類組：電機類　科目：控制系統(300D)　共 2 頁 第 1 頁

※請在答案卷內作答

Note: In this exam, you have 4 problems need to solve. Each problem has its own credit point as shown. The total credit point is 100.

1. (30%) Consider the feedback control system in Figure 1. Suppose that $G(s) = \frac{1}{(s+1)(s+2)}$ and $C(s) = K_P + \frac{K_I}{s}$, where K_P and K_I are positive constants. Answer the following questions.

(a) (10%) Find the conditions on K_P and K_I such that the closed-loop system is stable.

(b) (10%) Let $M(s) = \frac{Y(s)}{R(s)}$ be the closed-loop transfer function from r to y, where $R(s)$ and $Y(s)$ are the Laplace transforms of r and y, respectively. Find all possible values of $\frac{K_I}{K_P}$ such that $M(s)$ is a stable second-order system.

(c) (10%) (Continued from part (b)) For each $\frac{K_I}{K_P}$ and the associated $M(s)$ in part (b), find the conditions on K_P such that $M(s)$ is underdamped.

參考用

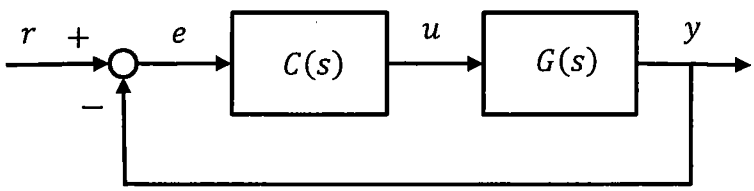

Figure 1: Feedback Control System

2. (20%) Consider the feedback control system in Figure 1. Let $G(s) = \frac{K}{s(s+a)}$ and $C(s) = \frac{(s+z)(s+\bar{z})}{s^2+4}$, where $z \in \mathbb{C}$, $\bar{z}$ is the complex conjugate of z, and $a, K > 0$. Answer the following questions.

(a) (10%) If $\text{Re}\{z\} = 1$, find the conditions on a such that the closed-loop system is stable as $K \to \infty$.

(b) (10%) Let $z = 1 + 2j$ and $a = 3$. Sketch the root locus of the system as K varies from 0 to ∞. Please calculate the intersection of the asymptotes and the departure angles of the complex poles at $\pm 2j$.

(Note: The location of the breakaway point is not required.)

3. (30%) Consider a unity feedback system as depicted in Figure 2 below, where $G_c(s)$ and $G_p(s)$ denote the controller and system plant, respectively.

注意：背面有試題

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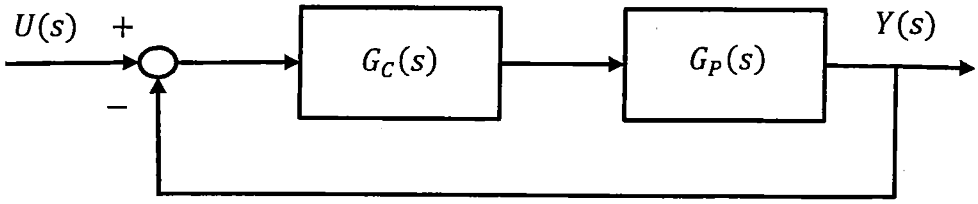

Figure 2.

Here, $U(s)$ and $Y(s)$ denote the Laplace transform of the input and output.

(a) (12%) Let $G_P(s)=\dfrac{1}{s(s+2)}$ and $G_C(s)=K$. Suppose we need to have the resonant peak M_r of the closed-loop system to be 1.1547. Then what will be the value of K? What will be the corresponding resonant frequency ω_r and the bandwidth BW ?

(b) (6%) Let the system plant $G_P(s)$ be the same as the one in part (a) with $G_C(s)=\dfrac{K}{s+a}$. Find the range of K and a so that the closed-loop system is stable.

(c) (12%) Let the system plant $G_P(s)$ and the controller $G_C(s)$ be the same as the ones given in part (b) with $a=1$ and $K=5$. Draw the Nyquist plot of the system. What will be the phase cross-over frequency and gain-margin?

4. (20%) Consider the closed-loop feedback system as given in Figure 2 above with $G_P(s)=\dfrac{1}{s^2(s+10)}$ and answer the following questions:

(a) (8%) Let $G_C(s)=K$. Draw the Nyquist plot of the system and determine whether the closed-loop system is stable by using Nyquist stability criterion. If system is stable, find the range of K for guaranteeing the system stability.

(b) (12%) Design a PD-controller or PI-controller to make the closed-loop system stable by using Nyquist stability criterion. That is, to change $G_C(s)=K_P+K_Ds$ or $G_C(s)=K_P+\dfrac{K_I}{s}$ with positive values of K_P, K_D and K_I. In addition, find the range of K_P with $K_D=1$ for PD-controller or the range of K_I with $K_P=1$ for PI-controller to guarantee the system stability.