

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. Draw the bode plot of a typical lag compensator. Why it is called as a lag compensator?
 - b. Where a pole should be placed on z-plane to drive the steady state error of a sampled system to zero?
 - c. Where is the region of stability on the z-plane? Compare that with the stability region in s-plane.
 - d. Under what conditions would you use an observer in your state space design? Which plant representation lends itself to easier design of an observer? Why?
- Q2 a. Draw the implementation for the digital compensator defined by 05
- $$G_c(z) = \frac{(z+0.5)}{z^2 - 0.5z + 0.7}$$
- b. Given the following open-loop plant: 15
- $$G(s) = \frac{20(s+2)}{s(s+5)(s+7)}$$
- Design a controller to yield a 10% overshoot and a settling time of 2 seconds by assuming that the plant is represented in the parallel form.
- Q3 a. Use frequency response methods to design a lead compensator for a 10
- unity feedback system where $G(s) = \frac{K(s+7)}{s(s+5)(s+15)}$ and the following specifications are to be met: percent overshoot=15%, Settling time=0.1sec, and $K_v=1000$.
- b. Given the unity feedback system with $G(s) = \frac{K}{s(s+3)(s+9)}$ use frequency 10
- response methods to determine the value of gain K to yield a step response with a 15% overshoot.
- Q4 a. Compare PI and Lag compensator to achieve the desired response, 10
- concerning to the pole zero locations and the transfer functions. Also develop the circuits for their realizations.
- b. A unity feedback system with forward path transfer function 10
- $$G(s) = \frac{K}{(s+1)(s+5)(s+8)}$$
- has 15% overshoot. Evaluate the current dominant poles using R.L and then design a PD controller to reduce the peak time by a factor of 2.

- Q5 a. Design an integral controller to yield a 10% overshoot, 0.5 sec. settling time and zero steady state error for a step input for the following plant. 10

$$\dot{x} = \begin{bmatrix} -2 & 1 \\ 0 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u; \quad y = \begin{bmatrix} 1 & 1 \end{bmatrix} x$$

- b. Consider the plant $G(s) = \frac{(s+2)}{(s+5)(s+6)(s+9)}$ which is represented in observer canonical form. Design an observer with a transient response described by $\zeta=0.6$ and $\omega_n=120$. 10

- Q6 a. Given a sampler and z.o.h. in cascade with $G(s) = \frac{K}{(s+5)}$ find the range of K to make the system stable. Sampling time $T=0.1$ second. 10

- b. For the digital system with forward transfer function $G(z) = \frac{0.13(z+1)}{(z-1)(z-0.74)}$ find the static error constants and the steady state error if the inputs are $u(t)$, $t u(t)$ and $\frac{t^2}{2} u(t)$ for $T=0.1$ 10