Code No: R05410205 **Set No. 1**

IV B.Tech I Semester Regular Examinations, November 2008
ADVANCED CONTROL SYSTEMS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. Obtain the state model of the mechanical system shown in Figure 1. Also obtain the transfer function matrix [16]

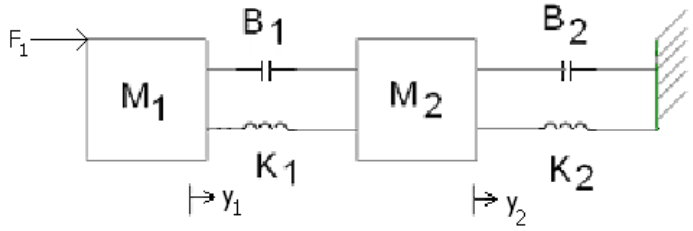


Figure 1

2. Consider the system

$$\dot{X} = \begin{bmatrix} -1 & 0 & 1 \\ 1 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix} X - \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U$$

and output

$y = \begin{bmatrix} 1 & 1 & 0 \end{bmatrix} X$

Transform the system into

   (a) controllable canonical form and

   (b) observable canonical form. [8+8]

3. Define describing function. Explain the signifances of describing function analysis. [16]

4. What is a singular point? Classify the different types of singular points by giving the phase portrait. [16]

5. Consider the systen shown in figure5. The non-linear function is replaced by the linear function ϕ(e)=Ke. Find the restriction on the parameter K to guarantee system stability. Use the Lyapunov's direct method. [16]

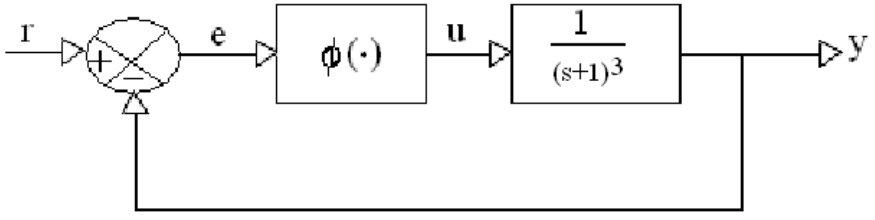


Figure 5

6. Consider the system with
$A = \begin{bmatrix} 0 & 1 & 0 \\ 3 & 2 & 0 \\ 1 & 1 & 1 \end{bmatrix}$ $B = \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix}$ $C = \begin{bmatrix} 1 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$
into equivalent observables comparsion form. [16]

7. (a) The functional given by
$J(x) = \int_1^{t_1} (2x + \frac{1}{2}\dot{x}^2)\ \mathrm{dt}$
$x(1) = 2,\ x(t_1) = 2, \quad t_1 > 1$ is free.
Final the extremals.
(b) Discuss the application of Euler-Lagrange equation and derive the equation. [8+8]

8. (a) Explain formulation of the optimal control problem.
(b) Explain formulation of the optimal control problem for the minimum-time problem. [8+8]

⋆ ⋆ ⋆ ⋆ ⋆

Code No: R05410205 **Set No. 2**

IV B.Tech I Semester Regular Examinations, November 2008
ADVANCED CONTROL SYSTEMS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. A feedback system is characterized by the closed loop transfer function $T(s) = \frac{s^2+3s+3}{s^3+2s^2+3s+1}$
   Construct a state model for this system and also give the block diagram representation for the same. [16]

2. (a) Determine the state controllability for the system represented by the state equation.
   $$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 2 & 1 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$$
   (b) Explain the different tests for controllability used for continuous time systems. [8+8]

3. What are the different types of non-linearities. Explain each of them in detail. [16]

4. Determine the type of singularity for each of the following differential equations. Also locate the singular points on the phase plane $\ddot{x} + 3\dot{x} + 2x = 0$. Draw the phase trajectory. [16]

5. Determine the stability of the origin of the following system
   $\dot{x}_1 = x_1 - 2x_2 - x_1^3$
   $\dot{x}_2 = x_1 + x_2 - x_2^3$ [16]

6. Find a controlleble system prove that

   $\int_{t_o}^{t_1} u^T(t)\ u(t)\ dt, \geq \int_{t_o}^{t_1} \dot{u}^T(t)\ \dot{u}(t).dt$, where $u_{[to,t1]}$ be any control that transfers the state $x(t_o)$ to the state x^1 at time t_1, with necessary conditions required under minimum energy control of continuoustime system. [16]

7. Show that the extremal for the functional
   $J(x) = \int_0^{\pi/8} (\dot{x}^2 - x^2)\ \mathrm{dt}$
   which satisfies the boundary conditions
   $x(0) = 0,\ x(\pi/8) = 1$. [16]

8. Consider the system
   $\dot{x}_1 = x_2 + u_1,$
   $\dot{x}2 = u_2$

Find the optimal control $u^*(t)$ for the functional

$J = \frac{1}{2} \int_0^4 (u_1^2 + u_2^2)\ \mathrm{dt}$

Given : $x_1(0) = x_2(0) = 1;\ \ x_1(4) = 0.$ [16]

⋆ ⋆ ⋆ ⋆ ⋆

Code No: R05410205 **Set No. 3**

IV B.Tech I Semester Regular Examinations, November 2008
ADVANCED CONTROL SYSTEMS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. A feedback system is characterized by the closed loop transfer function $T(s) = \frac{s^2+3s+3}{s^3+2s^2+3s+1}$
   Construct a state model for this system and also give the block diagram representation for the same. [16]

2. Block diagram representation of a linear time-invariant system is given in figure 2. Verify its complete controllable and observable conditions. [16]

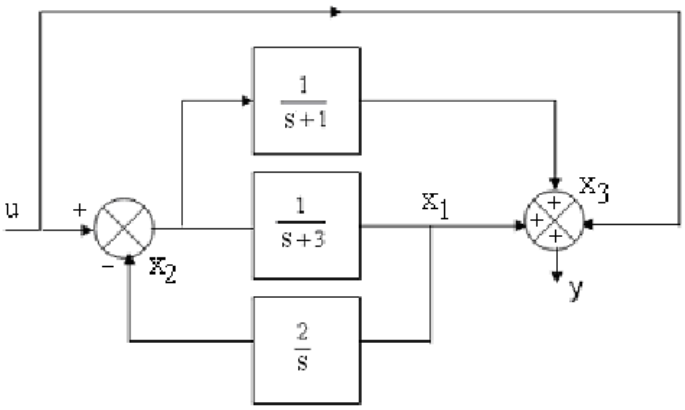


Figure 2

3. What is backlash? Derive the describing function of a backlash non-linearity. [16]

4. Determine the type of singularity for each of the following differential equations. Also locate the singular points on the phase plane $\ddot{x} + 3\dot{x} + 2x = 0$. Draw the phase trajectory. [16]

5. Determine the stability of the origin of the following system.
   $\dot{x}_1 = -x_1 + x_2 + x_1^3$
   $\dot{x}_2 = -x_1 + x_2 + x_2^3$ [16]

6. (a) For a multi-input syste explain pole placement by state feedback.
   (b) Discuss "Extra Degree of freedon" for the single input and multi-input system pole-placement by state feedback. [8+8]

7. (a) Derive Euler-Language equation.
   (b) Find the curve with minimum arc length between the point x(0)=1 and the line T_1=4. [8+8]

8. Consider a system described by the equation
   $\dot{x}(t) = f(x) + F(x)u(t)$
   where f(x) and the n × p matrix F(x) may be non linear. Use the Maximum Principle to show that it is necessary to use a Bang-Bang Controller to obtain the minimum - time response for this system if the input variables $u_i(t)$; i=1,2 .....p are constrained to a magnitude of less than a constant M. [16]

⋆ ⋆ ⋆ ⋆ ⋆

Code No: R05410205 **Set No. 4**

IV B.Tech I Semester Regular Examinations, November 2008
ADVANCED CONTROL SYSTEMS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. For the system shown in Figure 1, choose $v_1(t)$ and $v_2(t)$ as state variables and obtain the state variable representation. The parameters of the system are given as R=1MΩ; C=1μF. Find the state transition matrix. [16]

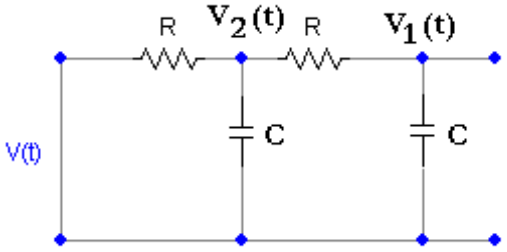


Figure 1

2. (a) What is Duality property? State and Prove Principle of Duality.
   (b) Define observability and controllability. Explain about Kalman's Test of controllability and observability. [8+8]

3. What are the different types of non-linearities. Explain each of them in detail. [16]

4. Linear second order servo is described by the equation $\ddot{e} + 2\tau w_n \dot{e} + w_n^2 e = 0$, where τ=0.15, $w_n = 1$ rad/sec e(0)=1.5 and $\dot{e}(0) = 0$. Determine the singular point. Construct the phase trajectory, using the method of isoclines. [16]

5. For the system
   $X = \begin{bmatrix} 0 & 1 \\ -2 & -2 \end{bmatrix} X$
   Find suitable Lypnunov function V(x). Find an upper bound on time that it takes the system to get from the initial condition
   $x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ to within the area defined by $x_1^2 + x_2^2 = 0.1$ [16]

6. Consider the system with

$$A = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 3 \end{bmatrix} \quad B = \begin{bmatrix} 1 & 1 \\ 1 & 0 \\ 1 & 1 \end{bmatrix}$$

   Obtain equivalent system in controllable companion form. [16]

7. Let f(x)=-x_1x_2 and let g(x)=$x_1^2 + x_2^2 - 1$. What are the potential candidates for minimize of f subject to the constraint g=0?
   Show that the points $\left(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right)$ and $\left(-\frac{1}{\sqrt{2}}, -\frac{1}{\sqrt{2}}\right)$ actually proride the minima. [16]

8. Formulate the two point boundary -value problem which when solved, yields the optimal control $u^*(t)$ for the system
   $\dot{x}_1 = x_2$
   $\dot{x}_2 = x_1 + (1 - x_1^2)\, x_2 + u$
   $x(0) = [\ 1 \quad 0\ ]^T$
   $J = \frac{1}{2} \int_0^2 (2x_1^2 + x_2^2 + u^2)\ \mathrm{dt}$
   when
   (a) u(t) is not bounded and
   (b) $|u(t)| \leq 1.0$ [8+8]

⋆ ⋆ ⋆ ⋆ ⋆