Paper / Subject Code: 32503 / Control System Design

TE Inst. Sem-VI Choice based 21-5-2019

Duration: 3 Hours **Max. Marks 80**

N.B.

1. **Q.1** is compulsory. Attempt **any three** from the remaining questions.
2. All questions carry equal marks.
3. Figures to the Right indicate full marks.
3. Assume suitable data if necessary

Q.1 Attempt **any four** **20**

a. Obtain the state space representation for following system in diagonal form

$$G(s) = \frac{1}{s^2 + 0.3s - 0.02}$$

b. Obtain the transfer function for the following system.

$$\begin{aligned} \dot{x} &= \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \\ y &= [1\ 0]\, x \end{aligned}$$

c. Explain PD compensator. Why it is required? Draw a typical circuit diagram for PD compensator.

d. Define controllability and stabilizability.

e. For the system

$$G(s) = \frac{s+1}{s(s+3)}$$

check if $s = -2$ pole is on root locus or not.

f. Write Cayley Hamilton theorem. Check if it holds for the matrix $F = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$.

Q.2 A. Check for the controllability and observability of the system, **10**

$$\begin{aligned} \dot{z}_1 &= -z_1 + u \\ \dot{z}_2 &= -2z_2 + z_3 \\ \dot{z}_3 &= -2z_3 + u \\ y &= z_1 + z_3 \end{aligned}$$

using Kalman's tests.

B. Represent the system transfer function **10**

$$G(s) = \frac{s + 0.5}{s^2 + 3s + 2}$$

in **(i)** controllable canonical form **(ii)** diagonal form.

TE Inst. Sem V, Choice Based   21-5-20..

Q.3 A. Design the lag compensator using root-locus for the system **10**

$$G(s) = \frac{1}{s(s+5)}$$

such that dominant closed loop poles are at $s_d = -1.91 \pm j1.78$.

B. Write the steps to design lead compensator using Bode plot. **10**

Q.4 A. Design the state feedback control for the system **10**

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -1.32 & 2.32 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

to place the poles at $-1, -2$.

B. Obtain $x(t)$ for the system **10**

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

if initial condition is $x(0) = [1\ 1]^T$.

Q.5 A. Prove the non-uniqueness of state space representation using similarity transformation. Also prove that eigenvalues of system are invariant under linear transformation. **10**

B. A system is given by **10**

$$\dot{x} = \begin{bmatrix} -4 & 1 \\ -3 & 0 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$$
$$y = [1\ 0]\, x$$

Design the observer that has poles at $-12, -15$.

Q.6 Write short notes on **20**

A. Ziegler-Nichols method for PID controller tuning.

B. Lag-lead compensator.