Ref.no.: Ex/PG/ETCE/T/113C/16/2017

M.ETCE.1St.SEM. EXAMINATION, 2017

NONLINEAR CONTROL SYSTEM

Time: 3 Hours | Answer Q.1 & any *Four* from the rest | Full Marks:100

1. Indicate True(**T**)/False(**F**) :
(write the answers serially)

10x2

i. Selection of *States* for a control system is unique
ii. Phase-plane trajectory for an over-damped system is a divergent locus
iii. An integral controller improves feedback-loop stability
iv. If a Liapunov function takes varying signs in the state-space - it is Negative Definite
v. Eigen values in state-space denote poles of the system
vi. Describing-Function (DF) method leads to time-domain analysis
vii. Ziegler recommendations for a PID-controller is based on one-half amplitude decay-ratio response
viii. If S-matrix is non-singular for a second-order system – it is uncontrollable
ix. In the transient response of a 2^{nd}.-0rder system, the first maximum value of output response occurs at $t_{max}= (0.5\,\pi)/[\omega_n\sqrt{(1-\partial^2)}]$; ∂ denote damping ratio & ω_n Natural frequency
x. Proportional Band (P_b) is defined as $\%P_b = 100/K$; if K is proportional-gain

2. State equation of a system is

10+10

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} \begin{bmatrix} x1 \\ x2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

a. Calculate STM
b. Evaluate time-response

3. a. Write the Ziegler Recommendations (ZR) on PID controller tuning
b. A unity-feedback control system is given by $G(s) = 100/[(s+1)(s+3)(10s+1)]$
Determine the PID controller settings as per ZR using Bode-plot

10+10

4. a. Define Controllability & Observability
b. Evaluate controllability if

8+6+6

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -1 \end{bmatrix} \quad ; \quad B = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$

c. Eavulate observability if

$$B = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} \quad ; \quad D = \begin{bmatrix} 1 & 0 \end{bmatrix}$$

5. a. What is state variable (SV); Derive the SV-representation of a n*th*-order system 12+8
   b. What is difference between canonic-variable and SV ; explain briefly

6. A feedback control system has a Nonlinear element $y = \pm sgn.\ e(t)$ cascaded to linear block with denominator $D(t) = D^2 + 0.5D + 1$ and numerator $N(t) = 1$. Draw the phase-plane trajectories with $e(0) = \dot{e}(0) = -1$; assuming a step-input; comment on the system stability 20

7. Closed- loop transfer function of a servo-system is $H(s) = 5K/[s^2 + 35s + 5K]$; assume step-input and calculate the following for K=200 and K =400
   a. Natural frequency f_n (Hz)
   b. Damping Ratio (∂)
   c. %Overshoot
   d. Tabulate the results and comment on loop-stability. 5x4

8. Write Short Note (Any Two) 10x2
   a. Stability analysis by DF
   b. Phase-variable
   c. Synchros
   d. Derivative controller action

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