EE 547 (PMP) Lab 2

Wednesday, January 14, 2015

Professor Linda Bushnell, UW EE

Demo Problem 1 Consider the following state-space representation of a system:

$$\dot{x} = \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$
$$y = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad (1)$$

(a) Create an m-file script to define the system in MATLAB.

(b) Use MATLAB script to convert the state-space representation to transfer function.

(c) Use MATLAB script to convert the transfer function in previous step back into state space.

(d) Response to the Step Inputs:

   a. Create a Simulink model, **Lab2**, of the given system by using the Simulink Blocks shown in Figure 1.

   b. Add a set of commands to the m-file script to simulate the response of the Simulink model. Please plot the input and outputs as a function of time.

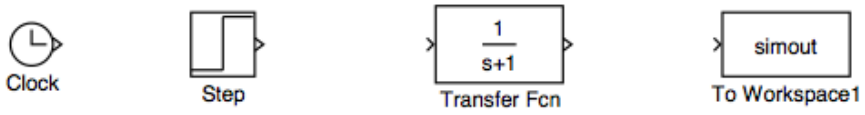


Figure 1 Simulink blocks to be sued in demo problem. Blocks **Clock** and **Step** can be found in folder *Sources*, block **To Workspace** in folder *Sinks*, and block **Transfer Fcn** in folder *Continuous*.

(e) Response to the Sine Inputs:

   a. Add second Simulink model into **Lab2** of the given system by using the Simulink Blocks shown in Figure 2.

   b. Add a set of commands to the m-file script to simulate the response of the Simulink model. Please plot the input and outputs as a function of time.

Figure 2 Simulink blocks to be sued in demo problem. Blocks **Clock** and **Sine** can be found in folder *Sources*, block **To Workspace** in folder *Sinks*, and block **Transfer Fcn** in folder *Continuous*.

(f) Response to the Ramp Inputs:

a. Add third Simulink model into **Lab2** of the given system by using the Simulink Blocks shown in Figure 3.

b. Add a set of commands to the m-file script to simulate the response of the Simulink model. Please plot the input and outputs as a function of time.

Figure 3 Simulink blocks to be sued in demo problem. Blocks **Clock** and **Ramp** can be found in folder *Sources*, block **To Workspace** in folder *Sinks*, and block **Transfer Fcn** in folder *Continuous*.

Individual Problem 1 Consider the following state-space representation of a system:

$$\dot{x} = \begin{bmatrix} -2 & 4 \\ 0 & 5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 2 \\ -4 \end{bmatrix} u$$
$$y = \begin{bmatrix} 3 & 10 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} - 2u \quad (2)$$

(a) Please build up state-space representation of this system in MATLAB.

(b) Use MATLAB function to convert state space into transfer function.

(c) Build the Simulink model with transfer function in previous step.

(d) Plot the output response of the system with respect to a sine input which is defined as u(t) = sin(100t).

Solution to Demo Problem 1:

(a) This lab is based on MATLAB implementation.

i. Define parameters

ii. Define A B C D matrices

(b) Convert state space to transfer function

i. **[num,den] = ss2tf(A,B,C,D,1);**

num is to return the coefficients of numerator.

dem is to return the coefficients of denominator.

"1" inside ss2tf means conversion with respect to 1st input.

(c) Convert transfer function into state space matrices.

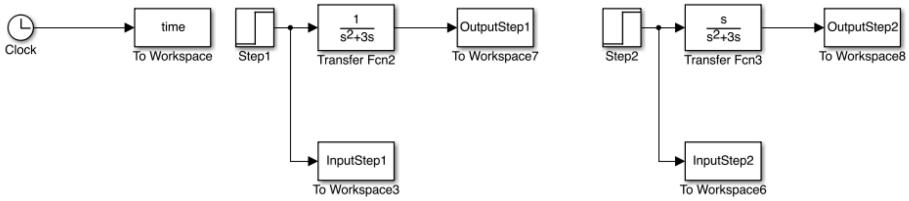
i. **[AA,BB,CC,DD] = tf2ss(num , den);**

Please note the order of state variables may be different.

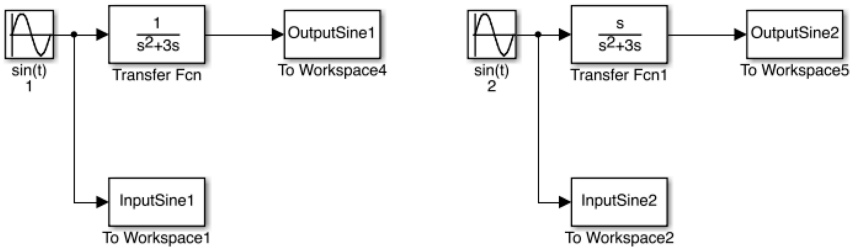
ii. **tf1 = tf(num(1,:),den);**

Transfer function corresponding to first output.

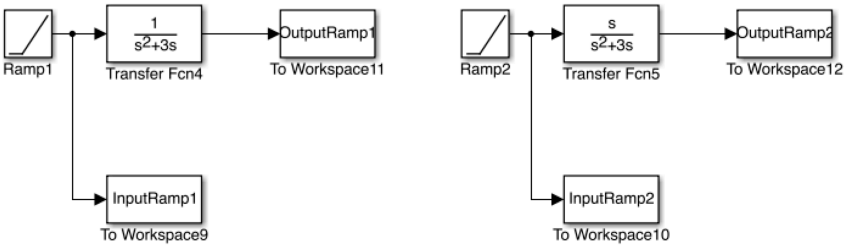
(d) Build up Simulink model with Step input.



(e) Repeat building up Simulink model with Sine input.



(f) Repeat building up Simulink model with Ramp input.



(g) Output figures from Simulink results.

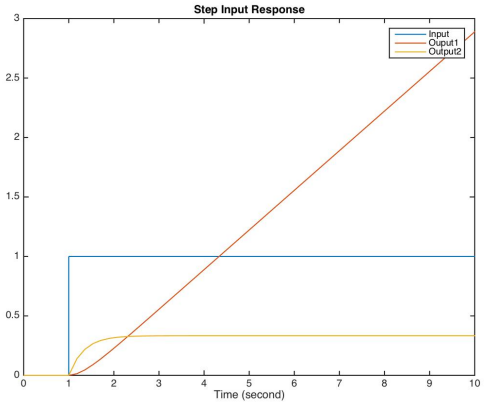


Figure 4 Step Input Responses of the system

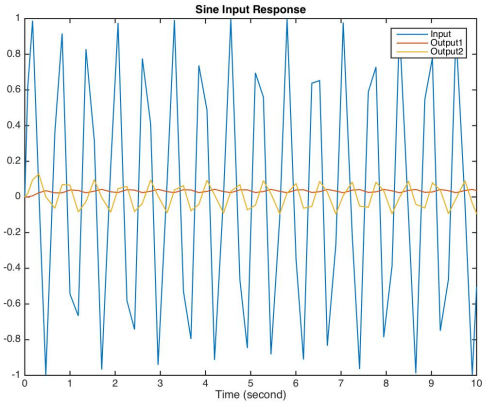


Figure 5 Sine Input Responses of the system

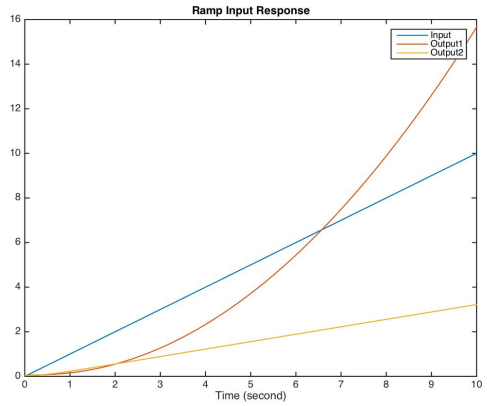


Figure 6 Ramp Input Responses of the system

MATLAB Code:

Demo Problem

```
%% EE547 Lab 2: State Space and Transfer Function
%% Developer : HRLin
%%
close all;
clear all;

%% Define parameters
xini = [0.05; 0.05];
tspan = 0:0.01:100;

%% Define A, B, C, D matrices of Lab 1 individual problem.
% Note: Remember we used state-space in lab1 ?
A = [0 1 ; 0 -3];
B = [0 ; 1];
C = [1 0 ; 0 1];    % eye(2)
D = [0 ; 0];        % zeros(2,1)

%% Define input
%u = [cos(tspan),sin(tspan)];

%% Convert state space to transfer function.
[num,den] = ss2tf(A,B,C,D,1);
% note: input is 1x1 vector; output is 2x1 vector.

%% Convert transfer function to state space.
[AA,BB,CC,DD] = tf2ss(num , den);               % reformed A B C D matrices.
% note: the reformed state variable order may not be the same as original.

%% Formulation of transfer functions and relative zeros and poles
tf1 = tf(num(1,:),den) % transfer function corresponding to first output.
tf2 = tf(num(2,:),den) % transfer function corresponding to second output.

zero1 = zero(tf1)
zero2 = zero(tf2)

pole1 = pole(tf1)
pole2 = pole(tf2)

%% Simulate Simulink Model
sim('EE547_Lab2Simulink_Winter2015_demo',10);    % 10 defines simulation time

%% Output figures
figure(1)
plot(time,InputStep1,time,OutputStep1,time,OutputStep2);
title('Step Input Response');
xlabel ('Time (second)');
legend('Input','Ouput1','Output2');
print -djpeg 'StepInputResponse.jpeg'

figure(2)
plot(time,InputSine1,time,OutputSine1,time,OutputSine2);
title('Sine Input Response');
xlabel ('Time (second)');
```

```
legend('Input','Output1','Output2');
print -djpeg 'SineInputResponse.jpeg'

figure(3)
plot(time,InputRamp1,time,OutputRamp1,time,OutputRamp2);
title('Ramp Input Response');
xlabel ('Time (second)');
legend('Input','Output1','Output2');
print -djpeg 'RampInputResponse.jpeg'
```