國　立　清　華　大　學　命　題　紙

九十二學年度 電機工程學 系（所） 乙 組碩士班研究生招生考試

科目 控制系統 科號 2405 共 2 頁第 1 頁 *請在試卷【答案卷】內作答

1. For the nonlinear system expressed by:

$$\frac{dx}{dt} = x^2 - u$$
$$y = 2x$$

(1) for the control input $u = 9$, find the operating points (u_0, x_0, y_0);

(2) find the linearized small-signal state and output equations at stable operating point;

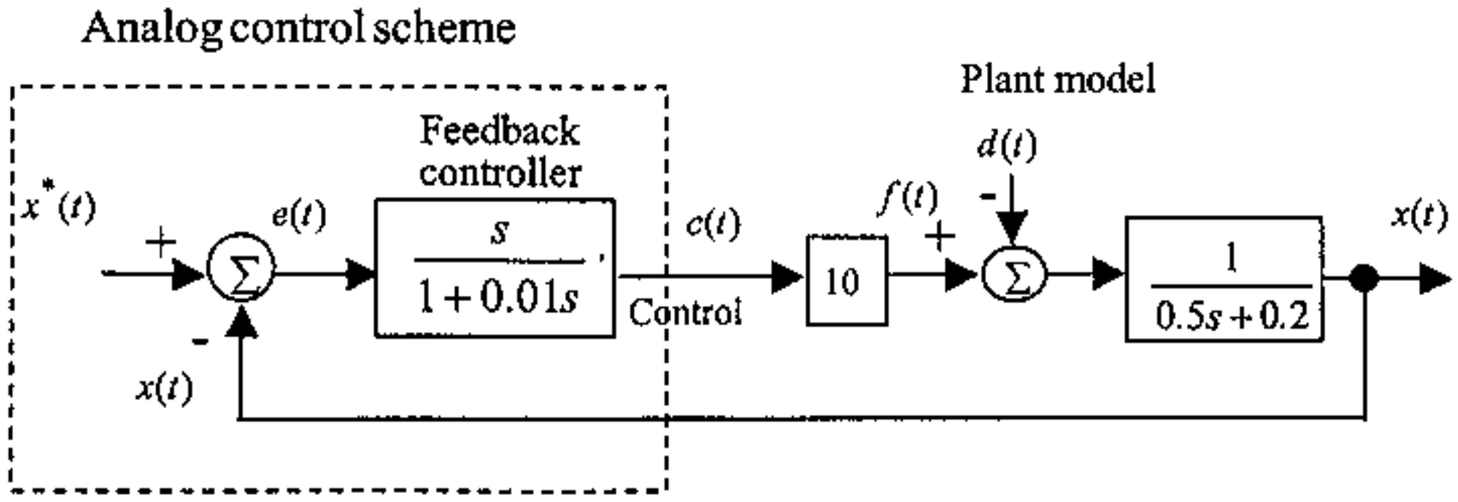
(3) find the transfer function $H(s) \overset{\Delta}{=} \Delta y(s) / \Delta u(s)$. (15%)

2. For the control system block diagram as shown:

(1) Realize the control scheme using only two operational amplifiers. Draw the circuit configuration with component values being indicated.

(2) Transform the analog control scheme into discrete-time domain using bilinear transformation method, and write down the digital control law *c(n)*. The sampling interval is chosen as $T=1ms$.

(3) Design an analog command feedforward controller to yield ideal tracking control, i.e., $x(t) = x^*(t)$. (20%)



3. Consider the case of rabbits and foxes in Australia. The number of rabbits is x_1 and if left alone would grow indefinitely until the food supply was exhausted so that $\dot{x}_1 = kx_1$. However, with foxes present on the continent, we have $\dot{x}_1 = kx_1 - ax_2$, where x_2 is the number of foxes. Now if the foxes must have rabbits to exist, we have $\dot{x}_2 = bx_1 - hx_2$. Determine whether this system is stable and thus decays to the condition $x_1(t) = x_2(t) = 0$ at $t = \infty$. What are the requirements on a, b, h, and k for a stable system? What is the result when k is greater than h? (20%)

4. A laser beam can be used to weld, drill, etch, cut, and mark metals. Assume that we have a work requirement for an accurate laser to mark a parabolic path with a closed loop control system with unity feedback. Furthermore, we assume that the system transfer function for the laser is $G(s) = \frac{K}{s^2}$. Calculate the necessary gain to result in a steady- state error of 5 mm for input $r(t) = t^2$ cm. (15%)

5. Consider the following linear state-space system

$\dot{X}(t) = A\,X(t) + B\,U(t)\quad X(0) = X_o$

(i) Please find X(t)=?

(ii) If U(t)=KX(t), please find X(t)=?

(iii) How do you check the controllability of the system?

(iv) How do you check the observability of the following system

$\dot{X}(t) = A\,X(t) + B\,U(t)$

$Y(t) = C\,X(t) + D\,U(t)$

(15%)

6. Consider the following linear system

$\dot{X} = AX + BU$

$Y = CX$

Suppose the following observer is used to estimate the state variable X

$\dot{\hat{X}} = A\,\hat{X} + BU + K\left(Y - C\hat{X}\right)$

(i) Please find the dynamic of estimation error $e = X - \hat{X}$

(ii) If $A = \begin{bmatrix} 0 & 20.6 \\ 1 & 0 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, $C = \begin{bmatrix} 0 & 1 \end{bmatrix}$ how do you specify K such that the eigenvalues of error dynamic of e are all at -10? (15%)