Rajshahi University of Engineering & Technology

Department of Electrical & Electronic Engineering

Course: Control Systems (EEE 3105)

Topic-wise Sorted Questions (2010-2023)

Contents

1 Introduction to Control Systems

1.1 Basics, Open-Loop, and Closed-Loop Systems

1. **(Q. 1(a), 2023)** What is meant by control? What are the basic elements of a control system?

2. **(Q. 1(b), 2023)** "Closed-loop control system is better than open-loop control system for noise reduction"-Justify.

3. **(Q. 2(a), 2023)** If a load is suddenly applied to an open-loop and closed-loop control system, what happens in stability?

4. **(Q. 1(a), 2022)** Define open loop and close loop with their suitable example. If a load is suddenly applied to an open loop and closed loop control system, what happens in stability?

5. **(Q. 1(b), 2022)** Prove that the output of the closed loop system clearly depends on both the closed-loop transfer function and the nature of the input.

6. **(Q. 1(a), 2021)** "Feedback improves disturbance rejection"- Prove it mathematically.

7. **(Q. 1(d), 2021)** What happens when a load is applied to an open-loop and closed-loop system?

8. **(Q. 1(a), 2020)** "Stability is a major concern in closed-loop control system". - Explain it.

9. **(Q. 1(b), 2020)** What is meant by automatic control? Prove that the output of the closed-loop system clearly depends on both the closed-loop transfer function and the nature of the input.

10. **(Q. 1(d), 2020)** Why most of the systems are non-linear in nature? Explain with example.

11. **(Q. 2(a), 2020)** Functionally, what are the differences between open-loop and closed-loop control system?

12. **(Q. 1(a), 2018)** "Stability is a major problem in closed-loop control system design" - Explain this statement.

13. **(Q. 1(a), 2017)** Differentiate between modern control theory and conventional control theory.

14. **(Q. 1(b), 2017)** What is sensor? Explain the function of each part of a feedback control system with a suitable block diagram and example.

15. **(Q. 1(d), 2017)** Differentiate between open loop and closed loop control.

16. **(Q. 1(a), 2016)** What is meant by modern control theory?

17. **(Q. 4(a), 2016)** Write three reasons for using feedback control systems and at least one reason for not using them.

18. **(Q. 1(a), 2015)** Define control. What are the basic elements of a control loop?

19. **(Q. 1(b), 2015)** "Closed loop control system is better than open loop control system for noise reduction"- Justify.

20. **(Q. 2(a), 2015)** What are the advantages of open-loop control over closed-loop control?

21. **(Q. 1(a,b), 2014)** Define open loop and close loop control system with suitable example. List the major advantages and disadvantages of closed loop control system over open loop control system.

22. **(Q. 1(b), 2013)** "Feedback can improve stability or be harmful to stability if it is not applied properly"- Justify the statement.

23. **(Q. 1(a), 2012)** What happens when the load is applied to an open loop and closed control system?

24. **(Q. 1(a,b), 2011)** What do you mean by open-loop and closed loop systems? For the given voltage divider network, explain whether the system is open loop or closed loop? [Diagram is provided in the 2011 paper]

25. **(Q. 1(a), 2010)** Explain (i) time invariant and time-varying control system, (ii) a.c. control system and D.C. control system.

2 System Modeling

2.1 Transfer Functions (Mechanical & Electrical Systems)

1. **(Q. 1(c), 2023)** Draw the block diagram and determine the transfer function of the circuit in the 2023 Q1(c) paper.

2. **(Q. 1(c), 2022)** Show the open loop transfer function for the DC servomotor is

$$\frac{\omega_o(s)}{V_i(s)} = \frac{k_t k_f}{R_f R_a (1 + s\tau_a)(1 + s\tau_f)s + \frac{k_b k_t R_f}{R_a(1+s\tau_a)}}$$

[Refer to the circuit diagram Fig. 1(c) in the 2022 exam paper.]

3. **(Q. 3(c), 2022)** Determine the transfer function of the system shown in Fig. 3(c) of the 2022 exam paper.

4. **(Q. 2(b), 2020)** Define transfer function. Find the transfer function, $I_1(s)/V(s)$ of the circuit shown in the 2020 Q2(b) paper.

5. **(Q. 1(b), 2018)** Derive the transfer function of a DC motor when $V_i(s)$ is the input, $\theta(s)$ is the output of the system. Also, express the transfer function in terms of the state-space elements.

6. **(Q. 1(c), 2018)** A series circuit in the figure consisting of resistance R and an inductance L is connected to a supply $v(t)$. Find the expression of the current in S domain. Also, calculate the value of current at $t = 0.5$ ms with $R = 1 \times 10^3\Omega$, $L = 25$ mH and supply is a step voltage of 50V. Neglect initial condition. [Refer to the circuit diagram in the 2018 Q1(c) paper.]

7. **(Q. 2(b), 2018)** Find the transfer function $V_o(s)/V_i(s)$ for the op-amp circuit shown in the 2018 Q2(b) paper.

8. **(Q. 1(e), 2017)** Represent the dynamics of a DC motor in a block diagram form which is compatible in SIMULINK platform.

9. **(Q. 1(b), 2016)** Derive the transfer function of a DC motor when $V_i(s)$ is the input and $\omega(s)$ is the output of the system. Also, express the transfer function in terms of the state-space elements.

10. **(Q. 2(c), 2016)** Find the transfer function, $I_2(s)/V(s)$ of the circuit shown in the 2016 Q2(c) paper.

11. **(Q. 1(c), 2014)** Define the block diagram and transfer function. For the following system, show that the open loop transfer function for the DC Servomotor is [Expression and Diagram provided in 2014 Q1(c) paper, similar to 2022 Q1(c)].

12. **(Q. 2(b), 2013)** Find out the transfer function of a armature control DC motor shown in the 2013 Q2(b) paper.

13. **(Q. 1(c), 2011)** Define transfer function. Determine the closed loop transfer function of the position control system shown in the 2011 Q1(c) paper.

14. **(Q. 1(b), 2010)** Prove that when a DC motor is connected with a load, the system will be closed loop and also determine the transfer function for the system.

15. **(Q. 2(b), 2010)** Obtain the transfer function $X_2(s)/F(s)$ and $X_1(s)/F(s)$ for the mechanical system shown in Figure 2(b) of the 2010 exam paper.

2.2 Block Diagram Representation

1. **(Q. 2(b), 2022)** Determine the ratio $C(s)/R(s)$ for the system shown in Fig. 2(b) using block diagram reduction method.

2. **(Q. 2(b), 2021)** Determine the ratio $C(s)/R(s)$ for the system shown in the 2021 Q2(b) paper using block diagram reduction method.

3. **(Q. 2(a), 2017)** For the system shown, find (i) The equivalent single block that represents the transfer function, $T(s) = C(s)/R(s)$. (ii) The damping ratio, natural frequency, percent overshoot, settling time, peak time, rise time, and damped frequency of oscillation. [Refer to the block diagram in the 2017 Q2(a) paper.]

4. **(Q. 3(a), 2015)** Draw the block diagram and find out the transfer function $C(s)/R(s)$ of the system from its signal flow graph representation. [Refer to the graph in the 2015 Q3(a) paper.]

5. **(Q. 2(b), 2014)** Find out the transfer function by using block diagram representation method for the system in the 2014 Q2(b) paper.

6. **(Q. 1(c), 2013)** For the block diagram in the 2013 Q2(c) paper, express $C(S)$ in terms of $G_1(S), G_2(S), H(S), D(S), R(S)$ and discuss the effect of disturbance $D(S)$ if $|G_2(S)H(S)| \gg 1$ and $|G_1(S)G_2(S)| \gg 1$.

7. **(Q. 3(b), 2013)** Find out the transfer function $Y(s)/R(s)$ by using block diagram simplification method. [Refer to the block diagram in the 2013 Q3(b) paper.]

8. **(Q. 2(a), 2012)** Find the input-output transfer function of the system shown in figure 2(a) using block diagram reduction techniques. [Refer to the block diagram in the 2012 exam paper.]

9. **(Q. 2(b), 2011)** Draw the block diagram of the circuit from the 2011 Q2(b) paper and find out the transfer function by using block diagram representation method.

2.3 Signal Flow Graphs (SFG) and Mason's Rule

1. **(Q. 3(a), 2023)** What is the importance of signal flow graph?
2. **(Q. 3(b), 2023)** For the given signal flow graph in the 2023 Q3(b) paper, find the ratio C(s)/R(s).
3. **(Q. 2(c), 2022)** For the given signal flow graph in Fig. 2(c), find $C(s)/R(s)$.
4. **(Q. 2(a), 2021)** What is signal flow graph? Describe the importance of signal flow graph in control system.
5. **(Q. 2(c), 2021)** For the given signal flow graph in the 2021 Q2(c) paper, find $C(s)/R(s)$.
6. **(Q. 3(b), 2020)** Determine $C(s)/R(s)$ of the system in the 2020 Q3(b) paper by using Mason's rule.
7. **(Q. 3(b), 2018)** Obtain the transfer function C/R from the signal flow graph shown in the 2018 Q3(b) paper.
8. **(Q. 3(b), 2017)** State Mason's rule. Determine $C(s)/R(s)$ for the system using Mason's rule. [Refer to the SFG in the 2017 Q3(b) paper.]
9. **(Q. 3(a), 2016)** State Mason's rule. Determine $C(s)/R(s)$ of the system by using Mason's rule. [Refer to the SFG in the 2016 Q3(a) paper.]
10. **(Q. 2(b), 2015)** Write down Mason's gain formula. Find the transfer function, $C(s)/R(s)$, for signal flow graph in Fig. 2(b) using Mason's gain formula.
11. **(Q. 2(c), 2014)** Define forward path & nontouching loop. State the Mason's rule. Consider the system in the 2014 Q3(a) paper. Determine Y_5/Y_1 & Y_6/Y_1 by using Mason's rule.
12. **(Q. 4(c), 2013)** For a system whose connection is represented by a signal flow graph (SFG), define Non-touching loops, self loop, mixed node. Draw the signal flow graph and determine transfer function by using Mason's gain formula for the block diagram in the 2013 Q4(c) paper.

3 State Space Representation & Analysis

1. **(Q. 2(b), 2023)** Find the state-space equation of the circuit in the 2023 Q2(b) paper when the outputs are the current through the resistor and voltage across the capacitor.

2. **(Q. 2(c), 2023)** Consider the system defined by:

$$\begin{bmatrix} \dot{x_1}(t) \\ \dot{x_2}(t) \\ \dot{x_3}(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t); \quad y(t) = [4\ 5\ 1] \begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \end{bmatrix} + [0]u(t).$$

   Is the system completely observable?

3. **(Q. 2(a), 2022)** What is state-space? Represent the dynamics of mass-spring-damper system in state-space form.

4. **(Q. 4(b), 2022)** Define state transition matrix. Prove that, $\phi(t) = \mathcal{L}^{-1}[(SI - A)^{-1}]$, where symbols have their usual meanings.

5. **(Q. 5(a), 2022)** For the electrical network in Fig. 5(a), find a state-space representation if the output is the voltage across the capacitor and the resistor.

6. **(Q. 5(b), 2022)** Define state vector. Find out the eigenvalues and eigenvector of the following system. Is this system controllable or not?

$$A = \begin{bmatrix} 0 & 1 \\ -5 & -2 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}, C = [1\ 0], D = [0]$$

7. **(Q. 1(c), 2021)** Express the dynamics of a mass-spring-damper system in state-space form. Also represent it in block diagram form.

8. **(Q. 3(a), 2021)** A single input single output system is given as:

$$\dot{x}(t) = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} u(t); \quad y(t) = [1\ 0\ 2]x(t)$$

   Test for controllability and observability.

9. **(Q. 3(b), 2021)** Find the state-space of the circuit shown in the 2021 Q3(b) paper when the outputs are the voltage across the capacitor and current through the inductor.

10. **(Q. 1(c), 2020)** Express the dynamics of a DC motor in state-space form. Also express it in transfer function form in terms of the state-space elements.

11. **(Q. 2(c), 2020)** Obtain the transfer function of the system defined by the following state-space equations:

$$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \\ \dot{x_3} \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -5 & -25 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 25 \\ -120 \end{bmatrix} u; \quad y = [1\ 0\ 0] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + [0]u$$

12. **(Q. 3(a), 2020)** What is an actuator? Find the value of K for which the following system will be uncontrollable.

$$\begin{bmatrix} \dot{x_1}(t) \\ \dot{x_2}(t) \end{bmatrix} = \begin{bmatrix} -1 & 0.4 \\ K & -1.2 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} -1 \\ 2 \end{bmatrix} u; \quad y(t) = [1\ 3] \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + [0]u$$

13. **(Q. 4(c), 2020)** Find the state-space equation of the circuit in the 2020 Q4(c) paper when the output current is taken through the resistor.

14. **(Q. 2(c), 2018)** Find the state-space model of the circuit in the 2018 Q2(c) paper when the output is the current through the capacitor.

15. **(Q. 2(b), 2017)** Draw an SFG for the following state equation:

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & -4 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u; \quad y = [1\ 1\ 0]x$$

16. **(Q. 2(b), 2016)** Differentiate between transfer function and state-space. Find the state-space of the circuit in the 2016 Q2(b) paper when the output is the current through the resistor.

17. **(Q. 5(a), 2013)** Draw the free body diagram of the mechanical system in the 2013 Q5(a) paper and obtain a state-space representation of the system.

18. **(Q. 5(b), 2013)** Consider a linear control system given by the following state space model. Determine the characteristic values (eigen values) of the system and determine the controllability of the system.

$$\dot{x} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix} x + \begin{bmatrix} 1 \\ 2 \\ 0 \end{bmatrix} u, \quad y = [1\ -1\ 1]x$$

19. **(Q. 4(a), 2010)** What is state transition matrix? Explain its significance.

20. **(Q. 4(b), 2010)** Obtain the state transition matrix for the system: $\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x$.

21. **(Q. 4(c), 2010)** Obtain state equation in matrix form for the transfer function: $Y(s)/U(s) = (s+1)/(s^2 + 7s + 12)$.

22. **(Q. 6(a), 2010)** Is the following system controllable or not? $\dot{x} = \begin{bmatrix} -1 & -1 \\ 0 & -2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$.

4 Time Domain Analysis

1. **(Q. 3(c), 2023)** Mathematically prove that for a zero damping ratio the system response will be oscillatory when subjected to a unit step input.

2. **(Q. 4(a), 2023)** Consider the closed-loop system given by $\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$. Determine the values of ξ and ω_n so that the system responds to a step input with approximately 5% overshoot and with a settling time of 2 sec (use the 2% criterion).

3. **(Q. 4(c), 2023)** Define steady-state error. Find the steady-state error of the system for different types of inputs, given the unity feedback system in the 2023 Q4(c) paper with a forward transfer function of $\frac{1}{Ts(s+1)}$.

4. **(Q. 5(b), 2023)** Prove that settling time of a second order dynamic system is $t_s = 4/(\xi\omega_n)$ for 2% tolerance band.

5. **(Q. 3(a), 2022)** Prove that the maximum overshoot occurs at $t_m = \frac{\cos^{-1}\xi}{\omega_n\sqrt{1-\xi^2}}$ for the case of transient response analysis of a second order system with impulse excitation. Here, ξ is damping ratio and ω_n is undamped natural frequency.

6. **(Q. 3(b), 2022)** Find the steady-state error of the system shown in Fig. 3(b) of the 2022 paper for unit step input.

7. **(Q. 4(a), 2022)** Consider the system whose $G(s) = \frac{10}{0.1s^2 + 10s}$, $H(s) = 1$ and $r(t) = A_0 + A_1 t + \frac{A_2}{2}t^2$. Evaluate the dynamic error co-efficient when the system is subjected to $r(t)$.

8. **(Q. 3(c), 2021)** Define steady-state error. Find the steady-state error of the following system for different types of inputs. The system has a forward path TF of $1/(Ts+1)$ in a unity feedback loop.

9. **(Q. 4(a), 2021)** The unit step response of a linear control system is shown in the 2021 Q4(a) paper ($c_{max} = 1.2, c_{ss} = 1.0, t_p = 0.1s$). (i) Find the transfer function of a 2nd order system. (ii) Find the rise time and settling time.

10. **(Q. 4(a), 2020)** Consider the closed-loop system given by $\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$. Determine the values of ξ and ω_n so that the system responds to a step input with approximately 5% overshoot and with a settling time of 2 sec (Use the 2% criterion).

11. **(Q. 4(b), 2018)** For a system having transfer function, $\frac{C(s)}{R(s)} = \frac{64}{s^2+5s+64}$; determine: (i) ω_n, (ii) ξ, and (iii) ω_d.

12. **(Q. 2(c), 2017)** What is the difference between the natural frequency and the damped frequency of oscillation?

13. **(Q. 3(c), 2016)** Consider a unity feedback control system with the closed-loop transfer function $\frac{C(s)}{R(s)} = \frac{Ks+b}{s^2+as+b}$. Determine the open-loop transfer function. Also, determine the steady state error for the unit ramp response.

14. **(Q. 3(b), 2014)** Define rise time and peak time. Show that the maximum % overshoot of a second order system for unit step response is %Mp $= e^{-\pi\xi/\sqrt{1-\xi^2}} \times 100$.

15. **(Q. 4(a), 2013)** Consider the system shown in the 2013 Q4(a) paper. Determine the value of K and k_h such that the system has a damping ratio ξ of 0.7 and an undamped natural frequency of 4 rad/sec. Then obtain the rise time t_r, peak time t_p, maximum overshoot M_p and settling time t_s in the unit-step response.

16. **(Q. 2(b), 2012)** For a control system shown in figure 2(b) of the 2012 paper, find the values of K and K_t so that the damping ratio ζ of the system is 0.6 and setting time (t_s) is 0.1 sec. Use $t_s = 4/\zeta\omega_n$. Assume unit step input.

17. **(Q. 3(b), 2010)** Define maximum overshoot. From the expression of maximum overshoot Mp and rise time tr for a unity response second order prototype system. The figure 3(b) shows a speed control system. The $\Omega_r(s)$ and $\Omega(s)$ are the reference speed and output speed respectively. Investigate the response of this system to the unit-step disturbance torque $T_D(s)$. Assume $\Omega_r(s) = 0$.

5 Stability of Control Systems (Routh-Hurwitz)

1. **(Q. 5(a), 2023)** Consider the closed-loop system shown in the 2023 Q5(a) paper. Determine the range of K for stability. Assume that K ¿ 0.

2. **(Q. 5(c), 2023)** Define stability. What does the Routh Hurwitz criteria tell us?

3. **(Q. 4(c), 2022)** For an open-loop transfer function of a certain unity feedback system, $G(s) = \frac{K(s+1)}{s(s-1)(s+6)}$. Determine: (i) The range of values of K for which the system is stable. (ii) The value of K that will result in the system being marginally stable. (iii) The location of the roots of the characteristics equation for the value of K found in (ii).

4. **(Q. 6(a), 2022)** Write down the limitations and conditions of Routh's stability criterion. What is meant by breakaway and break-in point?

5. **(Q. 6(b), 2020)** Determine the stability of a system with the following characteristic equation: $s^5 + 4s^4 + 2s^3 + 8s^2 + s + 4 = 0$.

6. **(Q. 5(b), 2018)** Using Routh Hurwitz criterion find the range of K for stability of the system with $G(s) = \frac{K(s+2)}{s(s+1)(s+3)(s+5)}; H(s) = 1$.

7. **(Q. 5(a), 2016)** Use the Routh-Hurwitz criterion to find how many poles of the following closed-loop system, T(s) are in the rhp, in the lhp, and on the jω-axis. $T(s) = \frac{s^3+7s^2+2s+10}{s^6+s^5-2s^4-3s^3-7s^2-4s-4}$. The denominator given in the paper seems to be mistyped, but should be transcribed as is. Corrected OCR from image: denominator is $s^6 + s^5 - s^4 - s^2 - s + 6$.

8. **(Q. 6(a), 2016)** Find the range of gain K for the system in the 2016 Q6(a) paper that will cause the system to be stable, unstable, and marginally stable. Assume K¿0.

9. **(Q. 6(b), 2013)** Using Routh's stability criterion determine the absolute stability of the of the closed loop transfer function $T(s) = \frac{10}{s^5+2s^4+3s^3+6s^2+5s+3}$.

10. **(Q. 3(a), 2011)** Is a closed loop system with the following open loop transfer function and with $k = 2$ stable? Find the critical value of the gain k for stability. $G(s)H(s) = \frac{k}{s(s+1)(2s+1)}$.

6 Root Locus Technique

1. **(Q. 6(b), 2023)** For the system $G(s)H(s) = \frac{K}{s(s^2+4s+8)}$: (i) Plot the complete root-locus. (ii) Find the value of K for which the system just oscillates. (iii) For K = 32, find ξ.

2. **(Q. 6(a), 2022)** 'Root loci are continuous curves'-justify the statement. For the unity feedback system the open-loop transfer function is given by $G(s) = \frac{K(s+9)}{s(s^2+4s+11)}$. Sketch the root-locus.

3. **(Q. 6(c), 2020)** Consider the following system $G(s) = \frac{K}{s(s+2)(s+3)}; H(s) = 1$. (i) Draw the complete root locus. (ii) Find the value of K for which the system just oscillates. (iii) Find the value of ξ for K = 6.

4. **(Q. 7(b), 2018)** Consider a unity feedback control system with the following feedforward transfer function $G(s) = \frac{K}{s(s^2+4s+8)}$. Plot the root locii for the system.

5. **(Q. 8(c), 2016)** A unity feedback system has a loop transfer function $G_c(s)G(s) = \frac{K(s+1)}{s(s-1)(s+4)}$. (i) Sketch the root locus. (ii) Determine range of K for stability, and (iii) Determine the ... [text cut off].

7 Frequency Domain Analysis

7.1 Bode Plots

1. **(Q. 7(c), 2023)** Draw the Bode diagram of the following system. Is this system stable or not? $G(s) = \frac{10(s+3)}{s(s+2)(s^2+s+2)}$.

2. **(Q. 7(b), 2022)** For control system design purpose, check the stability of the following system using Bode Plot: $G(s) = \frac{1000}{(1+0.1s)(1+0.001s)}$.

3. **(Q. 7(c), 2022)** Evaluate the transfer function from the asymptotic log-magnitude plot given in Fig. 7(c) of the 2022 paper.

4. **(Q. 7(b), 2020)** Draw the bode diagram for the following system and also determine (i) gain and phase cross over frequency, (ii) gain and phase margins, and (iii) stability of the system. $G(j\omega) = \frac{100(s+10)}{s(s+0.5)(4s+1)^2}, H(s) = 1$.

5. **(Q. 8(a), 2018)** Draw the Bode diagram of the following system. Is this system stable or not? $G(s) = \frac{10(s+3)}{s(s+2)(s^2+s+2)}$.

6. **(Q. 5(b), 2016)** Draw the Bode plots for the system with $G(s) = \frac{K(s+3)}{s(s+1)(s+2)}$.

7. **(Q. 6(b), 2016)** Find the transfer function G(s) from the magnitude plot in the 2016 Q6(b) paper.

8. **(Q. 7(c), 2016)** Draw the bode diagram of the following system. Is this system stable or not? $G(s) = \frac{4(1+\frac{s}{2})}{s(1+2s)[1+0.4(\frac{s}{8})+(\frac{s}{8})^2]}$.

7.2 Polar and Nyquist Plots

1. **(Q. 8(a), 2023)** Consider the following unity feedback system: $G(s) = \frac{K(1-s)}{s+1}$. Determine the stability of the system using Nyquist plot for two cases: (i) the gain K is small and (ii) K is large.

2. **(Q. 8(c), 2023)** Sketch polar plot for (i) $G(s) = \frac{K}{(1+sT_1)(1+sT_2)}$ and (ii) $G(s)H(s) = \frac{K}{s(s+1)(s+5)}$.

3. **(Q. 7(a), 2022)** Sketch the Polar Plot for $G(s) = \frac{K}{s^2(1+sT)}$.

4. **(Q. 8(a), 2022)** Consider the unity feedback system: $G(s) = \frac{K}{s(1+sT_1)(1+sT_2)}$. Determine the stability of the system using Nyquist plot for two cases: (i) the gain K is small and (ii) K is large.

5. **(Q. 8(c), 2020)** For the following unity feedback system determine the stability using Nyquist stability criterion. $G(s) = \frac{4s+1}{s^2(s+1)(2s+1)}$.

6. **(Q. 5(c), 2018)** Check the stability of the following unity feedback system by using Nichol's plot. $G(s) = \frac{5}{s(s+2)(s+3)}$.

7. **(Q. 6(b), 2018)** For the following unity feedback system determine the stability using Nyquist stability criterion, where K is large: $G(s)H(s) = \frac{K}{s(T_1s+1)(T_2s+1)}$.

8 Controllers and Compensators

1. **(Q. 6(c), 2023)** How pole placement technique is used to design a state feedback controller?

2. **(Q. 7(a), 2023)** Draw the PI, PD and PID controller with op-amp and write down the controller expression.

3. **(Q. 8(b), 2022)** Draw an op-amp circuit which will ensure the PID controller. Also derive its transfer function.

4. **(Q. 8(c), 2022)** Explain the effectiveness of integral controller over proportional control for compensating steady-state error.

5. **(Q. 7(a), 2018)** Draw a PID controller and write down the controller expression. How will you select between PI, PD, and PID controller when used as compensators?

6. **(Q. 4(c), 2016)** Design the value of gain K_p for the feedback control system shown in the 2016 Q4(c) paper, so that the system will respond with a 10% overshoot.

7. **(Q. 6(a), 2014)** Draw an Op-amp circuit which will ensure the PID control action. Write down the advantages of using PID controller.

8. **(Q. 6(c), 2013)** Consider the system shown in the 2013 Q6(c) paper. (i) Determine conditions on K and z so that the system is stable. (ii) Determine all possible conditions on K and z so that the system will have sustained oscillation and the oscillation frequency.

9 General Concepts & Short Notes

1. **(Q. 4(b), 2023)** Define: (i) Undamped, (ii) underdamped, (iii) over-damped, and (iv) critically damped. Also show the roots positions.

2. **(Q. 6(a), 2023)** What are the effects of adding a pole and a zero in a system?

3. **(Q. 7(b), 2023)** Define: (i) Gain margin, (ii) Phase margin.

4. **(Q. 8(b), 2023)** What is meant by detour? Why the Nyquist criterion is called a frequency response method?

5. **(Q. 6(b), 2022)** Write short notes on: (i) Gain margin, (ii) Phase margin, (iii) critically damped system, (iv) non-minimum phase system.

6. **(Q. 4(c), 2021)** Write short notes about the followings: (i) Absolute stability, (ii) damping ratio, (iii) frequency response, (iv) under-damped system.

7. **(Q. 4(b), 2020)** Write short notes about the followings: (a) critically damped system, (b) over damped system, (c) transition matrix, and (d) relative stability.

8. **(Q. 3(a), 2018)** Write short notes about the followings: (i) Undamped system, (ii) Overdamped system, (iii) Transition matrix, and (iv) Detour.

9. **(Q. 8(b,c), 2018)** Define frequency response. What are advantages of frequency response? What is nonminimum phase system?

10. **(Q. 3(c), 2016)** What is damping?

11. **(Q. 1(c), 2016)** Write short notes on nonlinear control. What is continuous time and discrete time system?

12. **(Q. 8(a), 2016)** Write short notes on PID controller.

13. **(Q. 8(b), 2016)** What is the effect of adding a pole and zero in a system? What is detouring?

14. **(Q. 4(b), 2014)** Define state vector and state transition matrix.

15. **(Q. 4(c), 2010)** Differentiate between linear and nonlinear control systems.