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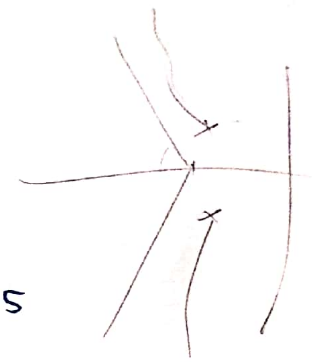
G

Test 1 Contol

Q1.



(a) (i) $G(s) = \dfrac{K(s+3)}{(s+4)(s+2+j1)(s+2-j1)}$

(ii) $\sigma_a = \dfrac{\sum poles - \sum zeroes}{\# pole - \# zeroes} = \dfrac{8-3}{3-1} = 2.5$

$\theta_a = \dfrac{(2k+1)\pi}{\# pole - \# zero} = \dfrac{(\overset{0}{\cancel{2}}+1)\pi}{3-1} = 1.57$, $k = 0$, ~~1~~

(iii) angle of departure;

$\theta_a = \sum(\theta_{pole\ to\ B})$

(b) $\%OS = 10\%$, $\zeta = 0.59$, $\omega_n = 4.08$ rad/s

(i) CL poles

$\theta = \cos^{-1}(\zeta)$
$= \cos^{-1}(0.59)$
$= 53.84$ — draw to the graph.

$-2.4 + j3.2$

s = CL poles (approximate) $= -2.4 + j3.2$

~~$CLTF = \dfrac{K(s+3)}{(s+4)(s+2+j)(s+2-j)(s+3)}$~~

(ii) use magnitude properties; $|G(s)| = 1$

$\left|\dfrac{K(s+3)}{(s+4)(s+2+j)(s+2-j)}\right| = 1$

at $s = -2.4 + j3.2$

$\dfrac{K(-2.4+j3.2+3)}{(-2.4+j3.2+4)(-2.4+j3.2+\cancel{j}+2)(-2.4+j3.2+2-j)} = 1 \rightarrow K = 10.37$

Q1

(b)

(iii) $G(s) = \frac{10.37(s+3)}{(s+4)(s+2+j)(s+2-j)}$

second order approximation is not valid; because the third poles $s=-4$ and the other poles at $s=-2\pm j$, ratio between third pole and dominance pole is less than 5

$$\text{ratio} = \frac{4}{2} = 2$$

(iv) $T_s = \frac{4}{|\text{real}|} = \frac{4}{\zeta\omega_n}$

$= \frac{4}{0.59(4.08)}$

$= 1.66\ s$

$T_p = \frac{\pi}{|\text{imag}|} = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$

$= \frac{\pi}{4.08(\sqrt{1-0.59^2})}$

$= 0.95\ s$

ess

Q2

$$G(s) = \frac{K(s^2-2s+8)}{(s+3)(s^2+4s+5)}$$

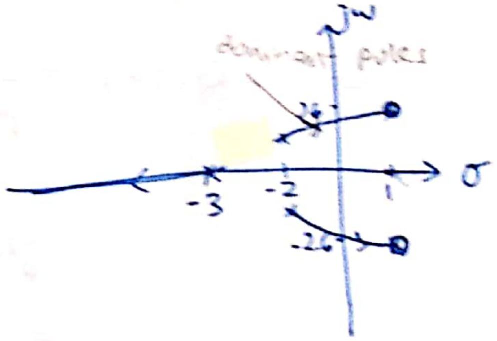
$S_d = -0.88 \pm j1.72$

$\%OS = 20\%$

(a) $T_{s\,new} = \frac{3}{5} T_s$

$OS = 20\% \rightarrow \zeta = 0.455$

uncompensated.



~~CLTF~~

from $S_d = -0.88 \pm j1.72$

$-0.88 = -\zeta \omega_n$

$-0.88 = -0.455\, \omega_n$

$\omega_n = +1.93$

$img = j1.72 = j\omega_n\sqrt{1-\zeta^2}$

$T_p = \frac{\pi}{\omega_d} = \frac{\pi}{1.72} = 1.83s$, $T_s = \frac{4}{|real|} = \frac{4}{0.88} = 4.54s$

(desired)

$T_{p\,new} = \frac{3}{5} T_p$

$= 3/5\,(1.83)$

$= 1.098s$

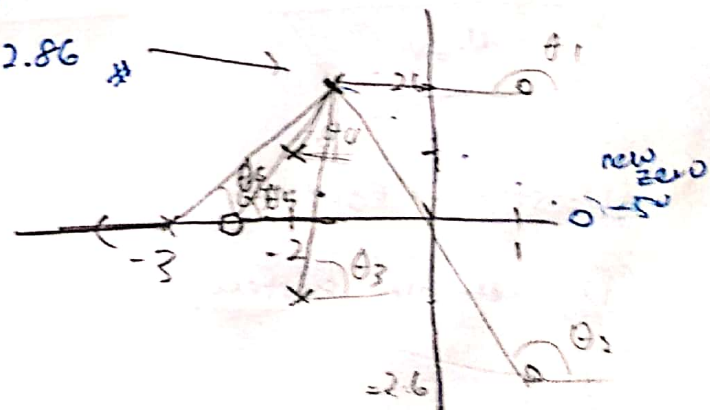
$\omega_d = \omega_n\sqrt{1-0.455^2}$

$\omega_n = 3.21$ rad/s

$1.098 = \frac{\pi}{\omega_d} \rightarrow \omega_d = 2.86$

CL-poles (desired) $= -\zeta\omega_n \pm j\omega_d$

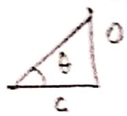
$= -1.46 \pm j2.86$



$\Sigma\theta_p - \Sigma\theta_z = 180°$

$\theta_4 + \theta_3 + \theta_6 - \theta_1 - \theta_2 - \theta_5 = 180$

$\theta_5 = 250.04°$



$\alpha_1 = \tan^{-1}\left(\frac{0.26}{3}\right) = 4.95$

$\theta_1 = 180 - 4.95 = 175.0$

$\theta_2 = 180 - \tan^{-1}\left(\frac{5.46}{2.46}\right) = 114.2$

$\theta_6 = \tan^{-1}\left(\frac{2.86}{1.54}\right) = 61.69$

$\theta_4 = \tan^{-1}\left(\frac{1.86}{0.54}\right) = 73.81°$

$\theta_3 = \tan^{-1}\left(\frac{4.86}{0.54}\right) = 83.66°$

new zero at positive side.

Q3. $G(s) = \frac{12}{s(s+6)}$

(a) (i)

(ii) when $w = 20$ rad/s

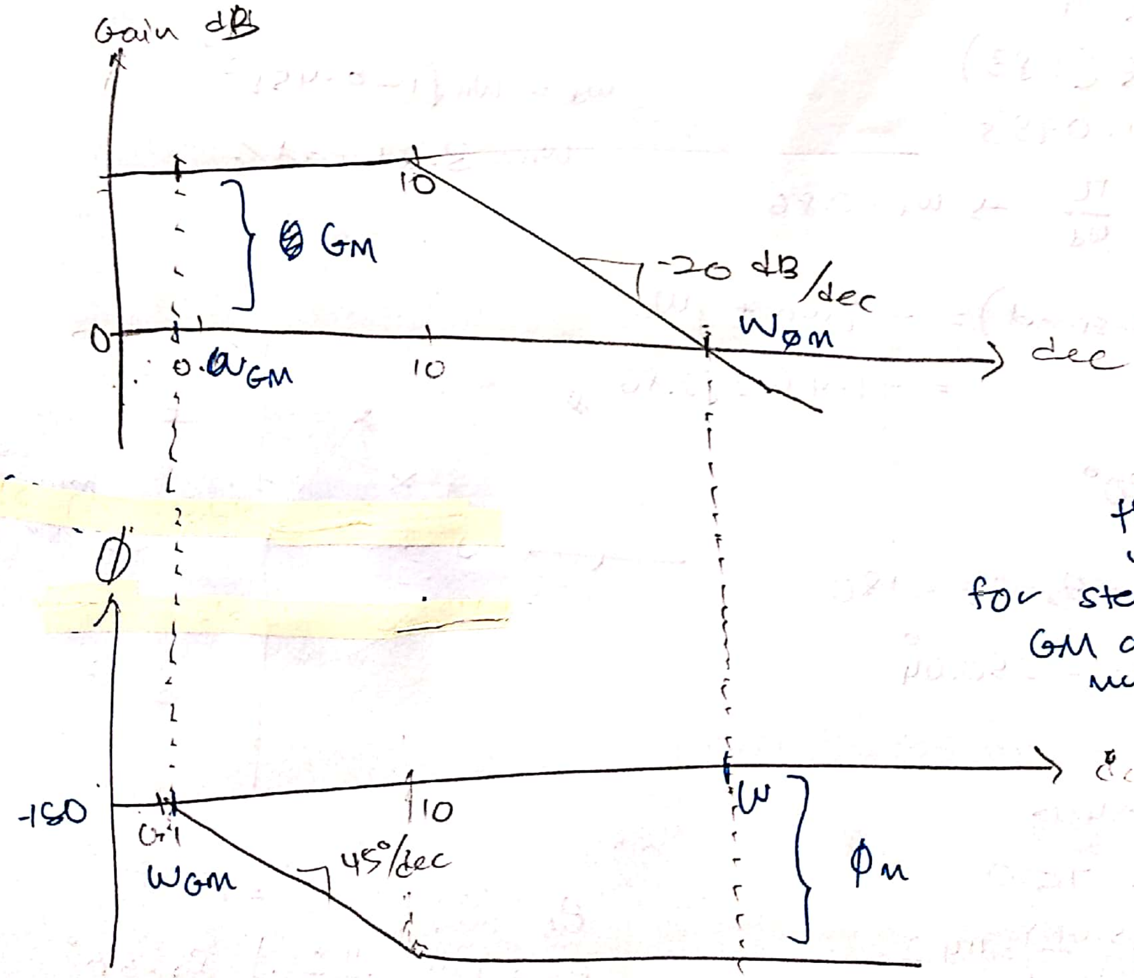
$$G(s) = G(j\omega) = \frac{12}{j\omega(j\omega+6)}$$

$$= \frac{12}{j20(j20+6)}$$

$$= -0.0275 - j8.26\times10^{-3}$$

$$|G(j\omega)| = 0.028$$ #

(b) $G(s) = \frac{100}{(s+10)} = \frac{100}{10(\frac{s}{10}+1)}$



this is unstable.

for stable; GM and ϕ_M must positive.