PI $\boxed{k_c = 2.14}$ $\boxed{\tau_I = 1.66}$

1.66

d) $$G_p = \frac{1.5e^{-2s}}{8s+1} \times \frac{0.5e^{-s}}{5s+1} \qquad G_c = \frac{k(\tau_I s+1)}{\tau_I s}$$

$$\tau_I = 2$$

$$G_pG_c = \frac{0.75ke^{-3s}\,(2s+1)}{(8s+1)(5s+1)(2s)}$$

$$\angle G_{OL} = -\tan^{-1}(8\omega_c) - \tan^{-1}(5\omega_c) - \pi/2 + \tan^{-1}(2\omega_c) - 3\omega_c = -\pi$$

$$\boxed{\omega_c = 1.36}$$

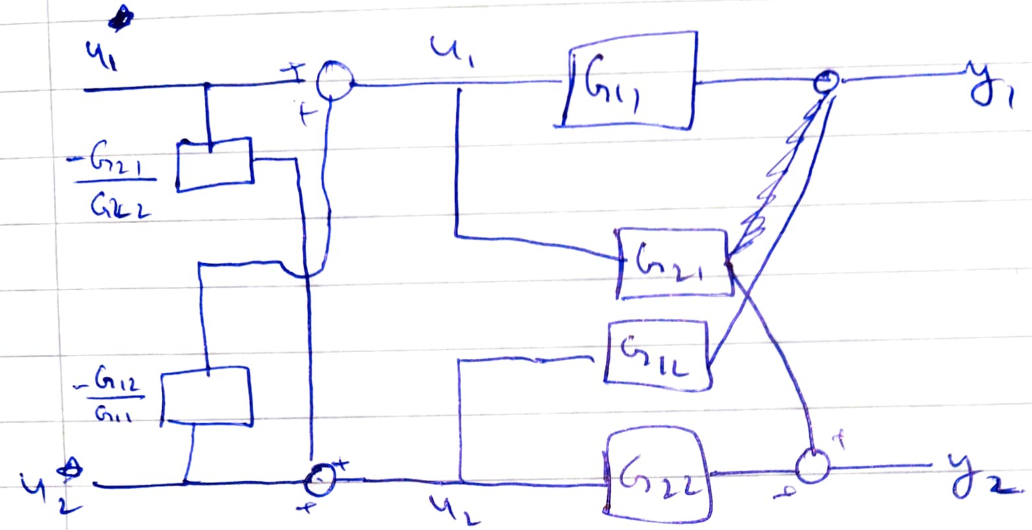
$$|G_{OL}| = \frac{1}{G_m} = \frac{1}{2} = \frac{0.375k\sqrt{4\omega^2+1}}{\sqrt{64\omega^2+1}\sqrt{25\omega^2+1}\;\omega}$$

$$k = \frac{\omega \cdot \sqrt{64\omega^2+1}\ \sqrt{25\omega^2+1}}{0.75 \cdot \sqrt{4\omega^2+1}}$$

$$k = 46.9$$

$$\boxed{k = 47.}$$

l.) dynamic decoupler



~~$G_{11} = \frac{e^{-2s}}{10s+1}$~~ ~~$G_{22} = \frac{0.5e^{-s}}{5s+1}$~~

~~$G_{12} = \frac{2e^{-0.5s}}{3s+1}$~~ ~~$G_{21} = \frac{1.5e^{-2s}}{8s+1}$~~

~~$\boxed{-\frac{G_{21}}{G_{22}} = -3 \cdot \frac{e^{-s}(5s+1)}{(8s+1)}}$~~

~~$\boxed{-\frac{G_{12}}{G_{11}} = -2\frac{e^{+1.5s}(10s+1)}{(3s+1)}}$~~

$G_{11} = \frac{2e^{-0.5s}}{3s+1}$ $G_{12} = \frac{e^{-2s}}{10s+1}$

$G_{21} = \frac{0.5e^{-s}}{5s+1}$ $G_{22} = \frac{1.5e^{-2s}}{8s+1}$

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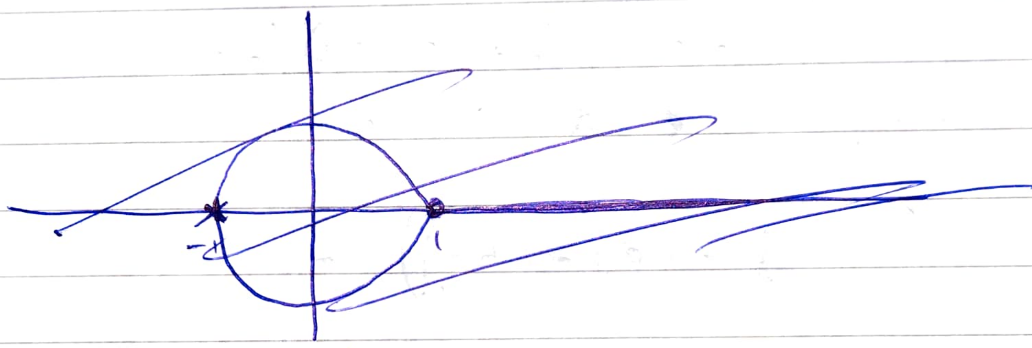
3 a) $G_P = \frac{2(-s+1)}{(s+1)^2}$ $G_c = k$

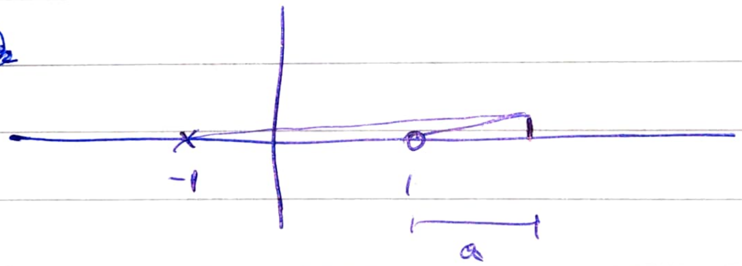
$G_P G_c = \frac{2k(-s+1)}{(s+1)^2}$

poles = $-1, -1$

zeros = $+1$



~~break~~



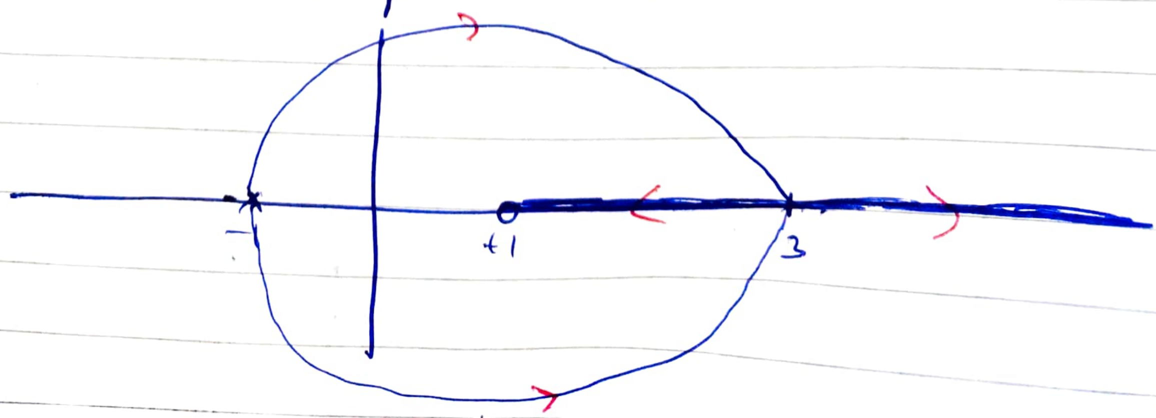
$$2\tan^{-1}\left(\frac{\delta}{a+2}\right) - \tan^{-1}\frac{\delta}{a} = 0$$

$$\frac{2}{a+2} - \frac{1}{a} = 0$$

$$2a - a - 2 = 0.$$

$$\boxed{a = 2}$$

break in pt at 3



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b) $1 + G_p G_c = 0$

$(s+1)^2 + 2k(1-s) = 0$

$s^2 + 2s + 1 + 2k - 2ks = 0$

$s^2 + (2-2k)s + 1 + 2k = 0$

$\xi = 1/\sqrt{2} \Rightarrow s = -a + aj$

$(-a+aj)(-a+aj) + (2-2k)(-a+aj) + 1 + 2k = 0$

$(\cancel{a^2} - a^2 j - a^2 j - \cancel{a^2}) + (-2a + 2aj + 2ka - 2kaj) + 1 + 2k = 0$

$(-2a^2 j + 2aj - 2kaj) + (-2a + 2ka + 1 + 2k) = 0$

$-2a^2 + 2a - 2ka = 0$

$-2a + 2 - 2k = 0$ — 1

$-2a + 2ka + 1 + 2k = 0$ — 2

using matlab

solving $\boxed{k = 0.1771}$

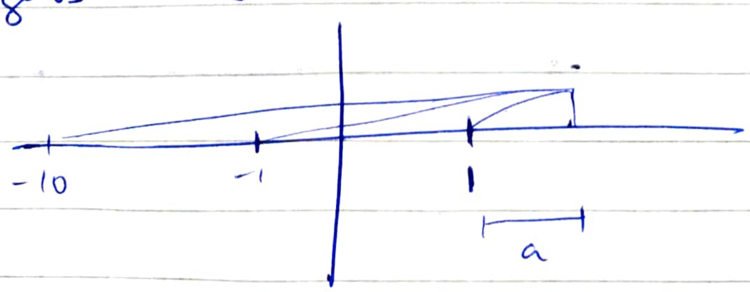
c) $G_p = \frac{2(-s+1)}{(s+1)^2}$ $G_c = \frac{k(z_D s + 1)}{(0.1 z_D s + 1)}$ $z_D = 1$ m.

$G_p G_c = \frac{2k(-s+1)}{(s+1)(0.1s+1)}$

poles $= -1, -10$

zeros $= 1$

$\tan^{-1}\frac{\delta}{a+1} + \tan^{-1}\frac{\delta}{a+2} - \tan^{-1}\frac{\delta}{a}$



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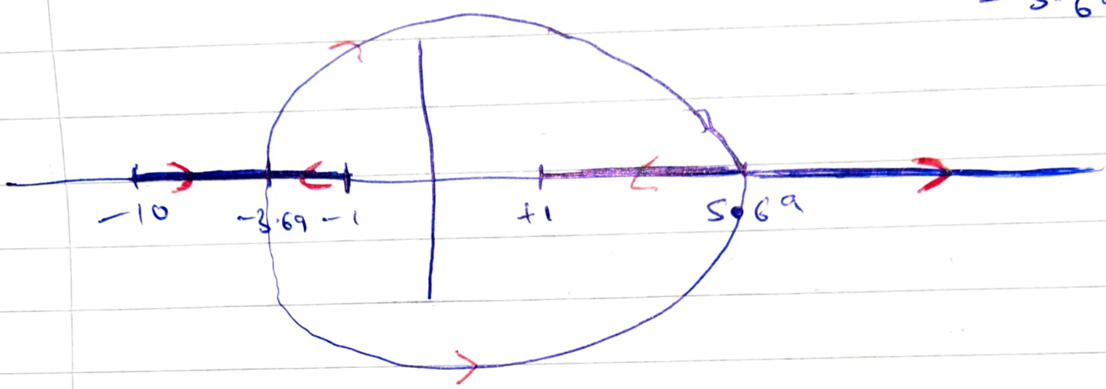
6TH SEM

$$\frac{1}{a+11} + \frac{1}{a+2} + \frac{1}{a} = 0$$

$$a = \sqrt{22} = 5.69, \; -3.69$$



d) $1 + G_p G_c = 0$

$$(s+1)(0.1s+1) + 2k(1-s) = 0$$

$$\xi = 1/\sqrt{2} \Rightarrow s = -a + aj$$

$$0.1s^2 + 1.1s + 1 + 2k - 2ks = 0$$

$$0.1(-a^2 j) - 1.1a + 1.1aj + 1 + 2k + 2ka - 2kaj = 0$$

$$\underbrace{(-0.1a^2 j + 1.1aj - 2kaj)}_{1} + \underbrace{(-1.1a + 1 + 2k + 2ka)}_{2} = 0$$

solving for 1 & 2 using matlab we get

$$\boxed{k = 0.2645}$$

4.) a) $G_p = \dfrac{2}{(2s+1)(s+1)^2}$ $\quad G_D = \dfrac{-1}{(4s+1)(2s+1)(s+1)}$

$$2\left[\left\{\frac{A}{(2s+1)} + \frac{B}{(s+1)} + \frac{C}{(s+1)^2}\right\} + \frac{D}{s}\right]$$

solvg for A, B, C

$A = -8 \quad B = +3 \quad C = +1 \quad D = 1$

$$2\left[\left\{\frac{-8}{2s+1} + \frac{3}{s+1} + \frac{1}{(s+1)^2}\right\} + \frac{1}{s}\right.$$

inversl laplace.

$$y = 2\left[4e^{-t/2} + 3e^{-t} + te^{-t} + 1\right].$$

$t_{28.3} \longrightarrow$ put $y = 0.5670$

$t_{63.2} \longrightarrow$ put $y = 1.2640.$

$t_{28.3} = 2.4$

$t_{63.2} = 4.3$

$$\tau = \frac{3}{2}(4.3 - 2.4) = 2.85$$

$$\theta = \frac{1}{2}(3 \times 2.4 - 4.3) = 1.45$$

$$\boxed{\hat{G}_p = \frac{2e^{-1.45s}}{2.85s+1}}$$

similarly for G_D

$$-1\left[\left\{\frac{A}{4s+1} + \frac{B}{(2s+1)} + \frac{C}{(s+1)}\right\} + \frac{D}{s}\right)$$

solving for A, B, C, D

$A = \frac{-32}{3}$ $B = +4$ $C = -\frac{1}{3}$ $D = 1.$

$$-1\left[\frac{8}{3(4s+1)} - \frac{2}{2s+1} + \frac{1}{3(s+1)}\right]$$

inverse laplace:

$$y = -1\left(-\frac{8}{3}e^{-t/4} + 2e^{-t/2} + \frac{1}{3}e^{-t} + 1\right)$$

$t_{28.3} \longrightarrow$ put $y = 0.2835$

$t_{63.2} \rightarrow$ put $y = 0.632$

$t_{28.3} = 4.03$

$t_{63.2} = 7.40$

$\tau = \frac{3}{2}(7.40 - 4.03) = 5.050$

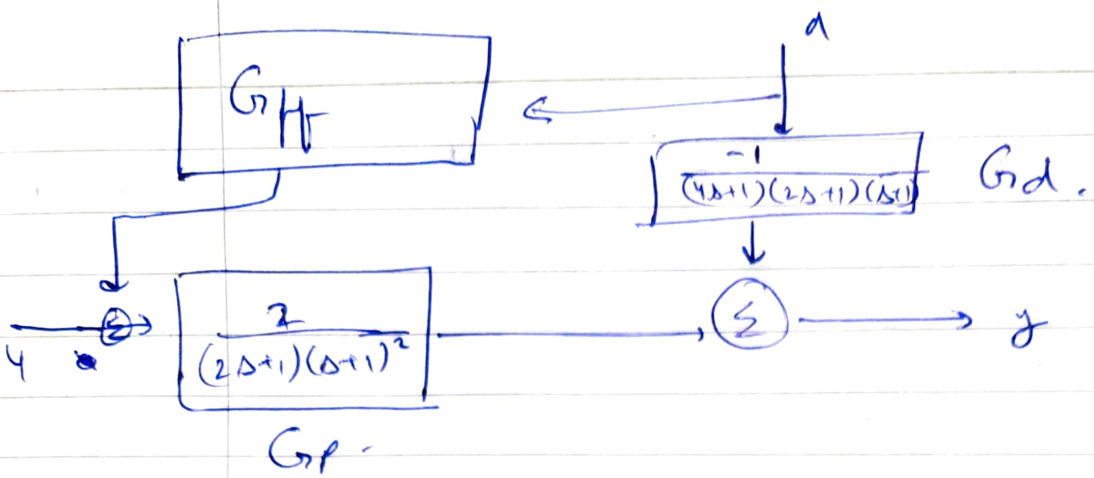
$\theta = \frac{1}{2}(3 \times 4.03 - 7.4) = 2.34$

$$\boxed{\hat{G}_p = \frac{-1\, e^{-2.34s}}{(5.05s+1)}}$$

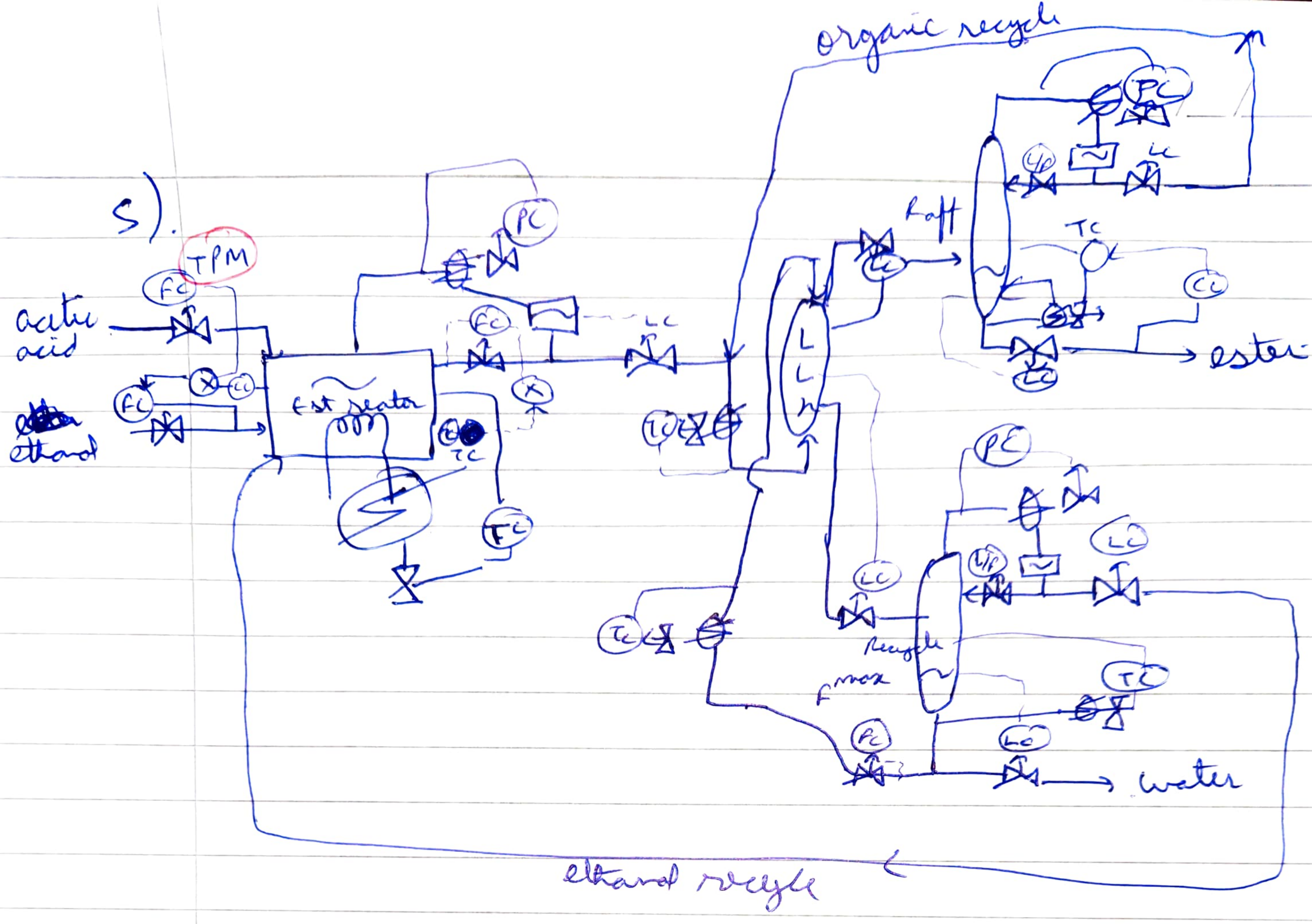
b.) $G_{ff} = -\frac{\hat{G}_D}{\hat{G}_p}$

$$G_{ff} = \frac{e^{-2.34s}(2.85s+1)}{2(5.05s+1)\cdot e^{-1.45s}}$$

$$\boxed{G_{ff} = \frac{1}{2}\frac{e^{-0.89s}(2.85s+1)}{(5.05s+1)}}$$



5).



Control DOF = 2 + 4 + 2 + 1 + 2 + 5 + 5

= 21

SS DOF = 2 + 2 + 2 + 1 + 2 + 2

= 11

[F_{AA}, F_{ETH}, $T_{est\ reactor}$, L/F est reactor, $T_{LLX\ bottom}$, $T_{LLX\ top}$, F_{water}, $T_{recycle}$, L/F recycle, $T_{raff.}$, (L/F) raffinate]