ELEC 4700 ASSIGNMENT 4

Contents

Part 1

```
clearvars
clearvars -GLOBAL
close all
set(0,'DefaultFigureWindowStyle', 'docked')

sizex = 6;
sizey = 6;

% Voltage Range

Vmin = 0.1;
Vmax = 10;

% Components

Cap = 0.25;
R1 = 1;
R2 = 2;
L = 0.2;
% R3 = R3finder(Vmin,Vmax,20);
R3 = 10;
alpha = 100;
R4 = 0.1;
Ro = 1000;
omega = 10;

% C Matrix
C = zeros(sizex,sizey);
C(2,1) = -Cap;
C(2,2) = Cap;
C(6,6) = L;

% G Matrix
G = zeros (sizex, sizey);
G(1,1) = 1;
G(2,1) = -1/R1;
G(2,2) = (1/R1) + (1/R2);
G(2,6) = -1;
G(3,3) = 1/R3;
G(3,6) = 1;
G(4,3) = -alpha/R3;
G(4,4) = 1;
G(5,4) = -R4;
G(5,5) = R4 - (1/Ro);
G(6,2) = 1;
G(6,3) = -1;
```

(a) C and G matrices

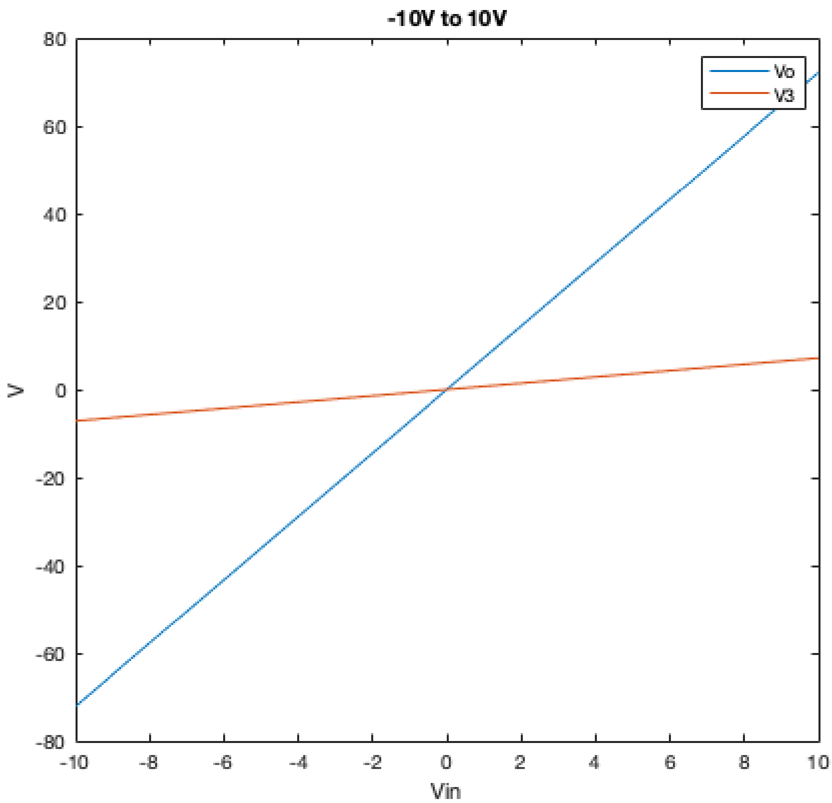
```
C
G
```

```
C =

         0         0         0         0         0         0
   -0.2500    0.2500         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    0.2000


G =

    1.0000         0         0         0         0         0
   -1.0000    1.5000         0         0         0   -1.0000
         0         0    0.1000         0         0    1.0000
         0         0  -10.0000    1.0000         0         0
         0         0         0   -0.1000    0.0990         0
         0    1.0000   -1.0000         0         0         0
```

(b) Plot of DC sweep

F Vector

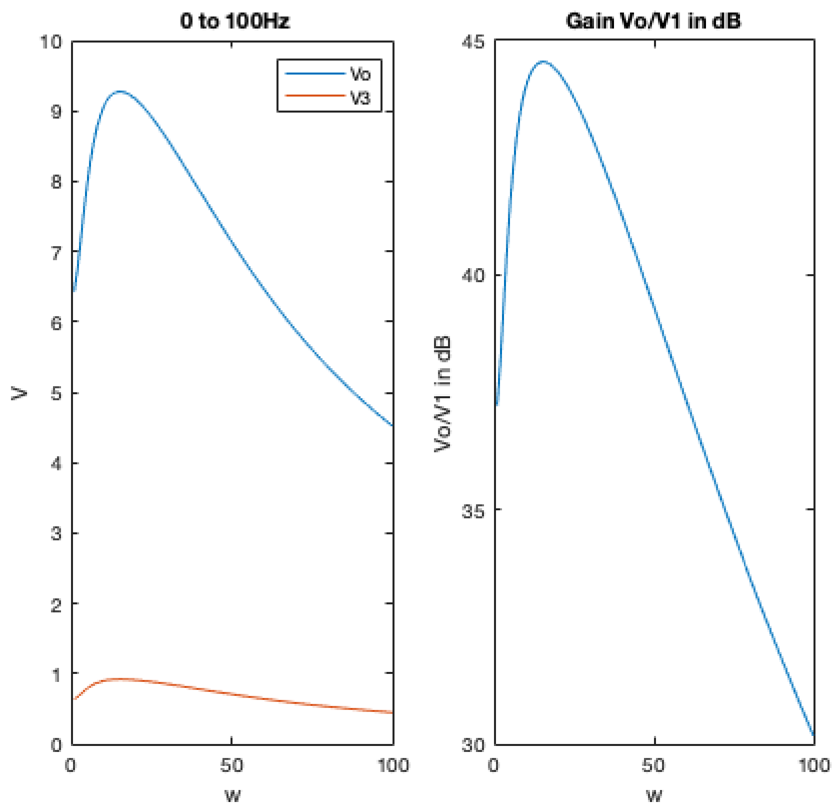
```
F = zeros(1,sizey);
stepsize = 21;

VoutVect = zeros(1,stepsize);
V3Vect = zeros(1,stepsize);

% DC Sweep

for i = -10:10
    F(1) = i;

    % V vector
    V = (G + omega.*C)\F';
    VoutVect(i+11) = V(5);
    V3Vect(i+11) = V(3);
end

figure

plot (linspace(-10,10,stepsize),VoutVect);
title('-10V to 10V');
hold on
plot (linspace(-10,10,stepsize), V3Vect);
legend('Vo', 'V3');
xlabel('Vin');
ylabel('V');
```



(c) Plots from AC case of Gain AC Sweep

```
F = zeros(1,sizey);
F(1) = 1;
stepsize = 100;

VoutVect = zeros(1,stepsize);
V3Vect = zeros(1,stepsize);

omega = linspace(1,100,stepsize);

for i = 1:stepsize
    V = (G + 1j*omega(i).*C)\F';
    VoutVect(i) = V(5);
    V3Vect(i) = V(3);
end
figure

subplot(1,2,1);

plot (omega,abs(VoutVect));
title(' 0 to 100Hz');
hold on
plot (omega, abs(V3Vect));
legend('Vo', 'V3');
xlabel('w');
ylabel('V');

gain = 20 * log(abs(VoutVect./F(1)));

subplot(1,2,2);
```

```
plot(omega, gain);
title('Gain Vo/V1 in dB');
xlabel('w');
ylabel('Vo/V1 in dB');
```



(d) (e) Plot of Vin and Vout from numerical solution in time domain and fourier transforms

```
deltaT = 1e-3;

% A vector
A = (C./deltaT) + G;

timesteps = 1000;
Vp = zeros(sizey,1);


% F vector
F = zeros(1,sizey);

% Vin and Vout Vectors
VinVect = zeros(timesteps,1);
VoutVect = zeros(timesteps,1);

% Time simulation - step function

timeVector = linspace(1,timesteps,timesteps);
figure
for i = 2:timesteps

    % F vector
```

```
    if (i == 30)
        F(1) = 1;
    end

    V = A\(((C * Vp)./deltaT) + F');

    subplot(2,3,1)
    plot([timeVector(i-1) timeVector(i)],[Vp(1) V(1)],'-r');

    hold on

    plot([timeVector(i-1) timeVector(i)],[Vp(5) V(5)],'-b');

    pause(0.01);

    VinVect(i) = V(1);
    VoutVect(i) = V(5);

    Vp = V;
end

legend('Vin', 'Vout');
title('Time Simulation - Step function');

xlim([0 1000]);
ylim([0 12]);
xlabel('Time (ms)');
ylabel('Voltage');

subplot(2,3,2)
plot(linspace(1,1000,1000),fftshift(20*log(fft(VoutVect))),'-b');
hold on
plot(linspace(1,1000,1000),fftshift(20*log(fft(VinVect))),'-r');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage (dB)');


% Time simulation - sinusoidal function

% Vin and Vout Vectors
VinVect = zeros(timesteps,1);
VoutVect = zeros(timesteps,1);
Vp = zeros(sizey,1);

for i = 2:timesteps

    % F vector

    F(1) = sin(2 * pi * (1/0.03) * timeVector(i) * deltaT);

    V = A\(((C * Vp)./deltaT) + F');

    subplot(2,3,3)
    plot([timeVector(i-1) timeVector(i)],[Vp(1) V(1)],'-r');

    hold on

    plot([timeVector(i-1) timeVector(i)],[Vp(5) V(5)],'-b');
```

```
    pause(0.01);

    VinVect(i) = V(1);
    VoutVect(i) = V(5);

    Vp = V;
end

legend('Vin', 'Vout');
title('Time Simulation - Sinusoidal function');

% xlim([0 1000]);
% ylim([0 12]);
xlabel('Time (ms)');
ylabel('Voltage');

subplot(2,3,4)
plot(linspace(1,1000,1000),fftshift(20*log(fft(VoutVect))),'-b');
hold on
plot(linspace(1,1000,1000),fftshift(20*log(fft(VinVect))),'-r');
legend('Vout', 'Vin');

xlabel('Frequency');
ylabel('Voltage (dB)');
% Time simulation - gaussian pulse

% Vin and Vout Vectors
VinVect = zeros(timesteps,1);
VoutVect = zeros(timesteps,1);
Vp = zeros(sizey,1);

pulsepos = 30 * randi(10);
% pulsepos = 5;
delayCnt = 0;
deltaT = 0.06;

for i = 2:timesteps

    % F vector

     if (i >= pulsepos)
        delayCnt = delayCnt + 1;
        if(delayCnt == 60)
          F(1) = 1;
          delayCnt = 0;
        end

     end

    V = A\(((C * Vp)./deltaT) + F');

    subplot(2,3,5)
    plot([timeVector(i-1) timeVector(i)],[Vp(1) V(1)],'-r');

    hold on

    plot([timeVector(i-1) timeVector(i)],[Vp(5) V(5)],'-b');

    pause(0.01);
```

```
    VinVect(i) = V(1);
    VoutVect(i) = V(5);

    Vp = V;
end
legend('Vin', 'Vout');
title('Time Simulation - Step function (delayed)');

 xlim([0 1000]);
% ylim([0 12]);
xlabel('Time (ms)');
ylabel('Voltage');

subplot(2,3,6)
plot(linspace(1,1000,1000),fftshift(20*log(fft(VoutVect))),'-b');
hold on
plot(linspace(1,1000,1000),fftshift(20*log(fft(VinVect))),'-r');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage (dB)');
```

```
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```
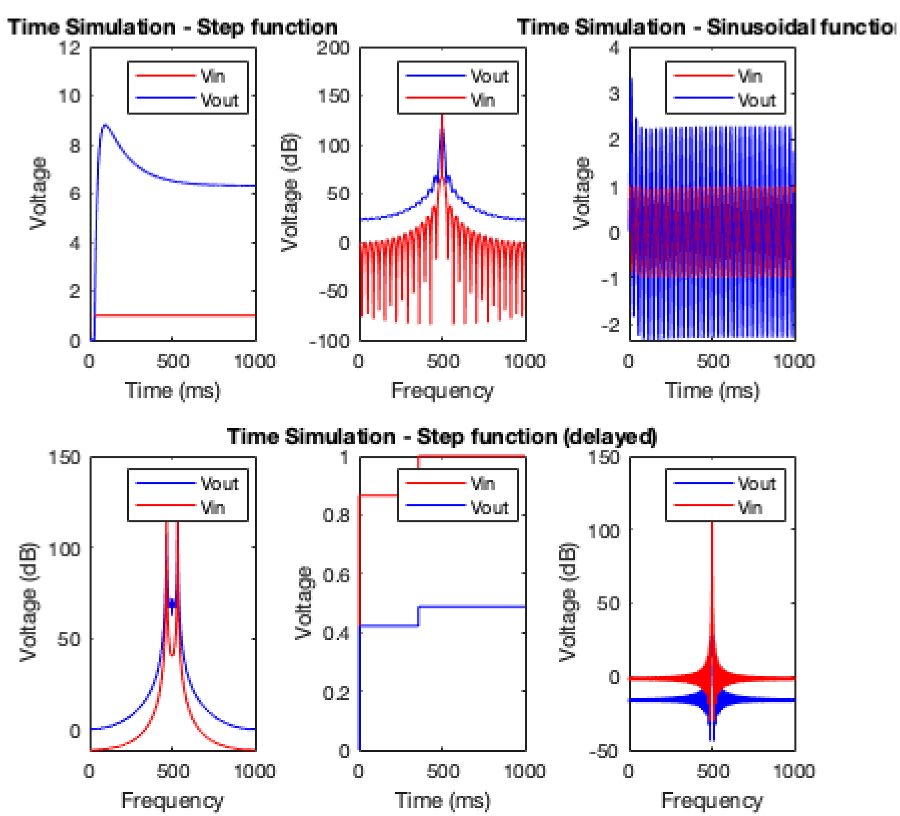



Part 2

```
clearvars
clearvars -GLOBAL
close all
set(0,'DefaultFigureWindowStyle', 'docked')

sizex = 6;
sizey = 6;

% Voltage Range

Vmin = 0.1;
Vmax = 10;

% Components

Cap = 0.25;
R1 = 1;
R2 = 2;
L = 0.2;
% R3 = R3finder(Vmin,Vmax,20);
R3 = 10;
alpha = 100;
R4 = 0.1;
Ro = 1000;
omega = 10;

% Noise components
In = 0.001;
Cn = 1e-5;

% C Matrix
C = zeros(sizex,sizey);
C(2,1) = -Cap;
C(2,2) = Cap;
C(3,3) = Cn;
C(6,6) = L;

% G Matrix
G = zeros (sizex, sizey);
G(1,1) = 1;
G(2,1) = -1/R1;
G(2,2) = (1/R1) + (1/R2);
G(2,6) = -1;
G(3,3) = 1/R3;
G(3,6) = 1;
G(4,3) = -alpha/R3;
G(4,4) = 1;
G(5,4) = -R4;
G(5,5) = R4 - (1/Ro);
G(6,2) = 1;
G(6,3) = -1;
```

(a) Updated C and G matrices

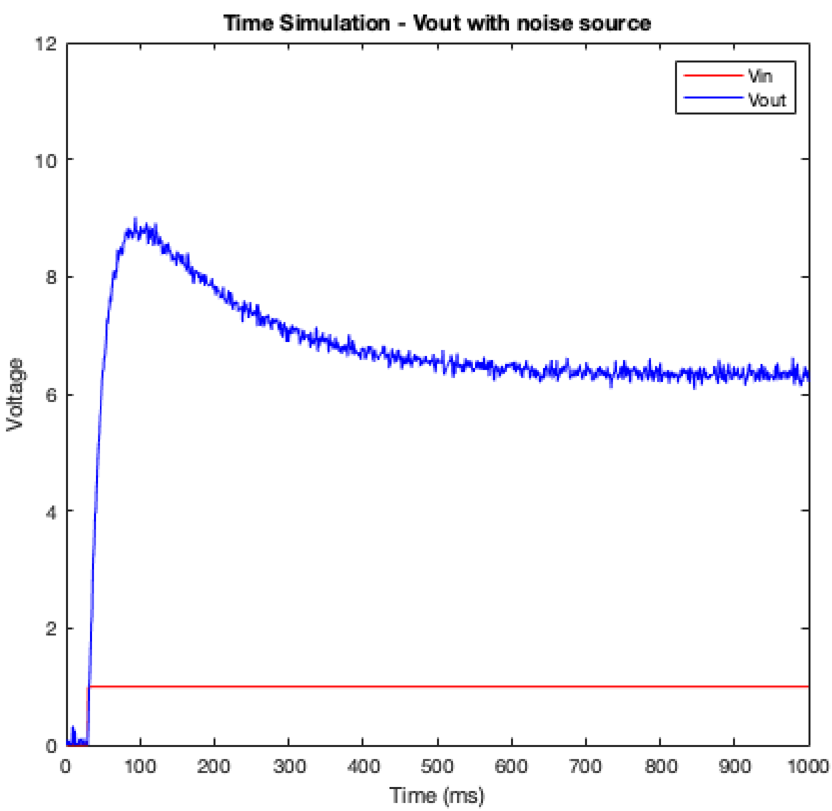
```
C
G
```

```
C =

         0         0         0         0         0         0
   -0.2500    0.2500         0         0         0         0
         0         0    0.0000         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0    0.2000


G =

    1.0000         0         0         0         0         0
   -1.0000    1.5000         0         0         0   -1.0000
         0         0    0.1000         0         0    1.0000
         0         0  -10.0000    1.0000         0         0
         0         0         0   -0.1000    0.0990         0
         0    1.0000   -1.0000         0         0         0
```

(b) Plot of Vout with noise source

```
deltaT = 1e-3;

% A vector
A = (C./deltaT) + G;

timesteps = 1000;
Vp = zeros(sizey,1);


% F vector
F = zeros(1,sizey);
F(3) = In;

% Vin and Vout Vectors
VinVect = zeros(timesteps,1);
VoutVect = zeros(timesteps,1);

% Time simulation - step function

timeVector = linspace(1,timesteps,timesteps);
figure
for i = 2:timesteps

    % F vector

    if (i == 30)
        F(1) = 1;
    end

    V = A\(((C * Vp)./deltaT) + F');


    plot([timeVector(i-1) timeVector(i)],[Vp(1) V(1)],'-r');

    hold on
```

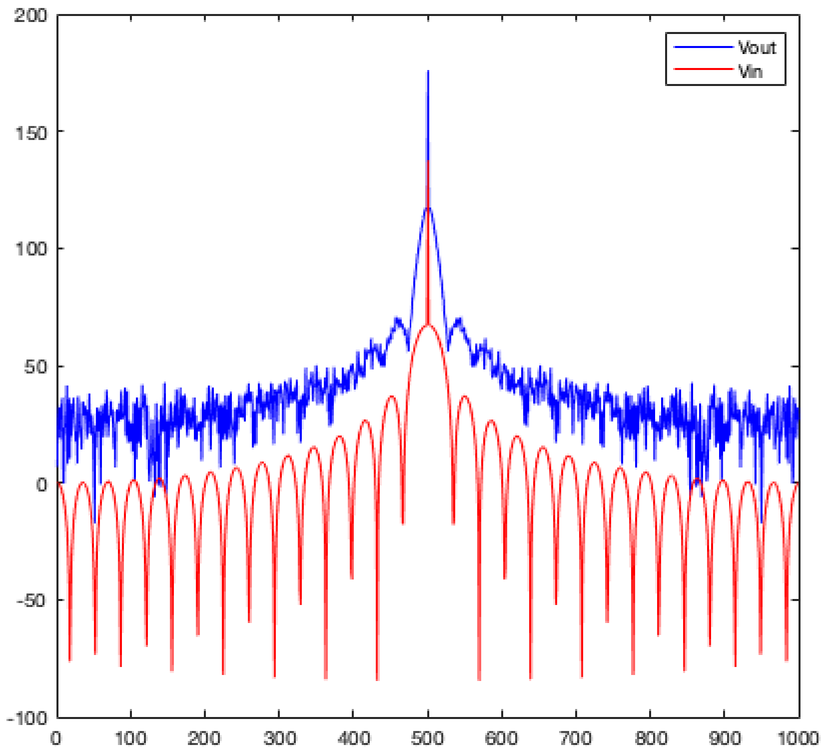
```
    plot([timeVector(i-1) timeVector(i)],[Vp(5) V(5)],'-b');


    pause(0.01);

    VinVect(i) = V(1);
    VoutVect(i) = V(5);

    Vp = V;
    F(3) = In*randn();

end
xlim([0 1000]);
ylim([0 12]);
xlabel('Time (ms)');
ylabel('Voltage');
legend('Vin', 'Vout');
title('Time Simulation - Vout with noise source');
```



(c) Fourier Transform plot

```
figure
plot(linspace(1,1000,1000),fftshift(20*log(fft(VoutVect))),'-b');
hold on
plot(linspace(1,1000,1000),fftshift(20*log(fft(VinVect))),'-r');
legend('Vout', 'Vin');
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored.
Warning: Imaginary parts of complex X and/or Y arguments ignored.
```



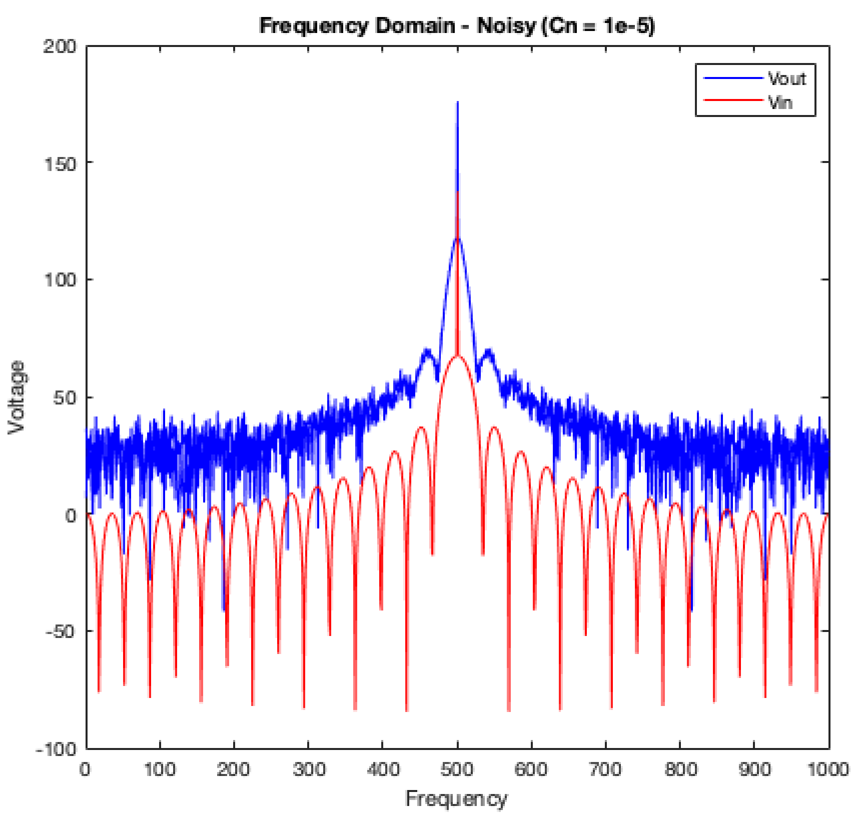
(e) 3 plots of Vout with different Cout

Cout = 1e-5

```
C(3,3) = 1e-5;
deltaT = 1e-3;

% A vector
A = (C./deltaT) + G;

timesteps = 1000;
Vp = zeros(sizey,1);


% F vector
F = zeros(1,sizey);
F(3) = In;

% Vin and Vout Vectors
VinVect = zeros(timesteps,1);
VoutVect = zeros(timesteps,1);

% Time simulation - step function

timeVector = linspace(1,timesteps,timesteps);
```

```
for i = 2:timesteps

    % F vector

    if (i == 30)
        F(1) = 1;
    end

    V = A\(((C * Vp)./deltaT) + F');

    VinVect(i) = V(1);
    VoutVect(i) = V(5);

    Vp = V;
    F(3) = In*randn();

end

plot(linspace(1,1000,1000),fftshift(20*log(fft(VoutVect))),'-b');
hold on
plot(linspace(1,1000,1000),fftshift(20*log(fft(VinVect))),'-r');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage');
title('Frequency Domain - Noisy (Cn = 1e-5)');
```

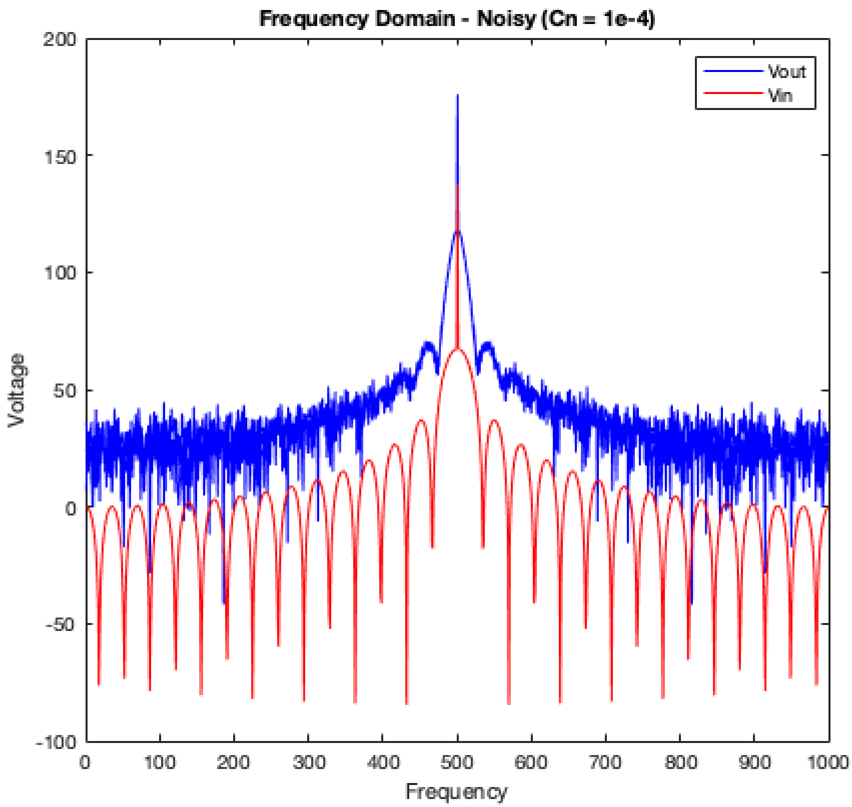
```
Warning: Imaginary parts of complex X and/or Y arguments ignored.
Warning: Imaginary parts of complex X and/or Y arguments ignored.
```



Cout = 1e-4

```
C(3,3) = 1e-4;
deltaT = 1e-3;

% A vector
A = (C./deltaT) + G;

timesteps = 1000;
Vp = zeros(sizey,1);


% F vector
F = zeros(1,sizey);
F(3) = In;

% Vin and Vout Vectors
VinVect = zeros(timesteps,1);
VoutVect = zeros(timesteps,1);

% Time simulation - step function

timeVector = linspace(1,timesteps,timesteps);

for i = 2:timesteps

    % F vector

    if (i == 30)
        F(1) = 1;
    end

    V = A\(((C * Vp)./deltaT) + F');

    VinVect(i) = V(1);
    VoutVect(i) = V(5);

    Vp = V;
    F(3) = In*randn();

end

plot(linspace(1,1000,1000),fftshift(20*log(fft(VoutVect))),'-b');
hold on
plot(linspace(1,1000,1000),fftshift(20*log(fft(VinVect))),'-r');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage');
title('Frequency Domain - Noisy (Cn = 1e-4)');
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored.
Warning: Imaginary parts of complex X and/or Y arguments ignored.
```

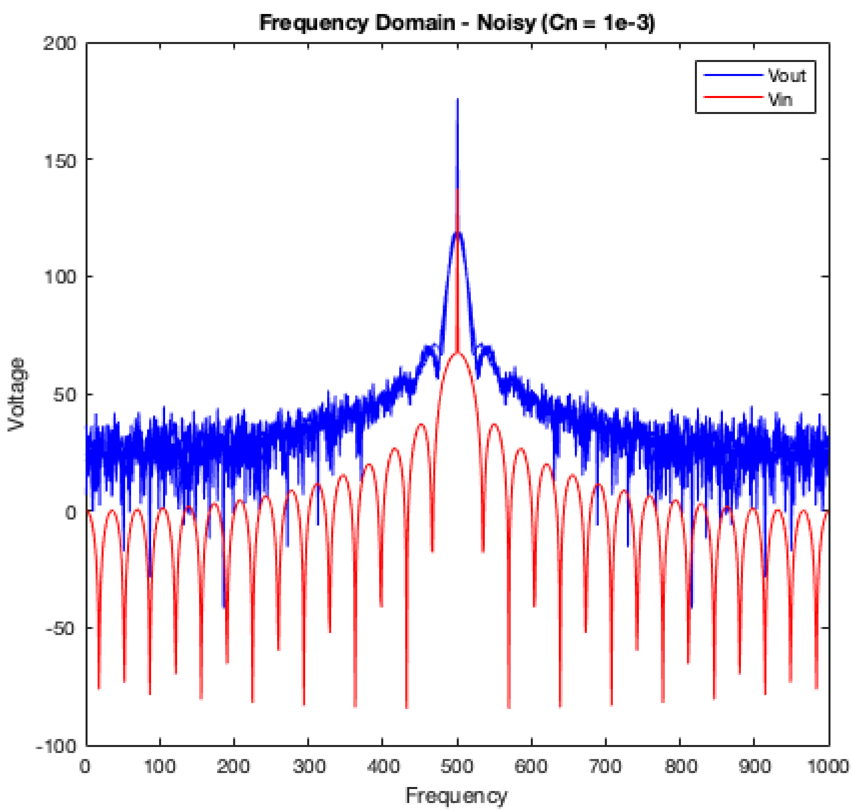


Cout = 1e-3

```
C(3,3) = 1e-3;
deltaT = 1e-3;

% A vector
A = (C./deltaT) + G;

timesteps = 1000;
Vp = zeros(sizey,1);


% F vector
F = zeros(1,sizey);
F(3) = In;

% Vin and Vout Vectors
VinVect = zeros(timesteps,1);
VoutVect = zeros(timesteps,1);

% Time simulation - step function

timeVector = linspace(1,timesteps,timesteps);

for i = 2:timesteps

    % F vector

    if (i == 30)
        F(1) = 1;
    end
```

```
    V = A\(((C * Vp)./deltaT) + F');

    VinVect(i) = V(1);
    VoutVect(i) = V(5);

    Vp = V;
    F(3) = In*randn();

end

plot(linspace(1,1000,1000),fftshift(20*log(fft(VoutVect))),'-b');
hold on
plot(linspace(1,1000,1000),fftshift(20*log(fft(VinVect))),'-r');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage');
title('Frequency Domain - Noisy (Cn = 1e-3)');
```

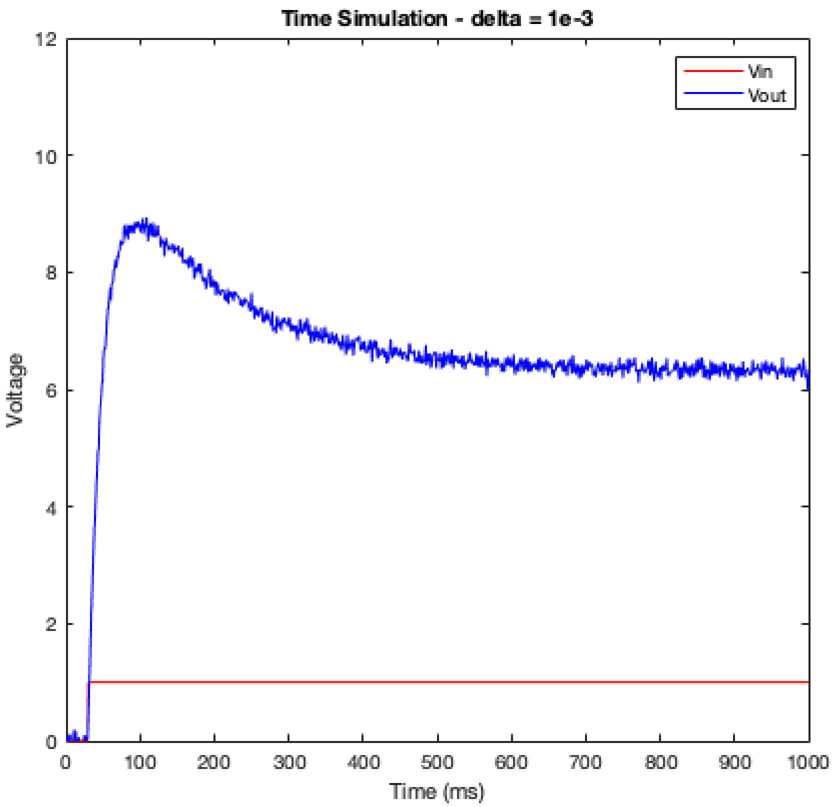
```
Warning: Imaginary parts of complex X and/or Y arguments ignored.
Warning: Imaginary parts of complex X and/or Y arguments ignored.
```



(f) 2 plots of Vout with different time stops delta = 1e-3;

```
deltaT = 1e-3;
C(3,3) = 1e-5;

% A vector
```

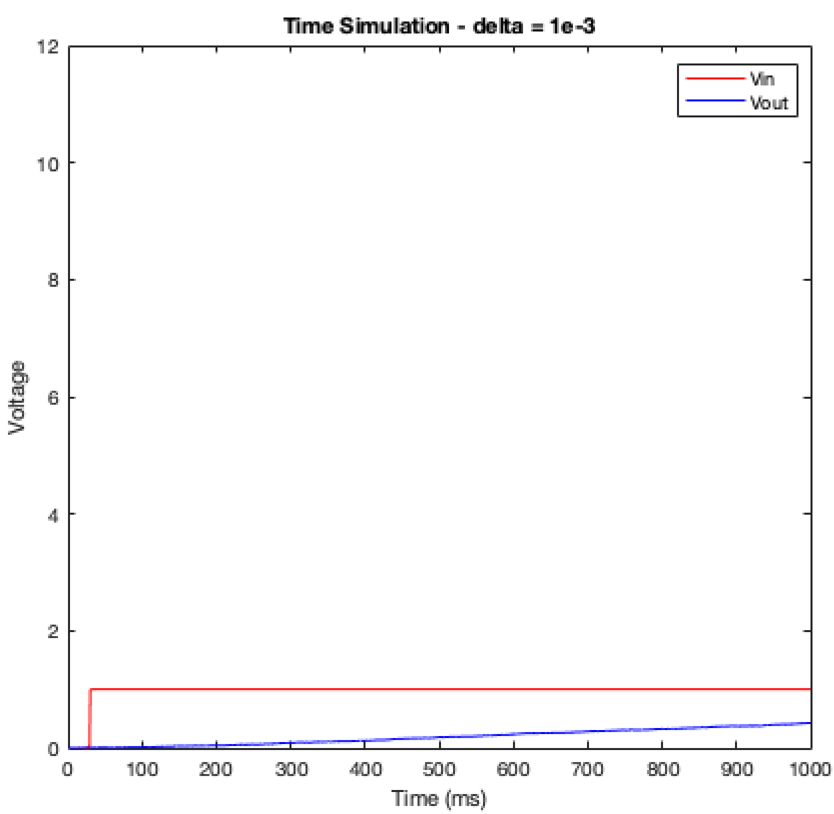
```
A = (C./deltaT) + G;

timesteps = 1000;
Vp = zeros(sizey,1);


% F vector
F = zeros(1,sizey);
F(3) = In;

% Vin and Vout Vectors
VinVect = zeros(timesteps,1);
VoutVect = zeros(timesteps,1);

% Time simulation - step function

timeVector = linspace(1,timesteps,timesteps);
figure
for i = 2:timesteps

    % F vector

    if (i == 30)
        F(1) = 1;
    end

    V = A\(((C * Vp)./deltaT) + F');


    plot([timeVector(i-1) timeVector(i)],[Vp(1) V(1)],'-r');

    hold on

    plot([timeVector(i-1) timeVector(i)],[Vp(5) V(5)],'-b');


    pause(0.01);

    VinVect(i) = V(1);
    VoutVect(i) = V(5);

    Vp = V;
    F(3) = In*randn();

end
xlim([0 1000]);
ylim([0 12]);
xlabel('Time (ms)');
ylabel('Voltage');
legend('Vin', 'Vout');
title('Time Simulation - delta = 1e-3');
```



delta = 1e-6;

```
deltaT = 1e-6;
C(3,3) = 1e-5;

% A vector
A = (C./deltaT) + G;

timesteps = 1000;
Vp = zeros(sizey,1);


% F vector
F = zeros(1,sizey);
F(3) = In;

% Vin and Vout Vectors
VinVect = zeros(timesteps,1);
VoutVect = zeros(timesteps,1);

% Time simulation - step function

timeVector = linspace(1,timesteps,timesteps);
figure
for i = 2:timesteps

    % F vector

    if (i == 30)
        F(1) = 1;
    end
```

```
    V = A\(((C * Vp)./deltaT) + F');


    plot([timeVector(i-1) timeVector(i)],[Vp(1) V(1)],'-r');

    hold on

    plot([timeVector(i-1) timeVector(i)],[Vp(5) V(5)],'-b');


    pause(0.01);

    VinVect(i) = V(1);
    VoutVect(i) = V(5);

    Vp = V;
    F(3) = In*randn();

end
xlim([0 1000]);
ylim([0 12]);
xlabel('Time (ms)');
ylabel('Voltage');
legend('Vin', 'Vout');
title('Time Simulation - delta = 1e-3');
```



Part 3

(a) Description of steps needed to implement the non-linearity This can be done by introducing the B matrix as discussed in class. All matrices will remain the same. Also the equation with V4 = alpha*I3 will change to include the new terms and constants. B(4) matrix will also include beta(^1/2) - gamma (^1/3). The rest of B must be zeros.

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