Question Paper

Exam Date & Time: 26-Apr-2018 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

INTERNATIONAL CENTRE FOR APPLIED SCIENCES
IV SEMESTER B. S. (ENGG)
END SEMESTER THEORY EXAMINATION - APRIL 2018
Date: 26.04.2018
Time: 9.30 A. M. TO 12.30 P.M.

Dynamics Of Systems [ME 244]

Marks: 100 **Duration: 180 mins.**

Answer 5 out of 8 questions.
Missing data, if any, may be suitably assumed
Semi-log and graph sheets will be provided

1) A) Define steady state error of a control system and derive an expression for the same. (4)

B) The open loop transfer function of a servo system with unity feedback is: (6)

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

Evaluate the static error constants. Also obtain the steady state error of the system when subjected to an input given by $r(t) = 1 + 2t + 1.5t^2$.

C) Sketch the Nyquist plot for an open loop transfer function with K=50: (10)

$$G(s)H(s) = \frac{K}{s(s+2)(s+10)}$$

2) A) Define a relatively stable and marginally stable system. Discuss the different cases of location of the characteristic roots of a general second order transfer function on the s-plane. Comment on the impulse response and stability for each case. (10)

B) Sketch the test input signals used in time domain analysis which resemble a constant acceleration and constant velocity. Write the mathematical expressions for these test signals. Derive the expression for the response of an over damped second order system for a unit step input and draw its response. (10)

3) A) For the mechanical rotational system shown in fig. 3(a), Write down the differential equations describing the system. Draw analogous electrical network using torque voltage and torque current analogy. Write down the analogous electrical equations for both the analogies. (12)

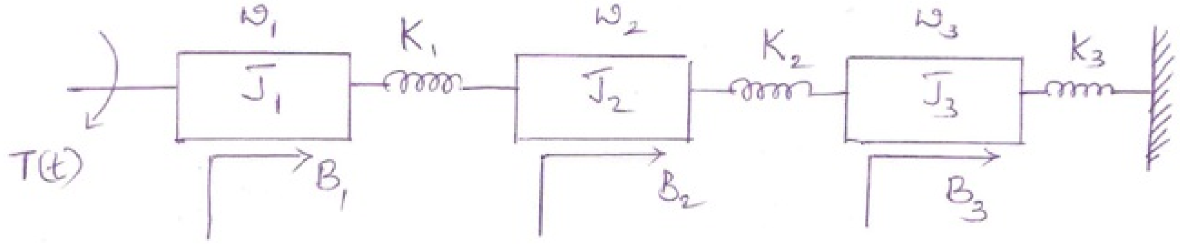

Fig. 3(a)

B) Define phase margin and gain margin with the respective mathematical representations. Derive the expression for phase margin of a second order control system. (8)

4) A) State four disadvantages of the classical LTI approaches which could be overcome by state space approach. Obtain the state space model for the following transfer function using phase variables. (10)

$$\frac{Y(s)}{U(s)} = \frac{s^2 + 3s + 4}{s^3 + 7s^2 - 8s + 4}$$

B) Define controllability and observability. Evaluate both for the following parameters of the state space model : (10)

$$A = \begin{bmatrix} 5 & 1 & 8 \\ -6 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix} \quad B = \begin{bmatrix} -2 \\ 0 \\ 1 \end{bmatrix} \quad C = [3 \quad 0 \quad 1]$$

5) A) Consider a system defined by $\dot{x} = Ax + Bu$, where, (16)

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

By using the state-feedback control u = -Kx, it is desired to have closed loop poles at -2-4j, -2+4j and -10 respectively. Determine the state-feedback gain matrix K. Verify the result by using Ackerman's formula.

B) Brief the characteristics of the following controllers with mathematical representations: (4)

a) Proportional plus derivative control
b) Proportional plus Integral control.

6) A) Sketch the root locus for the open loop transfer function of a unity feedback system given by: (12)

$$G(s) = \frac{K(s+9)}{s(s^2+4s+11)}$$

B) (8)

7)

Write the conditions for Bounded Input Bounded Output (BIBO) stability. For the characteristic equation given below, calculate the number of roots lying on the right hand side of the s-plane and comment on the stability of the system using the R-H stability criterion.

$$s^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$$

A) With the help of neat diagram, derive the transfer function of armature controlled DC servo motor. (10)

B) Define peak time and maximum overshoot. For a closed loop control system with negative feedback, $G(s) = K_1/s^2$ and $H(s) = 1+K_2s$. If the maximum overshoot is 25% and peak time is 4 seconds, calculate the value of K_1 and K_2 . Also calculate the rise time and settling time. (10)

8) (5)

A) Obtain the transfer function for a system having state model:

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \end{bmatrix} = \begin{bmatrix} 2 & -3 \\ -1 & 5 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 4 \\ 7 \end{bmatrix} U \text{ and } Y = \begin{bmatrix} 3 & 7 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} \text{ with } D = 0$$

B) Derive the transfer function $[e_o(s)/e_i(s)]$ of the electrical system shown in fig. 8(b). (7)

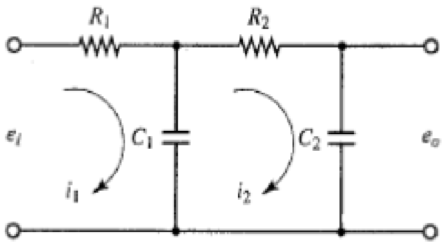

Fig. 8(b)

C) Determine the magnitude and phase using bode plot analysis for theopen loop transfer function (8)

$$G(s) = \frac{10}{s(1+0.4s)(1+0.1s)}$$

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