Ryan Lindsay 101038101 4/11/2021

1 Part 1

The step of the assignment was to find a value for resistor 3 by completing a simulation in assignment 3. I was unable to obtain a reasonable value for the resistance, so I decided to go with a value of 20 Ω

The first portion of the assignment is simply using the code from the MNPA that was done previously. C and G matrices needed to be determined from the circuit given in the assignment. The following figure shows the selected C and G matrices.

```
%Matrix Definitions

C = [0 0 0 0 0 0 0;
   -Cap Cap 0 0 0 0 0;
    0 0 -L 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 0 0 0 0;];

G = [1 0 0 0 0 0 0;
   -G2 G1+G2 -1 0 0 0 0;
    0 1 0 -1 0 0 0;
    0 0 -1 G3 0 0 0;
    0 0 0 0 -alpha 1 0;
    0 0 0 G3 -1 0 0;
    0 0 0 0 0 -G4 G4+GO];
```

The next question asks to do a DC and AC sweep of the circuit. The following block of code shows how this has been done.

```
for v = -10:0.1:10
    F(1,1)=v;
    VDC=G\F;

    figure(1)
    plot (v, VDC(7,1),'b.')
    plot(v, VDC(4,1), 'g.')
    hold on
end
    title('DC Sweep')
    xlabel('Vin (V)')
    ylabel('Voltage (V)')
    legend('V3','VO')

    hold off

w = logspace(0,5,500);
F(1,1) = 1;

for i = 1:length(w)
    VAC = (G+C*1j*w(i))\F;
    figure(3)
    semilogx(w(i), abs(VAC(7,1)), 'b.')
    hold on
end

    xlabel('log (w)')
    ylabel('VO (V)')
    title('AC Sweep')
    hold off

for i = 1:length(w)
    VAC = (G+C*1j*w(i))\F;
    gain = 20*log(abs(VAC(7,1))/F(1));

    figure(4)
    plot(i, gain, 'g.')
    hold on
end
    title('Gain Vo/Vin ')
    xlabel('Step')
    ylabel('Gain (dB)')
    hold off
```

The code produced the following two plots.

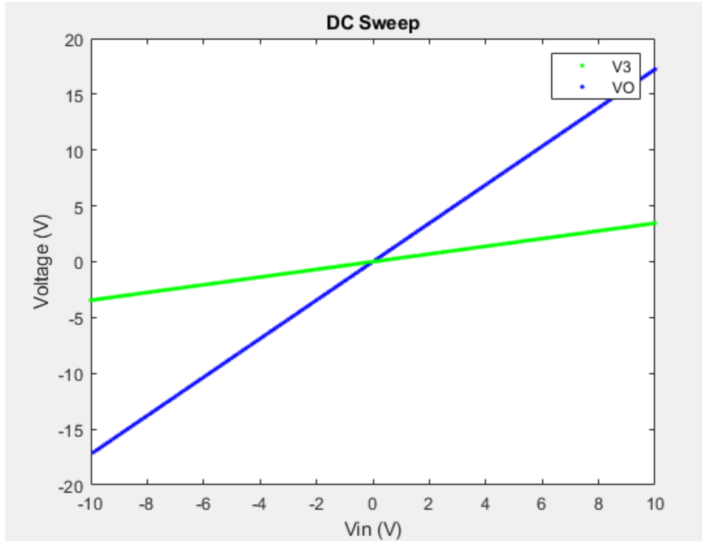

Figure 1: DC Sweep

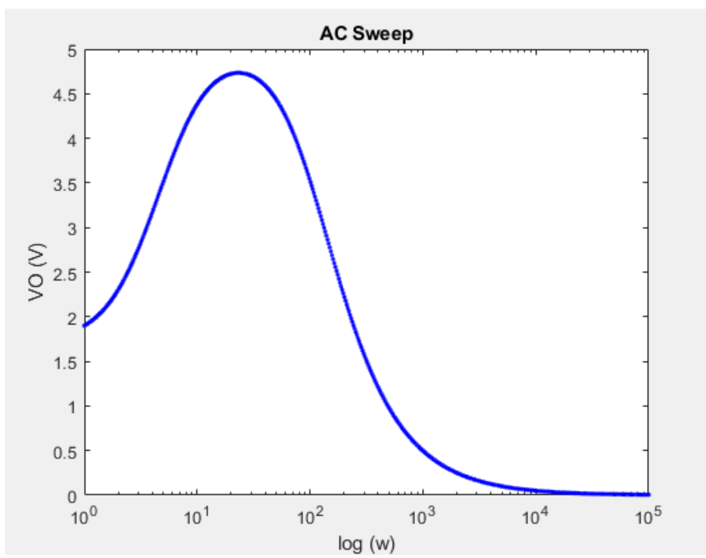

Figure 2: AC Sweep

Now that the sweeps have been completed, the gain can now be plotted. It can be seen in the figure below.

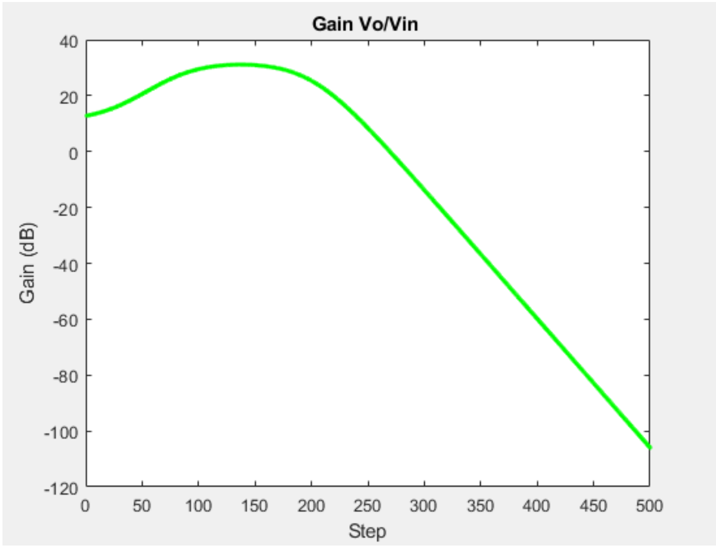

Figure 3: Gain Plot

By inspection the circuit appears to be an RLC circuit as it contains resistors, capacitors and inductors. This should lead to a response that resembles a filter when simulated.

From this, three different signals were used and their behaviour was examined. The first signal is a step that starts at 0, and transitions to 1 at 0.03 seconds. The code and respective plot can be seen in the two figures below.

```
F = [Vin; 0; 0; 0; 0; 0; 0;];

V0 = zeros(7,steps);
V1 = zeros(7,1);

Xval = 1:steps;

% Sim A

for i = 1:steps

    if i <30

        V0(:,i) = 0;

    elseif i == 30

        V0(:,i) = (C./dt+G)\(F+C*V1/dt);

    else

        V0(:,i) = (C./dt+G)\(F+C*Vprev/dt);

    end

    Vprev = V0(:,i);

end

figure(6)
plot(Xval, V0(7,:),'b')
hold on
plot(Xval, V0(1,:),'r')
title(' Plot of Vin and Vout')
xlabel('Time (ms)')
ylabel('Voltage')
legend('Vout','Vin')
```

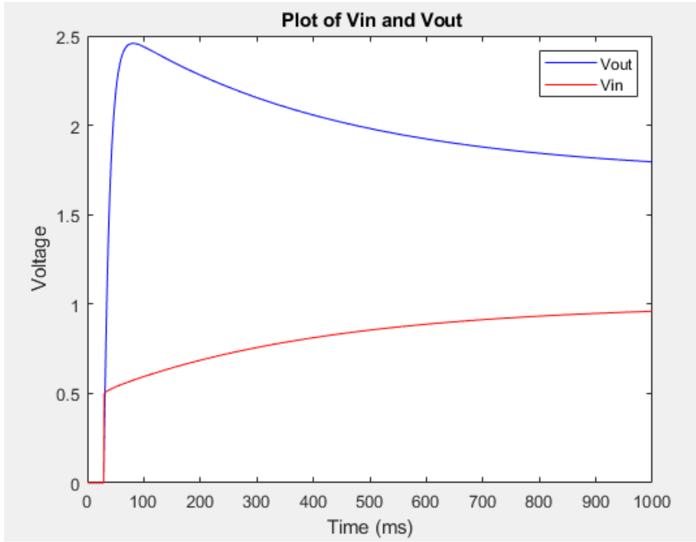

Figure 4: Step from 0 to 1

The second input signal was a sine pulse. The code and plots can be seen in the two figures below.

```
V2 = zeros(7,steps);
freq = zeros(7,1);


Vprev = zeros(7,1);

for i =1:steps

freq(1) = sin(2*pi*(1/0.03)*i/steps);
V2(:,i) = (C./dt+G)\(freq+C*Vprev/dt);

Vprev = V2(:,i);

end

figure(7)
plot(Xval, V2(7,:), 'b')
hold on
plot(Xval, V2(1,:), 'r')
title('Vin vs Vout (Sine Pulse)')
xlabel('Time (ms)')
ylabel('Voltage')
legend('Vout','Vin')
```

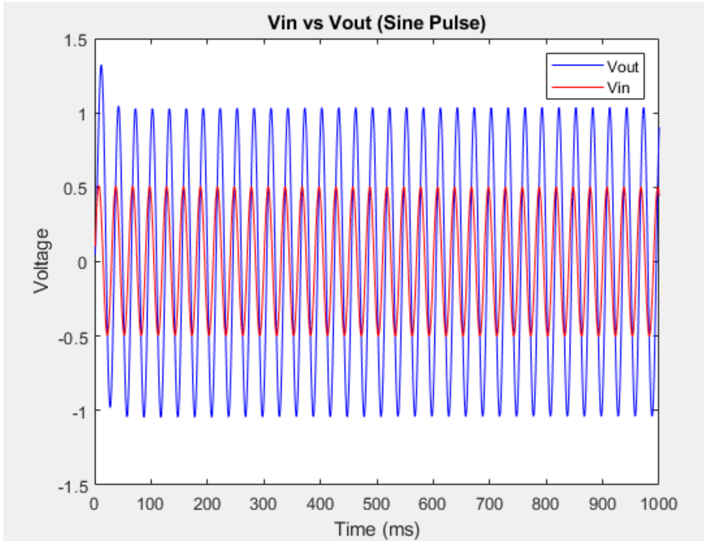

Figure 5: Sine Pulse

The final pulse was a Gaussian pulse with a magnitude of 1, std of 0.03 and a delay of 0.06. The code a plot can be seen in the following two figures.

```
V3 = zeros(7,steps);

Gpulse = zeros(7,1);


Vprev = zeros(7,1);

for i = 1:steps


    Gpulse(1,1) = exp(-1/2*((i/steps-0.06)/(0.03))^2);

    V3(:,i) = (C./dt+G)\(Gpulse+C*Vprev/dt);

    Vprev = V3(:,i);

end



figure(8)
plot(Xval, V3(7,:), 'b')
hold on
plot(Xval, V3(1,:), 'r')
title(' Vin vs Vout (Gaussian Pulse)')
xlabel(' Time (ms)')
ylabel('Voltage')
legend('Vout','Vin')
```

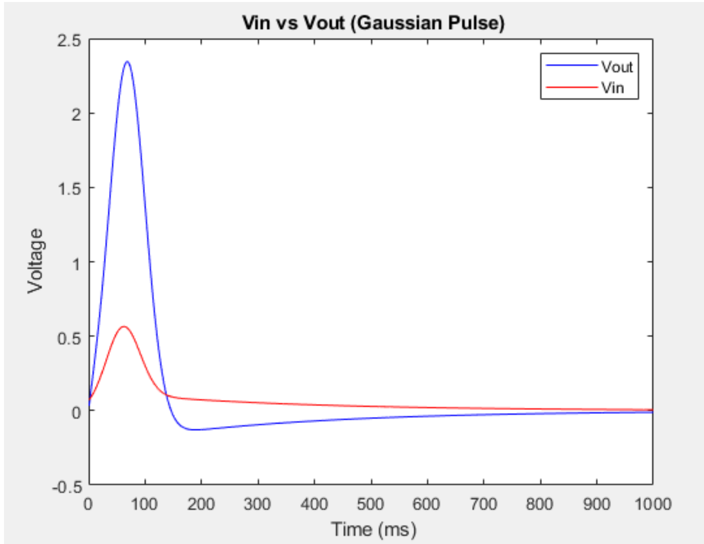

Figure 6: Gaussian Pulse

Now that the signals have all been plotted, the frequency response was determined using the fft() and fftshift() functions in Matlab. The following block of code shows how this was completed for each pulse. The corresponding responses can be seen below this block of code.

```
% Sim A
freq = linspace(-500,500,steps);

FV1 = fft(V0.');
FSV1 = fftshift(FV1);

figure(9)
plot(freq, 20*log10(abs(FSV1(:,1))),'r')
hold on
plot(freq, 20*log10(abs(FSV1(:,7))),'b')
axis([-500 500 -100 inf])
ylabel('Voltage')
xlabel('Frequency')
title('Fourier Transform Plot')

% Sim B

FV2 = fft(V2.');
FSV2 = fftshift(FV2);

figure(10)
plot(freq, 20*log10(abs(FSV2(:,1))),'r')
hold on
plot(freq, 20*log10(abs(FSV2(:,7))),'b')
axis([-500 500 -100 inf])
ylabel('Voltage')
xlabel('Frequency')
title('Fourier Transform Plot (Sine Pulse)')
% Sim C

FV3 = fft(V3.');
FSV3 = fftshift(FV3);

figure(11)
plot(freq, 20*log10(abs(FSV3(:,1))),'r')
hold on
plot(freq, 20*log10(abs(FSV3(:,7))),'b')
axis([-500 500 -100 inf])
ylabel('Voltage')
xlabel('Frequency')
title('Fourier Transform Plot (Gaussian Pulse')
```

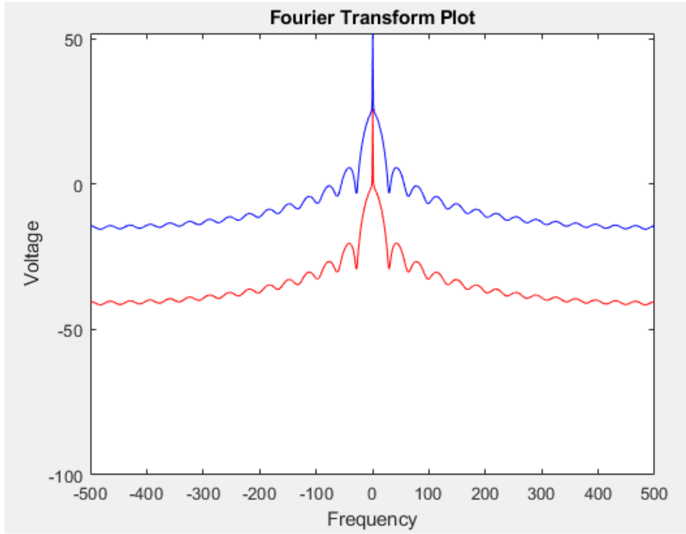

Figure 7: Standard Pulse

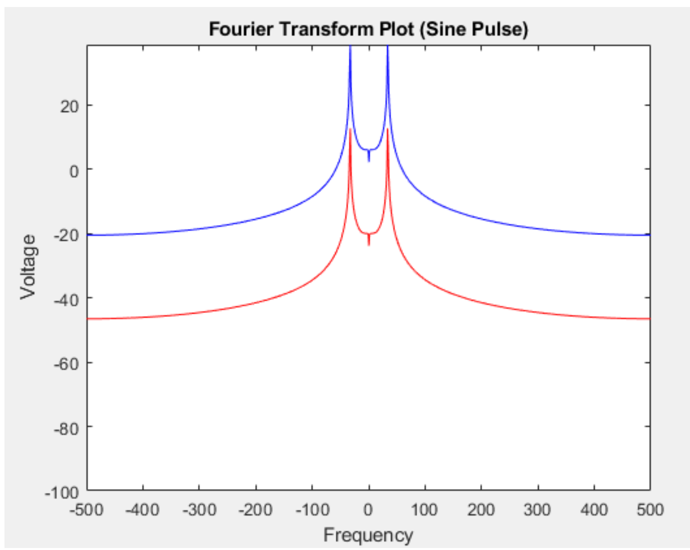

Figure 8: Sine Pulse

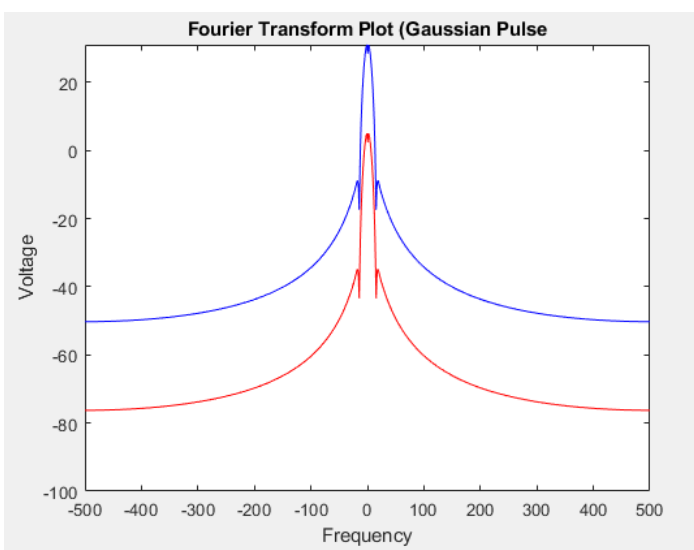

Figure 9: Gaussian Pulse

After this was completed, the step size was increased. While each plot maintained a similar behaviour, the plots became jagged and much less precise than the plots seen above.

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2 Part 2

In part 2 of the assignment, we are adding noise to the circuit that was previously simulated. To do this, a capacitor and current source was added in parallel with the resistor R3. The C matrix had to been adjusted to compensate for this change. The adjusted C matrix can be seen in the following block of code.

```
%Matrix Definitions

C1 = [0 0 0 0 0 0 0;
    -Cap Cap 0 0 0 0 0;
     0 0 -L 0 0 0 0;
     0 0 0 -Cn1 0 0 0;
     0 0 0 0 0 0 0;
     0 0 0 -Cn1 0 0 0;
     0 0 0 0 0 0 0;];
```

A current source In, was added to the code in order to simulate the thermal noise in the system.

```
for i = 1:steps

    % Current Source
    In = 0.001*randn();


    Gpulse(4,1) = In;

    Gpulse(1,1) = exp(-1/2*((i/steps-0.06)/(0.03))^2);

    V1(:,i) = (C1./dt+G)\(Gpulse+C1*Vprev/dt);

    Vprev = V1(:,i);

end

figure(1)
plot(Xval, V1(7,:),'b')
hold on
plot(Xval, V1(1,:),'r')
title('Vin vs Vout with Noise (Standard Cap)')
xlabel( 'Time (ms)')
ylabel('Voltage')

%Fourier
freq = linspace(-500,500,steps);

FV1 = fft(V1.');

FSV1 = fftshift(FV1);

figure(2)
plot(freq, 20*log10(abs(FSV1(:,1))),'r')
hold on
plot(freq, 20*log10(abs(FSV1(:,7))),'b')
title('Fourier Transform (Standard Cap)')
axis([-500 500 -100 inf])
```

The following figures show the plot of Vout with the noise source, and the Fourier transform.

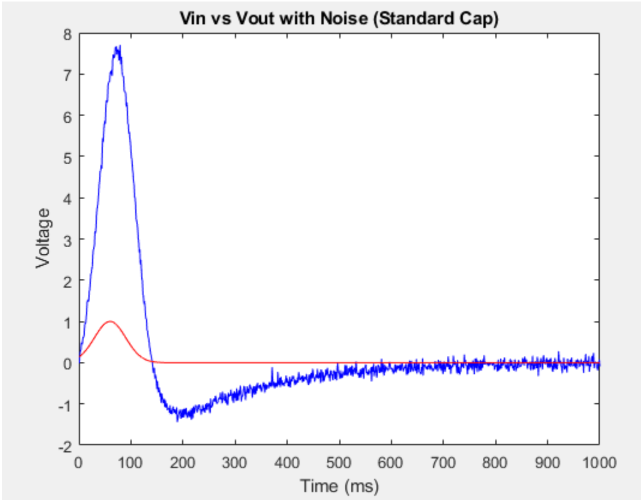

Figure 10: Vin/Vout with Noise

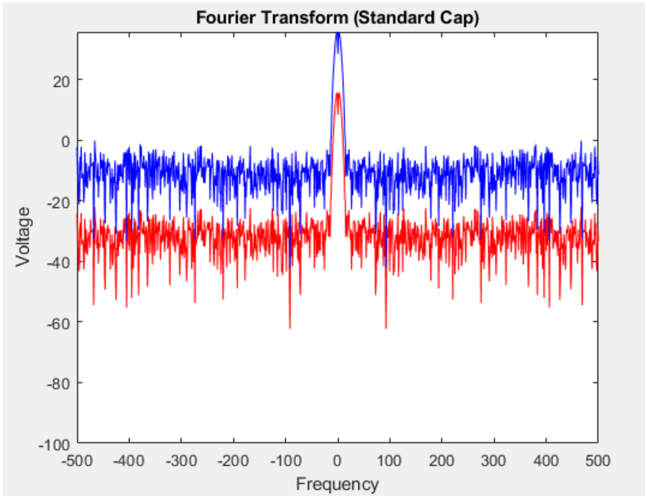

Figure 11: Fourier Noise

The next step of the assignment was to vary the value of the Cn capacitor to see how the bandwidth was affected. The C matrix was slightly adjusted to do this. The plots for a large value of Cn and a small value of Cn can be seen in the figures below.

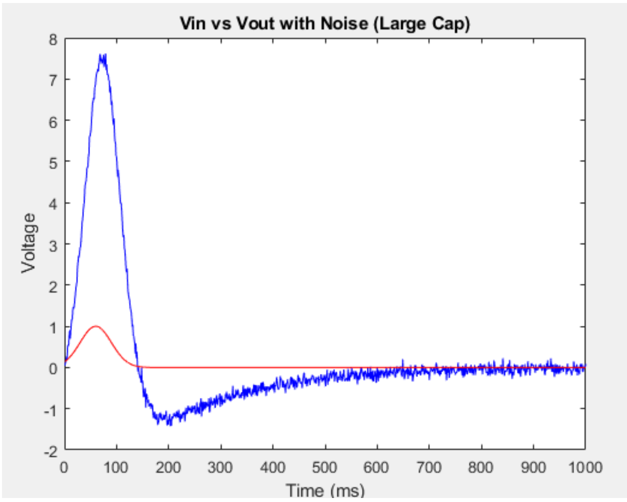

Figure 12: Large Cn

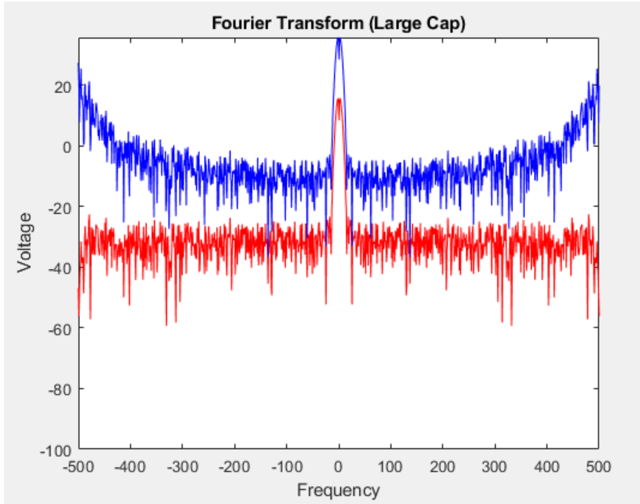

Figure 13: Fourier Plot Large Cn

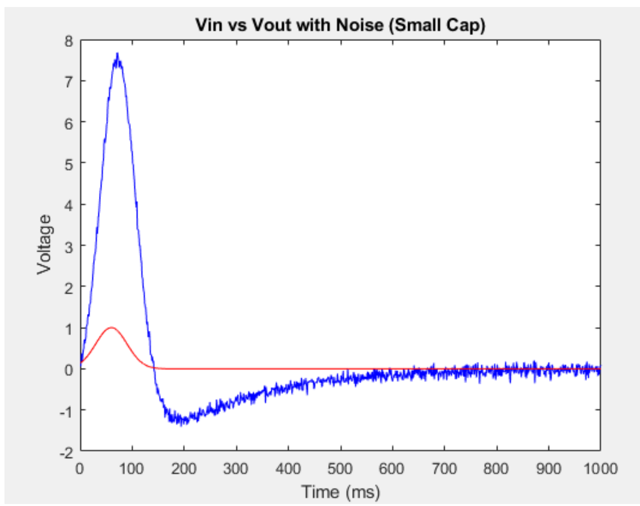

Figure 14: Small Cn

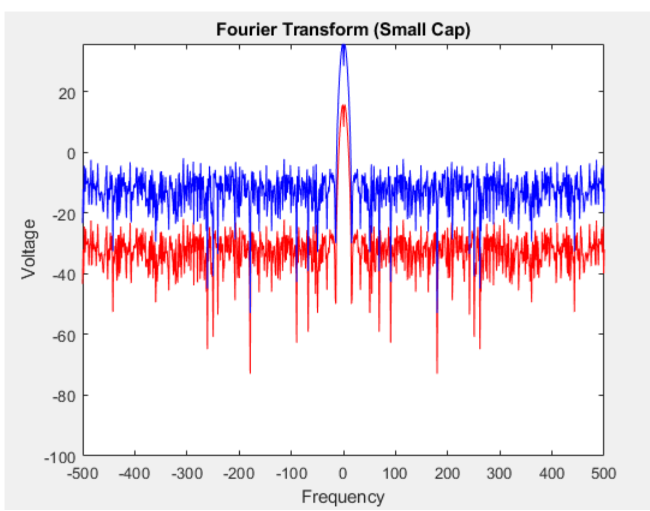

Figure 15: Fourier Plot Small Cn

The only difference between the three plots seemed to in the Fourier plot with a large capacitance. The tails of the output seemed to increase. Aside from this, the was no discernible difference. When the capacitance was changed to a very large value (not pictured), the simulation seemed to breakdown, while if the capacitance was reduced to zero, the behaviour did not seem to change much. The final step was to adjust the step size, and see how the plots are affected. The plots with a changed step size can be seen in the figures below.

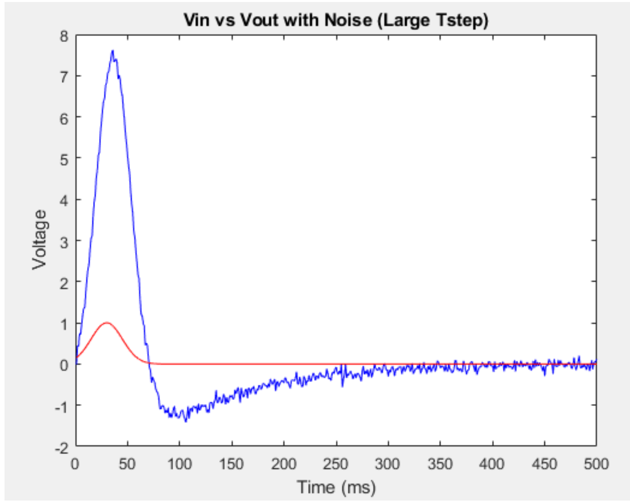

Figure 16: Large Time Step

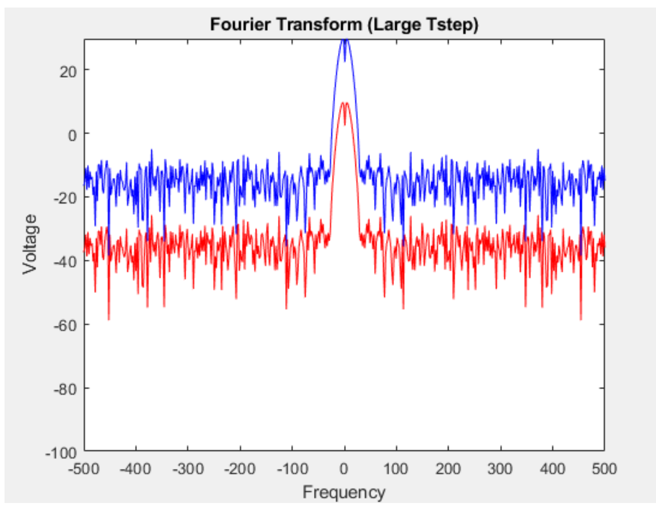

Figure 17: Fourier Large Time Step

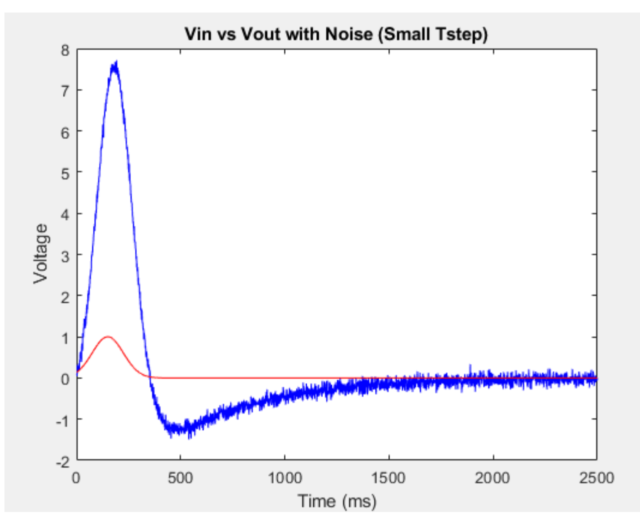

Figure 18: Small Time Step

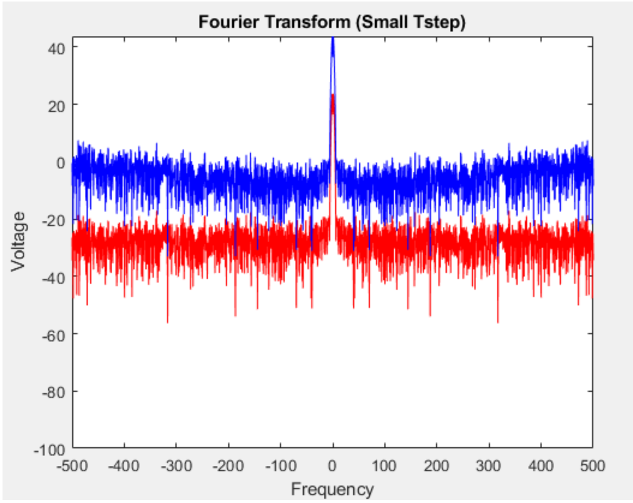

Figure 19: Fourier Small Time Step

3 Part 3

The final part of the assignment we need to investigate a non-linear voltage source. In order to approach this, we would need to implement Gamma and Beta into the C matrix that has been previously defined. A Newton-Raphson iteration for each time step would likely be necessary to obtain convergence. Aside from this, similar techniques in this assignment could be used to achieve a solution.