Ref. No.: Ex/ET/T/312/2019

B.E. in Electronics and Tele-Communication Engineering, Third Year First Semester Examination, 2019

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) Explain state-controllability and observability with the help of suitable state diagrams. Also narrate the conditions for state-controllability and obervability. [8]

c) 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]

d) Also draw the state diagram of the system referred to in Part (c). [3]

e) Do controllability and observability follow from the above state diagram?-Justify. [2]

2. a) Identify the input variable(s), output variable(s) and system state(s) in a series capacitor charging circuit, where output is taken across the capacitance. [3]

b) Given a system dynamics: $D^3c(t) + 5D^2c(t) + Dc(t) + 2\,c(t) = 2r(t) + Dr(t)$. Derive the state equation. [4]

c) Derive the system states for an autonomous system and a general system. [8]

[Turn over

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

e) Also obtain the system states. [5]

3\. a) Draw the Bode plot (magnitude and phase plots) of G()= 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^o. How will you select a phase-lead network to obtain a phase-margin of 45^o? Assume that the plant has a gain of $-10\log(a)$ at ω=50 rad/sec, where 'a' is one parameter of the compensator. [4]

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) Prove that a point P lies on the real axis root locus, if the number of poles plus zeroes to the right of point P is odd. [10]

b) 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]

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

b) Justify mathematically why steady-state response of a first order system with ramp input depends only on the time-constant of the system. [4]

c) Draw an arbitrary time-response of a second order system with step input, and hence plot error versus time, proportional action versus time, integral action versus time and differential action versus time. [8]

d) Why differential action is called complementary to proportional action?- Explain graphically. [3]

7. a) Develop the differential equation model of a magnetic suspension ball system. [4]
b) Linearize the differential equation around an equilibrium point. [5]

c) Identify from physical system consideration, the input and the output parameters of the system and hence obtain the transfer function of the magnetic suspension ball system. [3]

d) 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. [5]

8. 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]