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Code No: **R42022** **R10** **Set No. 1**

IV B.Tech II Semester Regular/Supplementary Examinations, April – 2015

ADVANCED CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks
*****

1 A unity feedback system is characterized by the closed loop transfer function $T(s) = \dfrac{s^2+4s+3}{s^3+3s^2+2s+4}$
Construct the suitable signal flow graph and therefrom construct a state model of the system [15]

2 The state model of a linear time invariant system is given by
$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix} = \begin{bmatrix}0 & 0 & -2\\ 1 & 0 & -5\\ 0 & 1 & -9\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix} + \begin{bmatrix}1\\ -1\\ 0\end{bmatrix}u$$
Determine the canonical form of the state model. [15]

3 a) Explain the principle of duality between controllability and observability. [8]

b) Develop the matrix representation of MIMO system. [7]

4 a) Obtain the expression for describing functions with diagram [6]

b) A nonlinear element system, with describing function, $K_N = (1/X) < -60^0$ in cascade with, $G(j\omega) = \dfrac{5}{j\omega(2+j0.4\omega)}$. Find the limit cycle of the system. [9]

5 a) Explain the stability in the sense of Lyapunov. [6]

b) A non-linear system described by the following equations
$\dot{x}_1 = -x_1 + 2x_2$
$\dot{x}_2 = 3x_1 - x_2 - x_2^3$
Observe the stability of equilibrium state. [9]

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Set No. 1

6 State equation of linear time invariant is defined by $\dot{x} = Ax + Bu$

$$where\ A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix}$$

By using the state –feedback control u = -Kx, consider closed –loop poles at s = -1±j3, s = -7. Calculate the state –feedback gain matrix K. [15]

7 Derive the Euler Lagrange equation and the boundary conclusion for the final time t_1 free and $x(t_1)$ specified, starting from a given $x(t_0)$ extremize

$$J(x) = \int_{1}^{t_1} g(x, \dot{x}, t)\, dt$$ [15]

8 Explain the linear quadratic optimal regular problem formulation. [15]

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Code No: **R42022** **R10** **Set No. 2**

IV B.Tech II Semester Regular/Supplementary Examinations, April – 2015

ADVANCED CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions
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*****

1 a) A linear time invariant system is characterized by the homogeneous state equation

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 2 & 3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Determine the solution of homogeneous equation, assuming the initial state vector $x_0 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ [6]

b) Consider now that the system has a forcing function and is represented by the following non-homogeneous state equation $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u,$

Where u is a unit step function

Determine the solution of this equation, considering initial conditions of part(a) [9]

2 The state model of a linear time invariant system is given by

$$[\dot{x}] = \begin{bmatrix} 0 & 0 & 1 \\ -2 & -3 & 0 \\ 0 & 2 & -3 \end{bmatrix} [x] + \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} [u]$$

$$y = [1 \quad 1 \quad 0][x]$$

Convert this state model to controllable phase variable form. [15]

3 Explain the multi variable Nyquist plot and singular values analysis. [15]

4 a) Discuss the basic concept of describing function methods. [6]

b) Explain the classification of non-linearities and give the examples for each. [9]

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Code No: **R42022** **R10** **Set No. 2**

5 a) What are the sufficient conditions of lyapunov stability [5]

b) Test the stability of the system described by

$$\dot{x}_1 = -2x_1 + 5x_1^2 x_2$$
$$\dot{x}_2 = -3x_2$$

Determine the region of asymptotic stability using krasovskii method [10]

6 a) Derive the Ackermann's formula for the determination of the state feedback gain matrix . [8]

b) Explain the effect of state feedback on controllability and observability. [7]

7 Calculate the extremal for the functional given below.

$$(x) = \int_{0}^{t_1} (3x + 7\dot{x}^2)\, dt$$

$(1)=5,\ x(t_1)=5,\ t_1 > 1$ [15]

8 Describe the optimal regulator design by parameter adjustment. [15]

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Set No. 3

IV B.Tech II Semester Regular/Supplementary Examinations, April – 2015

ADVANCED CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks
****

1 The state model of a linear time invariant system is given by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ -2 & -3 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} u$$

Transform this state model into a canonical state model and there from obtain the explicit solution for the state vector and output when the control force 'u' is a unit step function and initial state vector is $X_0^T = [0 \quad 1 \quad 0]$ [15]

2 The state model of a linear time invariant system is given by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ -1 & -2 & -1 \\ 0 & 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} -1 \\ 1 \\ 1 \end{bmatrix} u$$

$$y = [0 \quad 1 \quad -2] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Determine the canonical form of the state model. [15]

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3 a) Explain controllability and observability form other canonical forms. [8]

b) Discuss the multi variable Nyquist plot. [7]

4 Explain the following describing function with diagrams.

i) saturation non-linearity

ii) dead-zone non-linearity [15]

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5 a) State and prove lyapunov stability theorem [7]

b) Test the stability of the following system by using variable gradient method

$$\dot{x}_1 = -2x_1 + 3x_1^2 x_2$$
$$\dot{x}_2 = -4x_2$$ [8]

6 The state equation of linear time invariant systems is

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ -1 & -2 & 1 \\ 3 & 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} -1 \\ 2 \\ 1 \end{bmatrix} u$$

Consider the closed loop poles at $-1.5 \pm j4, -5.5$, design a state feedback controller. [15]

7 Consider the following system

$\dot{x} = u$, *with* $|u| \le 1$, determine the control which drive the system from an arbitrary initial state to the origin and minimize $J = \int_0^{t_1} |u(t)|\, dt, t_1$ is frees. [15]

8 Explain the optimal regulator design by continuous time algebraic riccati equation. [15]

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Code No: **R42022** **R10** **Set No. 4**

IV B.Tech II Semester Regular/Supplementary Examinations, April - 2015

ADVANCED CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks
*****

1 For the state model equation $\dot{x} = Ax$

Where A = $\begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 2 \\ -1 & -4 & -3 \end{bmatrix}$. Determine the initial condition vector $x_{(0)}$ which will exists only the mode corresponding to the eigen value with the most negative real part [15]

2 Test the observability of the systems for the following linear time invariant system using canonical form.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 2 & -1 & 3 \\ 1 & -1 & 1 \\ 1 & 2 & -1 \end{bmatrix} \begin{bmatrix} x_2 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 3 \\ 1 \\ 5 \end{bmatrix} u$$

$$y = \begin{bmatrix} -2 & 1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

[15]

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3 a) Explain the controllability form Jordan canonical form. [7]

b) Develop the transfer function representation of MIMO system. [8]

4 a) List out the common physical non-linearities with an example. [6]

b) Describe the saturation and backlash non-linearities with neat diagram. [9]

5 a) State and explain lyapunov stability analysis of control system. [7]

b) Check the positive definite for given quadratic form as follows: [8]

$Q = x_1^2 + 4x_2^2 + x_3^2 + 2x_1 x_2 - 6x_2 x_3 - 2x_1 x_3$

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Code No: **R42022** **R10** **Set No. 4**

6 The closed loop transfer function of a plant

$$\frac{C(s)}{U(s)} = \frac{7}{s^3 + 2s^2 + 5s + 9}$$

With the help of state feedback control $u = -kx$, It is desired to place the closed loop poles at $-1 \pm j3.5 \; and \; -4$. Calculate the necessary state feedback gain matrix 'K'. [15]

7 a) Explain the minimization of functionals of single input. [7]

b) Calculate the curve with minimum arc length between the point x(0) =1.5 and the line $t_1 = 3$. [8]

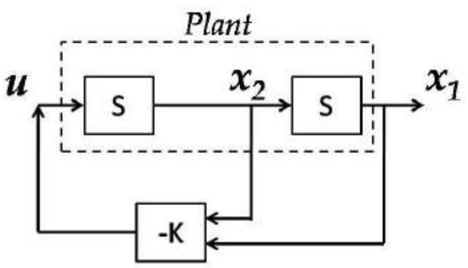
8 Consider the system shown in below figure. Assume the control signal to be

$$u(t) = -\overline{K}x(t)$$

Determine the optimal feedback gain matrix 'K' such that the following performance index is minimized.

$$J = \int_0^{\infty} \left(x^T Q x + u^2\right) dt$$

Where, $Q = \begin{bmatrix} 1 & 0 \\ 0 & u \end{bmatrix}$, $(u \geq 0)$



[15]

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