MECH-3221 Control Theory

Homework 6

Instructions

- Make sure the name and student number for this homework are yours, if not contact your course instructor immediately.
- This evaluation covers **material from the sixth week of classes**.
- Note that each student has a different version, so do not try to copy from one another as it would cost you both mark and risk of plagiarism.
- If asked, write all the steps involved and all the equations used. Final answer ≠ full mark!
- This evaluation **is not** strictly multiple-choice
- Be cautious of the **time cues**.
- If this is not a strictly multiple-choice evaluation
    a) For qualitative questions, write down the key points, illustrate key concepts, and be concise.
    b) Make sure to sectionalize your answers referring to question elements and put your final answer for each section in a box.
    c) You need to either print this document, complete writing your solution and scan the material back to PDF and upload it or use a tablet or any other device that allows you to write on PDF files, save it and upload it. If neither is possible, you can only scan your solution pages and upload. For multiple choice questions, on your answer sheet, mention the question number and your choice for the question.
    d) The filename to upload must follow the "Lastname_firstname_XX.pdf" where XX is the last 2 digits of your student number and your name as shown on top of this page.
- All submissions must be electronic, no other submission format is accepted.
- Late submission is not accepted and will get a mark of ZERO.

Evaluation

Questions are graded based on the rubrics

Question 1 [4 marks] [20 minutes] [LO. 3]

Given a system's SSR as

$$\dot{x} = \begin{bmatrix} 2.3 & 0.7 \\ 4.3 & 2.6 \end{bmatrix} x + \begin{bmatrix} -0.2 \\ -1.8 \end{bmatrix} u$$
$$y = \begin{bmatrix} 1.8 & 3.7 \end{bmatrix} x$$

a) Use MATLAB commands to obtain the dynamic response for a step input $u(t) = 1.6U(t)$ which is a step with magnitude of 1.6 at $t = 0$. The initial states are $x_1(0) = 0.2$ and $x_2(0) = 0.1$. the simulation time should be $t = 0$ to $t = 6$ sec with the step size of $dt = 0.001\ sec$ Plot the output vs. time, $y(t)$. You have to define all required matrices and vectors, use $ss(\cdot)$ and $lsim(\cdot)$ functions and your output plot must be in vector format inserted in the document. The submission for this evaluation must be in computer generated document format. No handwritten code or plot is accepted for this evaluation. All you code lines must be properly commented and explain what each line does. Your plot must have proper labels and titles.

b) Create a Simulink file that would generate the same output for the system provided. You must use a step input, state-space model block and a scope for output. The blocks and signals must also be clearly labeled. You need to copy a metafile of the Simulink model (not screenshot) in your report to have it as a vector format image. You must also show (in a screen shot) each of your block properties dialog filled with proper values.

You are required to show all the steps involved in finding your final answer even the smallest details. Make sure in your final answer, all numerical values are substituted, and equations are simplified to the simplest form.

Solution

Provide your step by step solution here. Note that only providing the correct final answer does not guarantee a full mark for the question!

a)

```
clc;clear;

A = [2.3 0.7;4.3 2.6]; %define state matrix
B = [-0.2; -1.8]; %define input-to-state matrix
C = [1.8 3.7]; %define state-to-output matrix
D = 0; %define feedthrough matrix

sys = ss(A,B,C,D); %create state-space model from defined matrices
dt = 0.001; %define step size for simulation time
t = 0:dt:6.0; %define simulation time domain
u = 1.6*ones(size(t)); %define step input with amplitude 1.6 for all time steps
x0 = [0.2 0.1]; %define initial states for x

%simulate time response of system using define variables for [y] system
%response at times [t]
[y,t] = lsim(sys,u,t,x0);

plot(t,y); %create plot of y vs. t
grid on; %creates grid on plot at all y and x ticks
title('Step Response'); %creates title for plot
xlabel('Time (s)'); %creates title for x axis
ylabel('Output (x units)'); %creates title for y axis
```

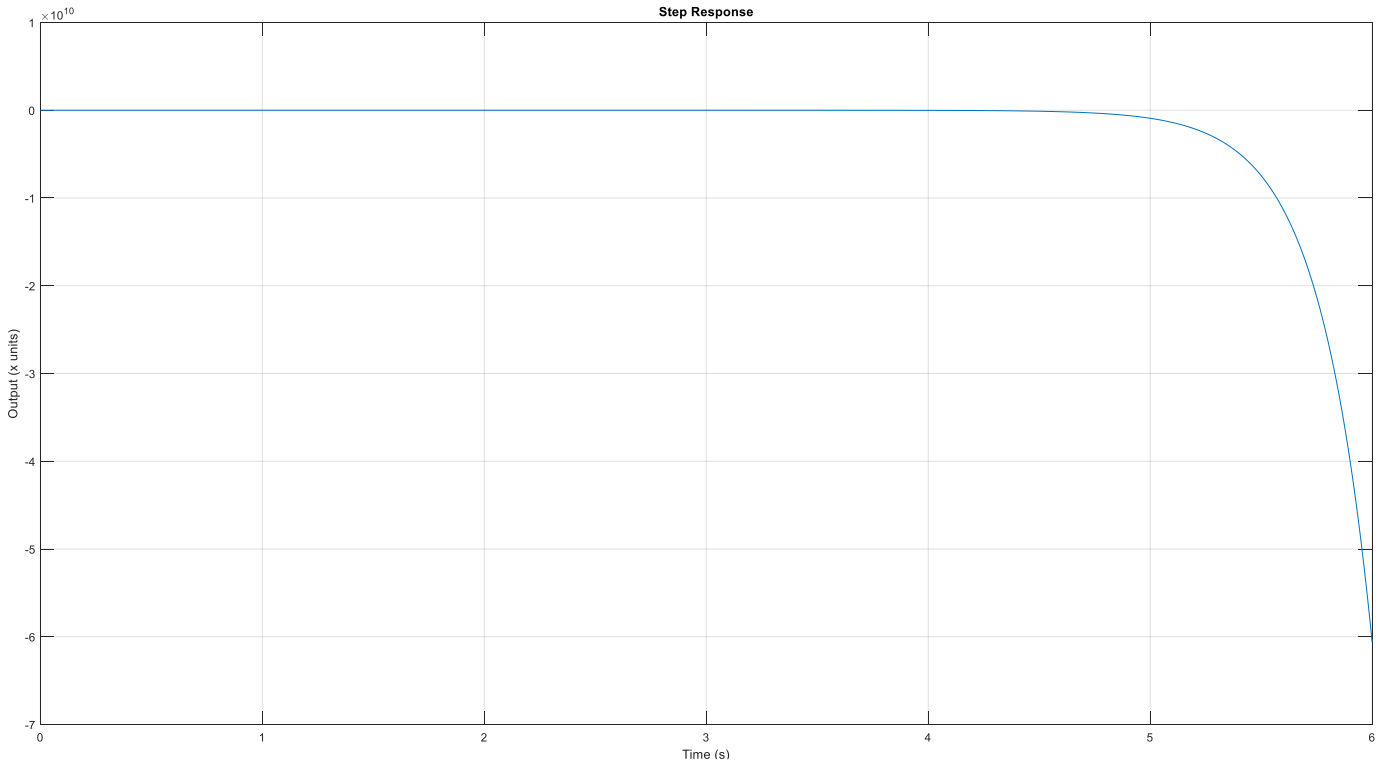

Figure 1. Step Response from MATLAB using lsim()

b)

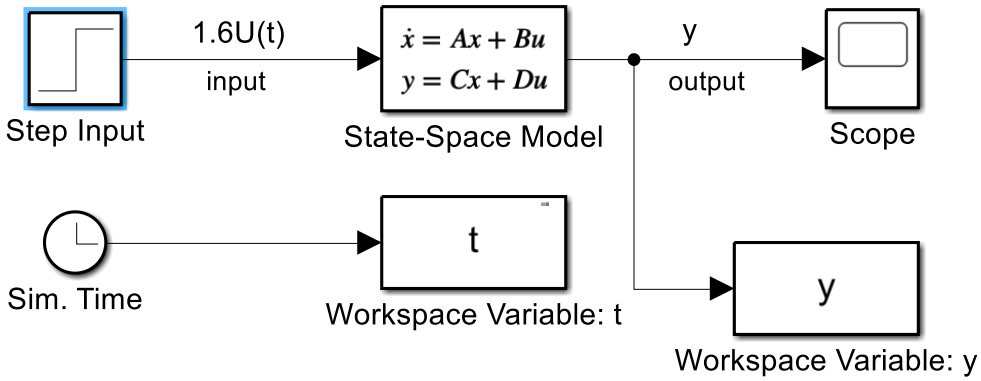

Figure 2. Simulink Model for State Space system

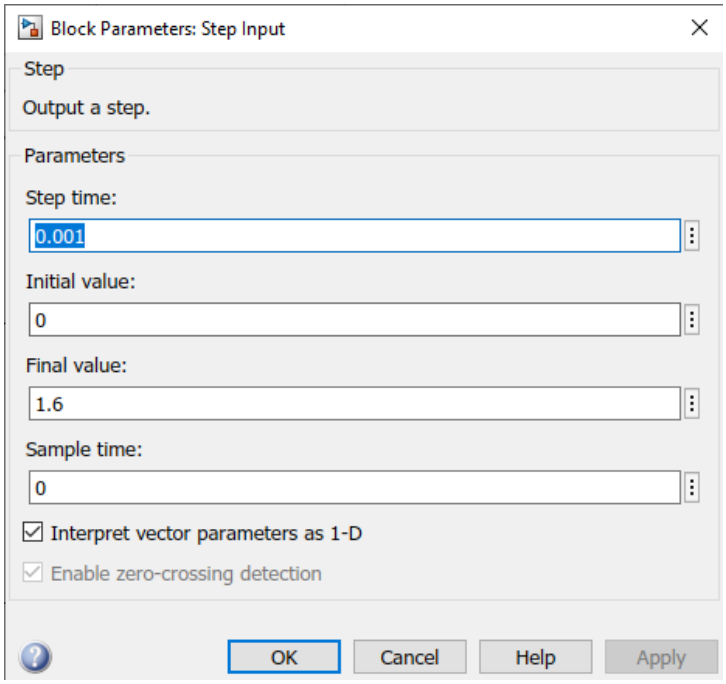

Figure 3. Step block parameters

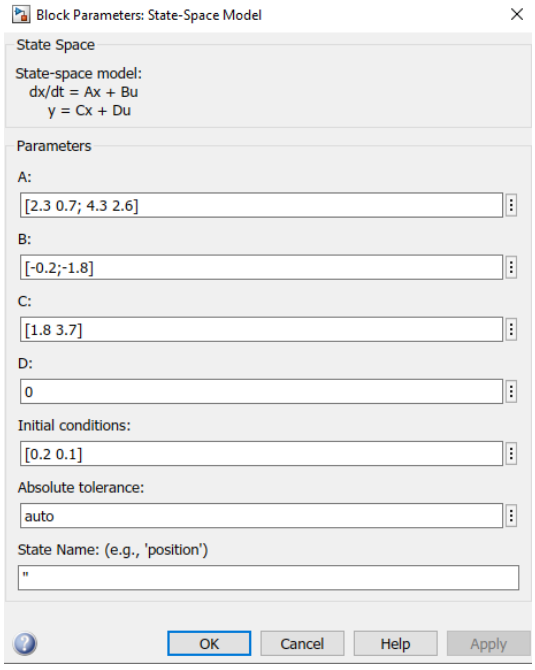

Figure 4. State-Space Model parameters

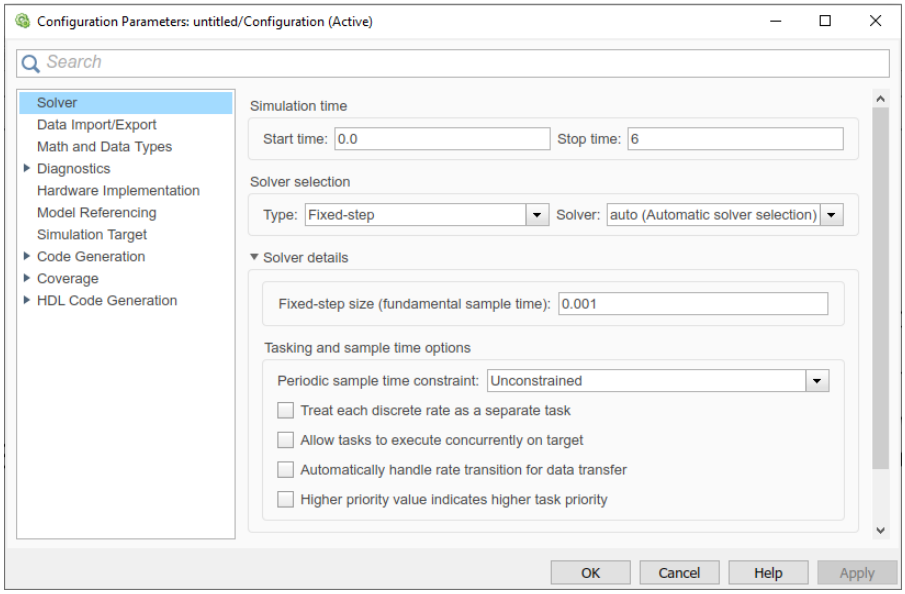

Figure 5. Simulation configuration for Solver: Fixed-step size

After the simulation is completed and the output is validated in the scope, the following MATLAB code is used to generate the Step Response from Simulink using the variables defined in the local cache of the workspace instance, written in the Command Window:

```
plot(t,y); %create plot of y vs. t
grid on; %creates grid on plot at all y and x ticks
title('Step Response - Simulink'); %creates title for plot
xlabel('Time (s)'); %creates title for x axis
ylabel('Output (x units)'); %creates title for y axis
```

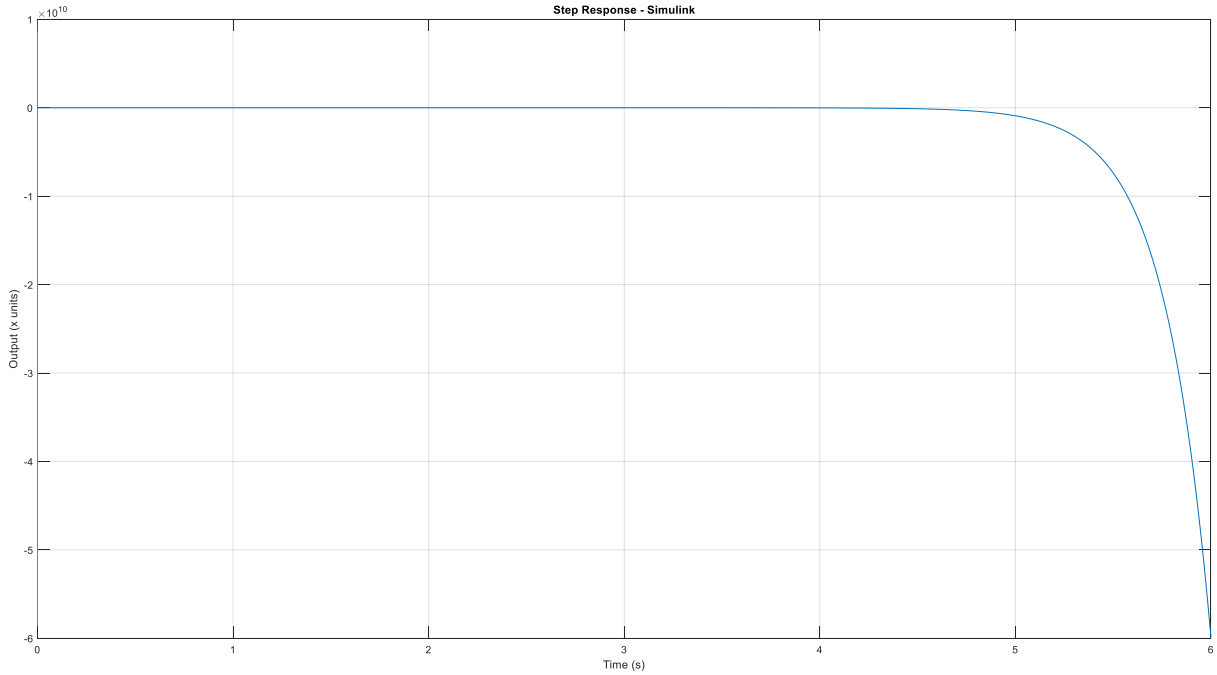

Figure 6. Step Response using Simulink from stored Workspace variables