

Code No: RT22026

R13

SET - 1

II B. Tech II Semester Regular/Supplementary Examinations, April/May-2017

CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours

Max. Marks: 70

- Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **THREE** Questions from **Part-B**

PART -A

1. a) What are the advantages and disadvantages of open loop control system? (4M)
- b) Define the terms (i) Rise time (ii) delay time. (4M)
- c) Define the term Angle of Departure? (4M)
- d) What are frequency domain specifications? (3M)
- e) Explain about lead-lag compensator? (3M)
- f) What are the properties of state transition matrix? (4M)

PART -B

2. a) Explain the construction and principle of operation synchro transmitter. (8M)
 - b) Explain the working of AC servo motor and find its transfer function? (8M)
 3. a) Illustrate the effect of the value of damping ratio on the location of closed-loop poles of a standard second order system. (8M)
 - b) Derive the expression for Rise time? (8M)
 4. a) Explain the procedure to draw root locus of a given transfer function. (8M)
 - b) Sketch the root locus of the open-loop transfer function as given below (8M)
- $$G(s)H(s) = \frac{K}{s(s+2)(s^2+2s+5)}$$
5. a) Sketch the Bode plot for the following transfer function and determine the system gain K for the gain crossover frequency to be i) 10 rad/s and ii) 0.5 rad/s. (8M)
- $$G(s)H(s) = \frac{Ks^2}{(1+0.25s)(1+0.025s)}$$
- b) Explain the general procedure for constructing Bode plots. (8M)
 6. a) Explain the design procedure of lead compensator? (8M)
 - b) Design a lead compensator for the system with an open loop transfer function (8M)
- $$G_f(s) = \frac{K}{s^2(1+0.1s)}$$
- for the specifications of $K_a = 10$ and $\phi_{pm} = 30^\circ$.
7. a) Define the term state variable. What are the advantages of state space representation? (8M)
 - b) Obtain the transfer function for linear time invariant system. And also draw the state model. (8M)

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SET - 2

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**PART -A**

1. a) What is signal flow graph? (3M)
- b) Explain about the (i) Step signal and (ii) Ramp signal. (3M)
- c) What are the advantages of Routh Criterion? (4M)
- d) State the Nyquist stability theorem. (4M)
- e) Write the differences between lag and lead compensator. (4M)
- f) Explain the concept of state and state variable? (4M)

**PART -B**

2. a) What is the classification of control systems and discuss the importance of mathematical modeling of a control system. (8M)
- b) Explain the necessity and effect of feedback in control systems? (8M)
3. a) The open-loop transfer function of unity feedback system is (8M)
 
$$G(s) = \frac{4}{s(s+1)}$$
 Determine the nature of the closed-loop system for a unit-step input. Also determine rise time, peak time and peak overshoot.
- b) Derive the expression for settling time? (8M)

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**SET - 2**

4. a) Explain the Routh's criteria with an example. What are its limitations? (8M)  
b) For the system whose characteristic equation is given by (8M)

$$F(s) = s(s+5)(s+6)(s^2 + 4s + 25) + K(s+3) = 0,$$

Determine the values of K which will cause sustained oscillations in the closed-loop system using Routh Criterion. What are the corresponding oscillations of frequency?

5. a) The open loop transfer function of a unity feedback control system is given by (8M)

$$G(s) = \frac{1000}{s(0.1s+1)(0.001s+1)}.$$

Draw Bode plots and from these plots determine gain margin and phase margin.

- b) A unit-step response test conducted on a second order system yielded peak overshoot  $M_p = 0.12$ , and peak time  $t_p = 0.2s$ . Obtain the corresponding frequency response indices ( $M_r, \omega_r, \omega_b$ ) for the system. (8M)

6. a) Explain the design procedure for lag-lead compensator? (8M)

- b) The open loop transfer function of a unity feedback system is (8M)

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

design a lead compensator to meet the following specifications.

- i) Velocity error constant  $K_v = 12 s^{-1}$       ii) Phase margin  $\phi_{pm} = 45^\circ$ .

7. a) Discuss the concept of controllability and observability with an example. (8M)

- b) Given the state equation  $\dot{X} = AX$ , Where  $A = \begin{bmatrix} -3 & 1 & 0 \\ 0 & -3 & 1 \\ 0 & 0 & -2 \end{bmatrix}$ . Determine the state transition matrix. (8M)

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**SET - 3**

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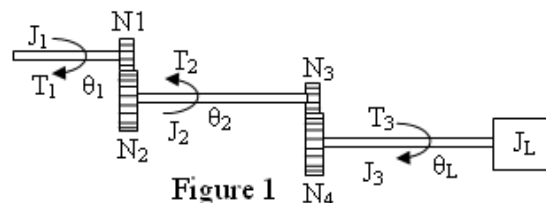
- Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)  
2. Answer **ALL** the question in **Part-A**  
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**PART -A**

1. a) What is the advantages and disadvantages of close loop control system? (4M)
- b) Explain the importance of Mason's gain formula. (4M)
- c) What is the necessary and sufficient condition for stability (4M)
- d) Define phase margin and gain margin? (3M)
- e) What is the need of lag-lead compensator? (3M)
- f) Explain about the concept of observability? (4M)

**PART -B**

2. a) State essential differences by giving suitable examples and also highlight their merits and demerits for open loop and closed loop systems. (8M)
- b) For the geared system shown below in Figure 1, find the transfer function relating the angular displacement  $\theta_L$  to the input torque  $T_1$ , where  $J_1, J_2, J_3$  refer to the inertia of the gears and corresponding shafts.  $N_1, N_2, N_3$ , and  $N_4$  refer to the number of teeth on each gear wheel. (8M)



**Figure 1**

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**SET - 3**

3. a) The open loop transfer function of a control system with unity feedback is (8M)  

$$G(s) = \frac{400}{s(1+0.1s)}$$
 .Evaluate the error series for the system and determine the steady state error for system when the input of  $r(t) = 1 + 2t + t^2$ ;  $t > 0$  is applied.
- b) Consider a unity feedback system with closed transfer function  $\frac{C(s)}{R(s)} = \frac{Ks+b}{s^2+as+b}$  (8M)  
 Determine the open loop transfer function  $G(s)$ . Show that the steady- state error with unit-ramp input  $s$  given by  $\frac{a-k}{b}$ .
4. a) Explain in detail about Routh-Hurwitz criterion. (8M)
- b) Comment on the stability, for a given characteristic equation by R-H Criterion (8M)  
 $s^6 + 2s^5 + 8s^4 + 15s^3 + 20s^2 + 16s + 16 = 0$ .
5. a) The open loop transfer function of a unity feedback control system is (8M)  

$$G(s) = \frac{K}{(s+1)(2s+1)}$$
 Use Nyquist stability criterion to determine the critical value of gain 'K' for stability.
- b) Sketch polar plots for the transfer function given below. Determine whether this (8M)  
 plot cross the real axis. If so, determine the frequency at which the plots cross the real axis the corresponding magnitude  $|G(j\omega)|$ .  

$$G(s) = \frac{1}{(1+s)(1+4s)}$$
6. a) Draw electrical network configuration for phase-lead compensator and hence (8M)  
 derive the transfer function for the same.
- b) Explain the procedural steps to design a phase lag compensator using Bode (8M)  
 analysis.
7. a) Obtain a state model for the system described by (8M)  

$$T(s) = \frac{Y(s)}{U(s)} = \frac{2s^3 + 7s^2 + 12s + 8}{s^3 + 6s^2 + 11s + 9}$$
- b) Discuss about the properties of state transition matrix. (8M)

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**PART -A**

1. a) Write the transfer function of AC servo motor. (4M)
- b) Define the following terms (i) Peak time (ii) Peak overshoot (4M)
- c) What are the limitations of Routh Criterion? (4M)
- d) What are the specifications in frequency domain? (3M)
- e) Draw the electrical equivalent circuits of lead-lag and lag-lead compensator. (3M)
- f) Explain about the concept of controllability? (4M)

**PART -B**

2. a) What are the important rules of the block diagram reduction techniques? (8M)
- b) Derive the transfer function of armature controlled DC servo motor. (8M)
3. a) A unity feedback control system has the open loop transfer function given by (8M)  

$$G(s) = \frac{10}{s(s+4)}$$
Determine damping ratio, natural un-damped resonance frequency, percentage peak overshoot and an expression for error response for a unit step input function.
- b) Obtain the time response of a first order system for a unit step input and plot its response. (8M)

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**SET - 4**

4. a) By using R-H criterion comment on stability for given characteristic equation (8M)  
 $s^6 + 2s^5 + s^4 + 2s^3 + 3s^2 + 4s + 5 = 0$ .
- b) Determine if the pole nearest to the imaginary axis is at -0.75 away from the (8M)  
 imaginary axis, for the system given by the characteristic equation  
 $s^4 + 5s^3 + 10s^2 + 10s + 4 = 0$ .
5. a) Given the open loop transfer function with unity feedback as (8M)  
 $G(s) = \frac{K e^{-10s}}{2(s+2)(1+5s)}$ . Draw the bode plot and determine the gain K for the gain cross  
 over frequency to be 5 rad/s.
- b) The open loop transfer function of a system is (8M)  
 $G(s) = \frac{K}{s(1+0.1s)(1+s)}$ . Determine the value of K so that the gain margin is 6 dB.
6. a) For the given open loop transfer function  $G(s) = \frac{K}{s(s+4)(s+6)}$ . Design suitable lead (8M)  
 compensation so that phase margin is  $\geq 30^\circ$  and velocity error constant  $K_v \geq 15$ .
- b) Design a lag compensator that will provide a phase lag of  $50^\circ$  and alternation of 15 dB at (8M)  
 2 rad/sec. Also determine the transfer function.
7. a) Explain the concept of state, state model, state variable, state space. (8M)
- b) By using parallel decomposition, Construct the state model for the system (8M)  
 represented by  $\frac{5(s+1)}{s(s+3)^2}$