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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; June - 2017

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 Based on control actions initiated, how the automatic controllers are classified and write the 5 controller configurations in control system with the block diagram. 5

b. Write the transfer function, the operational amplifier circuit realization of the PD controller for (i) Two Op-Amp circuit (ii) Three Op-Amp circuit. 5

c. Explain the draw backs of using the P-controller alone in a second order system and how the performance is improved by using PI and PD controllers. 10

2 a. What is compensator? Explain the need of compensators in a system and draw the block diagrams of different types of compensation. 6

b. Explain the effects of LEAD and LAG compensators on the system performance. 6

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

UNIT - II

3 a. For the system :

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \end{bmatrix} = \begin{bmatrix} 0 & +3 \\ -2 & 5 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} \text{ And } \begin{bmatrix} Y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 2 & 1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix};$$ 5

Obtain the transfer Matrix.

b. Determine the state model for the electrical network shown in the Fig 3b. Choosing i_1, i_2 and v_c are variables and the voltage drop across R_1 and R_2 as output variables. 7

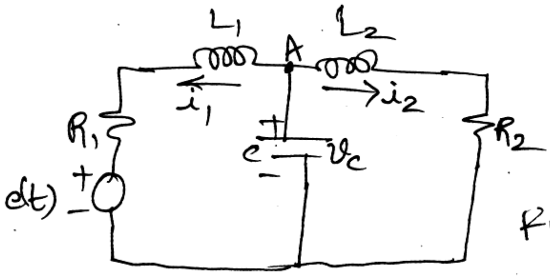

Fig.3b

c. A system defined by $\overset{(n)}{y} + a_1 \overset{(n-1)}{y} + \dots\dots\dots + a_{n-1}\dot{y} + a_n y = b_0 \overset{(n)}{u} + b_1 \overset{(n-1)}{u} + \dots\dots\dots + b_{n-1}\dot{u} + b_n u$, where 'u' is the input and 'y' is the output. Express the above system equation in, 8

(i) controllable (ii) observable

(iii) Diagonal (iv) Jordan canonical forms.

4 a. By using transformation matrix X = PZ, obtain the new state model for : 10

$$A=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -6 & -11 & -6\end{bmatrix};\quad B=\begin{bmatrix}0\\0\\6\end{bmatrix};\quad C=\begin{bmatrix}1 & 0 & 0\end{bmatrix}$$

b. Under linear transformation, shows that the Eigen values are invariant. 4

c. For the differential equation: $\dddot{y}+9\ddot{y}+26\dot{y}+24y=6u$ represent this in the canonical form. 6

UNIT - III

5 a. State the properties of state transition matrix. 4

b. A system has the following state equations $\dot{x}_1=-2x_1+u;\ x_2=x_1-x_2;$ Determine the homogeneous response to the initial conditions $x_1(0)=2$ *and* $x_2(0)=3$. 8

c. For the system $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}0\\1\end{bmatrix}u$; where *u(t)* is the unit step function occurring at t = 0, when $y=\begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$. Obtain the time response for the above system. 8

6. a Define: i) State controllability, ii) output controllability and iii) observability. Explain how they are tested by using two different methods. 10

b. Consider the system $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}2 & 0 & 0\\ 0 & 2 & 0\\ 0 & 3 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$ The output is given by $y=\begin{bmatrix}1 & 1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$;

(i) Show that the system is not completely observable

(ii) Show that the system is completely observable if the output is given by 10

$$\begin{bmatrix}y_1\\ y_2\end{bmatrix}=\begin{bmatrix}1 & 1 & 1\\ 1 & 2 & 3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}.$$

UNIT - IV

7 a. Explain how the stability and transient response of the system is to be improved by state feedback using pole placement technique. 10

b. For the system $\overset{\circ}{X}=AX+Bu$, 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 control law u=-kx. Determine the state feedback gain matrix 'K', with the desired closed loop poles at $S=-2\pm j4$ and $S=-10$ (use Ackerman's formula). 10

Contd…3

8 a. What is state observer? Explain the necessity of Full order observer by means of a block diagram. 10

b. For the system $\overset{\circ}{X} = AX$ and $y = CX$ where

$A = \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix}$; $C = \begin{bmatrix} 1 & 0 \end{bmatrix}$ Design a full order state observer, with the desired observer poles at S = - 5 and S = - 5. (Use Ackermann's formula). 10

UNIT - V

9 a. What is an autonomous system and explain the concepts of : 6

(i) Stability of an equilibrium state in the sense of Liapunov

(ii) Asymptotic stability of an equilibrium state

(iii) Instability.

b. For a scalar function V(x) of a vector X, define, 4

(i) Positive definite (ii) Positive semi definite

(iii) Negative definite (iv) Negative semi definite

c. Determine the definiteness of the quadratic form : 4

$V(X) = -4x_1^2 - 3x_2^2 - 2x_3^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$

d. Determine the stability of the origin of the system $\overset{\circ}{X} = AX$ where $A = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix}$. 6

Assume 'Q' to the Identity matrix, solve for the matrix 'P' in $A^T P + PA = Q$.

Write the Liapunov function.

10 a. Explain the Liapunov stability analysis of Linear time invariant systems. 8

b Determine the stability range for the gain K of the system shown in Fig. 10b. The state equation of the system is $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -2 & 1 \\ k & 0 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ k \end{bmatrix} u$ Assume the input 'u' to be zero. 12

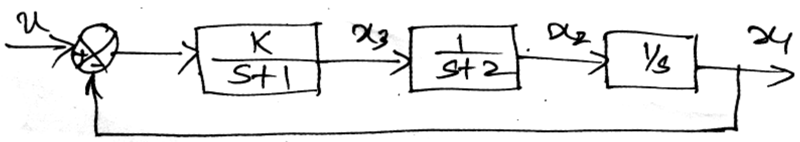

fig. 10.b.

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