Reg.No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

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

END SEMESTER EXAMINATIONS, DECEMBER - 2018

ADVANCED CONTROL SYSTEMS [ICE 5102]

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

Instructions to Candidates:

- Answer **ALL** the questions.
- Semilog Sheets may be provided.

1A	Write the transfer function, sketch the bode plot and list the characteristics of Lag-Lead compensator.	2
1B	Illustrate the design procedure of Lead compensator using Root locus method.	3
1C	A unity feedback system has the open loop transfer function $G_p(s) = \frac{K}{s(s+2)}$. It is desired to have a velocity error constant K_v =10. Design a lead compensator to meet the phase margin to be at least 45^0.	5
2A	The state transition matrix of a system is given as $e^{At} = \begin{bmatrix} 2e^{-t} - e^{-2t} & e^{-t} - e^{-2t} \\ -2e^{-t} + 2e^{-2t} & -e^{-t} + 2e^{-2t} \end{bmatrix}$. Using property of state transition matrix, determine the corresponding A matrix.	2
2B	Represent the following system in controllable canonical form and observable canonical form. $\ddot{y}(t) + 5\dot{y}(t) + 2y(t) = \dot{u}(t) + 3u(t)$	3
2C	Consider the system $\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t);\quad \begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ $y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix}$. i) Inspect the stability of the system. ii) Solve for the output response of the system to unit step input.	5
3A	Determine the minimal realization of a MISO system given by $\begin{bmatrix} \frac{s+2}{(s+1)^2} & \frac{s+1}{s+2} \end{bmatrix}$	2

3B Realize the pulse transfer function given by 3

$$\frac{Y(z)}{R(z)} = \frac{4z^3 - 12z^2 + 12z - 7}{z^3 - 4z^2 + 5z - 2}$$ in parallel form.

3C Solve for the response x(k) for k≥0 for the system described by 5

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 3/2 & -1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 3 \\ 2 \end{bmatrix} u(k); \quad \begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} -5 \\ 1 \end{bmatrix} \text{ with } u(k) = \left(\frac{1}{2}\right)^k \quad k \geq 0$$

4A A second order multivariable system is described by the following equations 2

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 2 & -5 \\ 1/2 & -1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 1 & -2 & 0 \\ 0 & 1 & 3 \end{bmatrix} \begin{bmatrix} u_1(k) \\ u_2(k) \\ u_3(k) \end{bmatrix}$$

$$\begin{bmatrix} y_1(k) \\ y_2(k) \end{bmatrix} = \begin{bmatrix} 2 & 0 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 0 & 4 & 2 \\ 0 & 0 & -2 \end{bmatrix} \begin{bmatrix} u_1(k) \\ u_2(k) \\ u_3(k) \end{bmatrix}$$

Obtain the pulse transfer function matrix.

4B Consider the system 3

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

Determine the discrete time model for the continuous time system with A and B matrix given with a sampling time of T=0.5 s

4C A discrete time plant model is given by 5

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 1 & 0.1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 0.005 \\ 0.1 \end{bmatrix} u(k)$$

. Using transformation to controllable canonical form design state variable feedback control law u(k)=k**x**(t) such that the closed loop system response has a damping ratio of 0.5 and undamped natural frequency of ω_n=4 rad/sec. Also verify the result using Ackerman's formula. Take T=0.2 sec.

5A Determine the controllability and observability of the following system. 2

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 1 & -2 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 1 & -1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} u_1(k) \\ u_2(k) \end{bmatrix}; \quad \begin{bmatrix} y_1(k) \\ y_2(k) \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

5B What is an observer? Illustrate the design philosophy of full order continuous time state observer along with computational procedure of observer gain vector m. 3

5C A regulator system has the plant 5

$$\dot{X}(t) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} X(t) + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U(t).$$

Design a dead beat state feedback control law by direct method. Also show the result obtained by Ackerman's formula.

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