Total No. of printed pages = 4

ECE 181504

06/01/2023

Roll No. of candidate

2022

B.Tech. 5th Semester (Regular) End-Term Examination

ECE

CONTROL SYSTEMS

(New Regulation & New Syllabus)

Full Marks – 70 | Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer question No. 1 and any *four* from the rest.

1. Answer the following (Short answer/MCQ/ Fill in the blanks) : (10 × 1 = 10)

   (i) Define transfer function of a Linear Time Invariant (LTI) system.

   (ii) $\mathcal{L}[e^{-6t} \sin 5t] =$ ————.

   (iii) State whether the following statement is true or false.: "Closed loop system is more sensitive with respect to forward path gain than feedback path gain."

   (iv) Approximate the transfer function $T(s) = \dfrac{2}{(s+1)(s+8)}$ into first order using the concept of dominant pole.

   (v) Signal flow graph is invalid when the value of ———— gain is 1.

   (vi) For a second order system, we are getting two real unequal negative poles. What information does it provide about the damping on the system?

   (vii) Consider the loop transfer function $G(s)H(s) = \dfrac{K(s+6)}{(s+3)(s+5)}$. In the root locus diagram, the centroid will be located at ————.

   (viii) State the Nyquist stability criteria for a closed loop system.

   (ix) In terms of filtering property, a P-D controller works similar to a ———— filter.

[Turn over

(x) Identify the system that generally operates under the type-0 system

(a) Servomechanism

(b) Regulator

(c) Both (a) and (b)

(d) None of these

2. (a) Define the following terms related to transfer function of a control system: pole, order, type, dc gain and time constant. State the advantages of using negative feedback closed loop control system over open loop control system. (5+2=7)

(b) The response of a system to a unit ramp input is

$$\frac{1}{2}tu(t)-\frac{1}{8}u(t)+\frac{1}{8}e^{-4t}u(t)$$

Calculate:

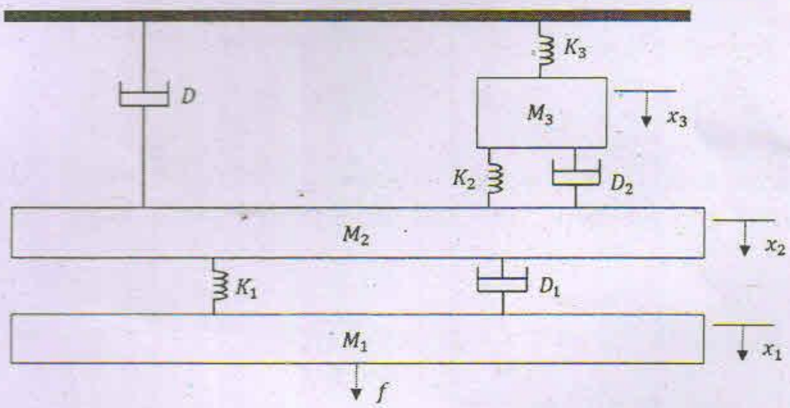
(i) Transfer function of the system

(ii) Unit impulse response of the system. (4+4=8)

3. (a) Obtain the system equations of the system shown in figure. Find the equivalent circuit by using

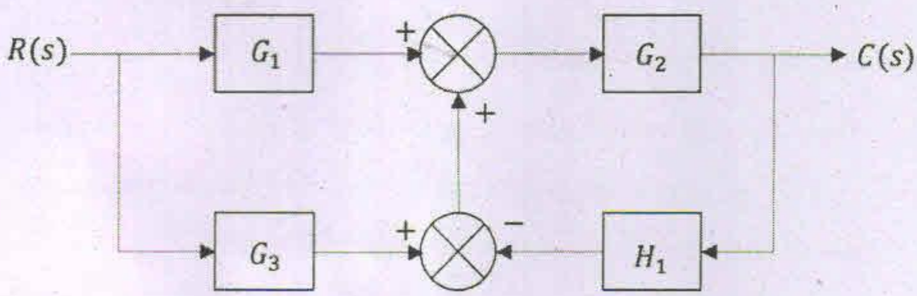
(i) force-voltage (f-v) analogy

(ii) force-current (f-i) analogy. (4+4=8)

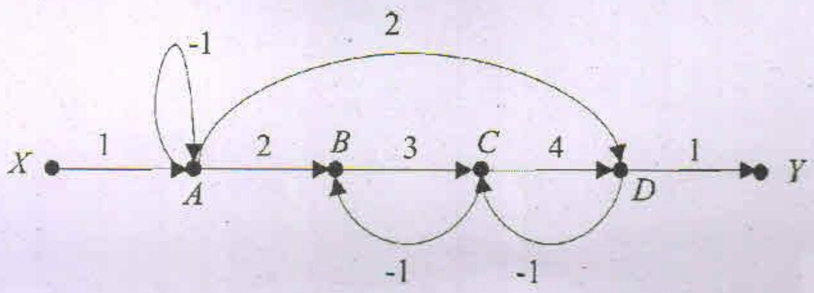


(b) Transfer function for the following block diagram is given as $\frac{C(s)}{R(s)}=\frac{G_2M}{1+N}$.

Calculate the values of M and N. (4)



(c) Find the gain of the following signal flow graph using Mason's Gain formula. (3)



4. (a) The forward path gain of a unity negative feedback control system is $\frac{20}{(s+1)(s+5)}$. For this system calculate the following: damped frequency of oscillation (ω_d), rise time (t_r), peak time (t_p), % maximum peak overshoot ($\%M_p$), settling time for 2% tolerance band (t_s), the time at which second overshoot occurs, time period of oscillation and number of cycles completed before reaching the steady state. (8)

(b) Derive the expression for steady state error (e_{ss}) in a negative feedback close loop system. (3)

(c) The characteristic equation of a system is $s^5+1.5s^4+2s^3+4s^2+5s+10=0$. Using Routh's stability criteria determine

(i) whether the system is stable or unstable and

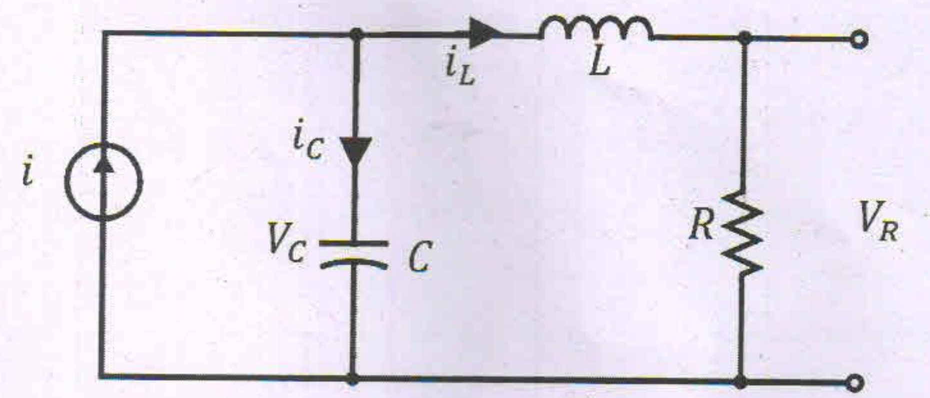
(ii) how many roots have positive real part. (4)

5. (a) The open loop transfer function of a system is given by $G(s)H(s)=\frac{K}{s(s+1)(s+3)}$. Draw the root locus plot for the system and calculate: (5+2+2=9)

(i) The condition for marginal stability

(ii) Gain margin for K=6

(b) Obtain the state model for the electric circuit shown below: (3)



(c) Find the transfer function when (3)

$A = \begin{pmatrix} -2 & 1 \\ 0 & -3 \end{pmatrix}, B = \begin{pmatrix} 0 \\ 1 \end{pmatrix}, C = \begin{pmatrix} 1 & 1 \end{pmatrix}$

6. (a) The open loop transfer function of a unity feedback system is $G(s)H(s) = \dfrac{K(s+3)}{s(s-1)}$. Draw the Nyquist plot for the same and comment on system stability. (7)

(b) A certain unity feedback control system is given by $G(s) = \dfrac{K}{s(1+s)(1+0.1s)}$.

Draw the Bode plot of the above system and determine: (4+2+2=8)

(i) Value of K for gain margin to be 10db.

(ii) Value of K for phase margin to be 50°.

7. (a) Discuss the working of Lag-lead compensator with proper circuit diagram and the pole-zero representation. (7)

(b) Illustrate the block diagram and op-amp based realization of P-I controller. Derive the expressions for proportional gain constant (K_p) and reset time (T_i) from the circuit. (4+2+2=8)