Reg. No.

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

FIFTH SEMESTER B. TECH. (INSTRUMENTATION AND CONTROL ENGG.)

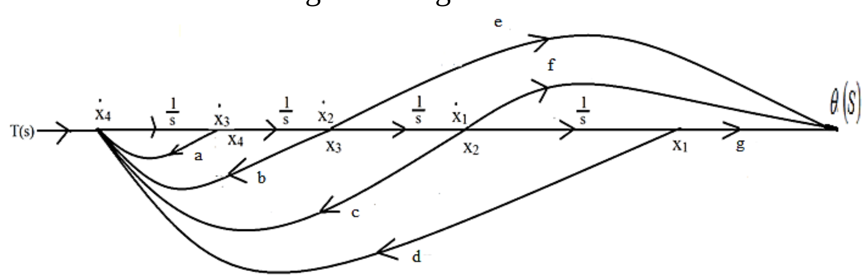
END SEMESTER DEGREE EXAMINATIONS, DECEMBER – 2018

SUBJECT: MODERN CONTROL THEORY [ICE 3101]

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

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

1A Write the system matrix A of following state diagram. 2



1B For the electrical system shown in Fig (Q1.B) select minimal state variables and obtain the state model in physical variable form. Take $V_O(t)$ as the output. 4

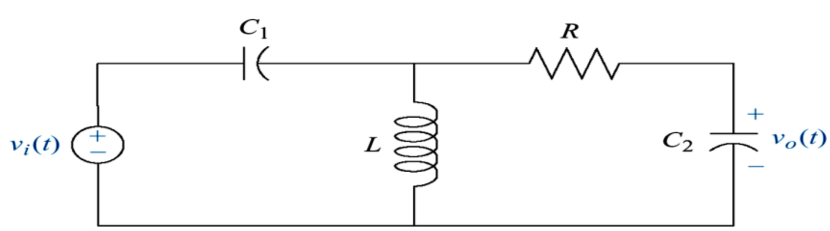


Fig (Q1.B)

1C Derive the Jordan canonical form of the given transfer function. 4

$$Y(s) = \frac{2}{(s-3)^3}U(s)$$

2A Diagonalize given system having 2

$A = \begin{bmatrix} -3 & 1 \\ -2 & 0 \end{bmatrix}$; $B = \begin{bmatrix} 3 \\ 1 \end{bmatrix}$; $C = [1 \quad 0]$ and $D = 0$

2B Find the homogeneous state equation solution by Cayley Hamilton's method. The system is **3**

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} \text{ if } x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

2C Derive the equation of a full order state observer with desired observer poles are at -10 and -10, for the system **5**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & -20.6 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \,;\; y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix};\; D = 0$$

3A Find the Pulse transfer function of the following discrete system **2**

$$F = \begin{bmatrix} 2.72 & 4.67 \\ 0 & 7.39 \end{bmatrix};\; G = \begin{bmatrix} 1.48 \\ 3.19 \end{bmatrix};\; C = \begin{bmatrix} 1 & 0 \end{bmatrix};\; D = 1$$

3B Find the response of the following system $y(k+2) - 3y(k+1) + 2y(k) = r(k)$, with $r(k) = 3^k$ and initial conditions $y(0) = 0$ and $y(1) = 1$. **3**

3C For the given transfer function **5**

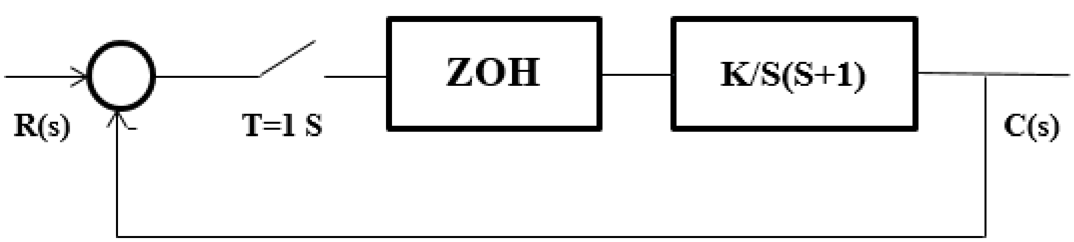
$\frac{y(z)}{u(z)} = \frac{z^2 + 4z + 4}{z^3 + 4z^2 + 3z}$ obtain a discrete time state model in (i) Observable canonical form and (ii) Controllable canonical form

4A Determine the sign definiteness of the given function **2**

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

(ii) $V(x) = 2x_1^2 + 3x_2^2 + x_3^2 + 6x_2x_3 + 4x_1x_3$

4B Obtain closed loop pulse transfer function of the following block **3**



4C Discretize the continuous time system **5**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u; \quad y = \begin{bmatrix} 1 & 0 \end{bmatrix} \text{ with sampling frequency 10Hz.}$$

5A By Ackermann's formula, design a state feedback control law for the system given if the desired poles are to be placed at -5 and -5. 5

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & 4 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

5B Check whether the given continuous system is completely output controllable. 2

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \quad C = \begin{bmatrix} 3 & 1 \end{bmatrix} \quad D = [1].$$

5C A LTI system is described by the discrete state model 3

$x(k+1) = \begin{bmatrix} -1 & -2 \\ 1 & -4 \end{bmatrix} x(k)$, using Lyapunov method, determine positive definite Lyapunov function $V(x)$, used to determine stability of equilibrium state.

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