Reg. No. | | | | | | | | | |

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

FIFTH SEMESTER B.TECH. (ELECTRONICS & INSTRUMENTATION ENGG.)

END SEMESTER DEGREE EXAMINATIONS, JANUARY - 2021

SUBJECT: Modern Control Theory [ICE 3153]

TIME: 3 HOURS 28-01-2021 MAX. MARKS: 50

Instructions to candidates :*Answer ALL questions and missing data may be suitably assumed.*

1A. Derive a state variable model for the circuit shown in FIG Q1A, considering $x_1 = v_1, x_2 = v_2$, and $x_3 = i$.

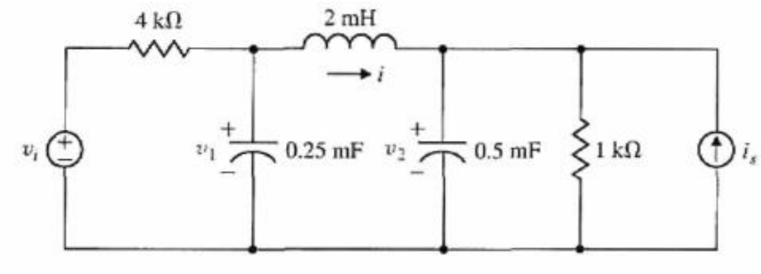

FIG. Q1A

1B. For the system described by following transfer function, obtain the controllable canonical form of state space representation and draw the equivalent state diagram.

$$\frac{Y(s)}{R(s)} = \frac{s^2 + 2s + 10}{s^3 + 4s^2 + 6s + 10}$$

1C. A control system is described in FIG Q1C, where a set of state variables are identified. The gains associated with system are K_1 and K_2, respectively. (a) Obtain the state differential equation, (b) Find the characteristic equation from the A matrix, (c) Determine the state transition matrix for $K_1 = 1$ and $K_2 = 1$.

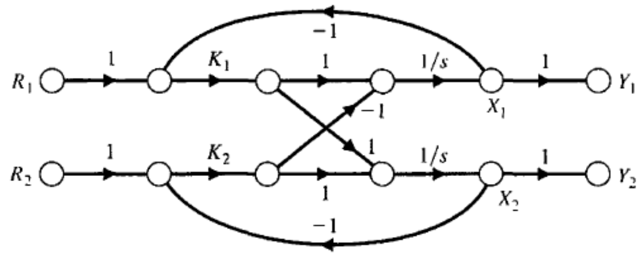

FIG. Q1C

(4+3+3)

2A. Convert the following system matrix to Diagonal/Jordan canonical form and using canonical transformation calculate the state transition matrix.

$$A = \begin{bmatrix} 4 & 1 & -2 \\ 1 & 0 & 2 \\ 1 & -1 & 3 \end{bmatrix}$$

2B. The attitude dynamics of a rocket is represented by Y(s)/ U(s), and state variable feedback is used where $x_1 = y(t), x_2 = \dot{y}(t)$ and $u = -x_2 - 0.5\,x_1$. Determine the roots of the characteristic equation of this system and the response of the system when the initial conditions are $x_1(0) = 0$ and $x_2(0) = 1$.

$$\frac{Y(s)}{U(s)} = \frac{1}{s^2}$$

2C. What is need of state observer? What is the necessary condition to be satisfied for design of state observer?

(5+3+2)

3A For a plant described by the transfer function Y(s)/ U(s), compute the state feedback gain using Ackermann's formulae to yield a 15% overshoot with a settling time of 0.5 secs.

$$\frac{Y(s)}{U(s)} = \frac{10}{(s+1)(s+2)}$$

3B Investigate the stability of the system

$$\underline{\dot{x}} = \begin{bmatrix} -1 & 2 \\ 2 & -3 \end{bmatrix} \underline{x}$$

3C Explain Isocline method for drawing phase trajectories

(5+3+2)

4A The nonlinearity in the system shown in FIG Q4A is an ideal relay with dead zone. Derive its describing function. Investigate the possibility of limit cycle. If exists, determine its amplitude and frequency of oscillation. Given G(s) = $\frac{25}{s(0.1s+1)(0.025+1)}$, b=4 and y=10.

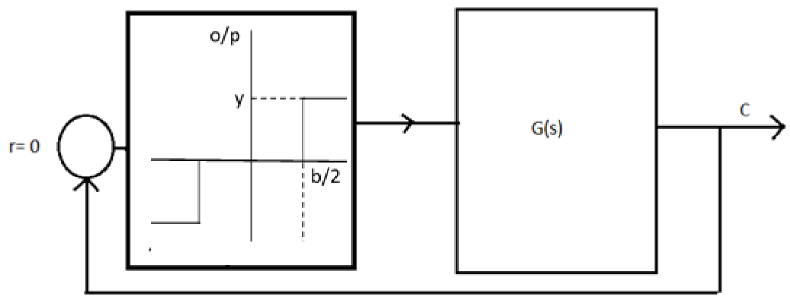

FIG Q4A

4B Linearize the nonlinear system $\ddot{x} + x^2(\dot{x} + x) - x(\dot{x} - 1)^2 + 1$ about the operating point $(x, \dot{x}) = (1, 1)$

4C List the characteristic of nonlinear systems.

(5+3+2)

5A Consider the nonlinear differential equation

$\ddot{y} - \left(0.1 - \frac{10}{3}\dot{y}^2\right)\dot{y} + y + y^2 = 0$. Find all singularities of the system and classify them.

5B Determine the stability of the origin of the following system

$$\mathring{X}_1 = -X_1 + X_2 + X_1(X_1^2 + X_2^2)$$
$$\mathring{X}_2 = -X_1 + X_2 + X_2(X_1^2 + X_2^2)$$

5C Show that the following quadratic form is PD

$$Q(x_1, x_2) = 6x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_2$$

(5+3+2)