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SECTION 6

Test 1 SKEE 3143 (2019/2020)

Question 1

1. a) i) OL poles = $-2 \pm j1$, -4

OL zeros = -3

$$G(s) = \frac{(s+3)}{(s+4)(s+2+j1)(s+2-j1)} = \frac{(s+3)}{(s+4)(s^2+4s+5)}$$

ii) Asymptote point, σ_a

# of asymptotes = $3-1=2$

$$\sigma_a = \frac{(-4-2-2)-(-3)}{2} = -2.5$$

$$\theta = \frac{\pi}{3}, \pi, \frac{5\pi}{3}$$

$= 60^\circ, 180^\circ, 300^\circ$ ~~90°~~

iii) $\theta_d = \sum \angle zero - \sum \angle poles = -180^\circ$

$$\theta_a = \sum \angle poles - \sum \angle zero = -180^\circ$$

b) 10% overshoot $\rightarrow \zeta = 0.59$, $\omega_n = 4.08$ rad/s

i) Dom. CL poles $= -\zeta\omega_n + j\omega_d$.

$= -\zeta\omega_n + j\omega_n\sqrt{1-\zeta^2}$

$= -(0.59)(4.08) + j(4.08)(\sqrt{1-0.59^2})$

$= -2.41 + j3.294$

ii) $K = \dfrac{|(s+4)(s+2+j1)(s+2-j1)|}{|s+3|}$

subs $s = -2.41 + j3.294$

$K = 10.99$

≈ 11

iii) $s = -2.41 \pm j3.294$

$$CLTF = \frac{K(s+3)}{(s+4)(s+2+j1)(s+2-j1)+K(s+3)}$$

char. eq?

$(s+4)(s+2+j1)(s+2-j1)+11(s+3)=0$

$(s+4)(s^2+4s+5)+11s+33=0$

$s^3+4s^2+5s+4s^2+16s+20+11s+33=0$

$s^3+8s^2+32s+53=0$

$s = -3.178, -2.41 \pm j3.296$

∴ 3rd pole @ -3.178

$$\text{Ratio} = \frac{3.178}{2.41} = 1.32 < 5$$

∴ 2nd order approximation not valid.

iv) unit step → K_p (type 0)

$$T_s = \frac{4}{|\text{Real}|} = \frac{4}{-2.41} = -1.66s$$

$$T_p = \frac{\pi}{|\text{Im}|} = \frac{\pi}{3.294} = 0.953\,s$$

$$K_p = \lim_{s\to 0} G(s)$$

$$= \lim_{s\to 0} \frac{11(s+3)}{(s+4)(s^2+4s+5)}$$

$$= 1.65$$

$$e_{ss} = \frac{1}{1+K_p} = 0.377$$

Question 2

2. OLTF = $G(s) = \dfrac{k(s^2+2s+8)}{(s+3)(s^2+4s+5)}$ ← $1 \pm j2.65$, ← $-2 \pm j1$

Dom. poles, $s = -0.88 \pm j1.72$ at 20% overshoot

↳ $\zeta = 0.456$

a) PD controller. (Transient response).

$T_s = \dfrac{4}{|Real|} = \dfrac{4}{0.88} = 4.55\ s$

$T_p = \dfrac{\pi}{|Im|} = \dfrac{\pi}{1.72} = 1.83\ s$

$T_{s\,new} = \dfrac{3}{5} \times 4.55 = 2.73\ s$

$T_{r\,new} = \dfrac{4}{|Real|} = \dfrac{4}{\zeta\omega_n} = 2.73$

$\zeta\omega_n = 1.465$ (Real)

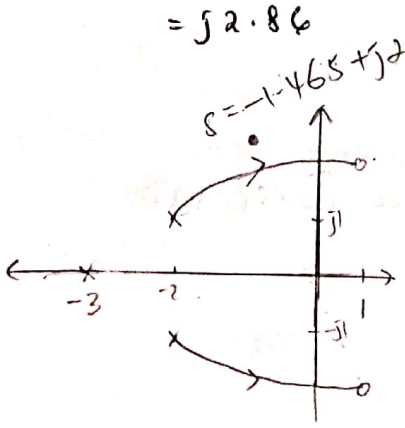
$\omega_n = 1.465/0.456 = 3.213$

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

$= j\,3.213\sqrt{1-0.456^2}$

$= j\,2.86$

∴ new CL poles $= -1.465 + j2.86$



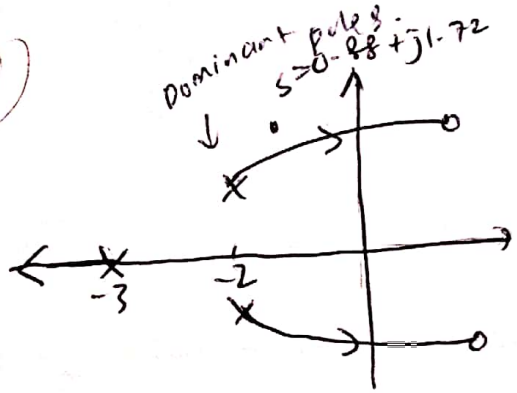
$\alpha = \tan^{-1}($

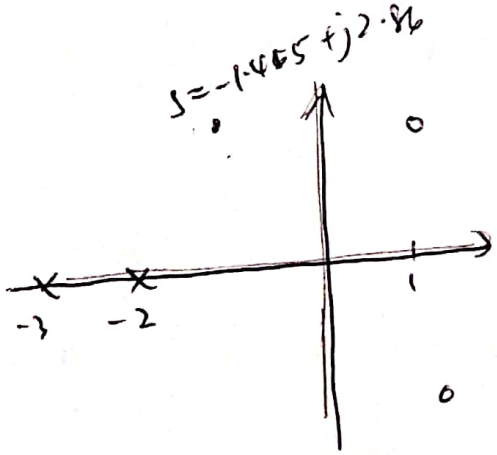
$G_{PD}(s) = K_p + K_D(s)$

$= K_D(s+z)$, $z = \dfrac{K_p}{K_D}$

$G_{PD}(s)\,G(s) =$

(b)





← tambah zero
so curve lain

Question 3

3 a) $G(s) = \dfrac{12}{s(s+6)}$

i) $G(jw) = \dfrac{12}{jw(jw+6)}$

$|G(jw)|_{dB} = 20 \log \dfrac{12}{w\sqrt{w^2+36}}$

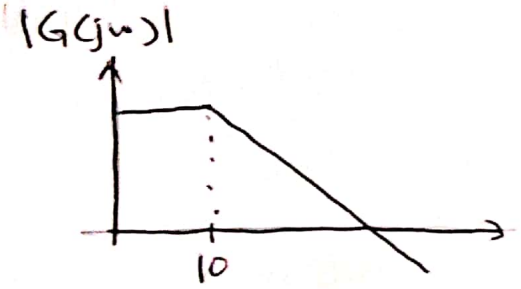
$\angle G(jw) = 0° - [90° + \tan^{-1} \dfrac{w}{6}]$

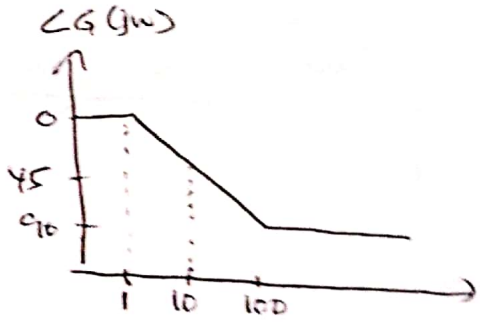
ii) $w = 20$

$|G(jw)|_{dB} = 20 \log 0.029 = -30.8\,dB$

$\angle G(jw) = -163°$

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

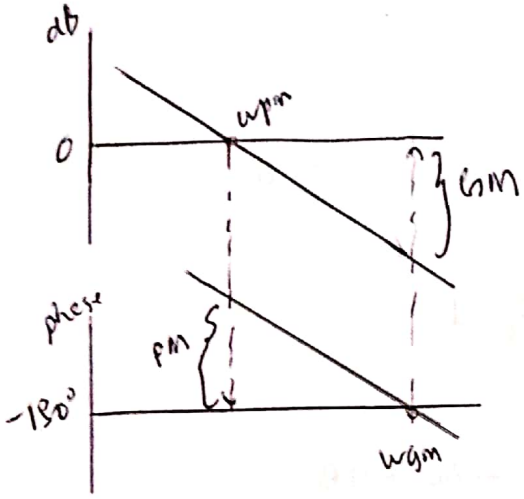




c)

i) Stable system

GM and PM both positive



-Both positive

ii) Unstable system

GM and PM both negative value