南京理工大学课程考试试卷（学生考试用）

课程名称： 控制工程基础　学分： 3.5/3.0　教学大纲编号： 10025406/5402/5403

试卷编号： 2024-A　考试方式： 闭卷　满分分值： 100　考试时间： 120 分钟

组卷日期：2024 年 12 月 26 日　组卷教师（签字）：课题组　审定人（签字）：樊卫华

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注意：所有答案均要写在答题纸上，计算题必须有解题步骤，否则不得分。
考试结束后，试卷和答题纸必须一起交上，否则以 0 分计算。

1. (10') Consider a system described by the following differential equation

$$\ddot{y}(t) + 6\dot{y}(t) + 8y(t) = \dot{r}(t) + 3r(t)$$

(1) Determine the transfer function $T(s) = Y(s)/R(s)$;

(2) Under zero initial conditions, determine the output response $y(t)$ when $r(t) = 8$.

2. (10') The block diagram of a system is shown in Figure 1. Determine the transfer function $T(s) = Y(s)/R(s)$ by using Mason's gain formula.

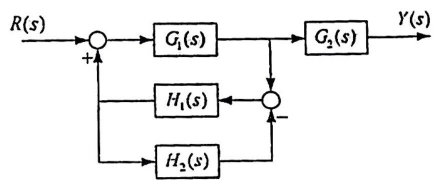


Figure 1. Block Diagram

3. (14') Consider a unity negative feedback system with the loop transfer function given by

$$L(s) = \frac{1}{(\tau s + 1)(s + 1)}, \quad \tau > 0$$

(1) Determine the closed-loop transfer function $T(s)$;

(2) Determine the value of τ such that the settling time (with $\pm 2\%$ criterion) of the unit step response is $T_s = 4\text{s}$, and then calculate the maximum peak value M_{pt}, the percent overshoot $P.O.$ and the peak time T_p of the unit step response.

4. (14') Consider a system with a disturbance $D(s)$ and a PI controller $G_1(s)$ as shown in Figure 2, where $G_1(s)$ and $G_2(s)$ take the following forms:

$$G_1(s) = 3 + K_I \frac{1}{s}, \quad K_I > 0 \quad , \quad G_2(s) = \frac{1}{s(s+1)(s+2)}$$

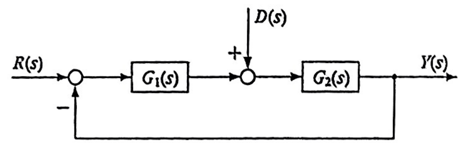


Figure 2. A Negative Feedback System with Disturbance

(1) Use the Routh-Hurwitz criterion to determine the range of the values of K_I such that the closed-loop system is stable;

(2) Determine all of the characteristic roots when the system is marginally stable;

(3) Suppose that the input is $r(t) = t^2/2$ and the disturbance is $d(t) = 1$. Then, find the steady-state error e_{ss} of the system.

5. (12') Consider a negative feedback system with the loop transfer function given by

$$GH(s) = \frac{10s^2 + K}{s(s^2 + K)}, \quad K > 0$$

$s = \pm j\sqrt{K}$
$s = 0$

(1) Sketch the root locus when K varies from 0 to $+\infty$;

(2) Determine the range of K when all the three characteristic roots are real.

6. (12') The characteristic equation of a closed-loop system is given by

$$1 + GH(s) = 1 + \frac{K(s+4)}{s(s-1)} = 0, \quad K > 0$$

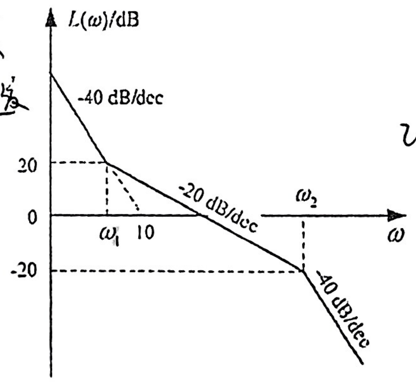
(1) Sketch the Nyquist plot of the loop transfer function GH;

(2) Determine the range of K for a stable system by using the Nyquist criterion.

7. (12') Consider a minimum-phase system with the logarithmic gain approximate curve of the open-loop system shown in Figure 3.

(1) Determine the open-loop transfer function $G(s)$ of the system;

(2) Determine the gain margin GM and the phase margin PM.



$20\lg\frac{K}{\omega_1^2} = 20$

Figure 3. Logarithmic Gain Approximate Curve

8. (16') Consider a unity negative feedback system as shown in Figure 4, where $G_c(s)$ is a phase-lag compensator and $G(s)$ represents the plant dynamics of a process.

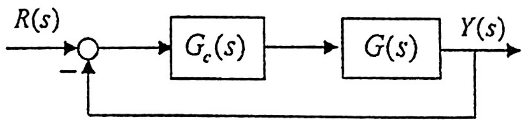


Figure 4. A Unity Feedback System

Suppose that

$$G(s) = \frac{K}{s(s+2)(s+20)}, \quad K > 0$$

KV

(1) Select a gain K such that velocity error constant subject to a ramp input is $K_v = 50$;

(2) With the gain K selected in (1), please sketch the Bode plot of the uncompensated system and calculate the phase margin γ_o of the uncompensated system;

(3) With the gain K selected in (1), please design a phase-lag compensator $G_c(s)$ by using Bode plot such that the compensated system has a phase margin $\gamma \geq 40°$.