Registration No.: | | | | | | | | | | |

Total Number of Pages: 03 **Course: B. Tech, IDD (B.Tech and M.Tech)**

Sub_Code: REL5C002

5th Semester Regular/Back Examination: 2024-25

SUBJECT: CONTROL SYSTEM

BRANCH(S): AEIE, ECE, EEE, EIE, ELECTRICAL, ELECTRICAL & C.E, ETC, EE

Time: 3 Hours

Max Marks: 100

Q.Code: R022

Answer Question No.1 (Part-1) which is compulsory, any eight from Part-II and any two from Part-III.

The figures in the right-hand margin indicate marks.

Part-I

Q1 Answer the following questions: **(2 x 10)**

a) What modifications are essential for an induction motor to be used for servo applications?

b) Why should derivative controllers not be used as standalone controllers in control systems? Discuss the inherent limitations and potential drawbacks that arise from relying solely on a derivative controller.

c) What is the effect of the addition of zero on transient response of the system?

d) Calculate the value of α for a lag compensator such that the compensated system will have a static error constant of 20 sec^{-1}. Use the open loop transfer function of the uncompensated system as $G(s)=\dfrac{16}{s(s+4)}$ and the general form of the lag compensator as $G_c(s)=K_c\alpha\dfrac{1+Ts}{1+\alpha Ts}$.

e) State under what condition all elements in one row of Routh array become zero. Also state, in such case how Routh array can be completed.

f) Explain when a function is said to be analytic. Also define singular points.

g) Determine the phase margin of the control system having open loop TF $G(s)H(s)=\dfrac{20}{(s^2+6s+8)}$. Given the gain crossover frequency of the system is 3 rad / sec.

h) Determine the breakaway points of the root locus for the following open loop TF.

$$G(s)H(s)=\frac{1}{s(s+2)(s^2+2s+10)}$$

i) List any four properties of state transition matrix.

j) Check whether the characteristic equation $1.5z^2+0.5z-0.1=0$ of the discrete time system is stable or not.

Part-II

Q2 **Only Focused-Short Answer Type Questions - (Answer Any Eight out of Twelve)** **(6 x 8)**

a) The open loop TF of a unity feedback control system is

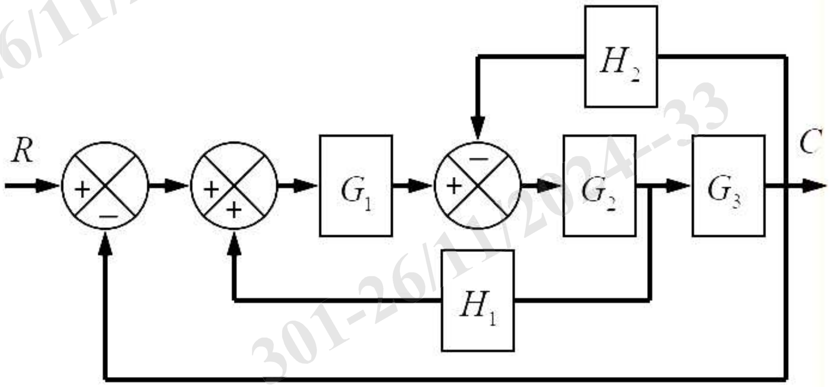
$$G(s) = \frac{K(s+5)(s+40)}{s^3(s+200)(s+1000)}$$

Discuss the stability of the closed loop system as a function of K by constructing Routh's array. Also, determine the value of K for which the closed loop system exhibits sustained oscillation and the frequency of oscillation.

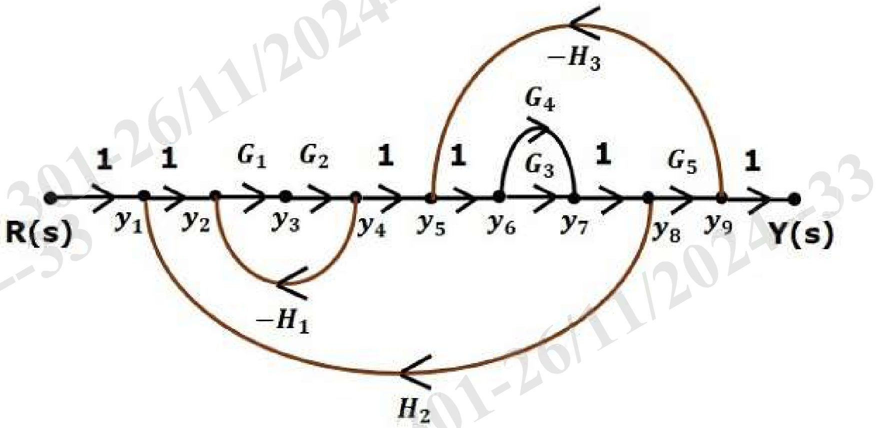
b) Derive the transfer function model of an armature-controlled DC servomotor.

c) For the open loop TF $G(s)H(s) = \frac{K(s+10)}{s(s+5)(s+25)(s+50)}$ sketch the root locus. Determine the complex conjugate roots for which the system will have damping ratio of 0.707.

d) Determine the overall transfer function of the following block diagram using block diagram reduction techniques.



e) Obtain the overall transfer function C / R of the following signal flow graph by using Mason's gain formula.



f) Applying Nyquist stability criterion, comment on the stability of the following unity feedback system for K = 2. $G(s) = K\frac{(1-s)}{(s+2)(s+3)}$

g) For a second order prototype system, discuss the effect of adding a P controller on transient response of the closed loop system by deriving relevant equations.

h) Sketch a Nyquist plot for a system with open loop TF $\frac{K(1+0.5s)(s+1)}{(1+10s)(s-1)}$.

i) Discuss the use of synchros as error detector for control system applications.

j) Compute the eigen values and the corresponding eigen vectors for the following system matrix.

$$A = \begin{bmatrix} 3 & 2 & -1 \\ 2 & 4 & 5 \\ -1 & 2 & 3 \end{bmatrix}$$

k) Given the open loop TF, $\frac{10}{s^3+3s^2+2s}$ design a state feedback controller so that the eigen values of the closed loop system are at $-2, -1 \pm j1$.

l) Design a suitable compensator using root locus technique for the unity feedback system having open loop transfer $\frac{K}{s(s+3)(s+6)}$ so that the dominant closed loop poles of the compensated system will have damping ratio of 0.5 and magnitude of the real part of the pole be less than unity. Further the static error constant should be at least 10 sec^{-1}.

Part-III

Only Long Answer Type Questions (Answer Any Two out of Four)

Q3 The open loop transfer function of a unity feedback system is given by $G(s) = \frac{K}{s(0.02s+1)(0.04s+1)}$. Draw the bode plot. Find the gain margin and phase margin. Hence find the value of the open loop gain so that the system has phase margin of 45° **(16)**

Q4 Derive the expression for the time response of a standard second order under damped system to a unit step input. Draw the time response plot and show the important time domain specifications. **(16)**

Further, determine the dominant closed loop pole locations of a servo system if the error response of the system is represented as $e(t) = 1.4e^{-4t}\sin(2.86t + 43^\circ)$.

Q5 Discuss in detail the methods used for tuning a PID controller, addressing both scenarios: when the plant dynamics are known and when they are unknown. **(16)**

Q6 For the following TF obtain the state space representation in controllable canonical form by drawing the necessary signal flow graph. **(16)**

$$TF = \frac{10(s+4)}{s(s+1)(s+3)}$$

For the system matrix obtained above, also compute the state transition matrix.