淡江大學九十學年度碩士班招生考試試題

系別：航空太空工程學系　　科目：自　動　控　制

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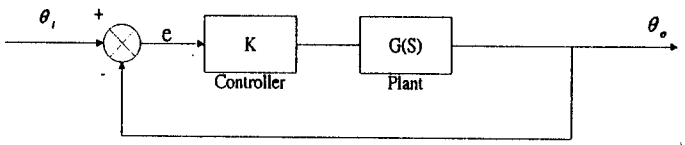
1. (30 points) A control system has the configuration shown below.



The open loop transfer function $G(s)$ is given by

$$G(s)=\frac{s+2}{s(s^2+4s+8)}$$

(a) Show that the open-loop system has a zero given by $z_1 = -2$ and three poles given by $p_1 = 0$, $p_{2,3} = -2 \pm 2j$ (3 points)
(b) Consider the root locus plot for $0<K<\infty$. Determine the angle at which the locus leaves $p_2 = -2 + 2j$. (7 points)
(c) Show that the point $-1.5 \pm 2.784j$ is on the locus. (5 points)
(d) Find the gain constant K which gives the root in (c).(5 points)
(e) Determine the other two closed loop characteristic roots for the gain in (c). (5 points)
(f) Sketch the root locus for $0<K<\infty$. (5 points)

2. (20 points) We wish to modify the controller in Problem 1 in order to obtain a closed loop root pair with a negative real part equal to –2 and a damping ratio $\xi = 0.5$.

(a) Show that the root pair in this case is given by $-2 \pm 3.464j$. (5 points)
(b) What is the undamped natural frequency ω_n for the root pair in (2a).(5 points)
(c) Assume that we modify the controller by adding a zero at $z_2 = -2$ and a pole p_4. What must be the pole p_4 to have the points $-2 \pm 3.464j$ be on the locus? (10 points)

3. (20 points) A control system has an open loop transfer function $KG(s)$, where

$$G(s)=\frac{1-s}{s(s+1)}$$

A table of $[G(j\omega)]_{real}$ and $[G(j\omega)]_{imag}$ versus ω is shown below:

ω	$[G(j\omega)]_{real}$	$[G(j\omega)]_{imag}$
0.25	-1.88	-3.53
0.5	-1.60	-1.20
1.0	-1.0	0.0
2.0	-0.4	0.3
4.0	-0.118	0.22
8.0	-0.031	0.12

Make a Nyquest plot and determine closed loop stability for all K, both positive and negative.

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4. (30 points) A spacecraft booster, when flying in the atmosphere, obeys the following differential equation: $\ddot{\theta}_0 - \theta_0 = f(t)$. Here θ_0 is the booster pitch angle and $f(t)$ is the thrust vector angle used for pitch control.

   (a) Referring to the figure in Problem 1, Let the booster be the plant in the feedback system. What is the transfer function? (5 points)

   (b) If the transfer function of the controller in the system to be K, sketch a root locus for $0 < K < \infty$. Is the system stable for $K > 0$. (10 points)

   (c) Next let the controller to be $Y(s) = \dfrac{5K(s+2)}{(s+10)}$. Sketch the root locus for $0 < K < \infty$. Is the system stable for $K > 0$. Explain. (15 points)