U.S.N

P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Sixth Semester, B.E. - Electrical and Electronics Engineering

Semester End Examination; May/June - 2019

Modern Control Theory

Time: 3 hrs *Max. Marks: 100*

***Note**: Answer **FIVE** full questions, selecting **ONE** full question from each unit.*

UNIT - I

1 a. Write with the transfer function for the operational amplifier circuit realization of the PI controller for the; i) Two Opamp circuit ii) Three Opamp circuit 6

b. Discuss the effects on 2nd order system performance with; 8

i) P-Controller alone ii) PI Controller iii) PD Controller

c. What are the effects on different terms such as transmittance, steady state error, relative stability, change in type number, change in system order for P, I, PI, and PID controllers with the tabular column. 6

2 a. Discuss the effects and limitations of lead compensators. 6

b. Discuss the effects and limitations of lag compensators. 6

c. With the help of graphs, explain the improvements in the responses (step and ramp) for systems with and without (Lead, Lag, Lag-Lead) compensators. 8

UNIT - II

3 a. Obtain the transfer matrix of the system, whose state and output equations are as given below: 6

$$\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} -2 & -3 \\ 4 & 2 \end{bmatrix} [X] + \begin{bmatrix} 3 \\ 5 \end{bmatrix} u, \quad y = [1 \quad 1][X]$$

b. By choosing $i_1(t)$, i_2(t) and v_c(t) are the state variables, derive the state model for the electrical network shown in Fig.3(b). 8

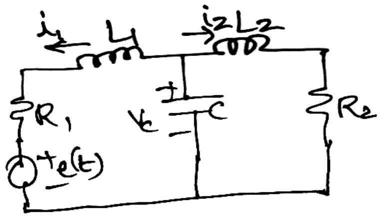

Fig. 3(b)

c. Determine the state model of a system shown below using the phase variables : 6

$$y(s)/u(s) = (2s^3 + s^2 + s + 2) \div (s^3 + 4s^2 + 5s + 2)$$

4 a. Determine the diagonal canonical state model for the system, 8

$\dddot{y} + 9\ddot{y} + 26\dot{y} + 24 = 2\dot{u} + 10u,$ and write the block diagram.

b. Consider the following state equation and output equation : 12

$$X = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 6 \end{bmatrix} u; \quad y = [1 \quad 0 \quad 0] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Determine the Eigen values, by using the linear transformation and diagonilisation of matrix A, develop the new state model Z.

UNIT - III

5 a. State the properties of state transition matrix. 5

Contd…2

b. A system has the following state equation : 7

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}-2 & 0\\ 1 & -1\end{bmatrix}[X]+\begin{bmatrix}1\\ 0\end{bmatrix}u;$$ Determine the homogeneous response to the initial condition $x_1(0) = 2, x_2(0) = 3.$

c. Obtain the time response of the following systems : 8

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}[X]+\begin{bmatrix}1\\ 0\end{bmatrix}u;$$ Where $u(t)$ is the step function occurring at $t = 0$, when, $y=\begin{bmatrix}1 & 0\end{bmatrix}\left[\begin{bmatrix}x_1\\ x_2\end{bmatrix}\right]$.

6 a. State and explain the concept of controllability and observability. Also explain how they are testing by two different methods? 8

b. Mention the conditions for the complete controllability and observability in the S-plane. 4

c. Is the following system completely state controllable and completely observable : 8

$$X=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -6 & -11 & -6\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}u; \quad y=\begin{bmatrix}20 & 9 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$

UNIT - IV

7 a. Explain the concept of pole placement technique using state feedback with the block diagram. Also state and prove the necessary condition for arbitrary pole placement. 10

b. For the regulator system with $\dot{X} = AX + Bu$ and $u = -Kx$, *where* $A=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -1 & -5 & -6\end{bmatrix}; \quad B=\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}.$ 10

Choose the desired closed loop poles at S = –2+j4, S = –2–j4, S = –10 and determine the state feedback gain matrix K. Use Ackermann's formula.

8 a. What is observer? Explain full order state observer with block diagram. 10

b. Design a suitable full order state observer for the system, 10

$\dot{X} = AX + Bu, Y = CX$, where $A=\begin{bmatrix}0 & 20.6\\ 1 & 0\end{bmatrix}; B=\begin{bmatrix}0\\ 1\end{bmatrix}; C=\begin{bmatrix}0 & 1\end{bmatrix}.$

Assume the desired Eigen values of the observer matrix are $\mu_1 = -10$, $\mu_2 = -10$, use Ackermann's method and write the equation for the full order observer.

UNIT - V

9 a. Explain the concepts of : i) Stability in the sense of Liapunov, ii) Asymptotic stability, iii) Instability. 9

b. Define; i) Positive definiteness ii) Negative definiteness 7

iii) Positive semi definiteness iv) Negative semi definiteness of scalar function

c. Check the definiteness of the following scalar function : 4

$V(x) = 10x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$

10 a. Explain the Liapunov stability analysis as applied to linear time invariant systems. 6

b. A second order system is represented by $\dot{X} = AX$ where, $A=\begin{bmatrix}0 & 1\\ -1 & -1\end{bmatrix};$ 8

Assuming matrix, '*Q*' to be identity matrix, clearly, the equilibrium state is the origin and determine the stability of this state. Write the Liapunov function *V(x)*.

c. For the non-linear system described by state equation, 6

$\dot{x}_1 = x_2$ and $\dot{x}_2 = -x_1 - x_1^2 - x_2$. Find the equilibrium state.

* * * *