Fifth Semester B.E. Degree Examination, June/July 2017
Modern Control Theory

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. With respect to control systems compare modern control theory with classical control theory. **(06 Marks)**

b. Given $\frac{y(s)}{u(s)} = \frac{3}{s^2+3s+2}$ derive the controllable phase variable canonical form of state model and draw the state diagram. **(06 Marks)**

c. Given $\frac{y(s)}{u(s)} = \frac{-[3s^2+4s-7])}{(s+1)^2\ (s+2)}$. derive Jordan canonical Form of state model. **(08 Marks)**

2 a. For the electrical shown in Fig. Q2(a) obtain the state model. Choose i_L and v_c as state variables. **(06 Marks)**

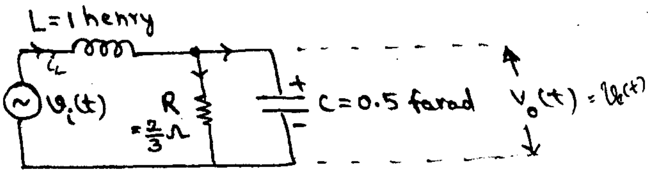

Fig. Q2(a)

b. Obtain the state model of the block diagram shown in Fig Q2(b). **(06 Marks)**

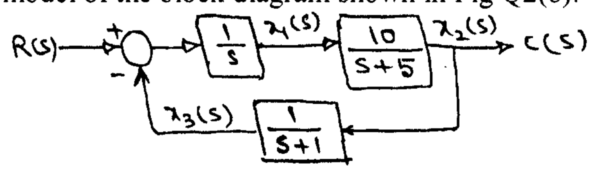

Fig. Q2(b)

c. Derive the state model of an armature controlled d.c motor by selecting $x_1(t) = \theta(t)$ $x_2(t) = \dot{\theta}(t)$ and $x_3(t) = i_a(t)$ as state variables. **(08 Marks)**

3 a. Given $\dot{x}(t) = \begin{bmatrix} 0 & -1 \\ 2 & -3 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(s); y(t) = [1 \quad 0]x(t)$

Determine the transfer function y(s)/u(s). **(06 Marks)**

b. Define: state controllability, observability and state transition matrix. **(06 Marks)**

c. Given $\dot{x}(t) = \begin{bmatrix} 0 & 1 \\ -4 & -4 \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t); y(t) = [1 \quad 0]x(t)$

Determine eigen values, eigen vectors, transformation matrix P and hence transform the given state model in x(t) into an alternate state model in z(t) such that x(t) = Pz(t). **(08 Marks)**

4 a. Given $A = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix}$. Determine e^{At} using Cayley Hamilton method. **(06 Marks)**

b. Given $\dot{x}(t)=\begin{bmatrix}1 & 1\\2 & -1\end{bmatrix}x(t)+\begin{bmatrix}1\\1\end{bmatrix}u(t)$; $y(t)=[1 \quad -2]x(t)$
Determine: state controllability, output controllability and observability using KALHANS TEST. **(06 Marks)**

c. Given $\dot{x}(t)=\begin{bmatrix}8 & -9\\4 & -5\end{bmatrix}x(t)$; $x(0)=\begin{bmatrix}1\\0\end{bmatrix}$
Determine the state transition matrix using Laplace transform method and hence obtain x (t). **(08 Marks)**

PART – B

5 a. Explain the concept of stability improvement of regulator by state feedback scheme. **(06 Marks)**

b. Given $\dot{x}(t)=\begin{bmatrix}1 & 1\\-4 & -3\end{bmatrix}x(t)+\begin{bmatrix}0\\2\end{bmatrix}u(t)$
Determine the state feedback gain matrix K for the desired eigen values of -2 and -6. Use Ackermann's formula. **(06 Marks)**

c. Given $\dot{x}(t)=\begin{bmatrix}0 & 20.6\\1 & 0\end{bmatrix}x(t)+\begin{bmatrix}0\\2\end{bmatrix}u(t)$; $y(t)=[0 \ 1]x(t)$.
Desired eigen values for the full order observer are $-1.8\pm 2.4j$. Determine the observer gain matrix K_e using canonical transformation method. Also given observer equation. **(08 Marks)**

6 a. State and prove the necessary condition for state feedback design by arbitrary pole placement scheme. **(06 Marks)**

b. Given $\dot{x}(t)=\begin{bmatrix}0 & 1\\0 & 0\end{bmatrix}x(t)+\begin{bmatrix}0\\1\end{bmatrix}u(t)$; $y(t)=[1 \quad 0]x(t)$. design a first order observer for the system with observer pole at $s = -10$. Assume x_1 is measurable. Use direct substitution method. Also give the observer equation of the first order observer. **(06 Marks)**

c. With the help of relevant figures/equations/graphs explain the phenomena of non linearity with respect to the following. Frequency – amplitude dependence, multivariable responses and Jump resonance. **(08 Marks)**

7 a. Give the procedural steps of constructing phase trajectories using isoclines method. **(06 Marks)**

b. Explain Delta method of constructing phase trajectories. **(06 Marks)**

c. Indentify and classify the singularities of the system given by
$\ddot{y}(t)+0.5\dot{y}(t)+2y(t)+y^2(t)=0$. **(08 Marks)**

8 a. State Liapunov stability theorems. **(06 Marks)**

b. Give $\dot{x}_1(t)=\begin{bmatrix}0 & 1\\-2 & -3\end{bmatrix}x(t)$. Determine its stability using Liapunov theorem and hence determine a suitable Liapunov function. Take the matrix $Q=\begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}$. **(06 Marks)**

c. Examine the stability of the system described by the following equation by Krasovskii's theorem. $\dot{x}_1(t)=-x_1(t), \dot{x}_2(t)=x_1(t)-x_2(t)-x_2^3(t)$. **(08 Marks)**

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