TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and technology

Department of Electrical and Electronic Engineering

UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY IN APPLIED PHYSICS

EEE 4450: CONTROL ENGINEERING III.

END OF SEMESTER EXAMINATION

SERIES: sept 2017

TIME: 2 HOURS

DATE: Pick DateSelect MonthPick Year

Instructions to Candidates

You should have the following for this examination

-*Answer Booklet, examination pass and student ID*

This paper consists of **five** Questions; Question ONE is compulsory. In addition attempt any Other TWO Questions.

Do not write on the question paper.

Question ONE (Compulsory 30 marks)

a) Find the transfer function and a single first order differential equation relating the output y (t) to the input u(t) for a system described by the first order linear state and output equations.

$$\frac{dx}{dt} = ax(t) + bu(t)$$
$$y(t) = cx(t) + du(t)$$

(10 marks)

b) Draw the block diagram of a direct form realization of a block diagram and write the state equations in phase variable form for a system with the differential equation

$$\frac{d^3y}{dt^3} + 7\frac{d^2y}{dt^2} + 19\frac{dy}{dt} + 13y = 13\frac{du}{dt} + 26u$$

(9 marks)

c.) Given a system defined by the equation

$$\dddot{y} + 6\ddot{y} + 11\dot{y} + 6y = 6u$$

where *y* is the output and *u* the input of the system.

i) Obtain the state space representation of the system in

I) Controllable canonical form

II) Diagonal canonical form

ii) Draw the block diagram for the representations in (i)

(11 marks)

Question TWO

a.) For the RLC in figureQ2a write down the state equations when

i) The state variables are $v_2(t)$ and $\dot{v}_2$

ii) The state variables are $v_2(t)$ and $i(t)$

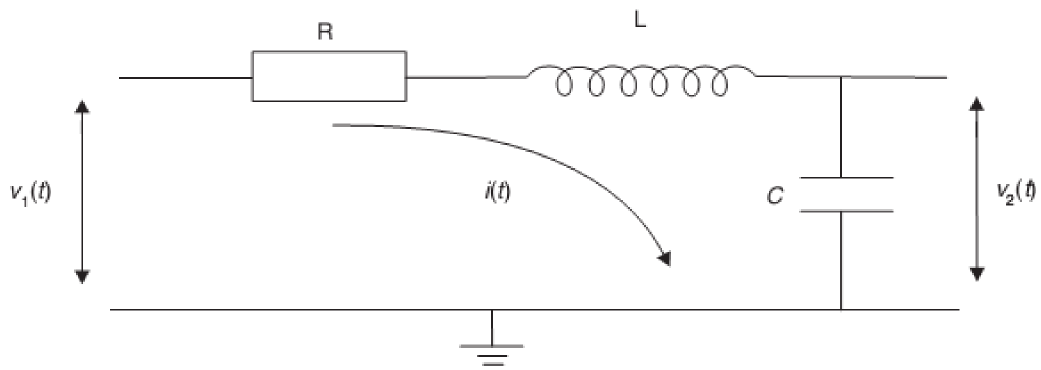

Figure Q2a

(10 arks)

b.) From the given block diagram in Figure Q2b obtain the Transfer function

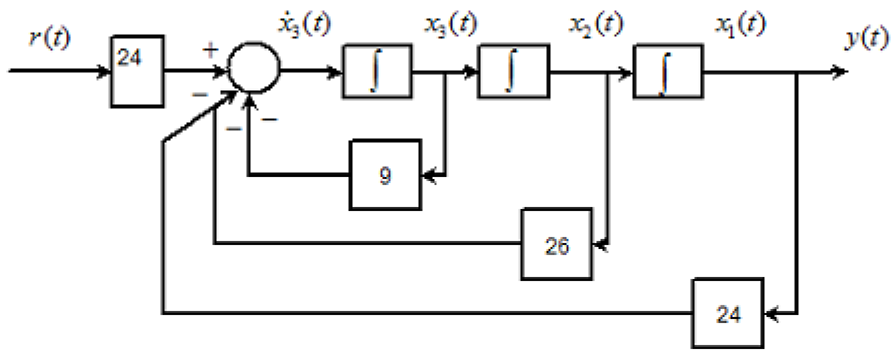

Figure Q2b

(10 marks)

Question THREE

a) **T**he state model of a system is of a system is given as

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}0 & 1\\ -12 & -7\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}0\\ 1\end{bmatrix}u(t)$$

$y = [-10 \quad -4]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + u(t)$

Assume the initial conditions are zero, determine

i) Transfer function of the system

ii) State transition matrix Φ(t)

iii) State response of the system

Also test for

iv) State controllability

v) Output controllability

vi) State observability

(16 marks)

b) Outline any FOUR advantages of state space modelling

(4 marks)

Question FOUR

a) Diagonalize the following system

$$\dot{x} = \begin{bmatrix} -5 & -5 & 4 \\ 2 & 0 & -2 \\ 0 & -2 & -1 \end{bmatrix} x + \begin{bmatrix} -1 \\ 2 \\ -2 \end{bmatrix} r$$
$$y = [-1 \quad 1 \quad 2]x$$

(8marks)

b) A system has a transfer function given as

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

The system has initial conditions y(0) = 1 and is subjected to unit ramp u(t)= t. Determine

i) The state and output equations

ii) The transition matrix $\Phi(s)$

iii) Expression for the time response of the state variables

(12 marks)

Question FIVE

Find the output response of the following system:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

with $y = [1 \quad 0]x$, where u(t) is the unit step input and $x_1(0) = 0 = x_2(0) = 0$.

(20 marks)