Ref. No.: Ex/ET/PC/B/T/312/2024

B.E. Electronics and Tele-Communication Engineering, Third Year First Semester Examination, 2024

CONTROL ENGINEERING

Time: 3 Hours Full Marks:100

Answer any FOUR questions.

1. a) Draw the state diagram for the following differential equation:

$$D^3c(t) + 3Dc(t) + 2c(t) = r(t),$$

where D denotes time-derivative, r(t) is the input of the plant and c(t) is the response of the plant at time t. [6]

b) Let a system be described by $dX//dt = AX(t) + Bu(t)$ and $Y(t) = CX(t)$, where

$$A = \begin{pmatrix} 0 & 1 \\ -2 & -3 \end{pmatrix}$$

$B = [0 \quad 1]^T$ and $C = [2 \quad 1]$

Test controllability and observability of the system. [6]

c) For A and B matrices as indicated in Question 1(b), determine the State-Transition Matrix (STM). [5]

d) Also obtain the system states. [8]

3. a) Draw the Bode plot (magnitude and phase plots) of $G(s) = 10/s(1+0.1s)$. [6]

b) For a phase-lead network, obtain the expression for maximum phase-shift and the frequency where the network offers maximum phase-shift. [8]

c) What is the gain of the network at this frequency? [3]

d) A plant has a phase margin of 25°. How will you select a phase-lead network to obtain a phase-margin of 45°? Assume that the plant has a gain of $-10 \log(a)$ at $\omega = 50$ rad/sec, where 'a' is one parameter of the compensator. [4]

[Turn over

e) Explain with Bode plots, when you prefer to use Phase-lead and when Phase-lag networks for phase margin compensation. [4]

4. a) State *the principle of argument* in complex number theory. [3]

b) State *Nyquist criterion* for stability analysis. [3]

c) Draw the Polar plot of $G(s)= K(s-1)/s(s+1)$ for $K>0$. [6]

d) Draw the Nyquist plot of $G(s)= K(s-1)/s(s+1)$ for $K>0$. [8]

e) What do you infer from the Nyquist plot and why? [5]

5. a) Draw the root locus of $G(s)= K/s(s + 4)(s^2 + 4s +20)$, $K>0$. Determine the breakaway points and maximum value of K for stability. [15]

b) Prove the theorem: "A Root Locus originates at open loop poles, terminates at open-loop zeroes, and if there are n poles and m zeroes (n>m), then n -m poles would look for zeroes located at infinity." [10]

6. a) Derive the expression for step response of a second order system and hence obtain its peak overshoot. [10]

b) Write down the torque equation of an AC Servomotor. Linearize the torque around an operating speed and control winding voltage, and hence derive the transfer function of a Servomotor. [8]

e) Draw a block diagram of an AC position control system and explain the role of Synchro in the diagram. [7]

7.Write notes on any TWO of the following:

a) Signal Flow Graph and Mason's gain formula,
b) Amplidyne,
c) Illustrating computation of Transfer Function from the Magnitude Bode Plot,
d) Computation of Approximate Factored Closed-Loop Transfer Function from the open-loop root locus plot,
e) Predator-Prey species dynamics and Predator species control in an ecosystem. [12 ½ × 2]