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```
clear all
close all
clc

cd code
```

Introduction

The purpose of assignment 4 is to use modified nodal analysis to simulate the two circuits given to me.

Part 1 Introduction

For part 1 I created the G and C by performing modified nodal analysis on the circuit given in figure 1 of the assignment. The next objective was to sweep the input voltage from -10V to 10V and plot the output voltage and the voltage at node 3. The next objective was to plot the gain of the circuit in dB as a function of angular frequency. The final objective was to plot the input voltage and output voltage in the time and frequency domain for the following input voltage signals.

A. A step that transitions from 0 to 1 at 0.03s.

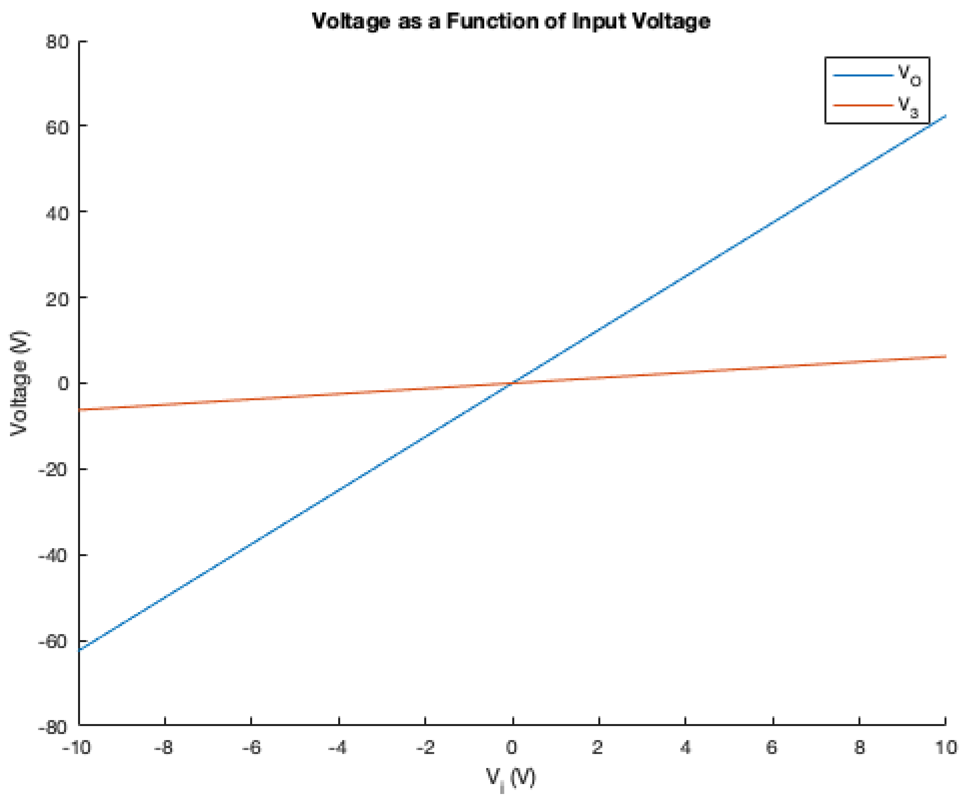
B. A sin(2(pi)f t) function with f = 1/(0.03) 1/s. Try a few other frequencies. Comment.

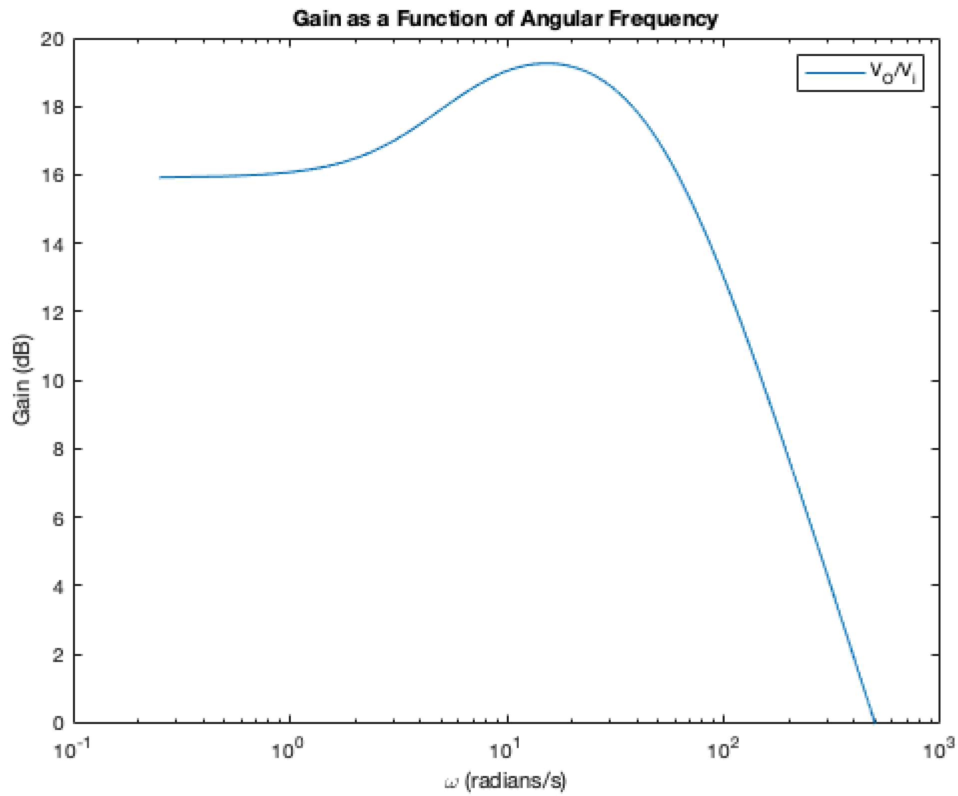
C. A Gaussian pulse with a magnitude of 1, std dev. of 0.03s and a delay of 0.1s.

Part 1 Figures and Command Line Outputs

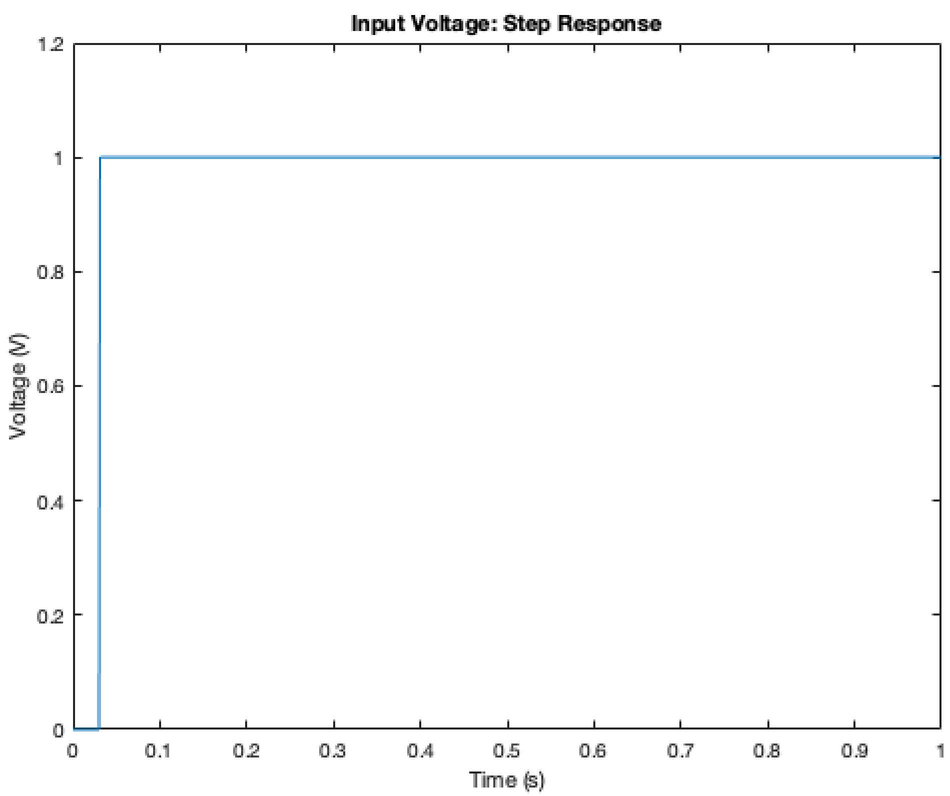
```
cd part1

part1

cd ..

G =
```

```
         1            0            0            0            0
    0
        -1          1.5            0            0            0
    1
         0            0          0.1            0            0
   -1
         0            0          -10            1            0
    0
         0            0            0          -10       10.001
    0
         0           -1            1            0            0
    0
C =
         0            0            0            0            0
    0
     -0.25         0.25            0            0            0
    0
         0            0            0            0            0
    0
         0            0            0            0            0
    0
         0            0            0            0            0
    0
         0            0            0            0            0
  0.2
```

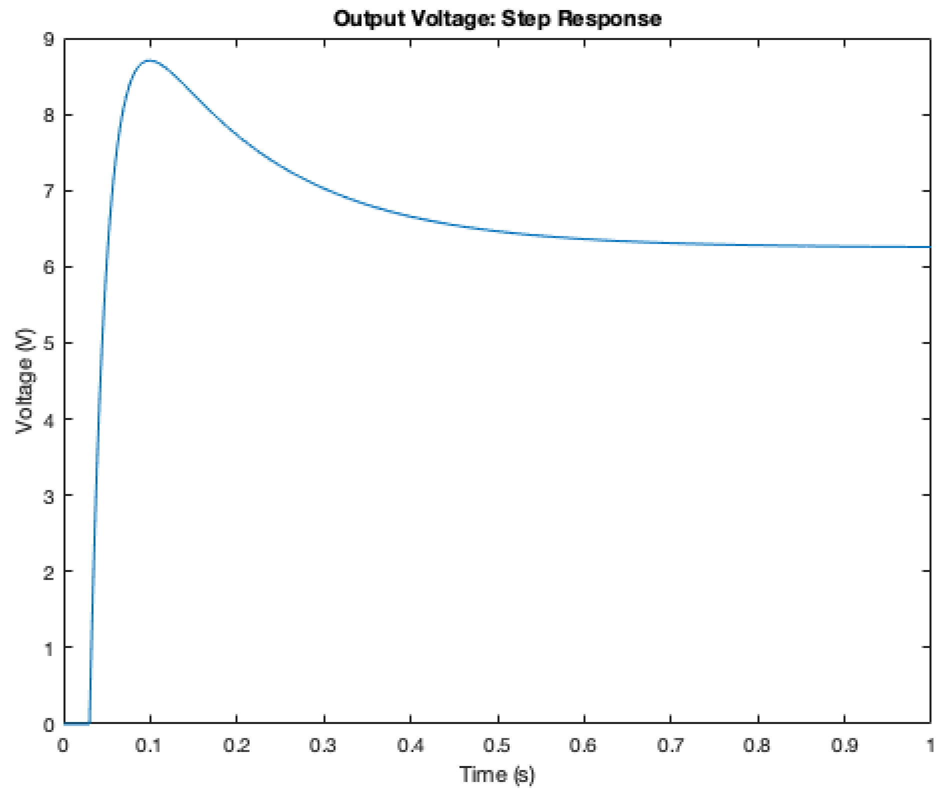


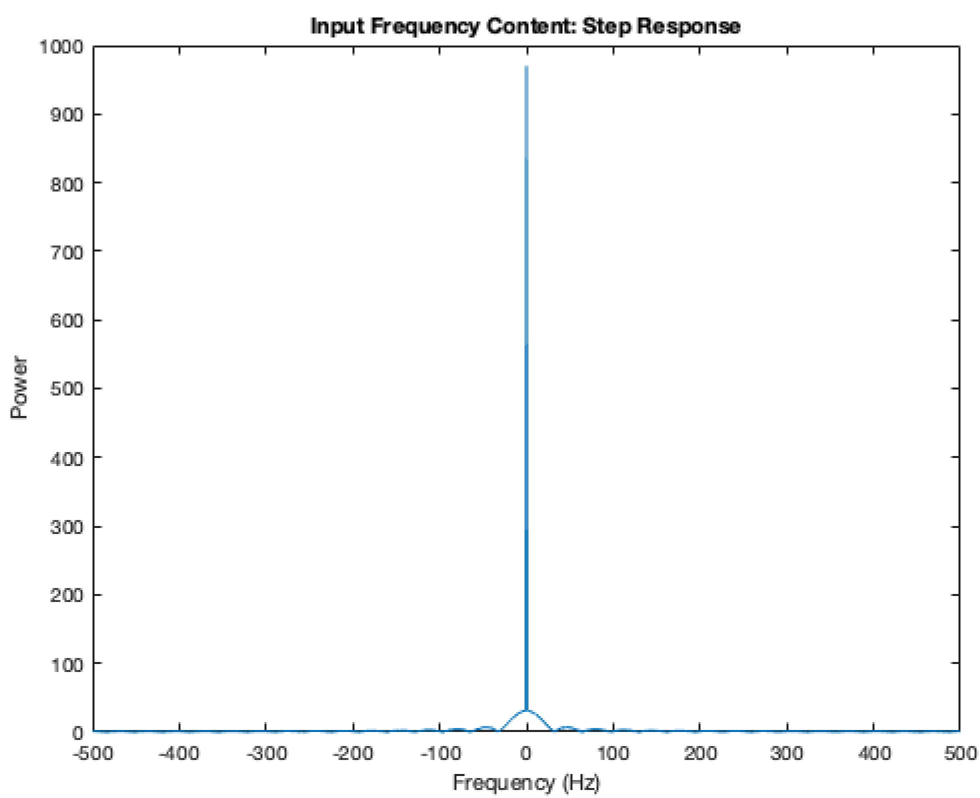


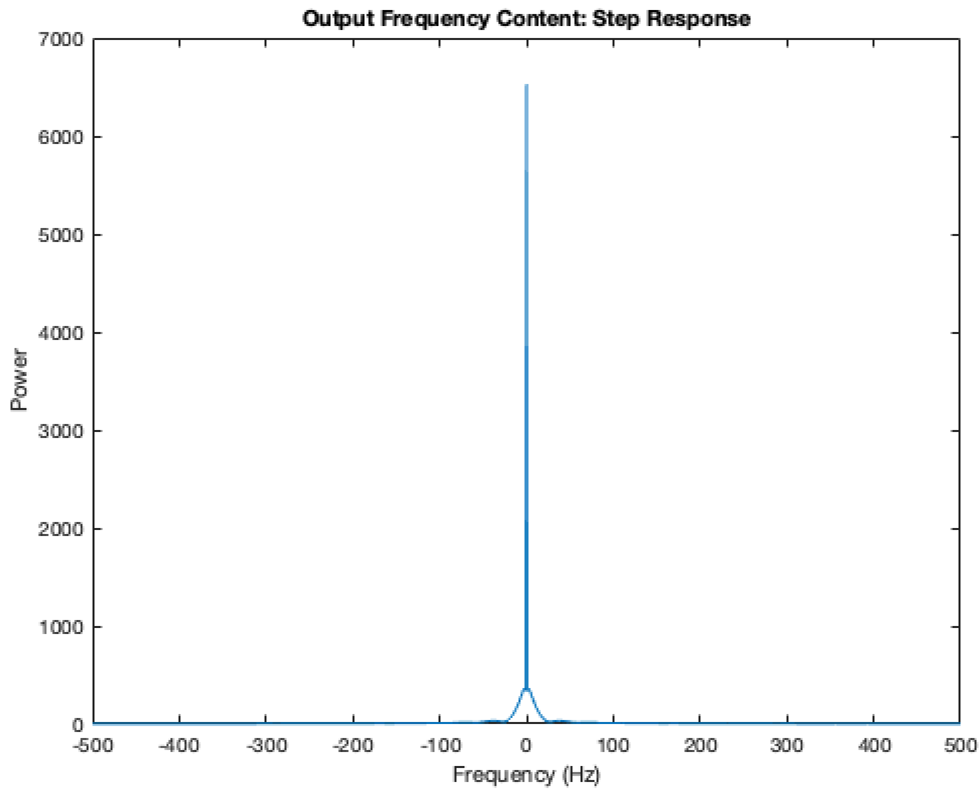
Gain as a Function of Angular Frequency
V_O/V_I
Gain (dB)
ω (radians/s)
20
18
16
14
12
10
8
6
4
2
0
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}

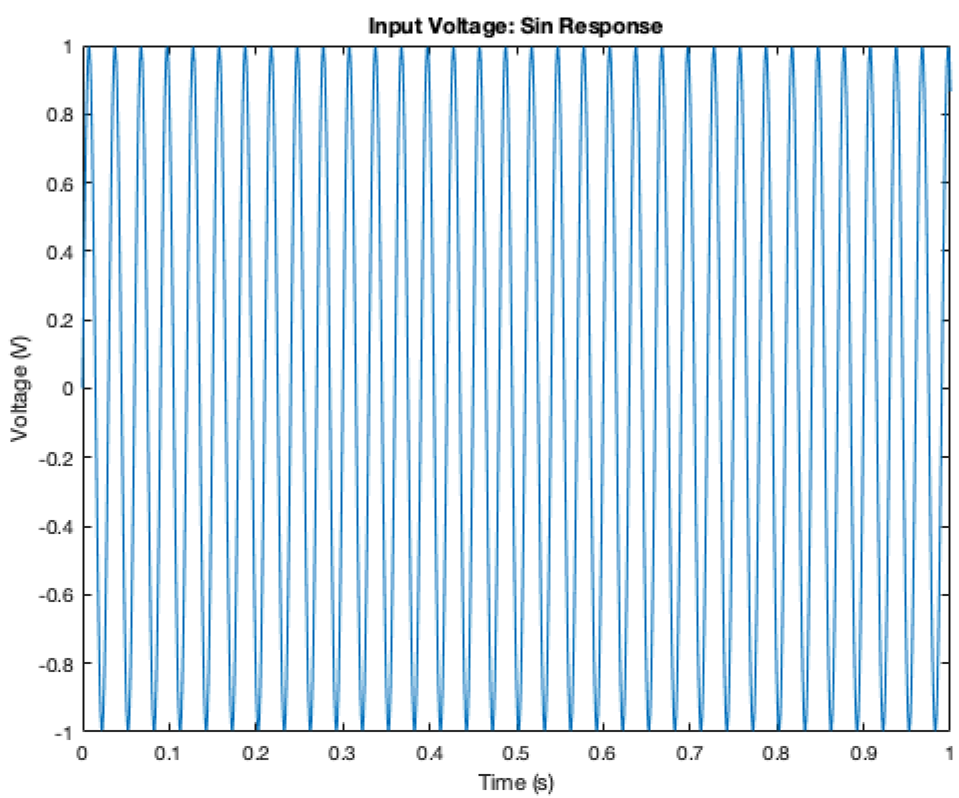


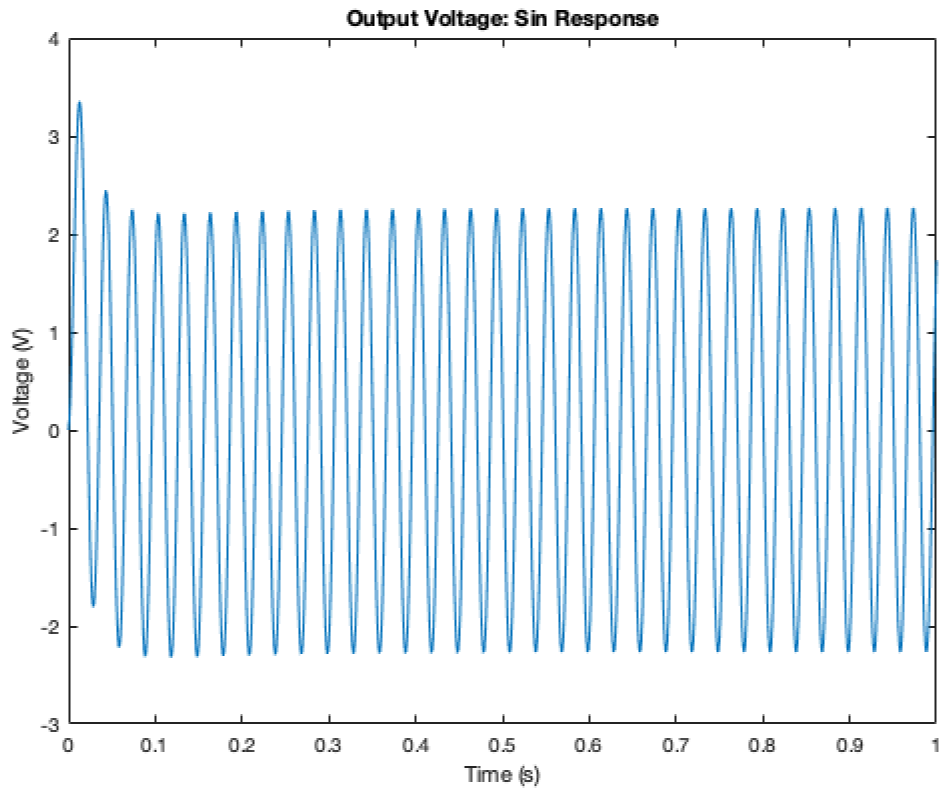
Input Voltage: Step Response
Voltage (V)
Time (s)
1.2
1
0.8
0.6
0.4
0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

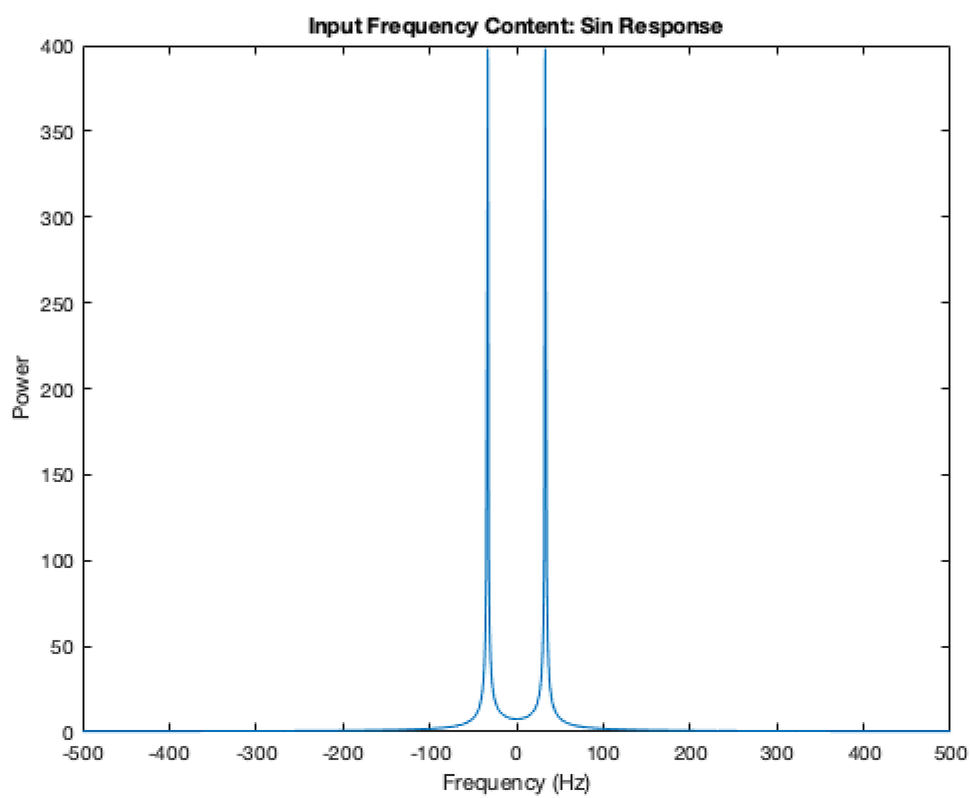

Output Voltage: Step Response
Voltage (V)
Time (s)
0
1
2
3
4
5
6
7
8
9
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

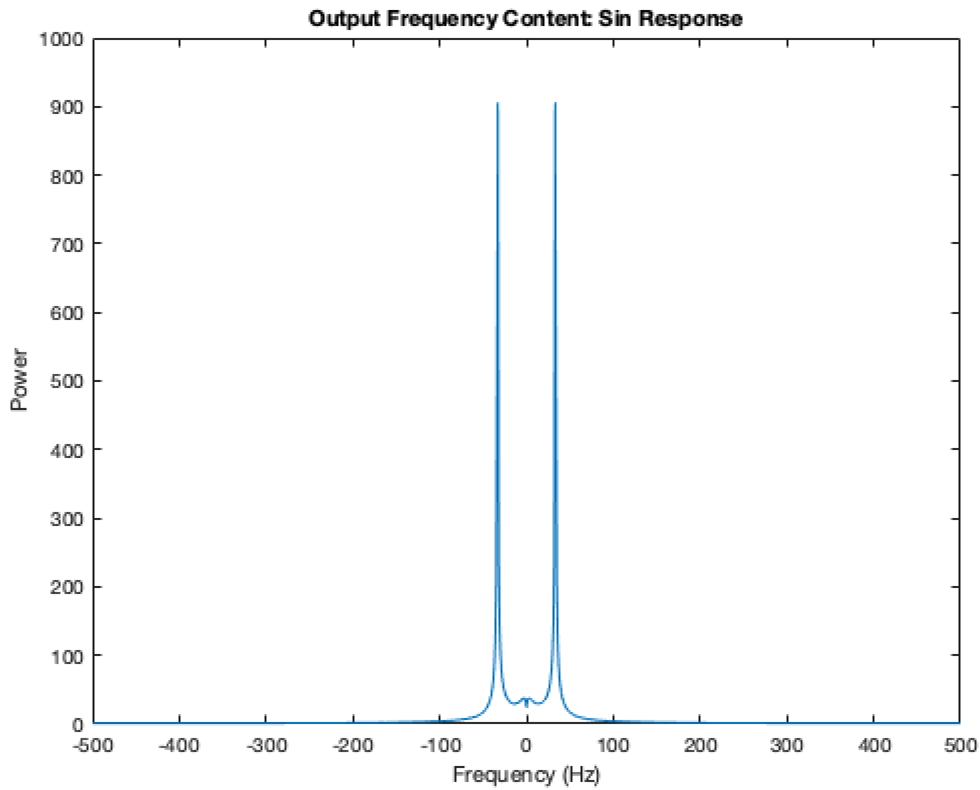

Input Frequency Content: Step Response
Power
Frequency (Hz)
0
100
200
300
400
500
600
700
800
900
1000
-500
-400
-300
-200
-100
0
100
200
300
400
500

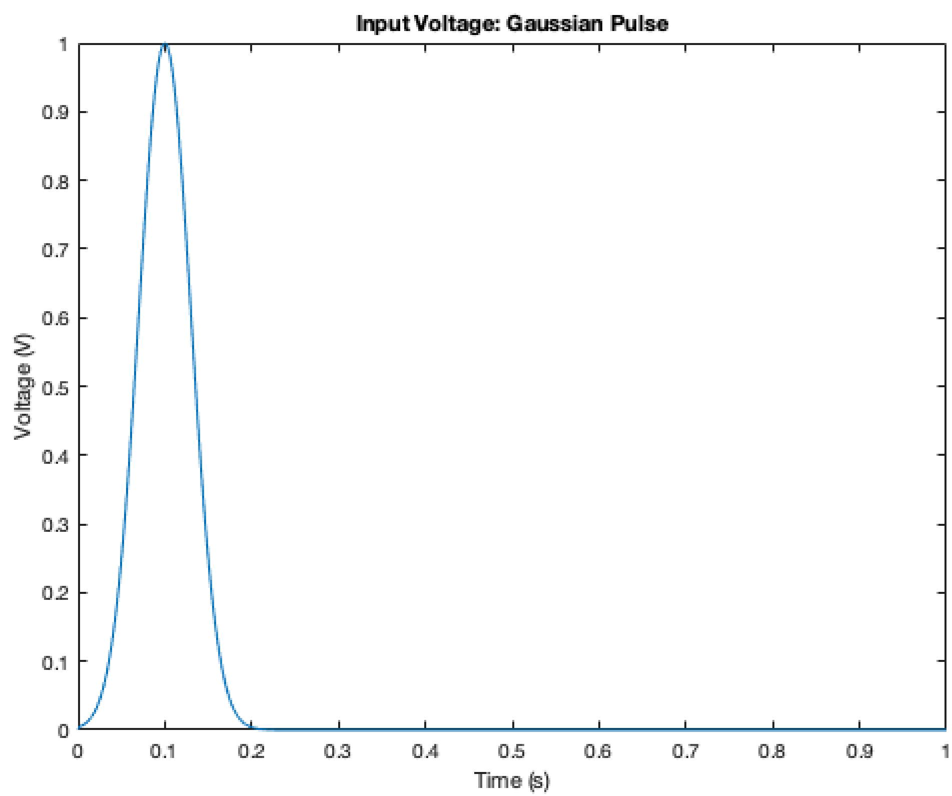

Output Frequency Content: Step Response
Power
Frequency (Hz)
7000
6000
5000
4000
3000
2000
1000
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

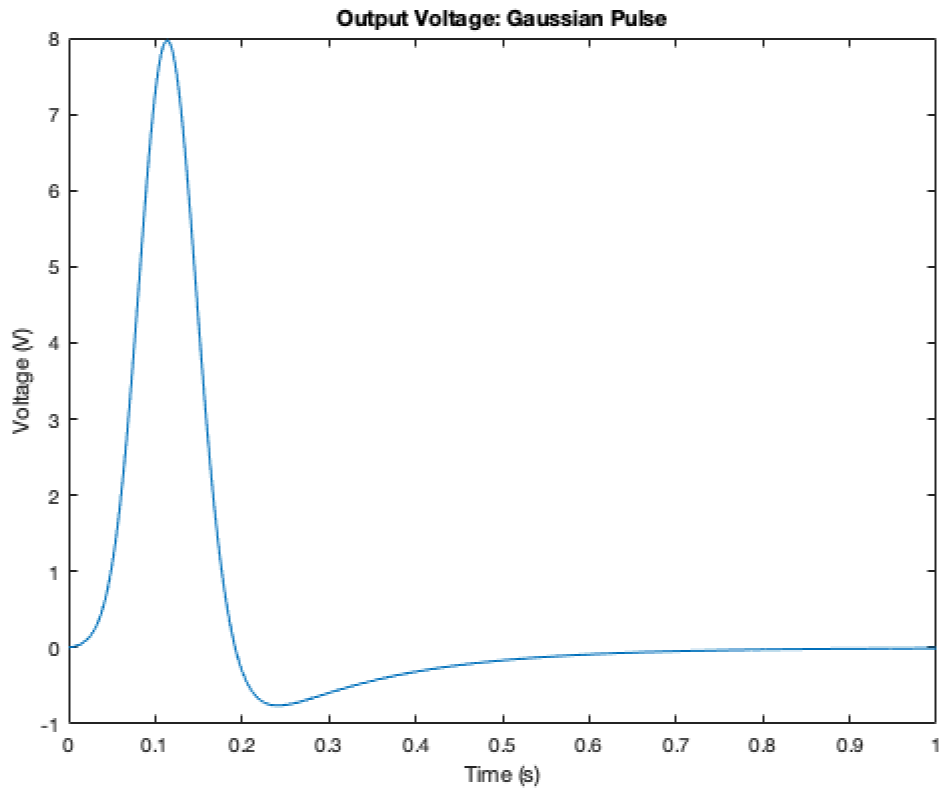

Input Voltage: Sin Response
Voltage (V)
Time (s)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

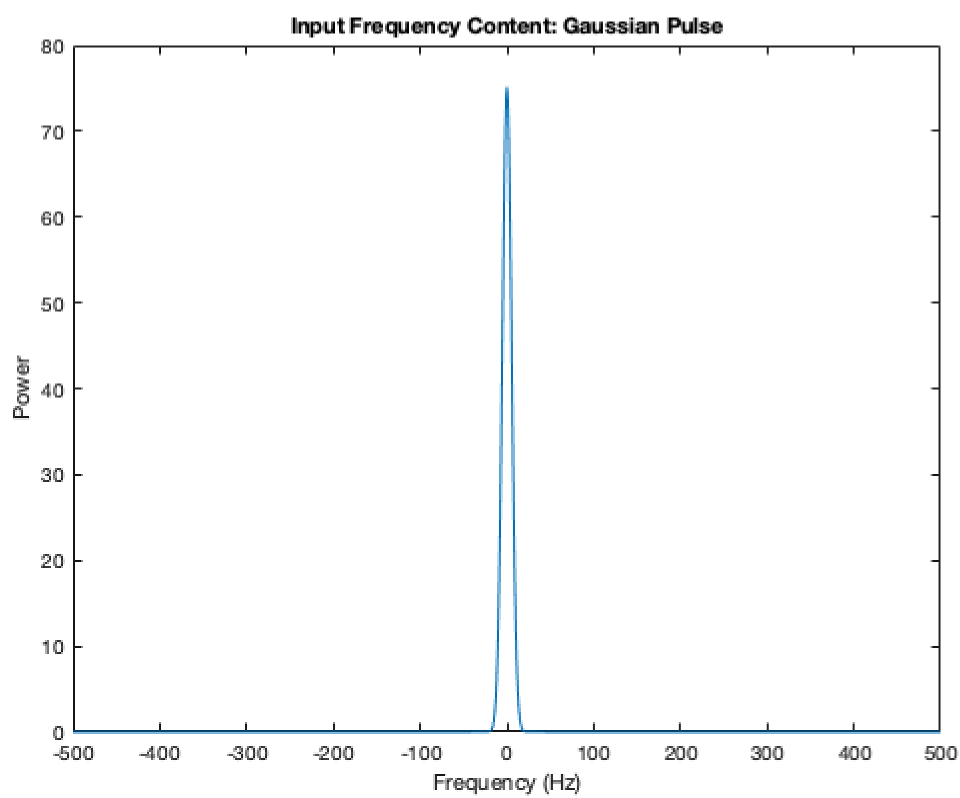

Output Voltage: Sin Response
Voltage (V)
Time (s)
4
3
2
1
0
-1
-2
-3
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

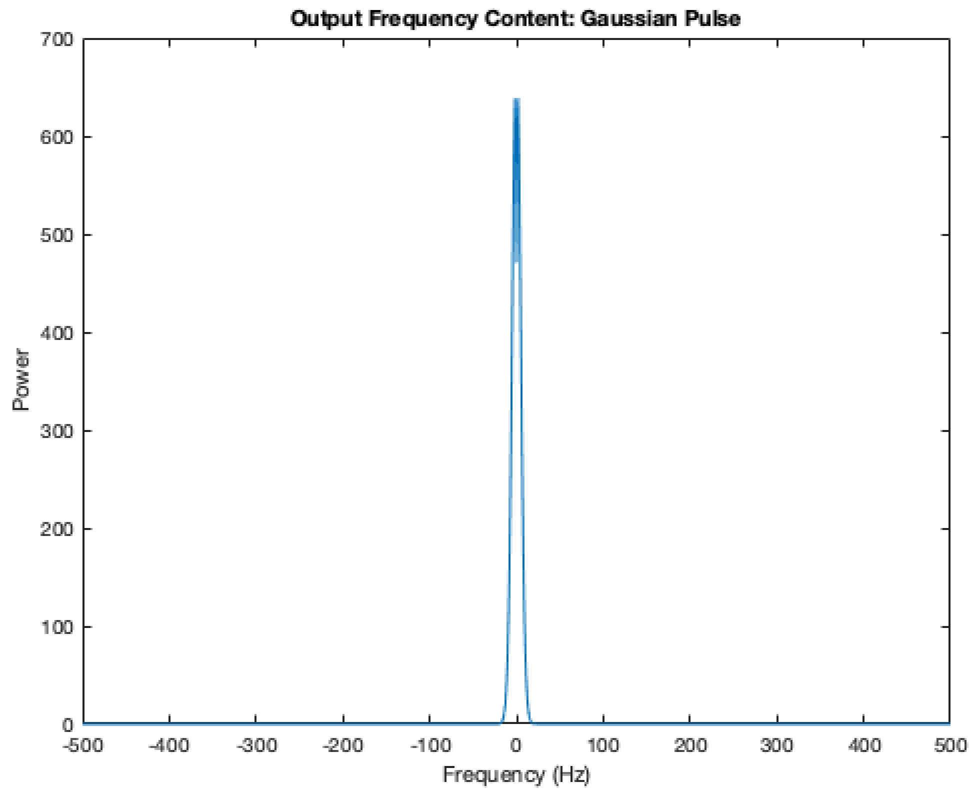

Input Frequency Content: Sin Response
Power
Frequency (Hz)
400
350
300
250
200
150
100
50
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Output Frequency Content: Sin Response
Power
Frequency (Hz)
1000
900
800
700
600
500
400
300
200
100
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Input Voltage: Gaussian Pulse
Voltage (V)
Time (s)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Output Voltage: Gaussian Pulse
Voltage (V)
Time (s)
8
7
6
5
4
3
2
1
0
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Input Frequency Content: Gaussian Pulse
Power
Frequency (Hz)
80
70
60
50
40
30
20
10
0
-500
-400
-300
-200
-100
0
100
200
300
400
500



Part 1 Conclusion

When looking at the gain as a function of angular frequency, it can be concluded that the circuit is a low pass filter. With a low pass filter, you would expect low frequencies to be transmitted and high frequencies to be attenuated. All the plots generated for part one are as expected. When looking at the DC sweep both the output voltage and the voltage at node 3 increase linearly with the input voltage, which makes sense because the circuit is linear.

Part 2 Introduction

For part 2 I created the G and C by performing modified nodal analysis on the circuit given in figure 2 of the assignment where In=0.001*randn() and Cn=0.00001. The next objective was to plot the input voltage and output voltage in the time and frequency domain for a Gaussian pulse input voltage. 3 Plots of the output voltage with different values of Cn were created. Final 3 Plots of the output voltage with different time steps were created.

Part 2 Figures and Command Line Outputs

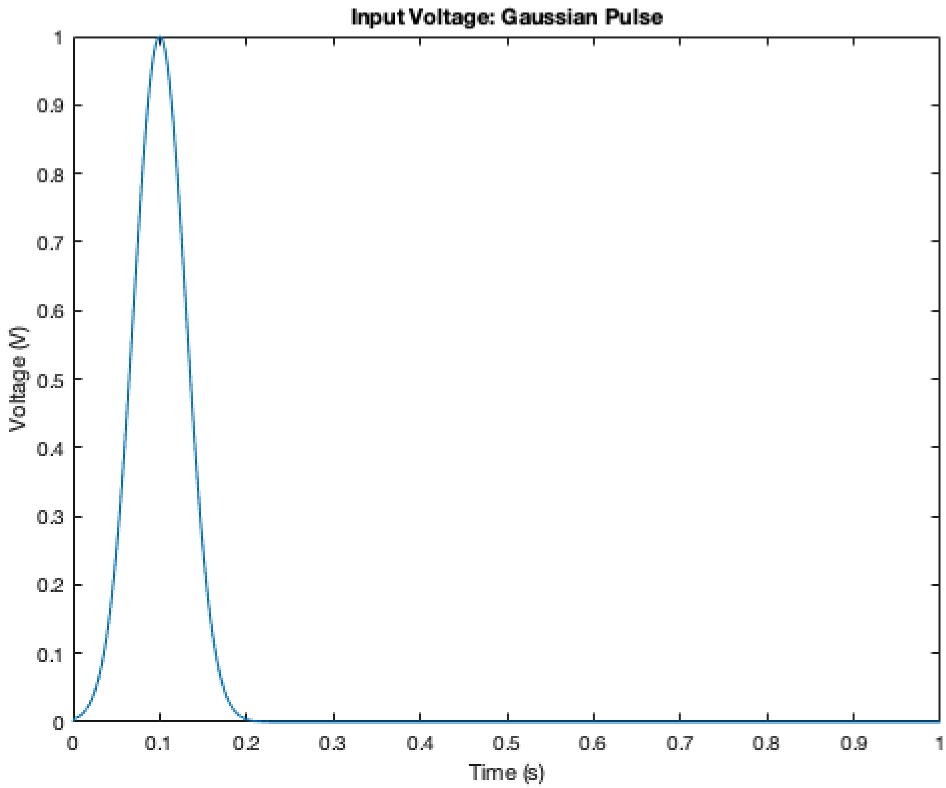
```
cd part2
```

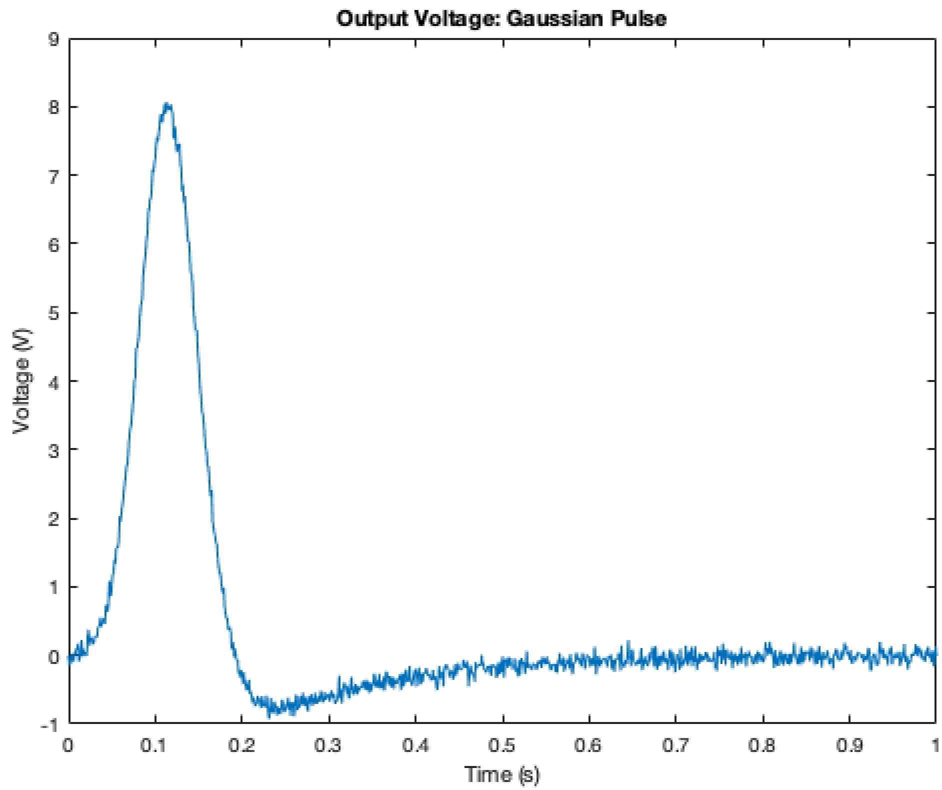
```
part2
```

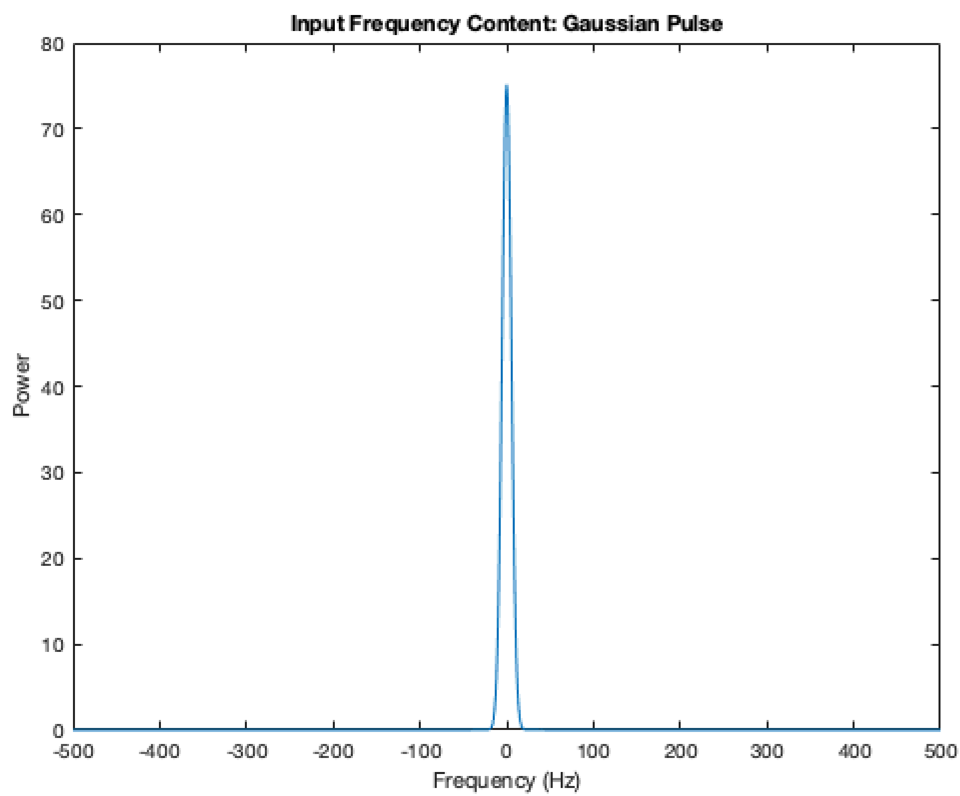
```
cd ..
```

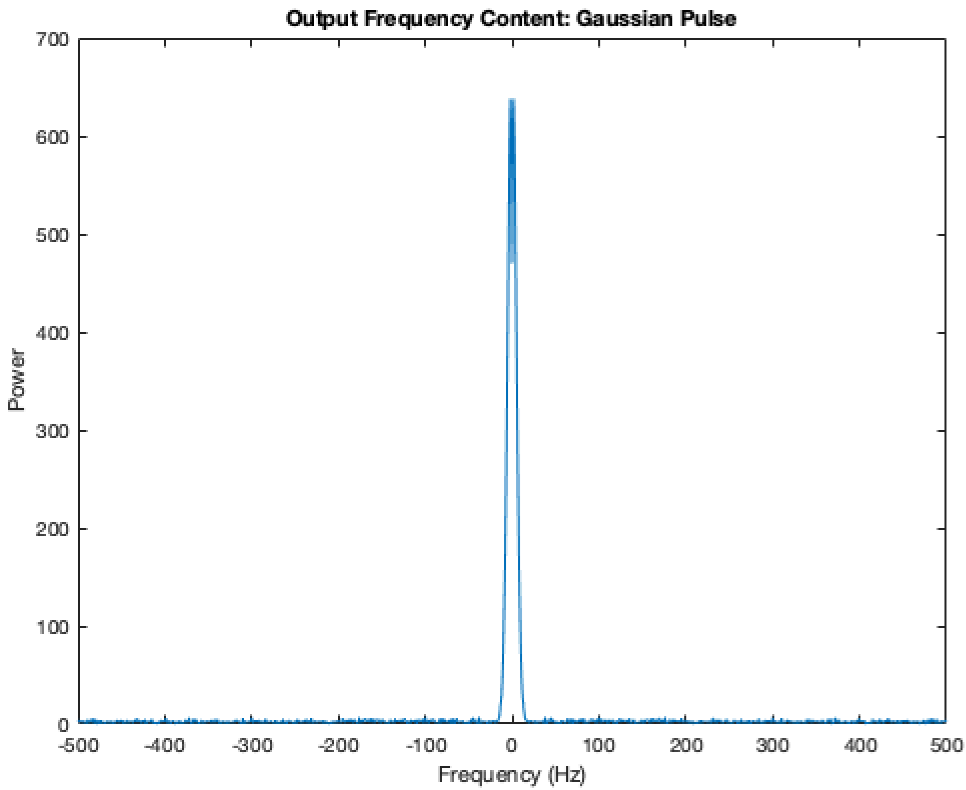
```
C =
```

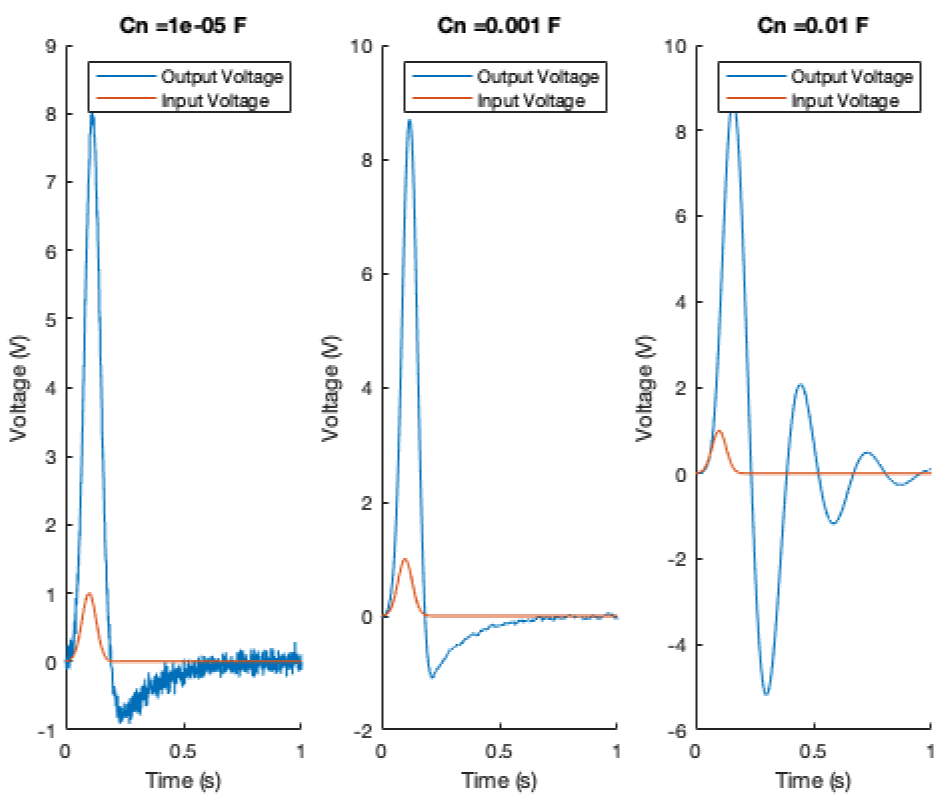
```
         0            0            0            0            0
    0
     -0.25         0.25            0            0            0
    0
         0            0        1e-05            0            0
    0
         0            0            0            0            0
    0
         0            0            0            0            0
    0
         0            0            0            0            0
  0.2
```

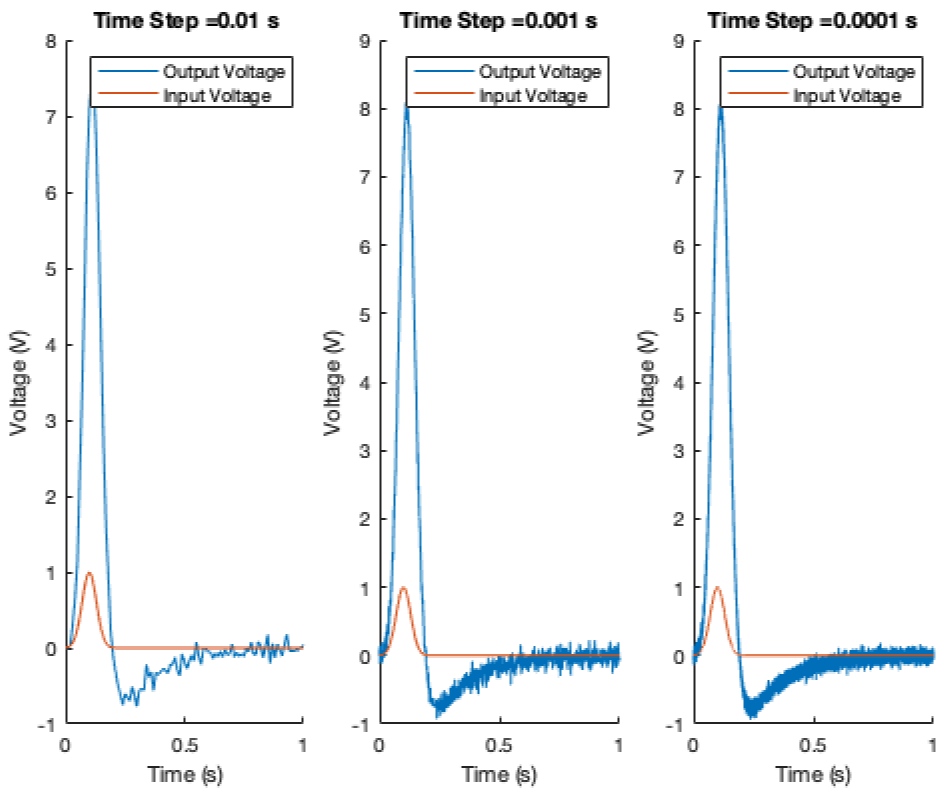



Output Voltage: Gaussian Pulse
Voltage (V)
Time (s)
9
8
7
6
5
4
3
2
1
0
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Input Frequency Content: Gaussian Pulse
Power
Frequency (Hz)
80
70
60
50
40
30
20
10
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Output Frequency Content: Gaussian Pulse
Power
Frequency (Hz)
700
600
500
400
300
200
100
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Cn =1e-05 F
Cn =0.001 F
Cn =0.01 F
Output Voltage
Input Voltage
Voltage (V)
Time (s)
0
0.5
1



Part 2 Conclusion

```
The results of part two are as expected. When a capacitor (Cn) and
current source (In) were added to the circuit in parallel with
R3 thermal noise was visible in the output signal frequency and
time domain representation. When the value of Cn has increased the
bandwidth of the noise was seen to decrease. One of the effects of
increasing the time step is that the output signal becomes more
distorted. This means to perform the best analysis a small time
step should be used. Another effect of increasing the time step is
that the current of In changes less frequently meaning less
thermal noise is visible.
```

How part 3 would be implemented

The first step would be to add the none linear parts of the circuit into a matrix called B so that the final equation for the circuit can be written in the form

$$C\frac{dV}{dt} + G\hat{V} + \hat{B}(\hat{V}) = \hat{F}(t)$$

Next, you need to form the Jacobian (J) which is the partial derivative of each of the equations in the B matrix with respect to the variables in the V matrix.

Next, rearrange the equation and put the matrix in the form as shown below

$$\left(\frac{\widehat{C}}{\Delta t}+\widehat{G}\right)\widehat{V_n}-\frac{C}{\Delta t}\widehat{V_{n-1}}-\widehat{B}(\widehat{V})-\widehat{F}(t)=0$$

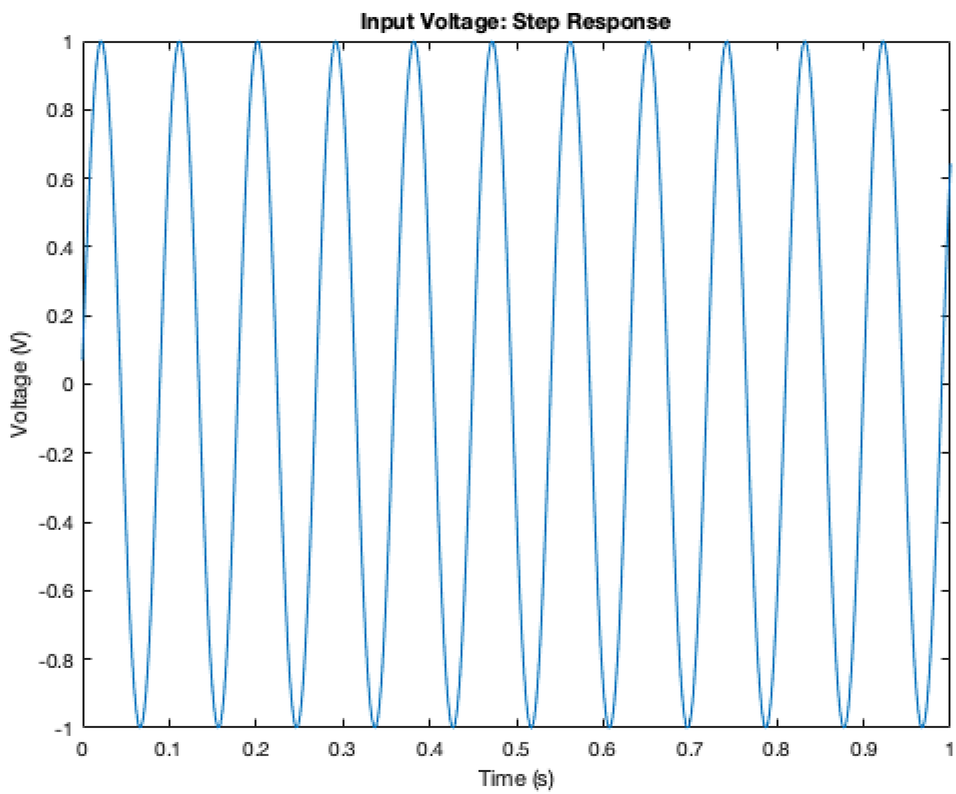
Using the above equation, the Jacobian, and Newton Raphson method the voltage at each time step can be solved for. The plot of the output and input signal in the time and frequency domain are given below for a sin wave.

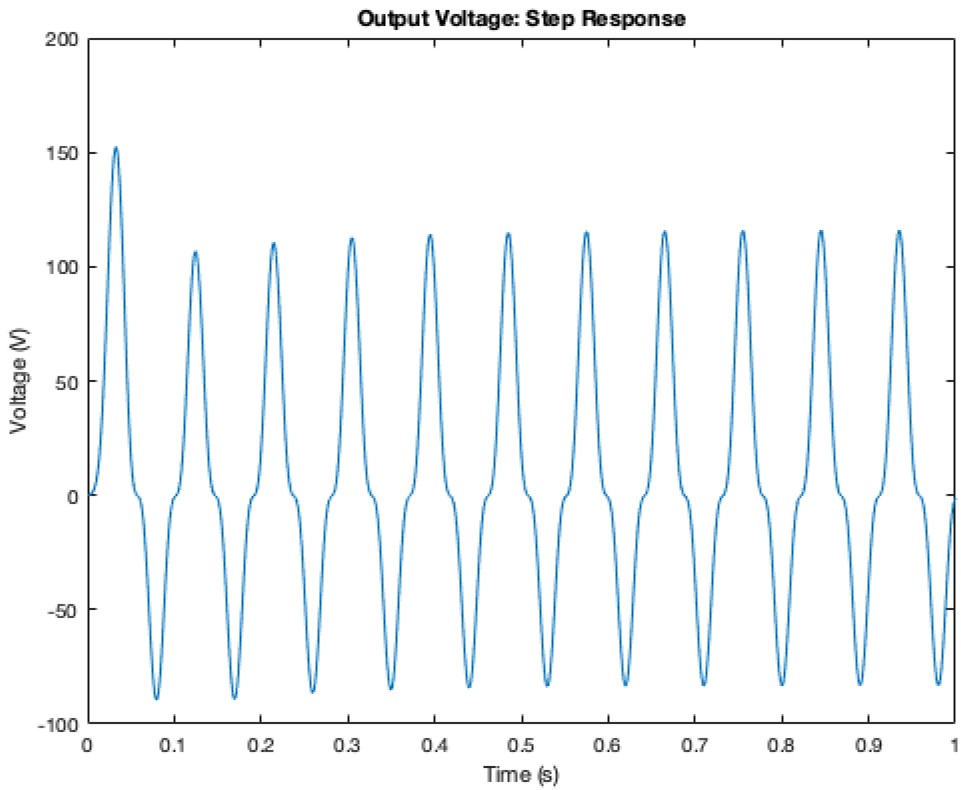
Part 3 Figures and Command Line Outputs

```
cd part3
```

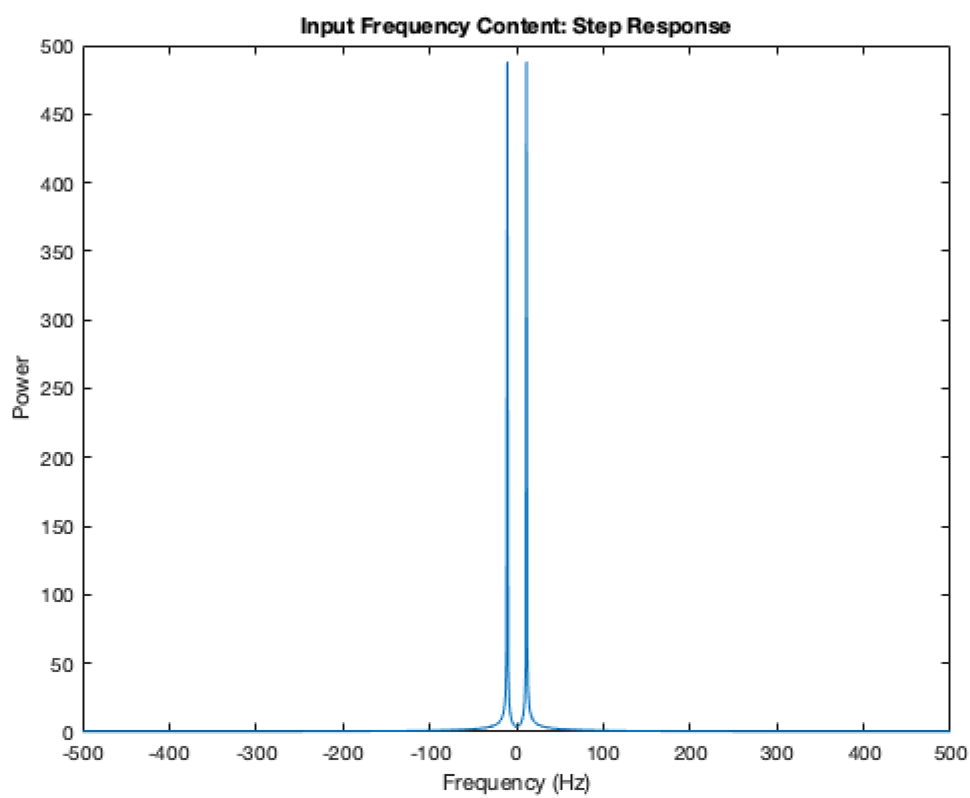
```
part3
```

```
cd ..
```

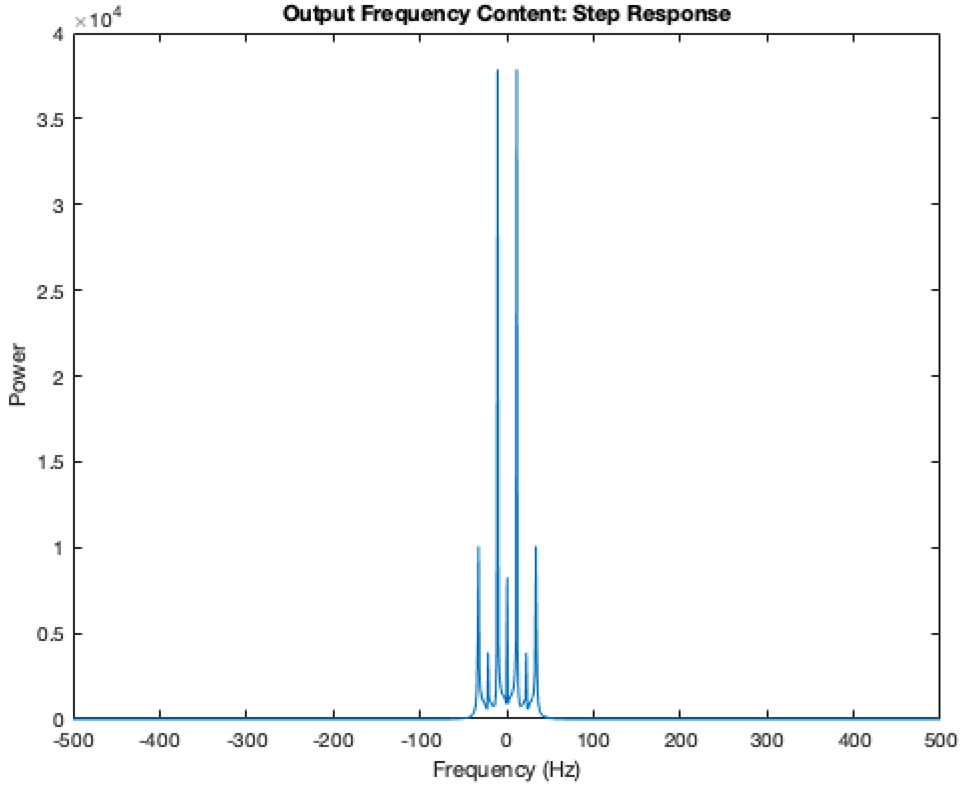




Output Voltage: Step Response
Voltage (V)
Time (s)



Input Frequency Content: Step Response
Power
Frequency (Hz)



Conclusion

Overall Assignment 4 was a success. I was able to complete every objective and my results matched my expectation.

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