

B.Tech III Year I Semester (R13) Supplementary Examinations June 2016

**CONTROL SYSTEMS ENGINEERING**

(Common to ECE and EIE)

(Use of ordinary graph sheets, semi log graphs and polar graphs is permitted in the examination hall)

Time: 3 hours

Max. Marks: 70

**PART – A**

(Compulsory Question)

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- 1 Answer the following: (10 X 02 = 20 Marks)
- Prove that the closed loop transfer function of a unity negative feedback control system having the forward path transfer function  $G(s)$  is given by  $\frac{G(s)}{1+G(s)}$ .
  - In an electrical circuit  $i = C \frac{dV}{dt}$  where  $i$  is current,  $C$  is Capacitance and  $V$  is Voltage. Write the analogous equations for: (i) Mechanical (translational) system. (ii) Mechanical (rotational) system. Use force-current analogy.
  - Define 'TYPE' and 'ORDER' of a system. What are the TYPE and ORDER of  $G(s)H(s) = \frac{2}{s(1+s)}$ ?
  - What is the effect of adding integral action to a proportional controller on: (i) Steady state error? (ii) Relative stability?
  - What is the location of breakaway point in the root locus for the open loop transfer function:  $G(s)H(s) = \frac{K}{(s+2)(s+4)}$ .
  - When is a system said to be Bounded Input-Bounded Output (BIBO) stable? What is the condition on impulse response for BIBO stability?
  - A unity feedback system has  $G(s) = \frac{100}{s(s+10)}$ . What is the resonant frequency of the system?
  - What is the importance of cut-off frequency and cut-off rate in control systems?
  - Define 'State' and 'State variables'.
  - What is the characteristic equation of a system having the State Matrix?

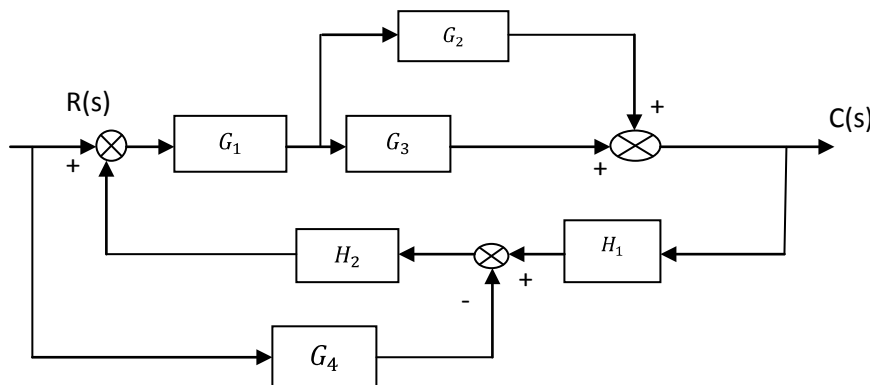
$$\mathbf{A} = \begin{bmatrix} 0 & 2 & 0 \\ 4 & 0 & 1 \\ -48 & -34 & -9 \end{bmatrix}$$

**PART – B**

(Answer all five units, 5 X 10 = 50 Marks)

**UNIT – I**

- 2 Find the overall transfer function, from  $R(s)$  to  $C(s)$ , of the system shown below.



OR

- 3 With the help of necessary diagrams, describe the constructional and operational features of A.C Servo Motors. Derive the transfer function between the rotor position and error signal of an A.C Servo motor.

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## UNIT – II

- 4 (a) A system has the closed loop transfer function  $\frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$ . It is required that the unit step response of the system should have a settling time of 2 sec according to 2% criterion; and the overshoot should be approximately 5%. What should be the closed loop pole locations?
- (b) A unity feedback control system has the closed loop transfer function  $\frac{ks+b}{s^2+as+b}$ . Determine the steady state error in the unit ramp response, in terms of  $k, a$ , and  $b$ .

OR

- 5 Derive the expressions for: (i) Rise time. (ii) Peak time. (iii) Maximum overshoot. (iv) Settling time of the unit-step response of an under damped prototype second order system. Hence determine the quantities for a system having the closed loop transfer function  $\frac{16}{s^2+2s+16}$ .

## UNIT – III

- 6 (a) How many roots of the characteristic polynomial of a system  $s^4 - s^2 - 2s + 2$  have positive real parts?
- (b) Determine the value of  $K$  for which the characteristic polynomial of a system  $s^4 + 8s^3 + 24s^2 + 32s + K$  has roots with zero real part.

OR

- 7 A unity feedback system has the open loop transfer function  $G(s) = \frac{K}{s(s+2)(s^2+6s+25)}$ .
- (a) Sketch the root locus for  $0 \leq K \leq \infty$ .
- (b) At what value of  $K$  does the system become unstable?
- (c) What is frequency of sustained oscillations of the system when it just loses stability?

## UNIT – IV

- 8 (a) Draw the Bode plot and determine the Gain Margin and Phase Margin for  $G(s)H(s) = \frac{e^{-0.3s}}{s(1+s)}$ .
- (b) A Unity feedback control system has the Open Loop Transfer Function  $G(s) = \frac{as+1}{s^2}$ . What should be the value of  $a$  for the system to have Phase Margin of  $45^\circ$ .

OR

- 9 (a) Draw a network of lag-lead compensator consisting of resistors and capacitors and derive its transfer function.
- (b) Draw the Nyquist plot for the open loop transfer function  $G(s)H(s) = \frac{(s+2)}{(s+1)(s-1)}$ . Applying Nyquist stability criterion, determine whether the closed loop system is stable or not.

## UNIT – V

- 10 Obtain the state model for the system represented by:

$$\frac{d^3y}{dt^3} + 6 \frac{d^2y}{dt^2} + 11 \frac{dy}{dt} + 10y = 3u(t).$$

OR

- 11 The state space representation of a system has the characteristic matrix  $A = \begin{bmatrix} 0 & 1 \\ -2 & 0 \end{bmatrix}$  and output matrix  $C = [1 \quad -1]$ . Find the zero excitation response of the system for  $X(0) = [1 \quad 1]^T$ .

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