Reg.No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

FIRST SEMESTER M.TECH. (CONTROL SYSTEMS AND AEROSPACE ENGG.)

END SEMESTER EXAMINATIONS, NOVEMBER - 2018

ADVANCED CONTROL SYSTEMS [ICE 5102]

TIME: 3 Hour **MAX. MARKS:50**

Instructions to candidates:
- Answer **ALL** questions.
- Missing data may be suitably assumed.

1A Enumerate the design philosophy of Lag compensator using Frequency response. 3

1B Correlate the time response specification and frequency response specification for a second order system. Hence derive the expression for phase margin and gain cross over frequency in terms of damping ratio and natural frequency. 3

1C A unity feedback system has the transfer function 4

$G_p(s) = \dfrac{4}{s(s+2)}$. Design a Lead compensator to place the closed loop poles to satisfy a damping ratio of 0.5 and natural frequency of 4 rad/sec. Also determine additional gain if any necessary.

2A List the advantages of state variable method of analysis compared to conventional method. 2

2B The state equations of a system are as follows: 5

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \\ \dot{x}_3(t) \end{bmatrix} = \begin{bmatrix} -4 & 1 & 0 \\ 0 & -3 & 0 \\ 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \\ 2 \end{bmatrix} u(t)$$

i) Determine the eigen values

ii) Determine a transformation matrix V which uncouples the states.

iii) Determine a transformation matrix P, which transforms system matrix into controllable canonical form.

2C Consider the system whose state and output equations are given as 3

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

$$y(t) = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix}$$

i) Obtain the transfer function.

ii) From the nature of transfer function and state model, comment on nature of realization and controllability and observability property.

3A For the system described by — 4

$$\begin{bmatrix}\dot{x}_1(t)\\ \dot{x}_2(t)\end{bmatrix}=\begin{bmatrix}0 & 2\\ 0 & -4\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\end{bmatrix}+\begin{bmatrix}1\\ 2\end{bmatrix}u(t)$$

$$y(t)=\begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\end{bmatrix}$$

Determine the state transition matrix using Cayley-Hamilton method. Hence determine the zero initial state and unit step input response for $x_1(t)$ and $x_2(t)$.

3B Realize the digital controller defined by — 2

$G(z)=\dfrac{U(z)}{E(z)}=\dfrac{4(z-1)(z^2+1.2z+1)}{(z+0.1)(z^2-0.3z+0.8)}$, in cascade form.

3C Obtain the state model for the following difference equation — 4

y(k+2)+3y(k+1)+2y(k)=0

Using the initial condition, y(-1)= $-\frac{1}{2}$, y(-2)=$\frac{3}{4}$, determine $x_1(0)$ and $x_2(0)$. Hence solve for y(k) using z transform method.

4A Derive expressions for obtaining a discrete time state model from a given continuous time state model. Hence obtain the discrete time state model for the system described in Q(3A) considering the sampling time as T=0.2 seconds. — 5

4B For the plant represented by — 5

$\begin{bmatrix}\dot{x}_1(t)\\ \dot{x}_2(t)\end{bmatrix}=\begin{bmatrix}0 & 1\\ -2 & -4\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\end{bmatrix}+\begin{bmatrix}0\\ 2\end{bmatrix}u(t)$, design a state feedback matrix K, that assigns the set of closed loop plant eigen values as [-3, -6] by direct method and using Ackerman's formula.

5A What is an observer? Derive the design formula for a full order observer. Show that the same is dual to state feedback control design and comment on the result. — 5

5B Consider a plant described by the following state variable model — 3

$$\begin{bmatrix}x_1(k+1)\\ x_2(k+1)\\ x_3(k+1)\end{bmatrix}=\begin{bmatrix}\frac{1}{2} & 1 & 0\\ -1 & 0 & 1\\ 0 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1(k)\\ x_2(k)\\ x_3(k)\end{bmatrix}+\begin{bmatrix}1 & 4\\ 0 & 0\\ -3 & 2\end{bmatrix}\begin{bmatrix}u_1(k)\\ u_2(k)\end{bmatrix}$$

$$Y=\begin{bmatrix}1 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1(k)\\ x_2(k)\\ x_3(k)\end{bmatrix}+\begin{bmatrix}0 & 4\end{bmatrix}\begin{bmatrix}u_1(k)\\ u_2(k)\end{bmatrix}$$

Design a full order observer for the estimation of the state vector X; the observer error poles are required to be at $-\frac{1}{2}\pm j\frac{1}{4}$,0.

5C What is dead beat control by state feedback and dead beat observers? — 2

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