Ref. No. Ex/ ET/T/312/2018

B. ETCE 3RD YEAR IST SEMESTER EXAMINATION, 2018

CONTROL ENGINEERING

Time: Three Hours | Full Marks - 100

Answer any FOUR questions.

1a) Draw the torque-speed characteristics of a servomotor and hence develop the equation of torque in terms of control winding voltage and speed. Determine the transfer function of the servomotor. (10)

b) How Synchro acts as an error detector in an AC position control loop? (5)

c) Draw the block diagram of an AC position control system and also derive the transfer function of the system. (10)

2 a) Determine the relative stability of the following system in the left of S= -1.

$$S^3 + 3S^2 + 25S + 39 = 0 \quad (5)$$

b) Find the step response of a second order system and hence determine its time location of the peak overshoot. Also determine the magnitude of the peak overshoot. (10)

c) Show that for a type-2 system, positional and velocity error constants are infinity and acceleration error constant is finite. (10)

3 a) Obtain the dynamics of a magnetic suspension ball system and linearize the dynamics. Also determine the transfer function of the linearized dynamics. Draw a closed loop control scheme for the linearized system. (12)

b) Given below the nodal equations of six variables and their inter-connectivity. Draw the signal flow graph hand hence determine $x_6(s)/x_1(s)$ and $x_4(s)/x_3(s)$by Mason's gain formula.

[Turn over

$x_2 = a_{12} x_1 + a_{32} x_3 + a_{42} x_4 + a_{52} x_5$
$x_3 = a_{13} x_3$
$x_4 = a_{34} x_3 + a_{44} x_4$
$x_5 = a_{35} x_3 + a_{45} x_4$
$x_6 = a_{56} x_5.$ (13)

4 a) Presuming that the polynomial: $4S^3 + 15S^2 + 16S + 6 = 0$ has a root at S= -2.3, draw the root locus plot for the open-loop transfer function

$$G(s)\,H(s) = K/\,S\,(S+3)\,(S^2 + 2S + 2).$$ (14)

b) Determine the angle of departure at S= -1 + j. (6)

c) Also determine the intersection of the root locus with the imaginary axis. (5)

5 a) Determine the minimum phase that a phase lag network can offer. At what angular frequency the phase margin is minimum? (8)

b) Explain graphically the design steps of a phase lag network as a phase compensator for a given plant transfer function. (8)

c) Draw the Magnitude Bode Plot of $G(S) = 10\,(1 + S)\,(1+0.01S)/\,S(1+0.1S)$. Now given the magnitude plot, reconstruct the transfer function mathematically. (4+5)

6 a) Draw the polar plot for the transfer function $G(s)\,H(s) = K(S-1)/(S+1)$. (12)

b) Test the Nyquist stability for the above transfer function by constructing Nyquist plot. (13)

7 a) For the plant

$$\begin{pmatrix} dx_1/dt \\ dx_2/dt \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ -2 & -3 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \begin{pmatrix} 0 \\ 1 \end{pmatrix} r(t)$$

determine the state transition matrix and the system states. (4 + 5)

b) Represent the following dynamics by a state equation. (4)

$$D^3c(t) + 5\,D^2\,c(t) + Dc(t) + 2C(t) = Dr(t) + 2r(t)$$

where D denotes time derivative operator.

c) Test controllability and observability of the system when the output equation is given by

$$Y(t) = [y_1(t) \quad y_2(t)]^T = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

and the state equation is same as introduced above. Also draw the state diagram for the system and justify your results of controllability and observability. (12)

8. Write notes on any TWO of the following:

a) PID Control,

b) Constant M-Circles and Nichols Chart,

c) Measurement of gain and phase margin from Bode plots. (10 + 10)