Semester test EERI 418 Test 3 - Memo
16 May 2014

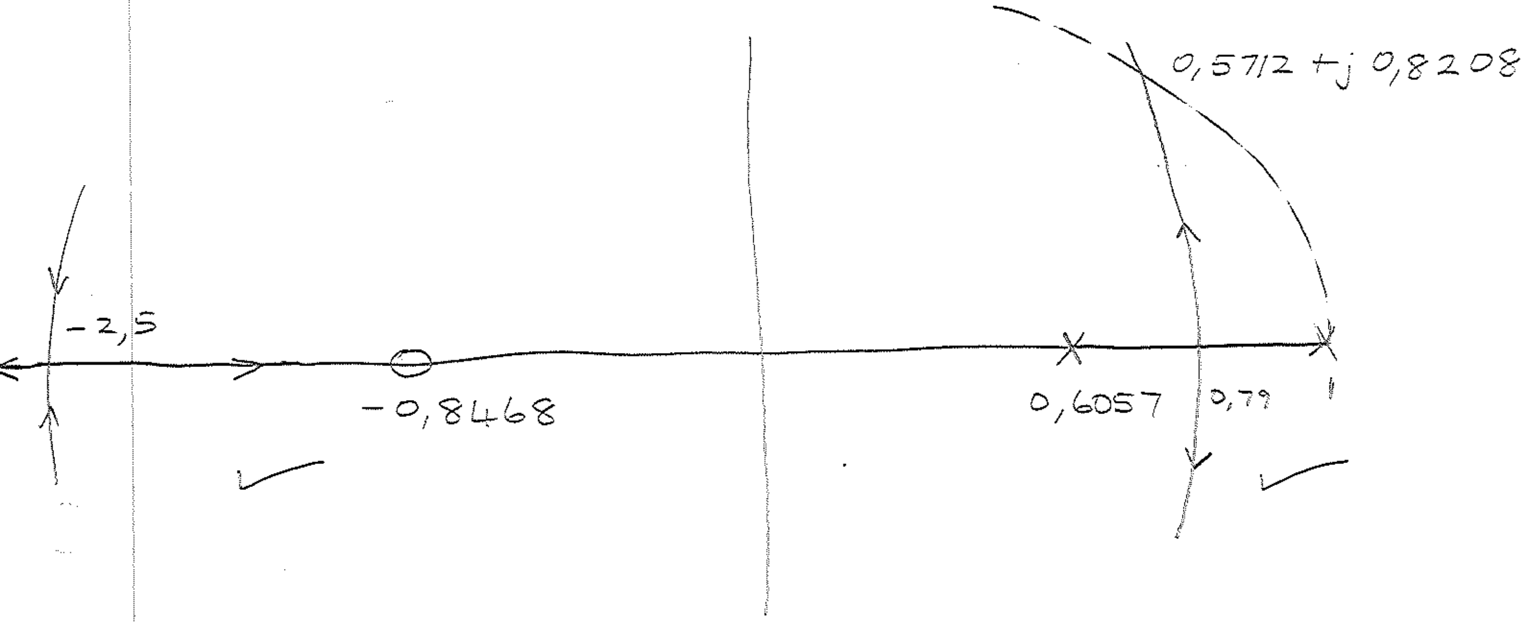
Question 1

$$G_p(s) = \frac{10k}{s(s+4)}$$

$$G(z) = \frac{K(0{,}06658z + 0{,}05638)}{z^2 - 1{,}607z + 0{,}6065} \qquad T = 0{,}125s$$

1.1 Wortellokus met $D(z) = 1$

$$G(z) = \frac{K \cdot 0{,}06658(z + 0{,}8468)}{(z-1)(z-0{,}6057)}$$



Breakaway point: $K = \frac{|z-1||z-0{,}6057|}{0{,}06658|(z+0{,}8468)|}$

K	0,3539	0,3544	0,3551	0,354
z	0,8029	0,8	0,79	0,78

K	807,67	314,84	168,9	121	101	100	109
z	-0,9	-1	-1,2	-1,5	-2	-3	-4

K	98,8
z	-2,5

Jury stability analysis:

$$Q(z) = 1 + G(z) = 0$$

$$\therefore \quad 1 + \frac{k\,0{,}06658\,(z+0{,}8468)}{(z-1)(z-0{,}6057)} = 0$$

$$(z-1)(z-0{,}6057) + k\,0{,}06658\,(z+0{,}8468) = 0$$

$$\therefore \quad z^2 - 1{,}607z + 0{,}6065 + k\,0{,}06658\,z + k\,0{,}05638$$

$$= z^2 + (0{,}06658k - 1{,}607)z + 0{,}05638k + 0{,}6065$$

① $Q(1) > 0$

$$1 + (0{,}06658k - 1{,}607) + 0{,}05638k + 0{,}6065 > 0$$

$$\therefore \quad 0{,}123k > 0 \quad \therefore \quad k > 0$$

② $(-1)^2 Q(-1) > 0$

$$1 - (0{,}06658k - 1{,}607) + 0{,}05638k + 0{,}6065 > 0$$

$$3{,}2135 - 0{,}0102k > 0$$

$$\therefore \quad -0{,}0102k > -3{,}2135$$

$$\therefore \quad k < 315{,}05$$

③ $|a_0| < a_2$

$$|0{,}05638k + 0{,}6065| < 1$$

$$\therefore \quad k < 6{,}9794$$

$$\therefore \quad 0 < k < 6{,}9794$$

Stelsel is marginaal stabiel vir $k = 6{,}9794$

$$\therefore \quad z^2 - 1{,}1423 + 1 = 0 \quad \therefore \quad z = 0{,}5712 \pm j\,0{,}8208$$

$$= 1 \,\underline{/\pm 0{,}9628}$$

(10)

(3)

Design a phase lead compensator
Retain critically damped poles and reduce the time constant of the system by a factor 2.

The critically damped poles are at $z = 0{,}79$ resulting in a time constant of

$$\therefore z = e^{sT} = e^{-\frac{T}{\tau}}$$

$$\therefore \tau = \frac{-T}{\ln z} = \frac{-0{,}125}{\ln 0{,}79} = 0{,}53035.$$

$\therefore$ To reduce the time constant by a factor 2

$$T_{new} = \frac{0{,}5303}{2}\ s = 0{,}2652$$

$$\therefore z = e^{-\frac{T}{\tau}} = e^{\frac{-0{,}125}{0{,}2652}} = 0{,}6242$$

Choose $z_o = 0{,}6057.$

If we estimate the new breakaway point of 0,6242 to be more or less half way between the pole at $z=1$ and the compensator pole at z_p.

$$\frac{z_p + 1}{2} = 0{,}6242$$

$$\therefore z_p \simeq 0{,}2484$$

$$\therefore D(z) = \frac{k_d(z - 0{,}6057)}{(z - 0{,}2484)}$$

$$D(1) = 1 \quad \therefore k_d = 1{,}906$$

$\therefore$ Now only the value of K_c needs to be determined

$$\therefore 1 + D(z) \cdot G(z) = 0 \quad \text{with } z = 0{,}6242$$

$$\therefore 1 + \frac{1{,}906(z - 0{,}6057)}{(z - 0{,}2484)} \cdot \frac{k_c 0{,}06658(z + 0{,}8468)}{(z-1)(z - 0{,}6057)} = 0$$

$$\therefore K_c = 0{,}7565$$

(10)

1.2. $K = 3$.

Phase lag design for PM of 40°

(a) Determine ω_{w1} where

$$\phi = -180^\circ + \phi_m + 5^\circ = -180^\circ + 40^\circ + 5^\circ = -135^\circ$$

$\therefore \omega_{w1} \simeq 2,8 \text{ rad/s.}$

$$G(j\omega_{w1}) = -3\,dB + 9,5\,dB = 6,5\,dB = 2,1135$$

Choose $\omega_{wo} = 0,1\,\omega_{w1} = 0,28 \text{ rad/s}$

$$\omega_{wp} = \frac{0,1 \cdot \omega_{w1}}{a_0\,|G(j\omega_{w1})|} = \frac{0,28}{1 \cdot 2,1135} = 0,1325 \text{ rad/s}$$

$$\therefore D(w) = \frac{1 + w/0,28}{1 + w/0,1325}$$

$$\therefore K_d = \frac{0,1325\,(0,28 + 2/0,125)}{0,28\,(0,1325 + 2/0,125)} = 0,4775$$

$$z_0 = \frac{2/T - \omega_{wo}}{2/T + \omega_{wo}} = \frac{2/0,125 - 0,28}{2/0,125 + 0,28} = 0,9656$$

$$z_p = \frac{2/T - \omega_{wp}}{2/T + \omega_{wp}} = \frac{2/0,125 - 0,1325}{2/0,125 + 0,1325} = 0,9836$$

$$\therefore D(z) = \frac{0,4775\,(z - 0,9656)}{(z - 0,9836)}$$

(10)

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