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Fourth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Control Systems

Time: 3 hrs.

Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

- 1 a. Define closed loop control systems and list its advantages and disadvantages with examples. (04 Marks)
- b. For the mechanical system shown in Fig.Q.1(b), write i) The mechanical network ii) the equations of motion and iii) the force-current analogous electrical network. (08 Marks)

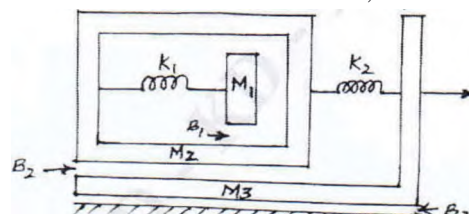


Fig.Q.1(b)

- c. For the system represented by the following equations, find the transfer function $X(S)/U(S)$ by signal flow graph technique.

$$x(t) = x_1(t) + 0_3 u(t)$$

$$x_1'(t) = -a_1 x_1 + x_2 + f_3 u(t)$$

$$x_2'(t) = -a_2 x_2 + 13 u(t)$$

(08 Marks)

OR

- 2 a. Define analogous systems. Show that two systems shown in Fig.Q.2(a) are analogous systems, by comparing their transfer functions. (08 Marks)

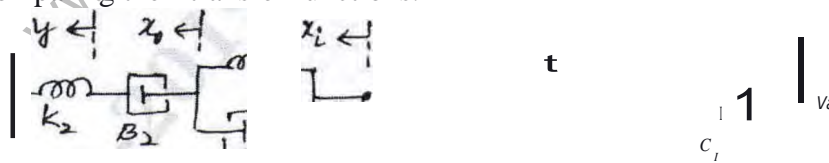


Fig.Q.2(a)

- b. For the block diagram shown in Fig.Q.2(b), determine the transfer function $C(S)/R(S)$ using block diagram reduction technique. (08 Marks)

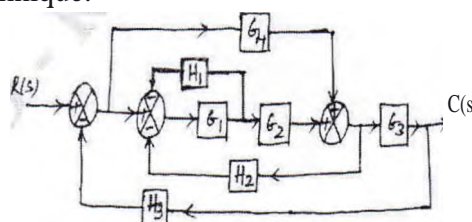


Fig.Q.2(b)

c. Define the following terms in connection with signal flow graph:

- i) Node
- ii) Forward path gain
- iii) Feedback loop
- iv) Non-touching loops.

(04 Marks)

Module 2

3 a. Define the following time response specifications for an underdamped second order system:

- i) Rise time, t_r
- ii) Peak time, t_p
- iii) Peak-overshoot, M_p
- iv) Settling time, i_s

(04 Marks)

b. A system is given by the differential equation $y''(t) + y'(t) + y(t) = x(t)$, where $y(t)$ is the output. Determine all time domain specifications for unit step input.

(08 Marks)

c. The open loop transfer function of a unity feedback system is given by $G(s) = \frac{K}{s(ST+1)}$

- i) By what factor should the amplifier gain K be multiplied in order that the damping ratio is increased from 0.2 to 0.8?
- ii) By what factor should K be multiplied so that the system overshoot for unit step excitation is reduced from 60% to 20%?

(08 Marks)

OR

4 a. Derive the expressions for i) Rise time, t_r and ii) Peak overshoot, M_p for the underdamped response of a second order system for a unit step input.

(06 Marks)

b. For the system shown in Fig.Q.4(b), compute the values of K and τ to give an overshoot of 20% and peak time of 2 sec for an unit step excitation.

(08 Marks)

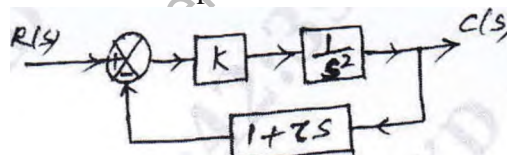


Fig.Q.4(b)

c. Find the position, velocity and acceleration error constant for a control system having open loop transfer function $G(S)H(S) = \frac{10}{S(S+1)}$. Also find the steady state error for the input

$$r(t) = 1 + t.$$

(06 Marks)

Module 3

5 a. State and explain Routh's stability criterion for determining the stability of the system and mention its limitations.

(06 Marks)

b. Determine the number of roots that are

- i) in the right half of s-plane
- ii) on the imaginary axis and
- iii) in the left half of s-plane

for the system with the characteristic equation $s^6 + s^5 - 2s^4 - 3s^3 - 7s^2 - 4s - 4 = 0$.

(06 Marks)

c. Sketch the root locus plot of a certain control system, whose characteristic equation is given by $s^3 + 10s^2 + ks + k = 0$, comment on the stability.

(08 Marks)

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OR

- 6 a. For a system with characteristic equation $s^4 + ks^3 + s^2 + s + 1 = 0$, determine the range of K for stability. (04 Marks)
- b. Determine the values of 'V' and 'a' for the open loop transfer function of a unity feedback system is given by $G(s) = \frac{K(s+1)}{s^3 + as^2 + 3s+1}$ so that the system oscillates at a frequency of 2rad/sec. (06 Marks)
- c. Draw the root locus diagram for the system shown in Fig.Q.6(c), show all the steps involved in drawing the root locus. Determine:
- The least damped complex conjugate closed loop poles and the value of ζ corresponding to these roots
 - Minimum damping ratio. (10 Marks)

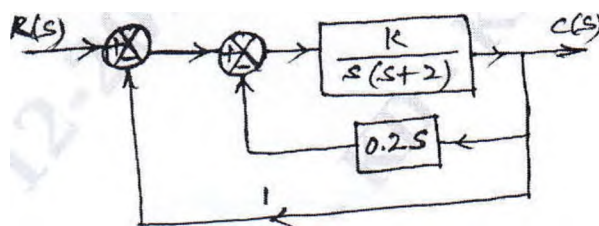


Fig.Q.6(c)

Module-4

- 7 a. Define the following terms in connection with bode plots:
- Gain cross over frequency
 - Phase crossover frequency
 - Gain margin
 - Phase margin. (04 Marks)
- b. A negative feedback control system is characterized by an open loop transfer function $G(S)H(S) = \frac{20}{S(S+1)(S+2)}$. Sketch the polar plot and hence determine w_g , w_{pc} , G_M and PM . Comment on the stability. (06Marks)
- c. A unity feedback control system has $G(s) = \frac{100(1+0.1s)}{s(s+0.01s+1)}$. Draw the Bode plots and hence determine W_{ec} , W_c , GM and PM . Comment on the stability. (10 Marks)

OR

- 8 a. A unity feedback control system has $G(s) = \frac{200(s+2)}{s(s^2 + 10s + 100)}$. Draw the bode plots and hence determine stability of the system. (10 Marks)
- b. Using Nyquist stability criterion, find the range of K for closed loop stability for the negative feedback control system having the open loop transfer function $G(S)H(S) = \frac{K}{S(S^2 + 2S + 2)}$ (Marks)

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Module-5

- 9 a. State the advantages of state variable analysis. (04 Marks)
b. Obtain the state model for the electrical system shown in Fig.Q.9(b). Take $i_o(t)$ as output. (06 Marks)

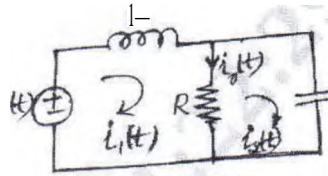


Fig.Q.9(b)

- c. For a system represented by the state model

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & -3 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(t)$$
and $y(t) = \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix}$

Determine:

- i) The state transition matrix, $\Phi(t, 0)$ and
ii) The transfer function of the system.

(10 Marks)

OR

- 10 a. Define state transition matrix and list its properties. (04 Marks)

- b. Consider a state model with matrix $A = \begin{bmatrix} 0 & 1 & 0 \\ 3 & 0 & 2 \\ -12 & -7 & -6 \end{bmatrix}$. Determine the model matrix M.

(06 Marks)

- c. Obtain the time response of the following non homogeneous state equation:

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

where $u(t)$ is a unit step function, when $x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$

(10 Marks)