Ref. No.: Ex/PG/ME/T/128A/2017

MME Second semester Examination, 2017

Subject: Principles and Applications of Linear Control Theory
Time: Three hours

Answer any five questions
(All questions carry equal marks)

Question 1. Find out the transfer functions for the following three systems: -

a. An integrating operational amplifier
b. A resistive-inductive circuit
c. A single degree of freedom spring-mass-damper

Question 2

a. Comment of the stability of the following characteristic equation using Routh's criterion: -

$$s^4 + 2s^3 + 3s^2 + 5s + 7 = 0$$

b. Comment on the significance of the root locus plot?

Question 3

Sketch Bode plot of the following system using asymptotes. The open loop transfer function of the system is given by

$$G(s) = \frac{20(s+1)}{s(s+2)(s+3)}$$

Question 4

a. Consider a system with unity feedback with $G(s)=\dfrac{8}{s+0.8}$. With the help of Bode plot (asymptotic) explain what happens to the phase margin when an integrator is added to the system.

b. Also discuss the effect of the integrator on K_p and K_v.

Question 5

a. Write down the transfer functions for lead and lag compensators.

b. Draw the Bode plots for lead and lag compensators.

c. Consider a unity feedback system with $G(s)=\dfrac{4}{s(s+2)}$. A lead compensator of the form $\dfrac{K_c\alpha(1+sT)}{(1+\alpha sT)}$ is added to the system. The requirements are as follows:-

$$K_v = 20/s$$
$$PM = 50^0$$
$$GM = 10dB(min)$$

If the designer takes a value of $\alpha = 0.24$ and $\dfrac{1}{T} = 4.41$, please qualitatively explain the effectiveness of the lead compensator using Bode plot.

Question 6

For a state space the matrices

$$[A]=\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix} \quad \{B\}=\begin{Bmatrix} 0 \\ 0 \\ 1 \end{Bmatrix} \quad \lfloor C \rfloor = \lfloor 1 \;\; 0 \;\; 0 \rfloor \quad [D]=0$$

(a) How many state variables are there? What is the number of inputs?

(b) What is the characteristic equation for the system?

(c) The eigenvalues of the system are $\lambda_1 = -5.0489, \lambda_2 = -0.3080, \lambda_3 = -0.6431$. Find out the Vandermonde matrix

(d) What will be state-space representation for the system in canonical form?

(e) Can you comment on controllability and observability from the canonical form?

Question 7

What do you understand by full state feedback control? Draw the block diagram for a regulator with full state feedback.

Consider the system specified in the previous question (Question 6). Compute the state feedback matrix for the system using the direct method. The desired poles are at $\lambda_1 = -2 + j4, \lambda_2 = -2 - j4, \lambda_3 = -10$
