KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (COMPUTER ENGINEERING)

EEE 311: CONTROL SYSTEM II

DATE: Wednesday, 18th April, 2012 TIME: 8.00 a.m. – 10.00 a.m.

INSTRUCTIONS:

Answer question ONE and any other TWO questions from the following FIVE questions.

Marks for each part of the question is indicated.

QUESTION ONE- COMPULSORY

Q1 a) In the context of state space analysis, define the following vectors:

i) State vector
ii) Input vector
iii) Output vector

(6 marks)

b) Define the terms Controllability and Observability that are important structural properties of a linear time – invariant dynamic system. (6 marks)

c) Obtain the transfer function of an electrical phase lead network in Laplace trans form. Sketch its circuit diagram in frequency response curve. (6 marks)

d) With the aid of diagrams and relevant transfer functions, deduce the expression for each of the THREE types of control system including PID. (6 marks)

e) A linear time- invariant system is characterised by the homogeneous state equation

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Compute the solution of the homogenous equation assuming the initial state vector

$$x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

(6 marks)

QUESTION TWO

Q2 a) From the homogeneous equation given as [1], show from the first principles that in terms of the matrix exponential it can be expressed as $x(t) = e^{At}\ x(0)$

$x = ax$...[1]

(10 marks)

b) Applying the principles of similarity transformation, deduce the expression for the following state equation:

$$x(t) = \begin{bmatrix} -3 & 1 \\ -2 & 0 \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

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

with the transformation matrix

$$P^{-} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix}$$

(10 marks)

QUESTION THREE

Q3 a) The system is described by the following closed – loop transfer function

$$\frac{Y}{U}(s) = \frac{160\,(s+4)}{s^3 + 18s^2 + 192s + 640}$$

Obtain the state-space representation of the system (10 marks)

b) Determine the Eigen values of the system defined by;

$$2\frac{d^3 y}{dt^3} + 12\frac{d^2 y}{dt^2} + 22\frac{dy}{dt} + 12y = 12u$$ (10 marks)

QUESTION FOUR

Q4 a) Given a single-input single-output state variable model

$\dot{x} = Ax + bu$

$y = cx$

Prove that $\frac{Y(s)}{U(s)} = G(s) = \mathbf{c}(s\mathbf{I} - \mathbf{A})^{-1}\mathbf{b}$ (10 marks)

b) Draw an electronic circuit using Omp amplifier to show how three P, I, D controllers can be realised (10 marks)

QUESTION FIVE

Q5 a) A system is described by;

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

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

Is this system controllable and observable? (10 marks)

b) Consider a system defined by

$$\dot{x} = Ax + bu$$

Where

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

By using the state feedback control U = -Kx, it is desired to have the closed poles at s= -2 ±j4 and s = -10. Determine the state feedback gain matrix K and draw a closed-loop system with the state feedback gain matrix K (10 marks)

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