淡江大學 101 學年度碩士班招生考試試題

系別：機械與機電工程學系　　科目：自　動　控　制

考試日期：2 月 26 日(星期日) 第 2 節　　本試題共四大題，2 頁

(寫答案時，請盡量詳述解答步驟。每小題後括號內的數字表示該小題所佔分數，四大題合計 100 分)

1. Figure 1 shows the block diagram of a closed-loop control system, where

$$G(s)=\frac{1}{(s+1)(s+2)(s^2+4s+8)}\quad,\quad H(s)=1$$

(a) Write the characteristic equation as $1+Kp(s)=0$; (4 分)
(b) Locate the root loci when $K=0$ and $K=\infty$; (4 分)
(c) Locate the segments of the real axis that are root loci and determine the number of separate loci, SL; (5 分)
(d) Find the center and angles of the asymptotes for the root loci as K approaches infinity; (4 分)
(e) Determine the point at which the locus crosses the imaginary axis, using the Routh-Hurwitz criterion; (5 分)
(f) Prove that the breakaway point on the real axis is located at s=-1.4691; (4 分)
(g) Determine the angles of departure of the locus from the poles using the phase angle criterion; (4 分)
(h) Complete the root locus plot approximately. (5 分)

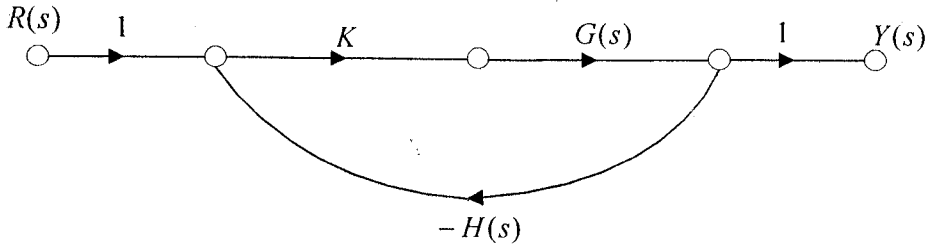

Figure 1　Closed-loop control system

2. A control system has the transfer function $T(s)$,

$$T(s)=\frac{Y(s)}{R(s)}=\frac{1}{s^3+10s^2+31s+30}$$

where $R(s)$ and $Y(s)$ are the input and output, respectively. We express the system in a phase-variable model with the following matrix differential equation,

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -a_0 & -a_1 & -a_2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}b_1\\ b_2\\ b_3\end{bmatrix}r(t)$$

$$y(t)=\begin{bmatrix}c_0 & c_1 & c_2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$

In the equation, x_1, x_2, and x_3 are the phase variables. $r(t)$ and $y(t)$ are the input and output in time-domain. Please find the coefficients a_0, a_1, a_2, b_0, b_1, b_2, c_0, c_1, and c_2. (15 分)

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3. A process for an electric motor is shown as Figure 2. Please answer the following questions.

(a) Find the process transfer function $G(s)=\dfrac{\omega(s)}{v(s)}$ for the motor process; (10 分)

(b) Determine the transfer function of the output to a disturbance, $\dfrac{\omega(s)}{T_d(s)}$, where $T_d(s)$ is the disturbance; (5 分)

(c) A speed control is applied to the motor process to form a closed-loop control system as shown in Figure 3. Where K_p is a proportional control and k_t is the transfer function of a sensor which is utilized to feedback the speed. Calculate the closed-loop transfer function, $\dfrac{\omega(s)}{R(s)}$, of the motor speed control system; (5 分)

(d) For the closed-loop control system described in Question (c), using the final-value theorem to find the steady-state error e_{ss} if the input is a unit-step function, $R(t)$=1. The error is defined as $e(t)=R(t)-\omega(t)$. (5 分)

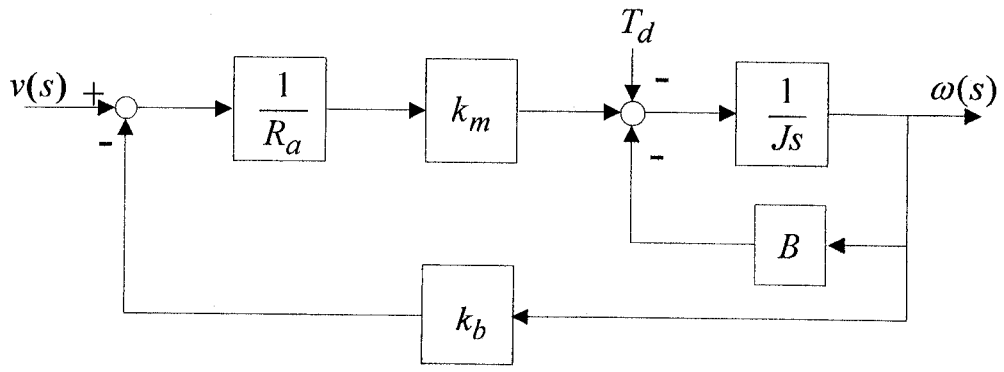

Figure 2 Motor process transfer function $G(s)$

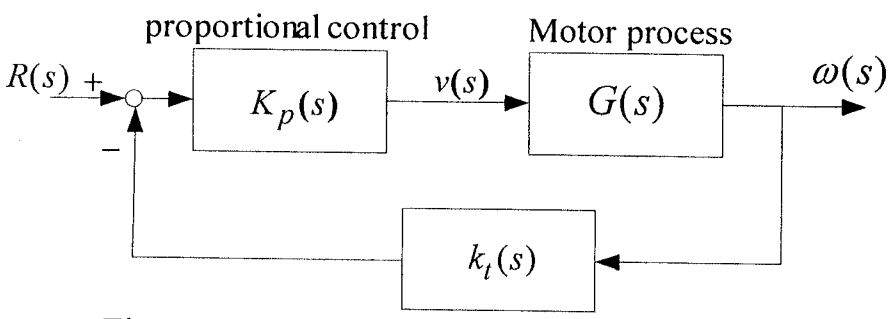

Figure 3　Closed-loop motor speed control

4. A closed-loop control system is shown in Figure 4, where

$$\frac{Y(s)}{R(s)}=\frac{20(s+4)}{(s+2)(s^2+16s+25)}$$

Please draw the Bode diagram of frequency responses for the system. (25 分)

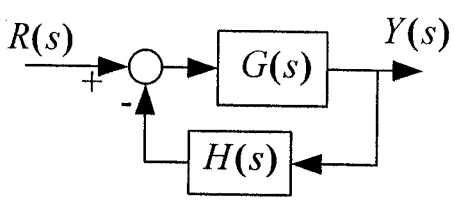

Figure 4 Closed-loop control system