Reg. No. : | | | | | | | | | | | | |

**Question Paper Code : 50768**

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2023.

Fourth Semester

Instrumentation and Control Engineering

IC 8451 — CONTROL SYSTEMS

(Common to Electrical and Electronics Engineering/ Electronics and Instrumentation Engineering)

(Regulations 2017)

Time : Three hours                                                  Maximum : 100 marks

(Provide Semilog sheet, Polar graph and ordinary graph sheet)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Write Mason's gain formula and mention the advantages.

2. What are the advantages of a closed loop control system over open loop system?

3. The damping ratio and the undamped natural frequency of a second order system are 0.5 and 5 respectively. Calculate the resonant frequency.

4. Differentiate transient and steady state response.

5. Mention the frequency domain specifications and define resonant peak and bandwidth.

6. Draw the electrical equivalent of lag- lead compensator and write the transfer function

7. Define stability.

8. State Nyquist stability Criterion.

9. What are the advantages of state space modeling using physical variable?

10. List the important properties of a state transition matrix.

PART B — (5 × 13 = 65 marks)

11. (a) Obtain the transfer function $\frac{C(S)}{R(S)}$ for the block diagram shown in figure 11 a. using block diagram reduction technique.

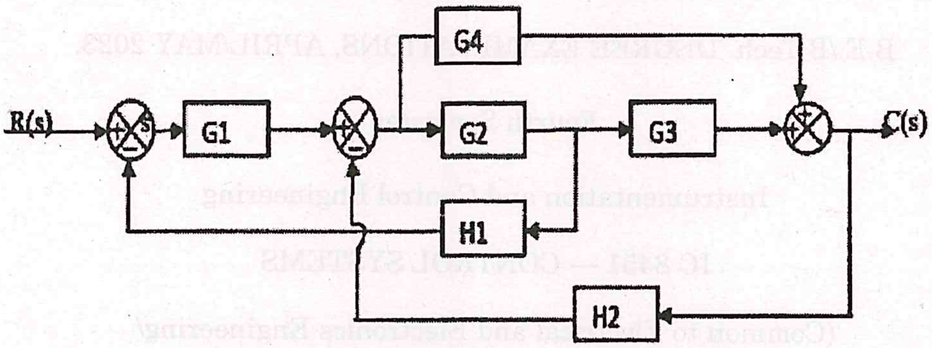


Figure 11a

Or

(b) Illustrate Mason's formula to derive the transfer function of a given signal flow graph in figure 11b.

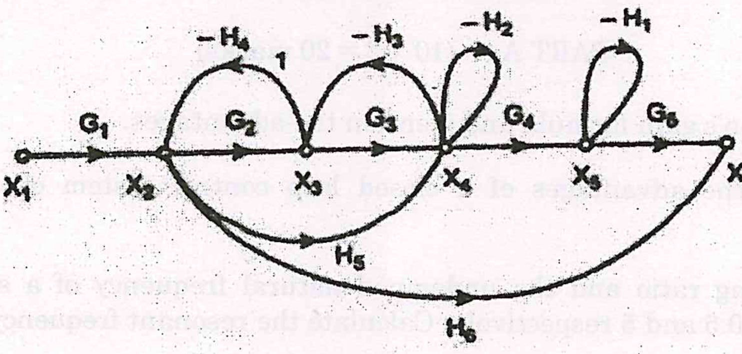


Figure 11b

12. (a) Estimate the step response of a second order under damped system. Use standard notations.

Or

(b) The unity feedback system characterized by open loop transfer function $G(S) = \frac{K}{S(S+10)}$ Evaluate the gain K such that damping ratio will be 0.5 and find time domain specifications for a unit step input.

13. (a) A unity feedback control system has $G(S)=\dfrac{15}{(S+1)(S+3)(S+6)}$. Draw the Bode plot.

Or

(b) Design a lead compensator to meet the following specifications for a unity feedback system with open loop transfer function $G(S)=\dfrac{K}{S(S+1)}$. It is desired to have the velocity error constant $K_v = 12\,\text{sec}^{-1}$ and phase margin is 40°.

14. (a) Consider the sixth order system with the characteristic equation $S^6+2S^5+8S^4+12S^3+20S^2+16S+16=0$. Use Routh-Hurwitz criterion to examine the stability of the system and comment on location of the roots of the characteristics equation.

Or

(b) The open loop transfer function of a unity feedback system is given by, $G(S)=\dfrac{K}{S(S+1)+(S+5)}$ where $K>0$. Apply Nyquist stability criterion to determine range of K over which the closed loop system will be stable.

15. (a) Solve the state equation for the system as given in below to obtain the time response $x(t)$ for a unit step input

$X=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}X+\begin{bmatrix}0\\1\end{bmatrix}u; Y=\begin{bmatrix}1 & 0\end{bmatrix}X$. Assume zero initial conditions.

Or

(b) Test the controllability and observability of the system by any one method whose state space representation is given as,

$$\begin{bmatrix}x_1\\x_2\\x_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\0 & 0 & 1\\0 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1\\x_2\\x_3\end{bmatrix}+\begin{bmatrix}0\\0\\1\end{bmatrix}u(t);\ y(t)=\begin{bmatrix}1 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1\\x_2\\x_3\end{bmatrix}+o[u]$$

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PART C — (1 × 15 = 15 marks)

16. (a) Develop the differential equations governing the mechanical translational system shown in figure 16a and determine the transfer function $\frac{V_1(S)}{F(S)}$

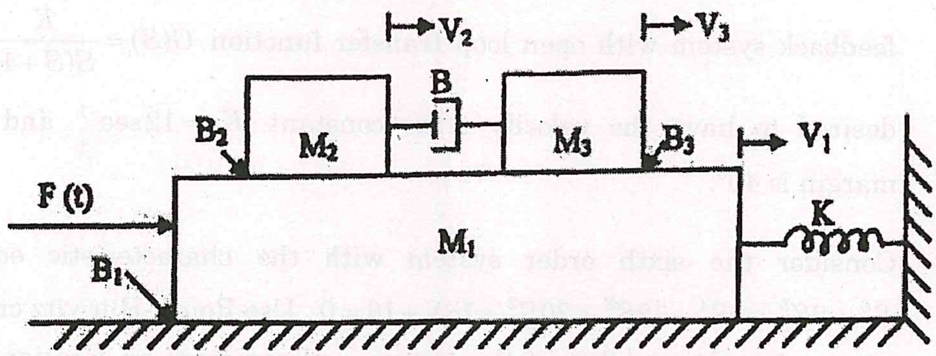


Figure 16a

Or

(b) Write the differential equations governing the mechanical system as shown it figure 16b. Draw force-voltage and force-current electrical analogous circuits.

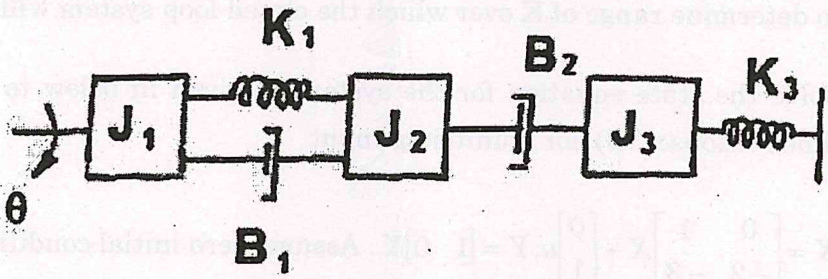


Figure 16b

**Reg. No. :** | | | | | | | | | | | |

## Question Paper Code : 90751

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2022.

Fourth Semester

IC 8451 – CONTROL SYSTEMS

(Common to: Electrical and Electronics Engineering/Electronics and Instrumentation Engineering/Instrumentation and Control Engineering)

(Regulations 2017)

Time : Three hours                                                                 Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define control system.

2. Draw the block diagram of closed loop control system.

3. List the parts of time response of a control system.

4. Draw the block diagram of a second order control system.

5. Write an equation for maximum overshoot.

6. For a second order system where does the resonant peak occur?

7. List the difficulties faced while applying Routh-Hurwitz criterion.

8. How does Nyquist criterion differ from Routh-Hurwitz criterion?

9. Define state variable.

10. Distinguish between state vector and state space.

PART B — (5 × 13 = 65 marks)

11. (a) Explain the poles and zeros of the transfer function.

Or

(b) Explain how you represent a continuous system by signal flow graph. List the rules for drawing signal flow graph. (9+4)

12. (a) Explain the specified input test signals applied for time response analysis of a control system.

Or

(b) Explain the time response of a first order continuous system subjected to unit step function.

13. (a) Explain the initial slope of Bode plot.

Or

(b) How do you determine gain margin and phase margin from Bode plot?

14. (a) How do you obtain closed loop frequency response of a unity feedback control system from Nyquist plot?

Or

(b) Explain the application of Nyquist criterion to determine stability of a closed loop control system.

15. (a) Explain the infinite series method to solve homogeneous state equation.

Or

(b) Explain the state space representation of $n^{th}$ order differential equation.

PART C — (1 × 15 = 15 marks)

16. (a) Explain the important rules for block diagram reduction.

Or

(b) With suitable schematic derive the transfer function of thermal water heating system.

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Reg. No. : | | | | | | | | | | | |

**Question Paper Code : 70790**

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2023.

Fourth Semester

Instrumentation and Control Engineering

IC 8451 — CONTROL SYSTEMS

(Common to : Electrical and Electronics Engineering / Electronics and Instrumentation Engineering)

(Regulations 2017)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. For the block diagram shown in the figure. 1, find the transfer function $\frac{Y(s)}{R(s)}$.

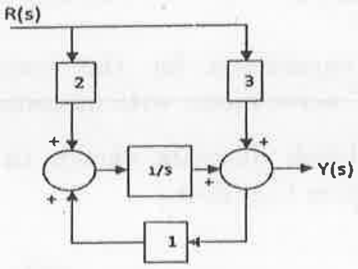


Figure. 1

2. For the mechanical system shown in Figure.2, draw the corresponding force-voltage analogy circuit.

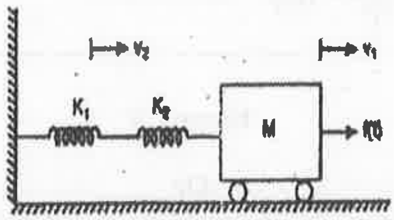


Figure. 2

3. The velocity error constant of a unity feedback control system is $K_v = 50$. Identify the information available from the given specification.

4. Mention the effects of Proportional-Integral controller on the system performance.

5. Enumerate the advantages of frequency response analysis.

6. Define gain margin and phase margin.

7. A feedback control system has characteristic equation, $s^4 + 2s^3 + 3s^2 + s + 5 = 0$. Check whether the system is stable or not.

8. The transfer function of a compensator is given as $G_c(s) = \frac{s+a}{s+b}$. If $G_c(s)$ is a lead compensator, find the value of $a$ and $b$.

9. The state space representation of a separately excited DC servo motor dynamics is given as $\begin{bmatrix} \frac{d\omega}{dt} \\ \frac{di_a}{dt} \end{bmatrix} = \begin{bmatrix} -1 & 1 \\ -1 & -10 \end{bmatrix} \begin{bmatrix} \omega \\ i_a \end{bmatrix} + \begin{bmatrix} 0 \\ 10 \end{bmatrix} u$

   where $\omega$ is the speed of the motor, $i_a$ is the armature current and $u$ is the armature voltage. Find the transfer function of the motor $\frac{\omega(s)}{u(s)}$.

10. Define controllability and observability.

PART B — (5 × 13 = 65 marks)

11. (a) (i) Derive the expression for the transfer function of armature controlled DC servo motor with suitable assumptions. (6)

(ii) Reduce the block diagram shown in Figure.3 to determine the transfer function C(s)/R(s). (7)

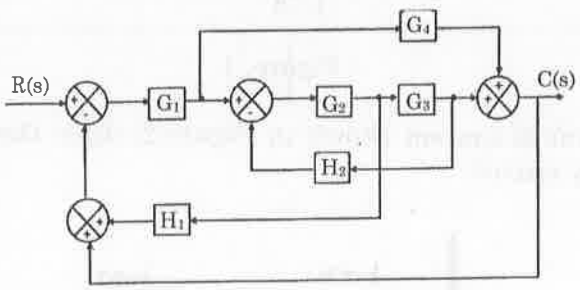


Figure. 3

Or

(b) (i) A mass-spring-dashpot system as shown in Figure.4 is mounted on a cart. The mass of the cart is $M_1$. The cart is moved at a constant speed. Obtain the transfer function $Y_2(s)/Y_1(s)$. (6)

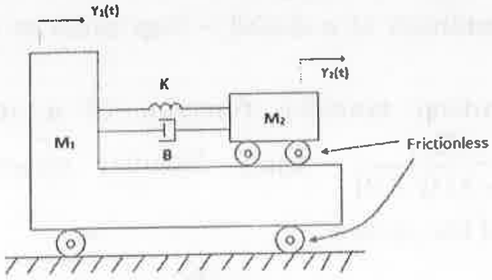


Figure. 4

(ii) From the signal flow graph shown in Figure. 5, determine the transfer function C(s)/R(s). (7)

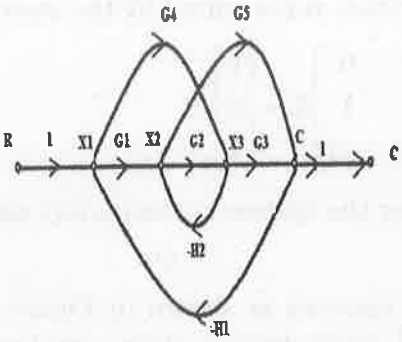


Figure. 5

12. (a) (i) Sketch the time-domain response a typical under damped second order system to a step input and indicate the relevant time domain specifications. (6)

(ii) A unity feedback system is characterized by the open loop transfer function $G(s) = \dfrac{1}{s(0.5s+1)(0.2s+1)}$. Determine the steady state errors to unit step, unit ramp and unit parabolic inputs. (7)

Or

(b) Sketch the root locus for a system with open-loop transfer function, $G(s)H(s) = \dfrac{K}{s(s+1)(s+3)}$.

13. (a) Sketch the asymptotic bode plot for the given open loop transfer function of a unity feedback system is $G(s) = \dfrac{200}{s(s+2)(s+20)}$. Calculate the gain margin and phase margin from the bode plot and assess the closed loop stability of the system.

Or

(b) Show that the magnitude response of a system with closed-loop transfer function $\frac{C(s)}{R(s)} = \frac{10}{(s+2)(s+5)}$ does not have peak resonance. Also show that the addition of a closed – loop zeros at $s = -1$ introduces resonant peak.

14. (a) The open-loop transfer function of a unity feedback system is $G(s) = \frac{Ks}{(s+1)(s+2)}$. Apply Nyquist criterion and investigate the stability of the system.

Or

(b) What are the factors to be considered for choosing suitable compensators? Realize the lag and lead compensators using electrical network and obtain the transfer functions.

15. (a) A dynamic system represented by the state equation

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

Check whether the system is completely controllable.

Or

(b) An electrical network is shown in Figure.6, select a set of proper state variables and write down a state equation in physical variable form to represent the system.

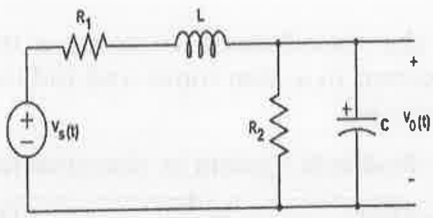


Figure. 6

PART C — (1 × 15 = 15 marks)

16. (a) A positional control system can be characterized by a unity feedback system with plant transfer function, $G_p(s) = \frac{6}{s(s+1)(s+2)}$. Design a lag compensator so that the compensated system has a phase margin of 45°.

Or

(b) For a linear time-invariant system, the transfer function is given as, $\frac{Y(s)}{R(s)} = \frac{2s+5}{s^2+4s+6}$. Draw two signal flow graphs and hence obtain two state models for the system.

Reg. No. : | | | | | | | | | | | |

# Question Paper Code : 20983

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2023.

Fifth Semester

Electrical and Electronics Engineering

EE 3503 — CONTROL SYSTEMS

(Regulations 2021)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Find the closed loop transfer function for the system shown in Fig. Q-1.

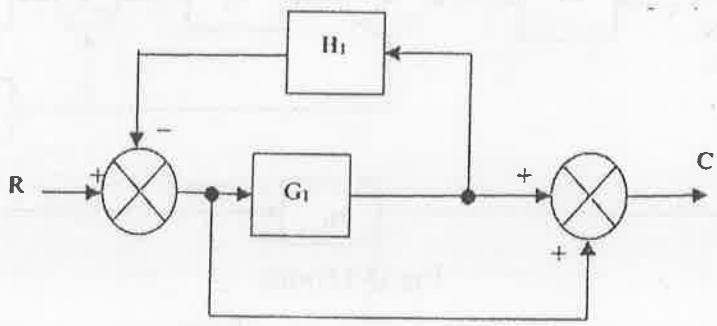


Fig. Q-1

2. Write the Mason's gain formula to determine overall closed loop system function using signal flow graph.

3. Find the damping factor, $\zeta$ and the natural frequency, $\omega_n$ for the unity feedback system with open loop transfer function, $G(S) = \dfrac{10}{s(s+1)}$.

4. What is the steady state error for a Type-0 system when the input is $r(t) = \dfrac{t^2}{2}$?

5. Relate bandwidth of a system to damping ratio $\zeta$ of the system and write the expression.

6. When drawing the Bode plot for an unity feedback system with open loop transfer function $G(S) = \frac{5}{s(1+0.5s)}$, will the phase plot cross the $-180^{\circ}$ line?

7. If the poles of a second order system are located at $s = -1$ and $s = -2$, indicate the state equation in 'diagonalized form'.

8. What do you mean by the term observability of a system with regard to state space model of the system?

9. Sketch the frequency response of a lag-lead compensator.

10. What is the effect of integral control on the performance of a system?

PART B — (5 × 13 = 65 marks)

11. (a) (i) The block diagram of a closed loop control system is shown in Fig Q-11(a)(i), determine the overall transfer $\frac{C}{R}$ using block diagram reduction technique. (8)

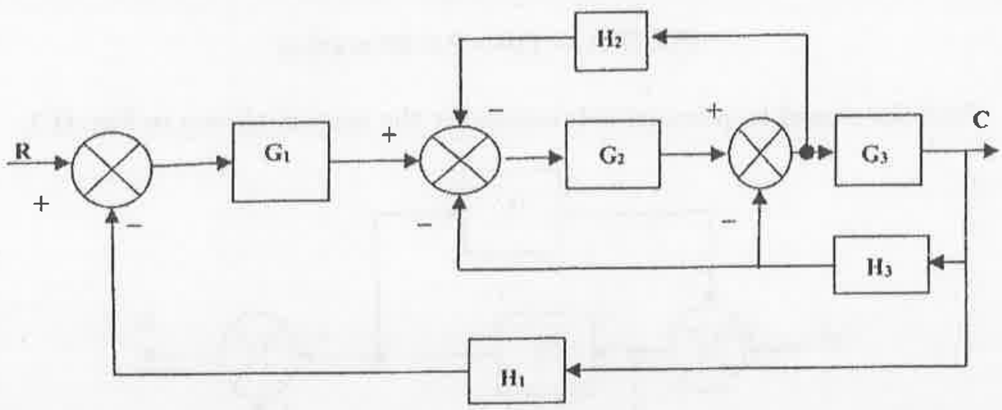


Fig Q-11(a)(i)

(ii) Determine the transfer function $\frac{E_0(s)}{E_i(s)}$ for the electric circuit shown in Fig.Q 11(a)(ii). (5)

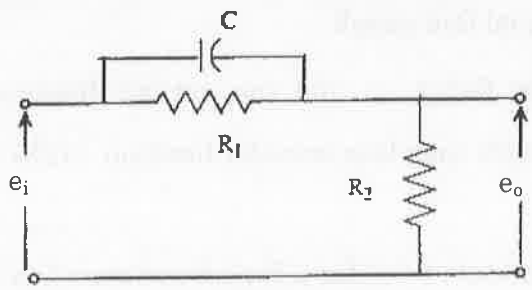


Fig. Q.11(a)(ii)

Or

(b) (i)

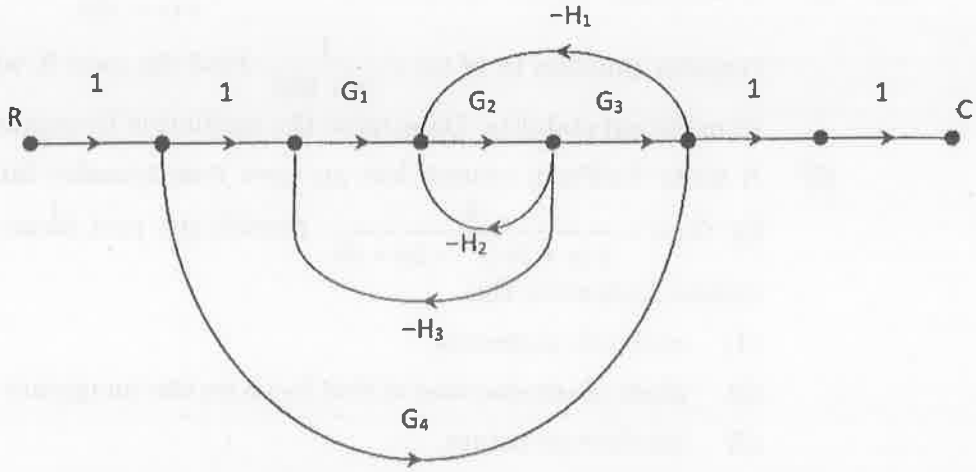


Fig.Q. 11(b)(i)

For the closed loop system shown as signal flow graph in Fig Q.11(b)-(i), deduce the overall transfer function using Mason's Gain Formula. (7)

(ii) Write down the differential equations that govern the mechanical system shown in Fig. Q.11(b)(ii), and obtain the transfer function $\frac{X_2(s)}{F(s)}$. (6)

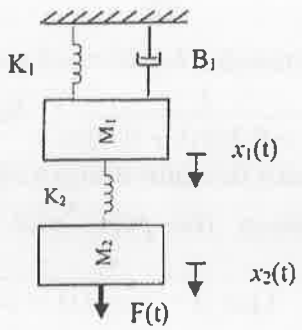


Fig. Q11(b)(ii)

12. (a) (i) Derive the expression for unit step response of an under damped second order system given by the transfer function $\frac{\theta(s)}{T(s)} = \frac{K\omega_n^2}{s^2 + 2\zeta\omega_n s + w_n^2}$ where $\omega_n$ is natural frequency and $\zeta$, the damping coefficient. (6)

(ii) A unity feedback system is characterized by the open loop transfer function $G(s) = \frac{10}{s(s+2)}$. Determine the response of this system for a unit step input. Evaluate the maximum overshoot and the corresponding time for maximum overshoot. (7)

Or

(b) (i) A feedback control system has $G(s) = \frac{K(s+40)}{s(s+10)}$ and the sensor transfer function is $H(s) = \frac{1}{(s+20)}$. Find the gain K which results in marginal stability. Determine the oscillation frequency. (6)

(ii) A unity feedback system has an open loop transfer function given by $G(s) = \frac{k}{s(s+3)(s^2+2s+2)}$. Sketch the root locus plot of this system indicating the

(1) real axis segments

(2) point of intersection of root locus on the imaginary axis,

(3) breakaway points. (7)

13. (a) (i) The open loop transfer function of a unity feedback system is given by $G(s) = \frac{5(1+2s)}{s(1+4s)(1+0.25s)}$. Sketch the Bode plot of this system and obtain the gain margin and phase margin. (8)

(ii) Determine the frequency domain specifications of a second order system whose closed loop transfer function in given by, $\frac{C(s)}{R(s)} = \frac{64}{s^2+12s+64}$. (5)

Or

(b) (i) The open loop transfer function of a unity feedback system is given by $G(s) = \frac{1}{s(1+0.1s)(1+0.01s)}$. Sketch the polar plot of this system and obtain the gain margin and phase margin. (8)

(ii) At what frequency the polar plot of the system with transfer function $G(s) = \frac{1}{(j\omega)(1+j\omega\tau_1)(1+j\omega\tau_2)}$ will cross the –180° axis. (5)

14. (a) (i) Construct the state model in Jordan canonical form, for the system whose closed loop transfer function is $\frac{C(s)}{U(s)} = \frac{10}{s(s+1)(s+3)}$. (6)

(ii) Given that the state model of the system as follows :

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u \quad \text{and} \quad y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}.$$

Check whether this system is completely state controllable and observable? (7)

Or

(b) (i) Construct the state model in phase variable form, for the system whose closed loop transfer function is $\frac{C(s)}{U(s)} = \frac{10}{s(s+1)(s+3)}$. (7)

(ii) If a second order system is given by the transfer function, $\frac{Y(s)}{U(s)} = \frac{10}{s^2 + 4s + 3}$ find the Eigen values for this system. (6)

15. (a) (i) Discuss in detail about the step by step procedure to design a lag compensator using Root Locus. (6)

(ii) The open loop transfer function of the uncompensated system is $G(s) = \frac{5}{s(s+2)}$. Design a suitable compensator for the system so that the static velocity error constant $K_v = 20\,\text{sec}^{-1}$ and the phase margin is at least 55° and the gain margin is at least 12 dB. (7)

Or

(b) (i) Discuss in detail the procedure to design a lead compensator using Bode plot. (6)

(ii) For the unity feedback system with open loop transfer function $G(s) = \frac{1}{s(s+1)}$, it is desired to obtain the phase margin greater than 45° and steady state error less than 0.1 for a unit ramp input. Design a lead compensator that meets the given specifications using Bode plot. (7)

PART C — (1 × 15 = 15 marks)

16. (a) The Fig. Q16(a)(i) shows a system employing proportional plus error rate control. Determine the value of error rate factor $K_e$ so that the damping ratio is 0.5. Determine the value of maximum overshoot for unit step input and the steady state error for unit ramp input, with and without error rate control.

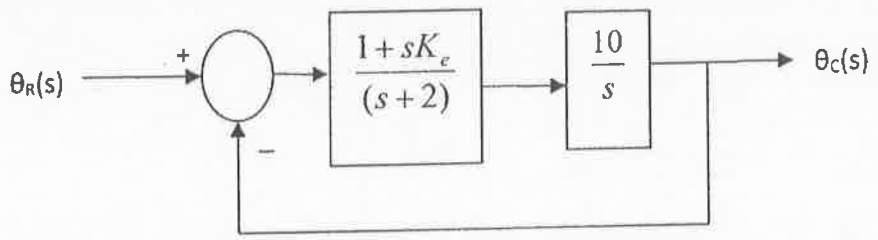


Fig. Q.16(a)(i)

Or

(b) (i) The state model of a system is given as,

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 11 \\ -12 & -7 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t) \text{ and } y = [-1 \quad -4] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + u(t).$$

Determine the state transition matrix. Assuming initial conditions as zero, find the transfer function for the system. (8)

(ii) For the state model given in Q.16(b)(i) obtain the unit step response assuming initial conditions as, $\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$. (7)

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**Question Paper Code : 51016**

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2024.

Fifth Semester

Electrical and Electronics Engineering

EE 3503 — CONTROL SYSTEMS

(Regulations 2021)

Time : Three hours Maximum : 100 marks

(Semi log sheets and polar sheets may be permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. List any two advantages of closed loop control system.

2. Write the characteristics of feed back control system.

3. Name any two standard test signals.

4. Write the condition for the system to be stable.

5. List any two frequency domain specifications.

6. Define phase cross over frequency.

7. List any two properties of state transition matrix.

8. Define controllability.

9. List any one advantages of using lag compensator.

10. Give the tuning method for PID controller design.

PART B — (5 × 13 = 65 marks)

11. (a) Build the transfer functions of the mechanical systems as shown in Figure 1.

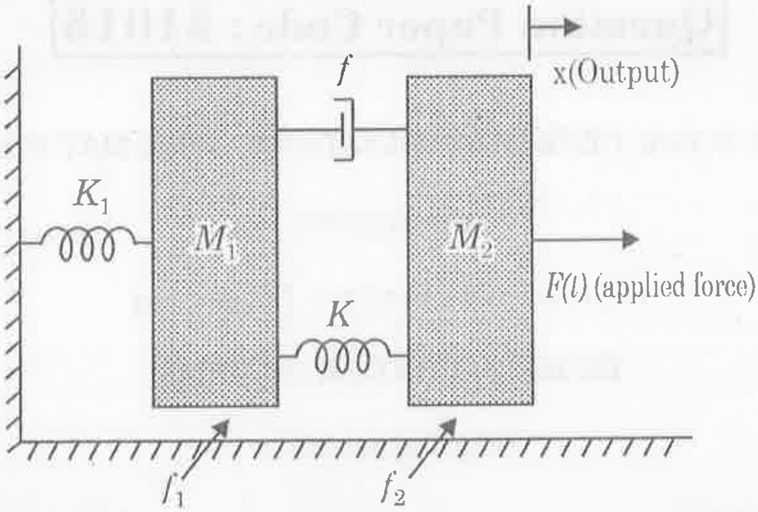


Figure. 1

Or

(b) Develop the overall transfer function C/R from the signal flow graph as shown in Figure. 2.

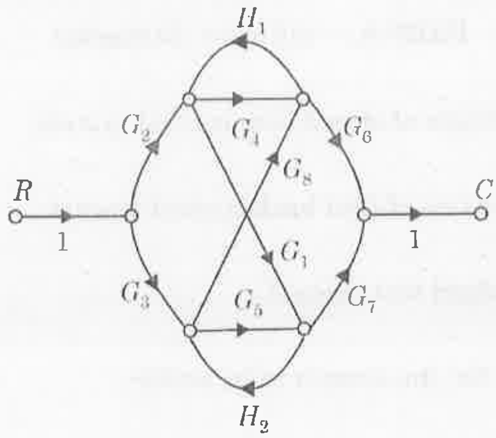


Figure. 2

12. (a) Construct an expression for an under damped second order system response for a unit step input.

Or

(b) Analyze the stability of the following characteristic equation using Rough criterion

$$s^5 + s^4 + 3s^3 + 9s^2 + 16s + 10 = 0$$

Also determine the number of roots lying one the right half of s-plane.

13. (a) Construct the bode plot of the following open loop transfer function and determine the gain cross over frequency.

$$G(s) = \frac{5(1+2s)}{s(4s+1)(0.25s+1)}$$

Or

(b) Draw the polar plot and obtain gain and phase margin of the following system.

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

14. (a) (i) A linear time invariant system is characterized by the homogeneous state equation (6)

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Compute the solution by assuming $X(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$.

(ii) Consider now that the system has a forcing function and is represented by the non-homogeneous state equation. (7)

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$$

Where $u$ is a unit-step input? Compute the solution by assuming initial conditions of part (i).

Or

(b) Determine the controllability and observability of the following system.

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} -2 & 1 \\ 1 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$$

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

15. (a) Explain in detail about the procedure to obtain the controller settings using Process Reaction Curve method.

Or

(b) With neat block diagram explain controller tuning using Ziegler-Nichols method.

PART C — (1 × 15 = 15 marks)

16. (a) Consider a type-1 unity feedback system with an open-loop transfer function

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

Design a suitable lead compensator in frequency domain with $K_v = 12$ sec$^{-1}$. PM = 40 degrees.

Or

(b) A unit feedback system is characterized by the open-loop transfer function

$$G(s) = \frac{4}{s(2s+1)}$$

It is desired to obtain a phase margin of 40 degrees without sacrificing the $K_v$ of the system. Design a suitable lag-network and compute the value of network components assuming any suitable impedance level.

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