GROUP C
(Long Answer Type Questions)

Answer any *three* questions. $3 \times 15 = 45$

7. (a) State the R-H criteria for stability. Find the range of open-loop gain (K) for which the system given below will be stable. Consider unity negative feedback. $G(s) = \frac{K}{s^5 + 2s^4 + 3s^3 + 4s}$ 2+2

(b) The open-loop transfer function is given by $G(s) = \frac{K(s+15)}{s^2(s+10)}$ 7

Sketch the root loci for the system when K is varied from 0 to infinity.

(c) A dynamic system has the characteristic equation $s^5 + s^4 + 2s^3 + 2s^2 + 3s + 5 = 0$ 4

Check whether the system is stable or not.

8. (a) The open loop transfer function of a unity feedback control-system is given below 10+5

$G(s)H(s) = \frac{(s+0.25)}{s^2(s+1)(s+0.5)}$. Determine closed loop stability using Nyquist-Criterion.

(b) Define the following: (i) Rise time; (ii) Delay time; (iii) Settling time; (iv) Overshoot; (v) Steady state error

9. (a) What are the differences between encirclement and enclosement? 3+2+10

(b) What do you understand by the terms gain and phase cross over frequency?

(c) The open loop transfer function of a unity feedback system is given by Nyquist criteria for, $G(s)H(s) = \frac{5}{s(s+1)(s+2)}$. Draw the Nyquist plot and hence find out whether the system is stable or not.

10. (a) Obtain the eigen values and eigen vectors for a system described by 5+4+6

$$\dot{X} = \begin{bmatrix} 0 & 6 & -5 \\ 1 & 0 & 2 \\ 3 & 2 & 4 \end{bmatrix} X + \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} U \text{ and } Y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} X$$

(b) Obtain the state transition matrix $\phi(t)$ from non-homogeneous state equation of a linear time invariant control system.

(c) A linear time-invariant system is characterized by the non-homogeneous state equation.

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \end{bmatrix} = \begin{bmatrix} -1 & 1 \\ 0 & 2 \end{bmatrix} \begin{bmatrix} x1 \\ x2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U \text{ and } \begin{bmatrix} x1 & (0) \\ x2 & (0) \end{bmatrix} = \begin{bmatrix} -1 \\ 0 \end{bmatrix}$$

Determine the non-homogeneous solution.

11. Write short notes on any *three* of the following: 3×5

(a) Static error coefficients
(b) Kalman's Test
(c) Eigen value and Eigen vectors
(d) S.T.M. (State Transition Matrix)
(e) Effect of Lag-Lead Compensator

EC-503

CONTROL SYSTEM

Time Allotted: 3 Hours Full Marks: 70

The questions are of equal value.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

GROUP A
(Multiple Choice Type Questions)

1. Answer any *ten* questions. $10 \times 1 = 10$

(i) The Laplace transform of $e^{-2t}\sin 2t$ is

(A) $\frac{4}{(s+2)^2+4}$ (B) $\frac{4}{s^2+4}$ (C) $\frac{2}{s^2+4s+8}$ (D) $\frac{2}{s^2+4}$

(ii) The transfer function is defined as

(A) The ratio of Laplace transformed of output to Laplace transform of input considering initial condition as zero
(B) The ratio of Laplace transform of input to Laplace transform of output considering initial conditions as zero
(C) The ratio of input to output
(D) The ratio of output to input

(iii) A closed loop control system has $G(s) = \frac{100}{s^2}$ and $H(s) = (s+1)$. The steady state output for a unit step input is

(A) 1.0 (B) 1/100 (C) 1/10 (D) 10

(iv) For the system $\frac{C(s)}{R(s)} = \frac{25}{s^2+6s+25}$ the damping factor ζ and damped frequency of oscillations ω_d will be

(A) $\zeta = 0.6, \omega_d = 5$ (B) $\zeta = 0.4, \omega_d = 6$ (C) $\zeta = 0.5, \omega_d = 3$ (D) $\zeta = 0.3, \omega_d = 5$

he phase margin is negative, it indicates the system is

(A) Highly stable (B) Unstable

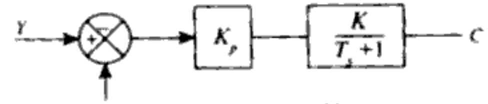
(C) Oscillatory (D) It has nothing to do with stability

oot locus is symmetrical w.r.t

(A) Negative real axis (B) Positive real axis

(C) Imaginary axis (D) Positive and negative real axis

steady-state error due to a step input for the system shown below is

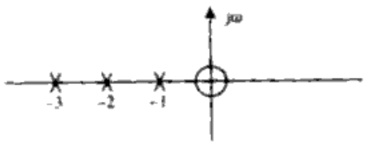


(A) zero (B) $\frac{1}{1+kk_p}$ (C) $\frac{kk_p}{1+kk_p}$ (D) infinite

settling time of a second order system 2% basis is given by

(A) $t_s = \frac{4}{\xi\omega_n}$ (B) $t_s = \frac{\xi\omega_n}{4}$ (C) $t_s = \frac{4\xi}{\omega_n}$ (D) $t_s = 4\xi\omega_n$

ransfer function of a system having a gain nd a pole zero map as in figure is



(A) $\frac{(s+1)(s+2)(s+3)}{s}$

(B) $\frac{(s-1)(s-2)(s-3)}{s}$

(C) $\frac{9s(s+1)}{+2)(s+3)}$

(D) $\frac{9s}{+3)(s+2)(s+1)}$

s the effect of transportation lag, e^{-sT} on Bode plot and Nyquist plot of a system?

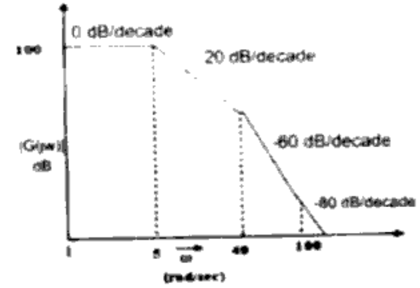
(A) ere is no change in magnitude plot of Bode plot but the critical point of Nyquist fts from $-1+j0$ to the locus of $-e^{j\omega T}$

(B) ere is some change in magnitude plot of Bode plot but the critical point of Nyquist nains at $-1+j0$

(C) phase plot of Bode plot undergoes a phase shift of $-\omega T$ rad but the critical nt of Nyquist remains at $-1+j0$

(D) phase plot of Bode plot undergoes a phase shift of $-\omega T$ rad but the critical nt of Nyquist shifts to the origin.

(xi) What is the transfer function of the following magnitude plot of the given Bode plot?



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

(B) $G(s)H(s) = \frac{10}{(1+0.2s)(1-0.01s)(1+0.025s)}$

(C) $G(s)H(s) = \frac{1}{s^2(1+s)(2+s)(3+s)}$

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

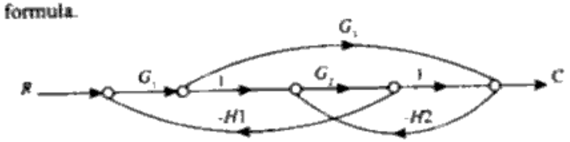
(xii) For the transfer $G(s)H(s) = \frac{1}{(1+sT)}$, what is the error at the corner frequency in log magnitude plot?

(A) -1 dB (B) -2 dB (C) -3 dB (D) -4 dB

GROUP B
(Short Answer Type Questions)

Answer any *three* questions. $3 \times 5 = 1$

2. Determine the transfer function relating C and R for the signal flow graph given below using Mason's gain formula.



3. Construct the state model for a system characterized by the differential equation $\ddot{y} + 5\dot{y} + 6y = 4$.

4. Sketch the Bode plots showing the magnitude in decibels and phases angle in degrees as a function of log frequency for the given transfer function: $G(s) = \frac{10(s+10)}{s(s+2)(s+5)}$

5. The open loop transfer function of a unity feedback control system is given below. $G(s) = \frac{s+0.25}{s^2(s+1)(s+0.5)}$ Determine closed loop stability by applying Nyquist criterion.

6. (a) Why PI and PID controllers are used in a closed loop control system? 1

(b) Draw the operational Amplifier realization of P-I, P-D controller and hence find the expression for gain.

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