PAPER ID : 2056

TEE-502

Printed Pages : 7

Paper ID and Roll No. to be filled in your Answer Book

Roll No. 0 7 1 2 0 1 0 8 0 4 5

B. Tech.

(SEM. V) (ODD SEM.) EXAMINATION, 2009-10

CONTROL SYSTEM

Time : **3** Hours] [Total Marks : **100**

Note : (1) Attempt all **five** questions.

(2) Each question carries **equal** marks.

(3) Assume any **data** if **necessary**.

(4) Use of **calculator** is permitted.

1 Attempt any **four** parts in this question :

(a) Explain mathematically the conditions for Linearity and Time Invariance.

(b) What are the standard test signals ? What are these used for ?

(c) List the major advantages and disadvantages of an open loop control system.

(d) Discuss the effect of feedback (i) on Bandwidth and (ii) on Transient response of the system.

(e) The damping ratio of a II order control system is increased from 0.3 to 0.6, what will be the corresponding change in percentage overshoot ?

(f) The magnitude of frequency response of an under-damped II order system is 5 at 0 rad/sec and peaks to $10\sqrt{3}$ at $5\sqrt{2}$ rad/sec. What will be the transfer function of the system ?

2 Attempt any **four** parts in this question :

(a) What are minimum phase and non-minimum phase systems ? Write down the transfer function for these systems.

(b) Write down the values of K_p, K_v and K_a for a zero order, first order and second order systems.

(c) Derive the coordinates of the centre and the radius of M circles in terms of M.

(d) The Nyquist plot of G (jw) H (jw) for a closed loop control system passes through (–1, j0) point in the GH plane. Calculate the Gain Margin of the system in dB.

(e) A linear system is described by the following state equation

$$\dot{X}(t) = A\,X(t) + B\,u(t),\ A = \begin{bmatrix} 0 & -1 \\ -1 & 0 \end{bmatrix}.$$ Calculate

the state transition matrix of the system.

(f) Define a singular matrix, an Orthogonal Matrix, a symmetric matrix and a Skew-Symmetric Matrix. Give one example for each of Singular Matrix, Orthogonal Matrix, Symmetric and a Skew-symmetric matrix.

3 Attempt any **two** parts in this question :

(a) Write the differential equations governing the behavior of the mechanical system shown in **Fig. 1**. Also obtain an analogous electrical circuit based on force voltage analogy.

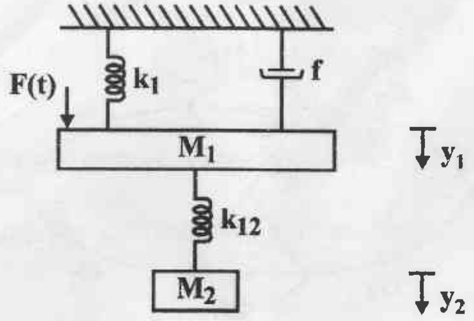

Fig. 1

(b) A unity feedback system is characterized by an open loop transfer function $G(s)=K/(s(s+10))$. Determine the gain K so that the system will have a damping ratio of 0.5. For this value of K, determine settling time, peak overshoot and time to peak overshoot for a unit step input.

(c) The open loop transfer function of a unity feedback system is given by

$$G(s)=K/(s(T_1s+1)(T_2s+1)).$$

Derive an expression for gain K in terms of T_1, T_2 and specified gain margin G_m.

4 Attempt any **two** parts in this question :

(a) Obtain the overall transfer function C/R from the signal flow graph shown in the **Fig. 2**.

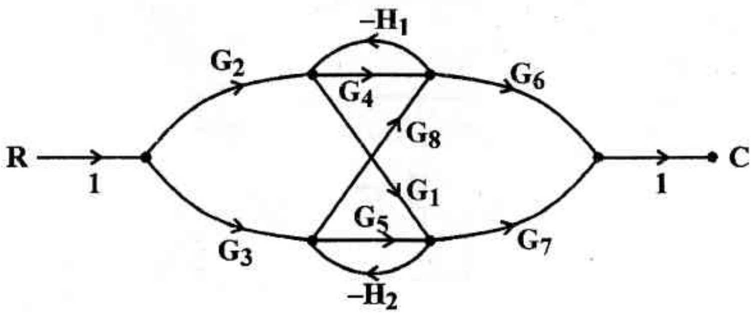

Fig. 2

(b) A unity feedback control system has an open loop transfer function

$$G(s) = K/\left(s\left(s^2 + 4s + 13\right)\right).$$

Sketch the root locus plot of the system by determining the following :

(i) centroid, number and angle of asymptotes

(ii) angle of departure of root loci from the poles

(iii) breakaway points if any

(iv) the value of K and the frequency at which the root loci cross the $j\omega$ axis.

(c) Sketch the direct and inverse polar plot for a unity feedback system with open loop transfer function.

$$G(s) = 1/\left(s(1+s)^2\right)$$

Also find the frequency at which $|G(j\omega)| = 1$ and the corresponding phase angle $\angle G(j\omega)$.

5 Attempt any **two** parts in this question :

(a) A unity feed back system has the forward path transfer function $G(s) = K/(s(s+\alpha))$.

(i) taking K as a constant, determine the value of α which minimizes ISE.

(ii) taking α as a constant, determine the value of K which minimizes ISE.

(b) The open loop transfer function of a unity feedback control system is given by

$$G(s) = K/\left((s+2)(s+4)\left(s^2+6s+25\right)\right).$$

By applying Routh Criterion, discuss the stability of the closed loop system as a function of K. Determine the value of K which will cause sustained oscillations in the closed loop system. What are the corresponding oscillation frequencies ?

(c) A LTI system is described by the following state model :

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Transfer this state into a canonical state model and therefrom obtain the explicit solutions for the state vector and output when the control force u is a unit step function and initial state vector is $x_0^T = \begin{bmatrix} 0 & 0 & 2 \end{bmatrix}$.