Duration: 3 Hours **Marks:80**

Note:
1. Q.no. 1 is compulsory.
2. Answer any three questions from Q. No. 2 to Q. No. 6.
3. Write in legible handwriting.
4. Make any suitable assumptions wherever required.
5. Must make suitable supporting diagrams wherever desired.
6. Figure to the right indicates marks.

Q1 Each question carries five marks **20**

a. Explain the design of state feedback controller by transformation.

b. Why is the phase margin increased above that desired, when designing a Lag compensator using Bode-plot?

c. Draw the realization for the digital compensator defined by $G_c(z)=\frac{z+8}{z^2+z-2.5}$

d. Compare PI and PD controllers with respect to application, electrical equivalent circuits and pole-zero plots in s-plane.

Q2 a. Determine the range of sampling interval, T, to make the system stable for a unity feedback system which has a forward transfer function of $G1(s)=\frac{10}{(s+4)}$ is connected in cascade with an ideal sampler, and zero order hold. **10**

b. A unity feedback system with forward path transfer function $G(s)=\frac{K}{s(s+5)(s+8)}$ has 12% overshoot. Evaluate the current dominant poles using root locus and then design a PD controller to reduce the settling time by a factor of 1.5. **10**

Q3 a. For a unity feedback system with $G(s)=\frac{K(s+4)}{s(s+6)(s+8)}$, design a lag compensator using bode plot so that the system operates with a 50° phase margin and a static error constant of 80. **10**

b. Explain the steps in lead compensator design using frequency domain analysis. Draw the pole zero plot and write a typical transfer function for a lead compensator. **10**

Q4 a. Define observability. Check the observability of the following system. **05**

$$\dot{x} = \begin{bmatrix} -2 & 1 & 0 \\ 0 & 0 & 2 \\ 1 & -2 & -4 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} u; \qquad y = [1 \quad 0 \quad 0]\, x$$

b. Design an observer for the plant with the transfer function $\frac{20}{(s+5)(s+10)(s+20)}$ if the plant is represented in cascade form. Transform the plant to observer canonical form for the design. Then transform the design back to cascade form. The characteristic polynomial for the controller is ζ=0.5 and wn=10 and the observer is 10 times faster than the controller. **15**

Q5 a. A compensator is given whose transfer function is G(s)= $\frac{(s+0.1)}{(s+0.02)}$. Identify the compensator, draw the circuit with the parameter values to realize the given compensator. **10**

b. Given the following open loop plant G(s) =$\frac{10(s+8)}{s(s+2)(s+4)}$. Design a controller to yield a15% overshoot and a settling time of 4 sec assuming that the plant is represented in the phase variables form. Draw the representation with the controller gains. **10**

Q6 a. Given unity feedback system which has a forward transfer function of $G_1(s)=\frac{20}{s(s+5)}$ is connected in cascade with an ideal sampler, and zero order hold. Find the steady state error if the inputs are 10u(t), 10t u(t) and $10t^2u(t)$. Sampling time T=0.5. **10**

b. Given the unity feedback system with G(s)=$\frac{K}{s(s+4)(s+10)(s+12)}$. Use root locus to determine the value of gain K to yield a step response with a 20% overshoot. **10**

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