17EC43

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)**
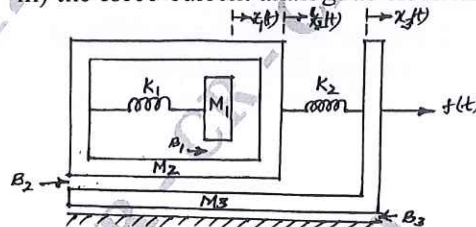

Fig.Q.1(b)

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

$$x(t) = x_1(t) + \beta_3 u(t)$$
$$x_1^1(t) = -a_1 x_1 + x_2 + \beta_2 u(t)$$
$$x_2^1(t) = -a_2 x_1 + \beta_1 u(t)$$

         (08 Marks)

OR

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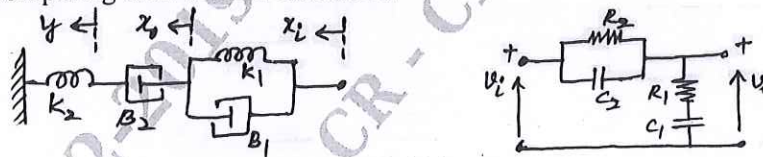   systems, by comparing their transfer functions.   **(08 Marks)**

Fig.Q.2(a)

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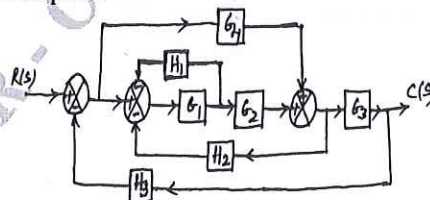   block diagram reduction technique.   **(08 Marks)**

Fig.Q.2(b)

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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, t_s (04 Marks)

   b. A system is given by the differential equation $y''(t) + y'(t) + y(t) = x(t)$, where $y(t)$ in 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 $G(s) = \dfrac{K}{S(ST+1)}$
   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)
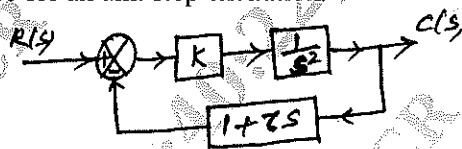

Fig.Q.4(b)

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

Module-5

9 a. State the advantages of state variable analysis. **(04 Marks)**

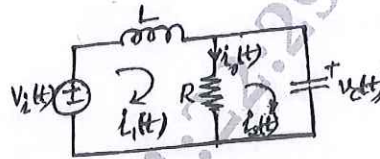b. Obtain the state model for the electrical system shown in Fig.Q.9(b). Take $i_o(t)$ as output. **(06 Marks)**

Fig.Q.9(b)

c. For a system represented by the state model

$$\begin{bmatrix} x_1'(t) \\ x_2'(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t) \text{ and } y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix}$$

Determine:

i) The state transition matrix, $\phi(t)$ 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:

$$\begin{bmatrix} x_1'(t) \\ x_2'(t) \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(t)$$

where $u(t)$ is a unit step function, when $x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ **(10 Marks)**

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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 'k' and 'a' for the open loop transfer function of a unity feedback system is given by $G(s) = \dfrac{K(s+1)}{s^3 + as^2 + 3s + 1}$, 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:
   i)   The least damped complex conjugate closed loop poles and the value of 'K' corresponding to these roots
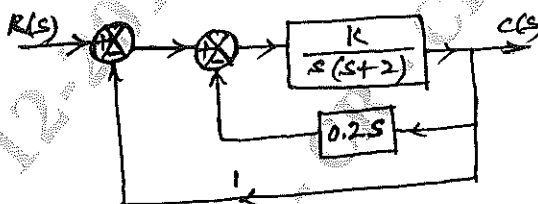   ii) Minimum damping ratio. **(10 Marks)**

Fig.Q.6(c)

Module-4

7 a. Define the following terms in connection with bode plots:
   i)   Gain cross over frequency
   ii) Phase crossover frequency
   iii) Gain margin
   iv) Phase margin. **(04 Marks)**

b. A negative feedback control system is characterized by an open loop transfer function $G(S)H(S) = \dfrac{20}{S(S+1)(S+2)}$. Sketch the polar plot and hence determine w_{gc}, w_{pc}, G_M and P_M. Comment on the stability. **(06 Marks)**

c. A unity feedback control system has $G(s) = \dfrac{100(1+0.1s)}{s(s+1)^2(0.01s+1)}$. Draw the Bode plots and hence determine W_{gc}, W_{pc}, GM and PM. Comment on the stability. **(10 Marks)**

OR

8 a. A unity feedback control system has $G(s) = \dfrac{200(s+2)}{s(s^2+10s+100)}$. 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 $G(S)H(S) = \dfrac{K}{S(S^2+2S+2)}$ **(10 Marks)**