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Question Paper Code : 80803

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2024.

Fourth Semester

Instrumentation and Control Engineering

IC 8451 – CONTROL SYSTEMS

(Common to : Electrical and Electronics Engineering/Electronics and Instrumentation Engineering)

(Regulations 2017)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define Transfer Function.

2. Give the analogy between Electrical and Thermal Systems.

3. Justify why steady state error can be found only for Stable System.

4. List the effects of PI controller on the system.

5. Define the terms Gain Margin and Phase Margin.

6. Give the Bode approximation for $\frac{1}{S+a}$.

7. State Nyquist stability criterion.

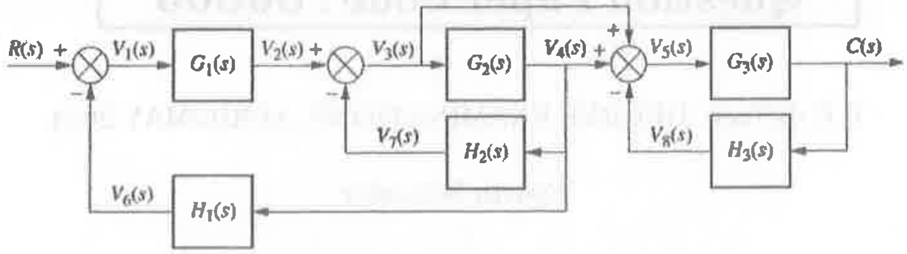
8. Give the importance of characteristic equation.

9. List the advantages of State Space Analysis.

10. Define the terms Controllability and Observability.

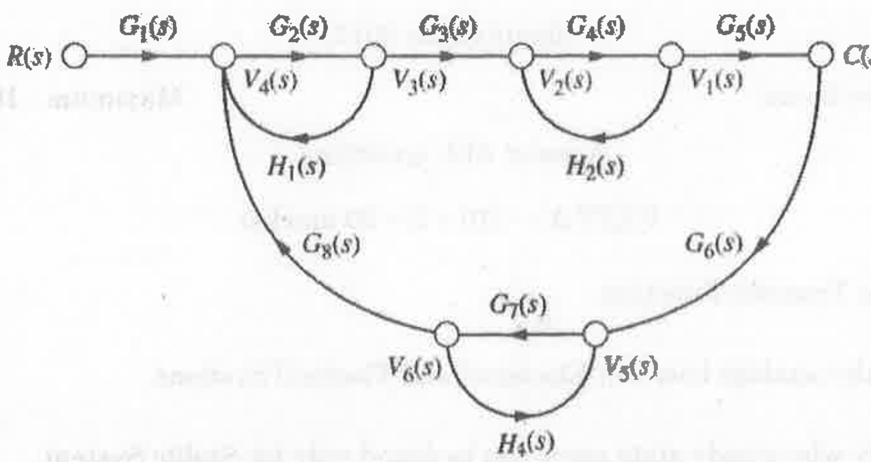
PART B — (5 × 13 = 65 marks)

11. (a) Reduce the given block diagram, into a single transfer function using block diagram reduction technique.



Or

(b) Determine the transfer function for the signal flow graph using Mason Gain Formula.



12. (a) The unity feedback system is characterized by an open loop transfer function $G(S)=\frac{K}{S(S+10)}$. Determine the gain K, so that the system will have a damping ratio of 0.5 for this value of K. Determine peak overshoot and time at peak overshoot for a unit step input.

Or

(b) A unity feedback system has the forward transfer function $G(S)=\frac{K(2S+1)}{S(5S+1)(1+S)^2}$. When the input $r(t)=1+6t$ determine the minimum value of K so that the steady error is less than 0.1

13. (a) Sketch the Bode plot for the function $G(S)=\frac{5(1+2S)}{(1+4S)(1+0.25S)}$ and determine the Gain Margin and Phase Margin.

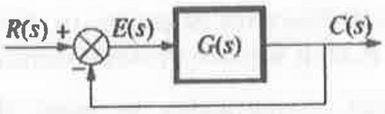
Or

(b) Sketch the root locus of the system whose open loop transfer function is,

$$G(S)=\frac{K}{S(S+2)(S+4)}.$$

Find the value of K so that the damping ratio of the closed loop system is 0.5.

14. (a) For the system given below, where $G(S)=\frac{K}{(S+2)(S+4)(S+6)}$.



do the following :

(i) Plot the Nyquist diagram

(ii) Use your Nyquist diagram to find the range of gain, K for stability.

Or

(b) Given the transfer function $G(S)=\frac{10(S+1)}{(S+2)(S+3)}$ analyze the stability and performance characteristics of the closed-loop system using the Nyquist stability criterion and frequency response compensation techniques.

(i) Apply the Nyquist stability criterion to determine the stability of the closed-loop system for varying values of gain K. (5)

(ii) Design a lag-lead compensator to improve system performance. The compensator should ensure a phase margin of at least 60 degrees and a gain crossover frequency of 5 rad/s. Employ the Bode plot method to design the compensator and provide its transfer function. (8)

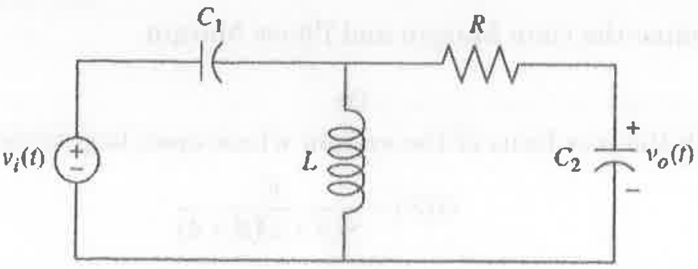
15. (a) Determine the transfer function T(s) = Y(s)/U(s) for the given state space representation.

$$\dot{X}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -1 & -2 & -3\end{bmatrix}x+\begin{bmatrix}10\\ 0\\ 0\end{bmatrix}u$$

$$y=[1 \quad 0 \quad 0]x.$$

Or

(b) Determine the state space representation for the following system



PART C — (1 × 15 = 15 marks)

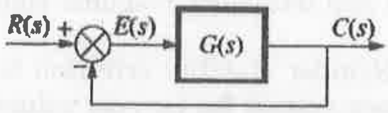
16. (a) Consider a transfer function $G(S) = \frac{K(S+1)}{(S+2)(S+3)(S+4)}$ representing a closed-loop system. Perform the following tasks:

(i) Use the Routh-Hurwitz criterion to determine the range of values for the gain K that ensure system stability.

(ii) Design a lead compensator to meet the following specifications: steady-state error less than 0.1 for a unit step input, phase margin of at least 45 degrees, and bandwidth of 10 rad/s. Utilize the Bode plot method to design the compensator, and provide the transfer function of the compensator.

Or

(b) For the system given below, where $G(S) = \frac{K}{(S+5)(S+20)(S+50)}$



do the following.

(i) Draw the Bode log-magnitude and phase plots.

(ii) Find the range of K for stability from your Bode plots.

(iii) Evaluate gain margin, phase margin, zero dB frequency, and 180° frequency from your Bode plots for K =10000.