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A17KE0005
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a) i) zero = -3

poles = -4, -2 ± j1

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

$(s+2+j1)(s-2-j1)$

$s^2 - 2s - js + 4 - j2$

$-2s + js + 4 - j2$

$-2s + 4 + j2 - j2$

$(s^2 - 4s + 5)(s+4)$

$s^3 + 4s^2 - 4s^2 - 16s + 20$

$+20$

$s^3 - 16s + 20$

$s^3 + 4s^2 - 4s^2 - 16$

$s^3 - 16s + 20$

ii)

b) OS1. = 10-1 , $\zeta = 0.59$

$\theta = 53.84$

i) $-2.4 + j3$

ii) $k = |s+4||s^2 - 4s + 5|$

$= 97.376$

iii) char eqn $= s^3 - 11s + 20$

$s = 8.7$

Real $= 2.4$

ratio $= \frac{8.7}{2.9} = 3.6 < 5$ ∴ 2nd order approximation is not valid.

iv) $T_s = \frac{4}{|Real|} = \frac{4}{2.4} = 1.67\,s$

$T_p = \frac{\pi}{|imaginary|} = \frac{\pi}{3} = 1.047\,s$

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

$= \frac{97.376\,(s+3)}{(s+4)(s^2-4s+5)}$

$= 14.606$

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

$= \frac{1}{1+14.606}$

$= 0.064$

b) %OS = 10%, $\zeta = 0.59$

a)

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

ii) $s_d = -0.88 \pm j1.72$

%OS = 20%, $\zeta = 0.456$

$T_{snew} = \frac{3}{5} T_{sold}$.

iii)

$$t_{sold} = \frac{4}{|Real|} = \frac{4}{0.88}$$

$$= 4.55\ s$$

$$t_{snew} = \frac{3}{5}(4.55)$$

$$= 2.73\ s.$$

iv) $$2.73 = \frac{4}{\zeta \omega_n}$$

$$\omega_n = \frac{4}{0.456 \times 2.73} = 3.21\ rad/s.$$

$$K = |s+3||s^2 + 4s + 5|$$

$$= 24.05$$

imaginary CL - poles $= j\omega_n\sqrt{1-\zeta^2}$

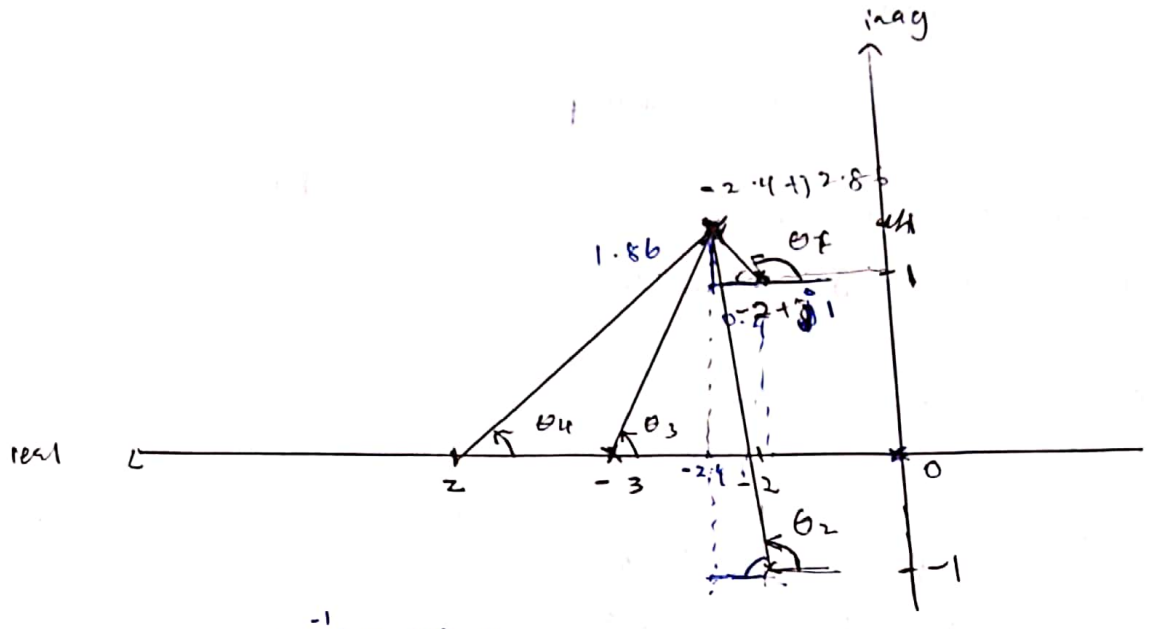
$$= j\,3.21\sqrt{1 - 0.456^2}$$

$$= j2.86$$

real-CL poles $= -\zeta\omega_n$

$$= -1.24$$

CL - poles $= -1.24 \pm j2.86$



$$\theta_3 = \tan^{-1}\left(\frac{2.86}{0.6}\right)$$

$$= 78.15.$$

$$\theta_1 = 180^\circ - \tan^{-1}\left(\frac{1.86}{0.4}\right)$$

$$= 102.$$

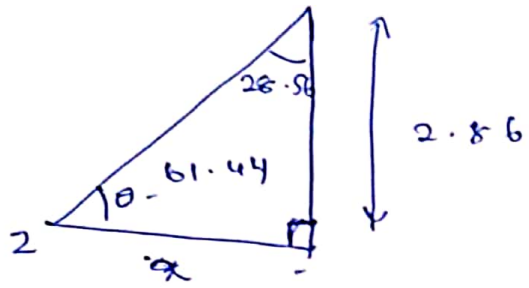
$$\theta_2 = 180^\circ - \tan^{-1}\left(\frac{1.86}{0.4}\right)$$

$$= 94.71$$

$$-\theta_1 - \theta_2 + \theta_3 + \theta_4 = -102 - 94.71 + 78.15 + \theta_4 = 180$$

$$\theta_4 - 118.56 = 180$$

$$\theta_4 = 61.44$$



$$\frac{x}{\tan(28.56)} = \frac{2.86}{\tan(61.44)}$$

$$x = 0.547$$

$$z = 3.247$$

$$G_{PD}(s)\,G_{CS} = \frac{24.05\,(s + 3.247)}{(s+3)\,(s^2 + 4s + 5)}$$

3. $G(s) = \frac{12}{5(s+6)}$

$|G(j\omega)|_{dB} = 20 \log 12$

$= 21.584$

ii:

c)