台灣聯合大學系統106學年度碩士班招生考試試題

類組：電機類　科目：控制系統(300D)　

※請在答案卷內作答

1. (24%) Consider the following closed-loop feedback system as depicted in Figure 1, where G_P and G_C denote the system plant and controller, respectively.

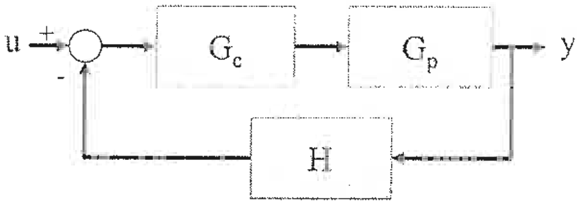

Figure 1.

Let the Laplace transform of the error $e(t)$ be defined as $E(s)=U(s)-Y(s)\cdot H(s)$. Here, $U(s)$, $Y(s)$ and $H(s)$, respectively, denote the Laplace transform of the input, output and feedback block.

(a) (6%) Let $G_P=\dfrac{100}{s(s+2)}$, $G_C=1$ and $H(s)=0$. Solve the maximum overshoot of the system output $y(t)$ and the corresponding time for the unit-step input, i.e., $U(s)=\dfrac{1}{s}$.

(b) (4%) Let $G_P=\dfrac{100}{s(s+2)}$, $G_C=K$ and $H(s)=1$. Find the value of K so that the closed-loop poles will have damping ratio $\zeta=0.5$. In addition, what will be the value of the corresponding undamped natural frequency ω_n?

(c) (8%) Let $G_P=\dfrac{100}{s(s+2)}$, $H(s)=1$ and the input u be a unit step. Design a PD-controller G_C to make the settling time be less than 0.1 second with damping ratio $\zeta=0.8$. What will be the corresponding steady-state error of the closed-loop system when the input u becomes unit ramp?

(d) (6%) Let $G_P=\dfrac{100}{s(s+2)}$, $G_C=K$ and $H(s)=\dfrac{s+15}{s+10}$. Find the range of K so that the closed-loop system is stable.

2. (26%) Consider the closed-loop feedback system as given in Figure 1 above.

(a) (8%) Let the characteristic equation of the closed-loop system be given by $s^3+(15+K)s^2+(50+2K)s+K=0$. Let $G_C=K$ and $H(s)=1$. Then find function G_P and plot the root loci for $K\geq 0$.

(b) (8%) Let the system plant G_P be the same as the one obtained in part (a) and $G_C=K$. Now, let the feedback block be changed from $H(s)=1$ to $H(s)=\dfrac{1}{(s+1)(s+0.5)}$. Plot the root loci for $K\geq 0$ and find the range of K for guaranteeing the stability of the closed-loop system.

(c) (10%) Let the system plant G_P be the same as the one obtained in part (a) and

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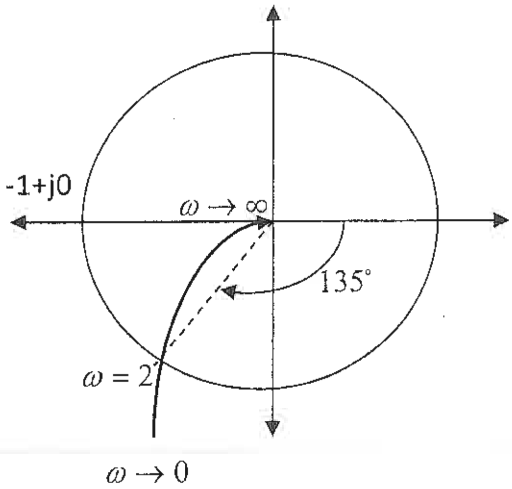
$H(s)=\dfrac{1}{(s+1)(s+0.5)}$. Now, we change the controller from $G_C=K$ to $G_C=K(s+4)$. Plot the root loci for $K\geq 0$ and find the range of K for guaranteeing the stability of the closed-loop system.

3. (24%) A control engineer has the experimental data for a minimum-phase open-loop system $G(s)$ and sketches them as the following Nyquist plot.



(a) (8%) Determine $G(s)$ as minimum order as possible.

(b) (2%) If a delay e^{-sT} is added to $G(s)$, what is the maximum T so that the system is still stable?

(c) (4%) If a PD controller $G_C(s)=K_P+K_Ds$ is added, what the parameters are selected so that the steady state error for unit-ramp input is less than 1% and the maximum overshoot is less than 5%?

(d) (10%) What is the phase margin? If we would like to increase the phase margin by pole-zero cancellation $G_C(s)=K\dfrac{s+z}{s+p}$, choose suitable z and plot K v.s. p to meet the spec. that the steady state error for unit-ramp input is less than 1% and phase margin $\geq 60^\circ$ for $\omega_g=2$.

4. (26%) The open loop transfer function of a linear time-invariant system is

$$G_p(s)=\frac{Y(s)}{U(s)}=\frac{s+\alpha}{s^3+7s^2+14s+8},$$ and the state equations are $$\dot{x}(t)=Ax(t)+Bu(t);\quad y(t)=Cx(t)+Du(t).$$

(a) (6%) Write the controllability canonical form (CCF) of the state equation.

(b) (3%) Determine all possible α so that the system is either uncontrollable or unobservable.

(c) (6%) Design the control law $u(t)=-Kx(t)$, where $K=[k_1, k_2, k_3]$ and $\alpha=4$ so that the closed-loop system poles contain $-1\pm j$.

(d) (5%) Show that the response of the state is $x(t)=\phi(t)x(0)+\int_0^t\phi(t-\tau)Bu(\tau)d\tau$, where $\phi(t)$ is the state transition matrix and initial condition is $x(0)$.

(e) (6%) If $A=\begin{bmatrix}0&2&0\\2&0&0\\0&0&2\end{bmatrix}$, $B=\begin{bmatrix}0\\1\\0\end{bmatrix}$, $C=\begin{bmatrix}1&0&0\end{bmatrix}$ and D=1. Find the state transition matrix $\phi(t)$ and the transfer function.

注意：背面有試題