

MCE 503: Modeling and Simulation of Mechatronic Systems
Homework 4 - Spring 2009

OUT: 03-12-09. DUE: 03-26-09 in class. No homework will be accepted past the due date and time.

1. (25 pts) Enter the bond graph shown in Prob. 5-17 into appropriate software (20sim recommended) and obtain a symbolic state space description of the form:

$$\begin{aligned}\dot{x} &= Ax + Bu \\ y &= Cx + Du\end{aligned}$$

where x is the vector of states, u the input (v_i) and y the output (the velocity of the top of the building, f_{10}). You must find matrices A , B , C and D in symbolic forms using the same symbols as in the book (M_m , C_{12} , etc.). A few hints:

- Flip the causalities assigned by 20sim as necessary to match those of Prob. 5-17.
- You can leave numeric values for the 1- and 2-ports to defaults (usually 1). You can still obtain a symbolic answer.
- Check the model and ignore warnings (but no errors should appear).
- Start the simulator and choose Tools/Frequency Domain Toolbox/Model Linearization. Select input and output and choose to output the results to a Matlab file
- Use the Find/Replace functions in your favorite editor to replace the symbols created automatically by 20sim (for example TF\ \mathbf{r} for transformer modulus) with the symbol used in the book (for example R).
- Give the A , B , C and D matrices using the symbols of the book.

2. (75 pts) Modify the mathematical model for the electric vehicle discussed in class so that changes in road elevation are included (gravity effects). Define the road profile by a function $y_r = y_r(x)$ where x is the distance traveled and y_r is the elevation measured from some baseline. The derivative of y_r can be used to define the direction of the gravity force component along the vehicle axis under analysis. Simulate the operation of the vehicle with the guidelines of the handout, using the same stick input profile:

1. Simulate with $y_r = 0$ and find the distance traveled by the vehicle until the battery has zero charge. Call this distance D .
2. Simulate with the following y_r :

$$y_r(x) = \begin{cases} 0.01x, & 0 \leq x < \frac{D}{3} \\ -0.04x, & \frac{D}{3} \leq x < \frac{2D}{3} \\ 0, & \frac{2D}{3} \leq x \end{cases}$$

Simulate this case until the battery has zero charge.