EE3331C Y1213 SI

Q1 (a). $G(s) = \dfrac{s^2+2s+2}{s^3+0.5s^2}$ NB: There are 2 poles at the origin.

(b) To find the minimum K, substitute $s=j\omega$ to the closed-loop pole equation :-

$$s^3 + (0.5+K)s^2 + 2Ks + 2K = 0 \quad — ①$$

$\Rightarrow K = \frac{1}{2}$

(c) The desired CL poles are :

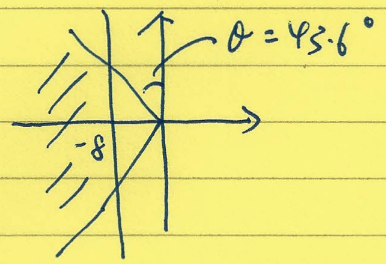
$$(s+2.32)(s^2+\omega_n s+\omega_n^2) = 0 \quad —② ; \ \zeta = 0.5$$

① & ②, $K = 3.58$, $s = -0.88 \pm j1.52$

(d) $K = 2$

Q2 (a) $M_p < 5\% \Rightarrow \zeta > 0.69$

$2\%\ t_s < 0.5 \Rightarrow \zeta\omega_n > 8$



(b) Find the CL poles from block diagram, compared with 2nd order prototype system.

$\Rightarrow K_1, K_2$. choose ζ and ω_n at boundary.

(d) Closed-loop poles given by $\underset{a}{s^2} + \underbrace{(10+10K_1K_2)}_{b}s + \underbrace{10K_1}_{c} = 0$.

For underdamped system, $b^2 - 4ac < 0$.

EE3331C Y1213 S II

Q1 (a) $G(s) = \dfrac{s^2+2s+2}{s^3}$

(b) Desired ch. poles : $(s+\alpha)(s^2+2\overset{0.5}{\zeta}\omega_n s+\omega_n^2) = 0$ — ①

Actual ch. poles : $1+G(s)K(s) = 0$ — ②

① & ②, $K = 4$, $s = -2, -1 \pm j1.73$

(c) Poles are : $s = -1.3, -0.35 \pm j1.72$

(d) The limiting gain can be found by substituting $s = j\omega$ into ② which gives $K = 1$. The system would be stable for small e. For large e, once the gain drops below 1, system is unstable.

Q2 (a) $G_{cl}(s) = \dfrac{Y(s)}{R(s)} = \dfrac{K_1}{s^2+(2+K_1K_2)s+K_1}$

(b) 2% $t_s \leq 3$ sec. $\Rightarrow \zeta\omega_n \geq 4/3 \Rightarrow K_1K_2 \geq \frac{2}{3}$

s.s. error for ramp i/p less than 25%.

$\Rightarrow e_{ss} = \lim_{s\to 0} sE(s) \leq 0.25$

$\Rightarrow \quad 2+K_1K_2/K_1 \leq 0.25$

Choose K_1, K_2 at boundary.