類組：電機類　科目：控制系統(300D)　※請在答案卷內作答

1. (16%) Consider the closed-loop feedback system as given by

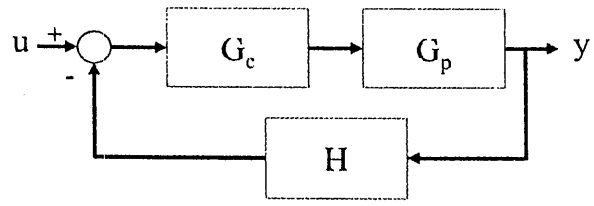

Figure 1.

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

(a) (4%) Let $G_P=\dfrac{s+2}{(s+5)(s+20)}$, $G_C=5$ and $H(s)=1$. Solve the steady-state error for the two cases of input u being a unit step and unit ramp function.

(b) (4%) Let $G_P=\dfrac{s+1}{s(s+5)(s+10)}$, $G_C=5$ and $H(s)=s$. Solve the steady-state error for the two cases of input u being a unit step and unit ramp function.

(c) (8%) Let $G_P=\dfrac{10}{(s+1)\cdot(s+50)}$ and the input u be a unit step. Obtain the settling time (for the definition of 2% error) for the open-loop system approximately. Consider $H(s)=1$ and design a controller G_C to make the settling time be less than 0.1 second.

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

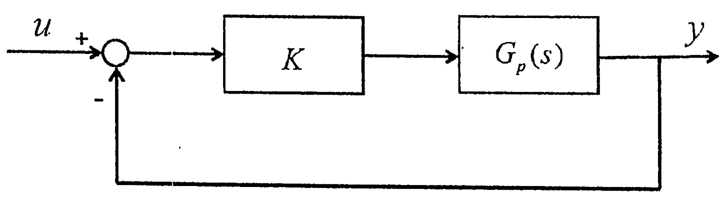

Figure 2.

Let the system plant G_P be given in the form of $G_P=\dfrac{\prod_i (s+z_i)}{\prod_j (s+p_j)}$.

(a) (12%) Obtain G_P from Figure 3 and plot the root loci for $K\ge 0$. Find the angles of asymptotes, the breakaway and/or break-in points on the real axis. What will be the range of K for guaranteeing the asymptotically stability of the closed-loop system?

注意：背面有試題

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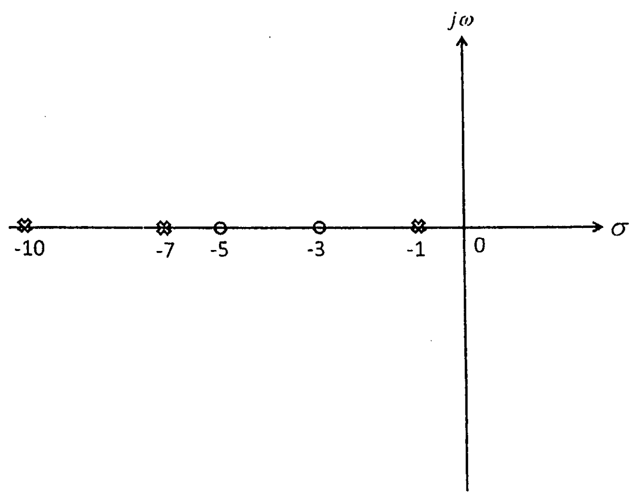

Figure 3.

(b) (14%) Obtain G_p from Figure 4 and plot the root loci for $K \geq 0$. Find the angles of asymptotes, the interception of asymptotes on the real axis and the breakaway and/or break-in points on the real axis. What will be the range of K for guaranteeing the asymptotically stability of the closed-loop system?

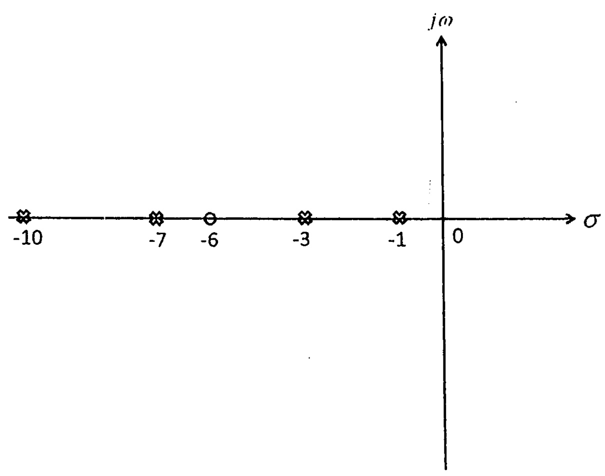

Figure 4.

3. (8%)

(a) (4%) Derive the closed-loop transfer function of the system with respect to all inputs as depicted in Figure 5.

(b) (4%) Derive the closed-loop transfer function of the system with respect to all inputs as depicted in Figure 6.

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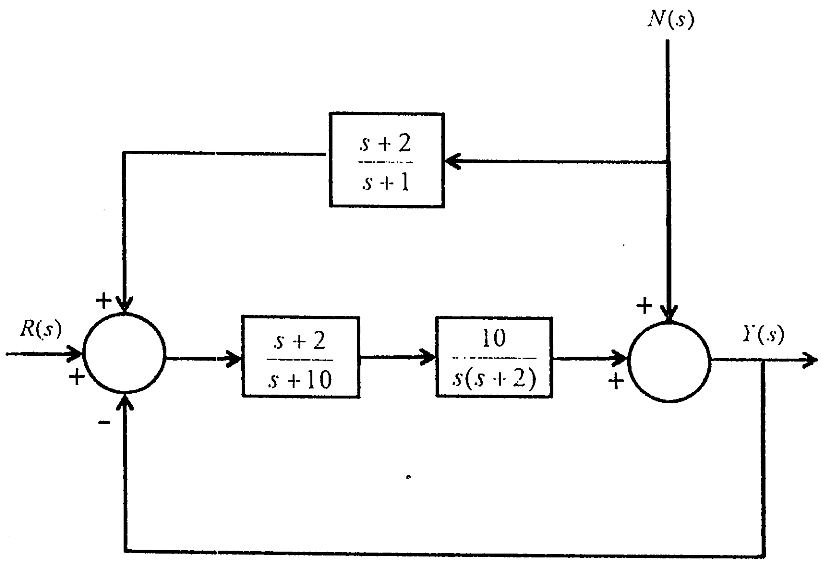

Figure 5.

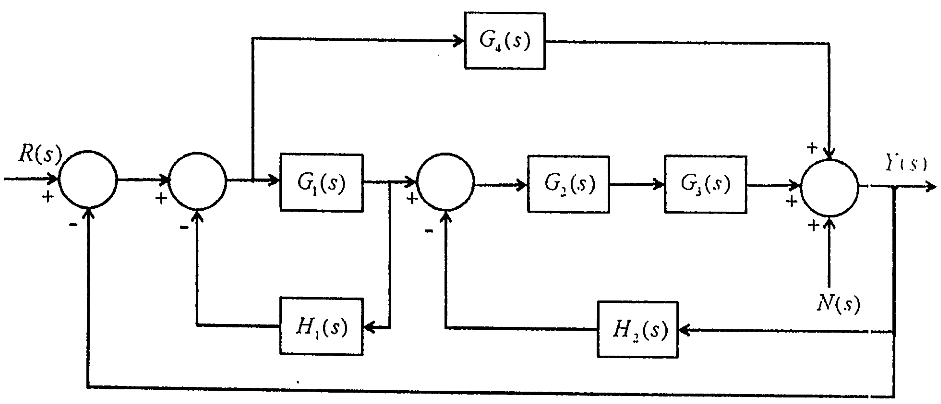

Figure 6.

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4. (34%) Consider the feedback system in Figure 7, where $G_p(s)=\dfrac{1}{s(s-1)}$ and the P controller $G_c(s)=K$.

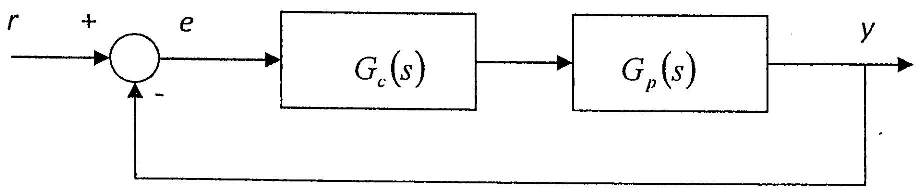

Figure 7.

(a) (8%) Sketch the Nyquist plot of the open-loop transfer function $G_c(s)G_p(s)=\dfrac{K}{s(s-1)}$ for $K>0$.

(b) (4%) Determine the range of K for stability of the feedback system, where $-\infty<K<0$.

(c) (10%) To improve the stability, a PD controller is applied, that is, $G_c(s)=K(s+z)$, where $z>0$ and $K>0$. Sketch the Nyquist plot and find the range of K for stability. Find the asymptotes if available. Hint: $G_c(j\omega)G_p(j\omega)=\dfrac{-K\omega(z+1)+jK(z-\omega^2)}{\omega(\omega^2+1)}$.

(d) (8%) Choose $z=1$ and design the control system to have the phase margin of 45°. Find the corresponding gain crossover frequency ω_g and the phase crossover frequency ω_p. What is the PD controller, i.e. $K=$?

(e) (4%) What is the maximum allowable time delay in (d).

5. (16%) For a unity-feedback system with the open-loop transfer function $L(s)$.

(a) (8%) If $L(s)=\dfrac{K}{s^2}$, draw the Nyquist plot and magnitude-phase plot. Also determine its phase margin for $K>0$.

(b) (8%) If $L(s)=\dfrac{K}{s^3}$, draw the Nyquist plot and magnitude-phase plot. Also determine its phase margin for $K>0$.

注意：背面有試題