EE_105_021_23W Lab 4

Aedyn Green

TOTAL POINTS

100 / 100

QUESTION 1

1 2.2 (a,b,c,d,e) **15 / 15**

✓ **- 0 pts** *Correct*

QUESTION 2

2 2.3 (b,c) **15 / 15**

✓ **- 0 pts** *Correct*

QUESTION 3

3 2.4 (b,c,d) **15 / 15**

✓ **- 0 pts** *Correct*

QUESTION 4

4 2.4 (e) **20 / 20**

✓ **- 0 pts** *Correct*

QUESTION 5

5 3 **10 / 10**

✓ **- 0 pts** *Correct*

QUESTION 6

6 Prelab (points assigned based on Prelab completion prior to lab) **25 / 25**

✓ **- 0 pts** *All questions complete before lab*

Part 2

Simulink:

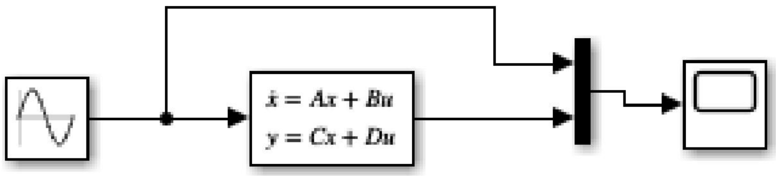

fig. 2 - Simulink

Code:

```
clear all;
close all;
%define system params
a = 10e-4;
b = 1e-6;
c = 100;
d = 40e-3;

%calculate matrices A,B,C,D
A = [0 (1/b) 0 0;(-1/a) 0 0 (-1/a);0 0 0 (1/d); 0 (1/b) (-1/b) (-1/(b*c))]
B = [0; (1/a); 0; 0]
C = [0 0 1 0]
D = [0]

%calculate poles (eigen values) of matrix A
poles = eig(A)
rp = real(poles)
abs_rp = abs(rp)
min_pole = min(abs_rp)

%calculate dominant time constant
d_tc = 1 / min_pole

%settling time
ts = d_tc*4

%nun => numerator polynomial
%den => denominator polynomial
[nun,den] = ss2tf(A,B,C,D)
```

1 2.2 (a,b,c,d,e) **15 / 15**

✓ **- 0 pts** *Correct*

```
%find the roots of nun & den
nun_roots = roots(nun)
den_roots = roots(den)

%bode plot with grid on
grid on
bode(nun,den)
```

<u>Output for Section 2</u>

Matrix Calculation

```
A =

           0     1000000           0           0
       -1000           0           0       -1000
           0           0           0          25
           0     1000000    -1000000      -10000


B =

           0
        1000
           0
           0


C =

     0     0     1     0


D =

     0
```

fig. 3 - Matrix [A]

<u>Poles of [A]</u>

```
poles =

   1.0e+04 *

  -0.2500 + 4.4510i
  -0.2500 - 4.4510i
  -0.2500 + 0.2516i
  -0.2500 - 0.2516i
```

fig. 4 - Poles of [A]

2 2.3 (b,c) **15 / 15**

✓ **- 0 pts** *Correct*

Settling time T_s

```
ts =

     0.0016
```

fig. 5 - T_s

Roots vs Pole

The calculated roots do match the poles (eigenvalues) of [A]

```
den_roots =

   1.0e+04 *

  -0.2500 + 4.4510i
  -0.2500 - 4.4510i
  -0.2500 + 0.2516i
  -0.2500 - 0.2516i
```

fig. 6 - Roots vs Poles

3 2.4 (b,c,d) **15 / 15**

✓ **- 0 pts** *Correct*

Settling time T_s

```
ts =

    0.0016
```

fig. 5 - T_s

Roots vs Pole

The calculated roots do match the poles (eigenvalues) of [A]

```
den_roots =

   1.0e+04 *

  -0.2500 + 4.4510i
  -0.2500 - 4.4510i
  -0.2500 + 0.2516i
  -0.2500 - 0.2516i
```

fig. 6 - Roots vs Poles

4 2.4 (e) **20 / 20**

✓ **- 0 pts** *Correct*

Part 3

Bode Plot

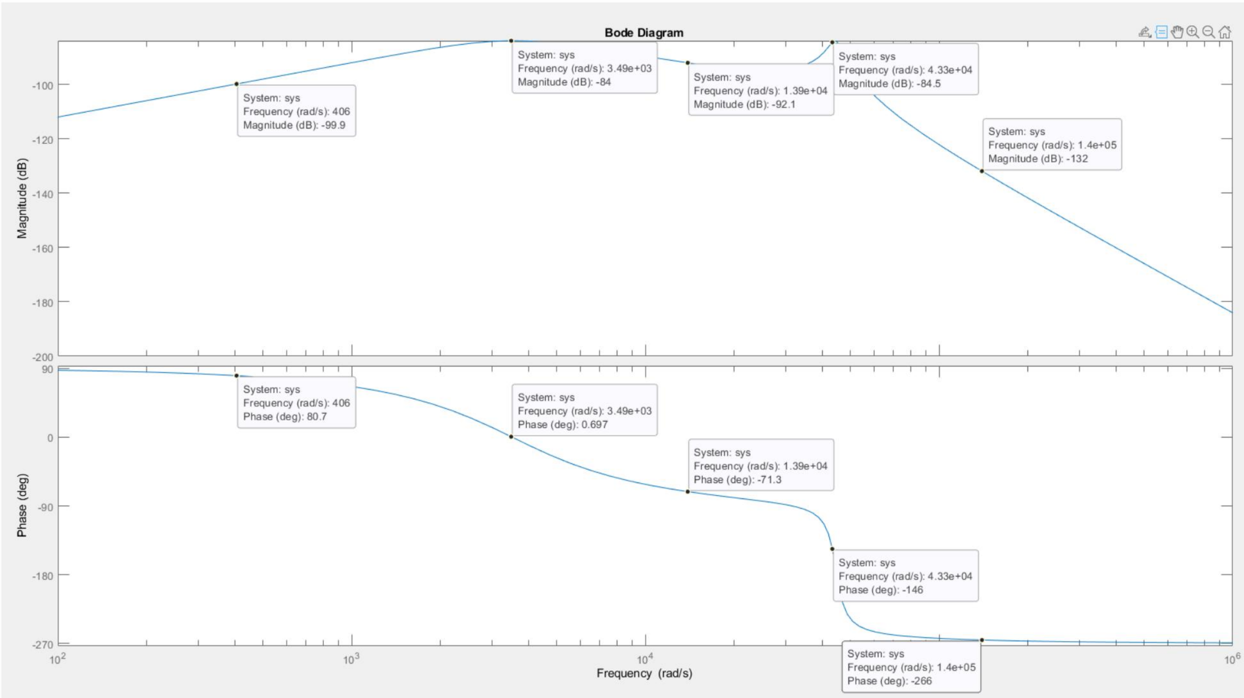

fig. 7 - Bode Plot

Selected Frequencies

	Frequency [rad/s]	Magnitude	Phase
f_1	406	-99.9	80.7
f_{p1}	$3.49\,x10^3$	-84	0.697
f_2	$1.39\,x10^4$	-92.1	-71.3
f_{p2}	$4.33\,x10^4$	-84.5	-146
f_3	$1.4\,x10^5$	-132	-266

fig. 8 - Table of Frequencies

Part 4

The frequency I selected to evaluate was f_2 with a frequency (rad/s) of $1.4\ x10^4$. Figure X is a screenshot of the adjusted output of f_2 as seen with using the Scope tool with Simulink. It took a great deal of tweaking the settings to make the output visible. Calculations for T_s, magnitude and phase were made using the trace selection tool and comparing the output at various points.

For T_s, the time at which the signal achieved steady state was approximately $1.6x10^{-3}$s (fig. x), which matches the calculated value for T_s from part 2. Magnitude relates to the change in ΔY and phase is calculated $360 * \frac{\Delta T}{period}$.

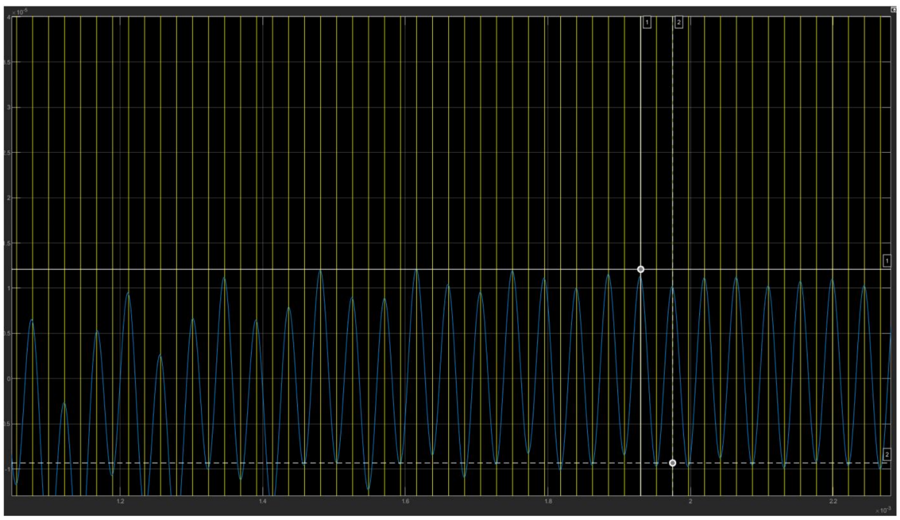

fig. 9 - Scope output of f_2

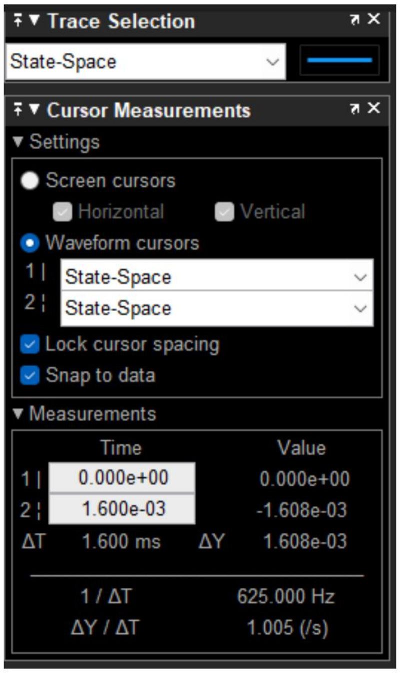

fig. 10 - Trace output

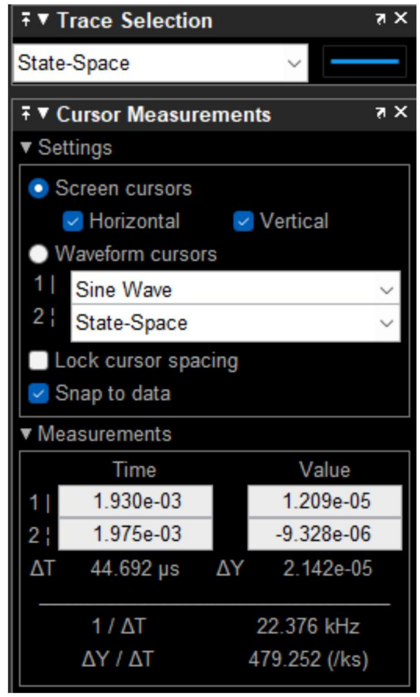

fig. 11 - Trace Output

5 3 **10 / 10**

✓ **- 0 pts** *Correct*

Report

Results:

Part 1 (Prelab)
<u>Bond Graph</u>

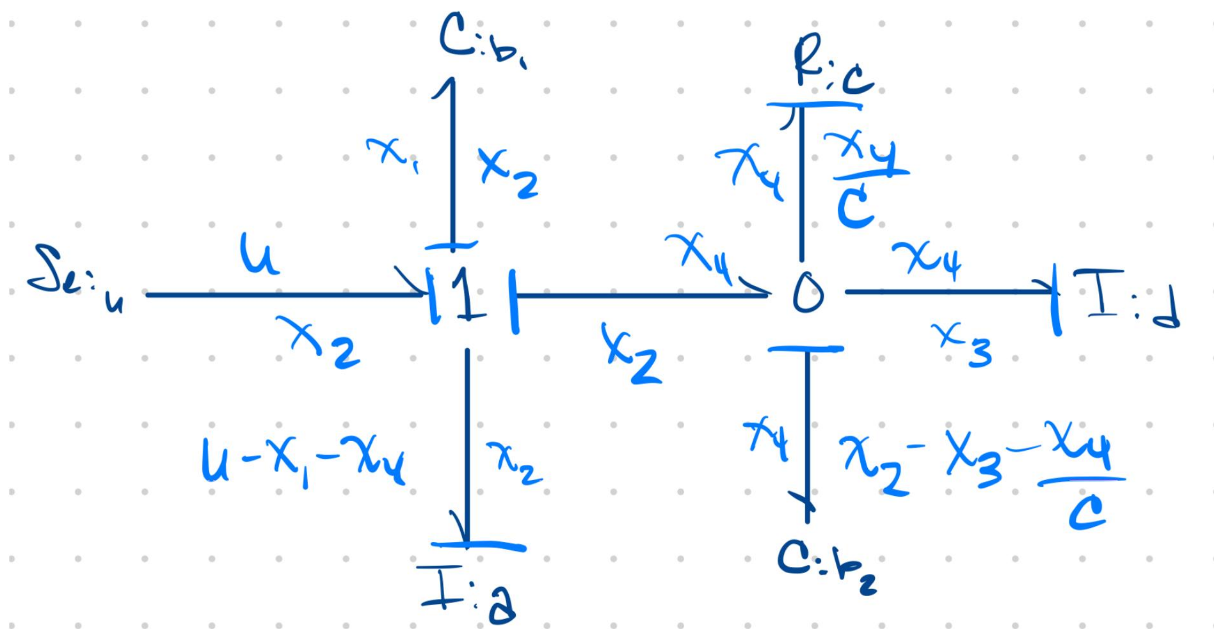

fig. 1 - Bond Graph

<u>State Space Model</u>

$$\dot{x} = \begin{bmatrix} 1/b_1 \cdot (x_2) \\ 1/a \cdot (u - x_1 - x_4) \\ 1/d \cdot (x_4) \\ 1/b_2 \cdot (x_2 - x_3 - x_4/c) \end{bmatrix} = \begin{bmatrix} 0 & 1/b_1 & 0 & 0 \\ -1/a & 0 & 0 & -1/a \\ 0 & 0 & 0 & 1/d \\ 0 & 1/b_2 & -1/b_2 & -1/cb_2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} + \begin{bmatrix} 0 \\ 1/a \\ 0 \\ 0 \end{bmatrix} u$$

$$y = \begin{bmatrix} 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} + 0u$$

Given parameters:
$a = 10e^{-4};\ b = 1e^{-6};\ c = 100;\ d = 40e^{-3}$

6 Prelab (points assigned based on Prelab completion prior to lab) 25 / 25

✓ **- 0 pts** *All questions complete before lab*

Simulation as an Engineer's Problem Solving Tool
(Linear State Space Block)

Lab 4 - EE 105
2/23/2023

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