Modeling and Simulation

Time Allowed: 3 Hrs.
2nd Year Students.
Total Marks:
16 / 1 / 2013

[1]

A. Define

I. Controllable system
II. Observable system
III. Regulator Poles
IV. Eigenvalues

B. Consider that a third-order system has the coefficient matrices

$$A=\begin{bmatrix}1 & 2 & -1\\ 0 & 1 & 0\\ 1 & -4 & 3\end{bmatrix} \quad B=\begin{bmatrix}0\\0\\1\end{bmatrix}$$

Check system **controllability**?

C. For the system that have

$$A=\begin{bmatrix}-2 & 0\\ 0 & -1\end{bmatrix} \quad B=\begin{bmatrix}3\\1\end{bmatrix} \quad C=[1 \quad 0]$$

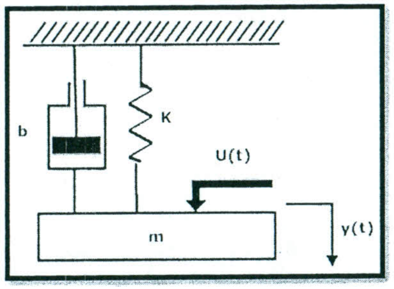
Check system **Observability**?

[2]

A. Find out if the matrix $\begin{bmatrix}-e^{-t} & 0\\ 0 & 1-e^{-t}\end{bmatrix}$ can be **state-transition** matrix

B. For the spring-mass-damper system shown below. The state equations are

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}0 & 1\\ -\frac{K}{m} & -\frac{C}{m}\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}0\\ \frac{1}{m}\end{bmatrix}u$$



Given: $\mathbf{m = 1\ kg}$, $\mathbf{C = 3\ Ns/m}$, $\mathbf{K = 2\ N/m}$, $\mathbf{u(t) = 0}$. Evaluate,

- The characteristic equation, its roots
- The transition matrices $\varphi(s)$ and $\varphi(t)$
- The transient response of the state variables from the set of initial conditions $y(0) = 1.0, \dot{y}(0) = 0$

[3]

A. Define

I. State observer
II. Pole Placement

B. Consider a system defined by

$$\dot{X} = AX + BU$$

Where

$$A=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}, \qquad B=\begin{bmatrix}0\\2\end{bmatrix}, \qquad C=[1 \quad 0]$$

It is desired to have egenvalues at -3 and -5 by using state-feedback control $u = -Kx$. Determine the state-feeddback gain matrix

[4]

Use MATLAB to compute and plot the impulse and step responses of the state-space model

$$A=\begin{bmatrix}-2 & -2.5 & -0.5\\ 1 & 0 & 0\\ 0 & 1 & 0\end{bmatrix}, \qquad B=\begin{bmatrix}1\\0\\0\end{bmatrix}$$

$$C=[0 \quad 1.5 \quad 1], \qquad D=[0]$$

Then simulate and plot the state response $x(t) = [x_1(t) \quad x_2(t) \quad x_3(t)]^T$ when the input is $u(t) = \begin{cases}2 & 0 \le t \le 2\\ 0.5 & t \ge 2\end{cases}$ and the initial condition is $x(0) = [1 \quad 0 \quad 2]^T$

[5]

Consider the system defined by

$$\dot{X} = AX + BU$$

Where

$$A=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -1 & -5 & -6\end{bmatrix} \quad B=\begin{bmatrix}0\\0\\1\end{bmatrix}$$

By using the state feedback control $u = -Kx$, It is desired to have the closed loop ploes at $s = -2 \pm j4$ and $s = -10$. Determine the state feedback gain matrix using **MATLAB**

[6]

Consider a system defined by

$$\dot{X} = AX + BU$$
$$Y = CX$$

Where

$$A=\begin{bmatrix}-1 & 0 & 1\\ 1 & -2 & 0\\ 0 & 0 & -3\end{bmatrix}, \qquad B=\begin{bmatrix}0\\0\\1\end{bmatrix}, \qquad C=[1 \quad 1 \quad 0]$$

Transform the system into

- Controllable canconical form
- Draw state diagram of Controllable canconical form
- Observable canonical form
- Find eigenvalues

BEST WISHES
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