

ECE 388

Automatic Control

LAB 4

Mathematical Modeling of Physical Systems

Objectives: The objective of this exercise is to learn more about State Space Models of the transfer equations and Canonical Forms of linear transformations.

List of Equipment/Software

MATLAB, Simulink

TASKS (by hand) :

1) Determining State Equation

The transfer function of a linear system is given by

$$G(s) = \frac{12(s + 1)}{s(s + 3)(s + 2)^2}$$

Write the state equations in

- The Controllable Canonical form
- The Observable Canonical form
- Can you write it in Diagonal Canonical form. Why?
- If your answer to part c is NO, please find closest form to diagonal Canonical form. (Namely Jordan Canonical Form)
- Simulate the state space models in **a**, **b** and **d**.

2) Determining Transfer Function from State Equation

The linearized equations for a satellite in a circular equatorial orbit are given by :

$$\dot{x} = Ax + Bu$$

where

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

With following state variables:

x_1 = the distance from the center of the earths

x_2 = the rate of change of x_1

x_3 = angular displacement in the equatorial plane

x_4 = the rate of change of x_3

The input $u(t)$ is the thrust produced by a rocket engine. Given this information, determine the transfer function relating $X_1(s)$ to $U(s)$. ($Y(s) = X_1(s)$)