Code :R7321306

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III B.Tech II Semester(R07) Regular & Supplementary Examinations, April/May 2011

ADVANCED CONTROL SYSTEMS

(Electronics & Control Engineering)

Time: 3 hours Max Marks: 80

Answer any FIVE questions

All questions carry equal marks

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1. (a) 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 $R_1 = R_2 = 1M\Omega; C_1 = C_2 = 1\mu F$. find the state transition matrix.

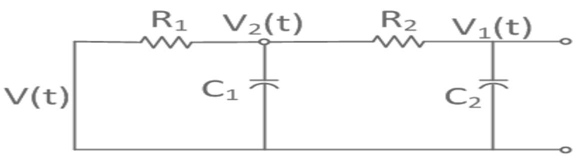

Figure (1)

2. Consider the system

$$\overset{0}{x} = \begin{bmatrix} -1 & 0 & 1 \\ 1 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix} x - \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U \text{ and output}$$

Y=[1 1 0] X

Transform the system into

   (a) Controllable canonical form and

   (b) Observable canonical form.

3. What are the different types of non linearities. Explain each of them in detail.

4. Draw a phase-plane portrait of the system defined by $\overset{0}{x}_1 = x_1 + x_2, \overset{0}{x}_2 = 2x_1 + x_2$.

5. (a) Define Lyapunov stability and instability theorems.

   (b) Define:

      i. Positive definite

      ii. Negative definite. Give examples for both.

6. (a) Explain the design of full-order state observer.

   (b) Consider the system with

   $A = \begin{bmatrix} 0 & 20.6 \\ 1 & 0 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 0 & 1 \end{bmatrix}$

   Design a full order state observer. Assume that the desired eigen values of the observer matrix are $\mu_1 = -1.8 + i2.4, \mu_2 = -1.8 - i2.4$

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

8. (a) Explain formulation of the optimal control problem for the minimum time problem.

   (b) Explain formulation of the optimal control problem for the minimum energy problem.

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1. A feed back 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.

2. (a) What is Duality property ? State and prove principle of duality.
   (b) Define observability and controllability. Explain about Kalman'x test of controllability and observability.

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

4. Consider a system with an ideal relay as shown in figure
   Determine the singular point. Construct phase trajectories, corresponding to initial conditions, (i) C(0)=2, $C^0(0)$=1 and (ii) C(0)=2, $C^0(0)$=1.5. Take r=2 volts and M=1.2 volts.

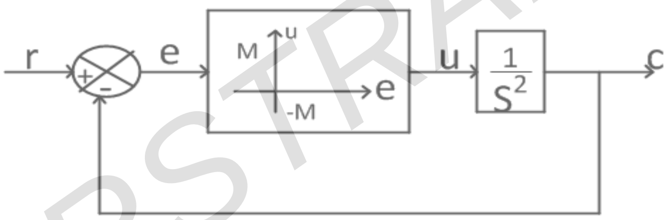

Figure (1)

5. For the system : $\overset{0}{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x$
   Find a suitable lyapunov 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 $x_1^2 + x_2^2 = 0.1$

6. (a) Explain the different methods of determination of observer gain matrix.
   (b) Consider the system described by the state model $\overset{0}{x} = Ax$ where $A = \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix}$ and y=cx, c=[1 0].
   Obtain the state observer gain matrix. The desired given values for the observer matrix are: $\mu_1 = -5, \mu_2 = -5$.

7. (a) Derive 'Euler-lagrangine' equation.
   (b) Find the curve with minimum arc length between the point x(0)=1 and the line T_1=4.

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 $J = \frac{1}{2}\int_0^4 (u_1^2 + u_2^2)dt$.
   Given :$x_1(0) = x_2(0) = 1, x_1(4) = 0$

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Code :R7321306 **3**

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1. Obtain the state model of the mechanical system shown in figure (1). Also obtain the transfer function matrix.

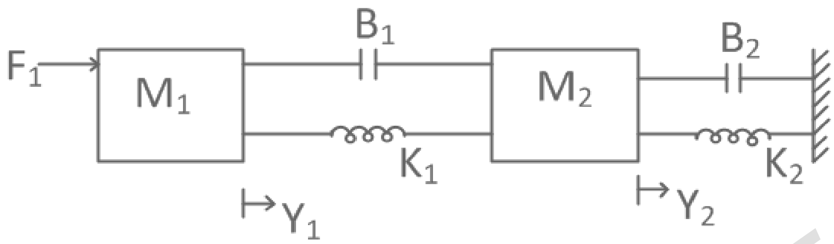

Figure (1)

2. Consider a system described by the state equation $\dot{x} = A.X(t) + Bu(t)$
Where $A = \begin{bmatrix} 1 & e^{-t} \\ 0 & -1 \end{bmatrix}; B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$
Is this system controllable at t=0 ? if yes, find the minimum energy control to drive it from x(0)=0 to $x^1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ at t=1.

3. Obtain the describing function analysis for the system shown in figure.

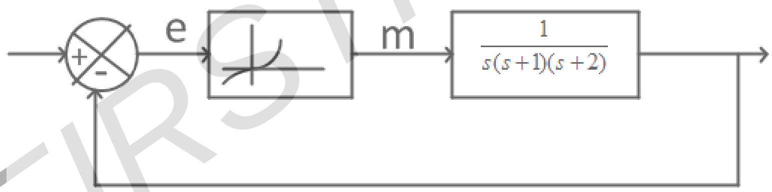

Figure (2)

4. A linear second order servo is described by the equation
$\ddot{e} + 2\xi\omega_n \dot{e} + \omega_n^{\gamma} e = 0.$ *where,* $\xi = 0.15, \omega_n = 1rad/\sec, e(0) = 1.5$ *and* $\dot{e}(0) = 0.$
Determine the singular point. Construct the phase trajectory, using the method of isoclines.

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

6. (a) Explain the linear system with full-order state observer with neat block diagram.
   (b) Design a full-order state observer for the given state model.
   $A = \begin{bmatrix} 1 & -1 \\ -2 & 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 \end{bmatrix}$ and given values are: $\mu_1 = -5, \mu_2 = -5$

7. (a) The functional given by
   $J(x) = \int_1^{t1} (2x + \frac{1}{2}\dot{x}^2)dt, x(1) = 2, x(t_1) = 2, t_1 > 1$ is free.
   Find the extremals.
   (b) Discuss the application of Euler-lagrangine equation and derive the equation.

8. (a) Explain minimum time problem.
   (b) Explain state regulator problem in brief.

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1. (a) Explain about different properties of state transition matrix.
   (b) Explain:
      i. Controllable canonical form
      ii. Jordan canonical form
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 how linear time invariant system transform into controllability canonical form.
3. (a) Explain the effect of inherent nonlinearities on static accuracy.
   (b) Derive the describe function for an on-off non linearity with hysteresis.
4. Explain the construction of phase trajectory by using
   (a) Analytical method.
   (b) Isocline method.
5. Determine the stability of the system described by the equation:
   $\dot{x} = A.x$. where, $A = \begin{bmatrix} -1 & -2 \\ 1 & -4 \end{bmatrix}$ using lyapunov's direct method.
6. (a) For a multi input system explain pole placement by state feedback.
   (b) Explain the designing of reduced order observer with neat block diagram.
7. (a) Find the Eular-lagrangine equations and the boundary conditions for the extremal of the functional
   $J(x) = \int_0^{\pi/2} (\dot{x}_1^2 + 2x_1x_2 + \dot{x}_2^2)dt.$
   $x_1(0) = 0, x_1(\frac{\pi}{2}) = -1$ is free.
   (b) Discuss the application of Eular-lagrangine equation.
8. (a) Explain output regulator problem.
   (b) Explain tracking problem.

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