Elec 4700

Precious usoroh

101031041

Assignment 4

Question:1

C and G matrix

C

6x6 double

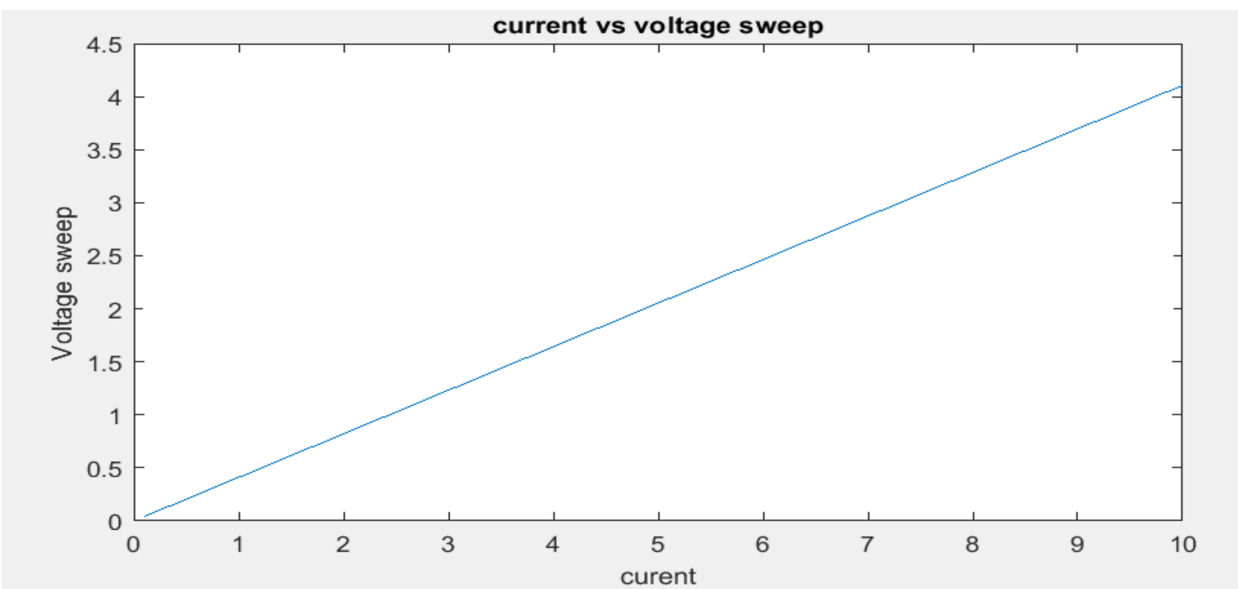
	1	2	3	4	5	6
1	0	0	0	0	0	0
2	-0.2500	0.2500	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0.2000

G

6x6 double

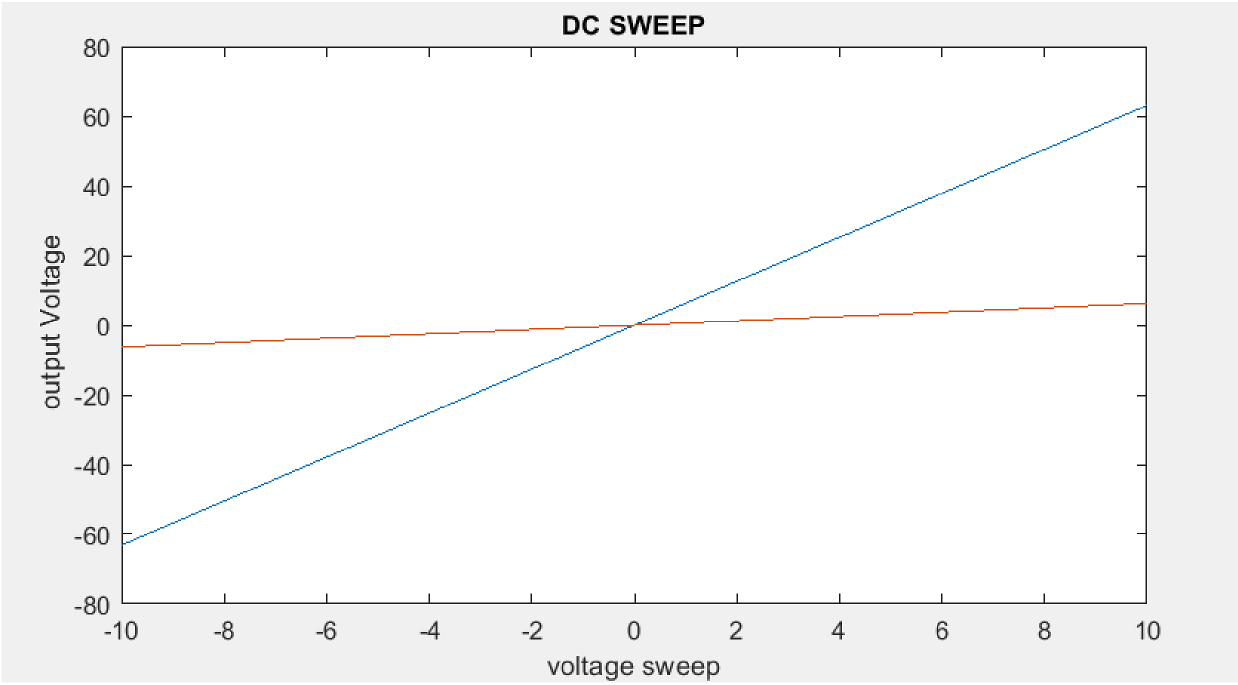
	1	2	3	4	5	6
1	1	0	0	0	0	0
2	-1	1.5000	0	0	0	-1
3	0	0	0.1000	0	0	1
4	0	0	-10	1	0	0
5	0	0	0	-0.1000	0.0990	0
6	0	1	-1	0	0	0

The linear fit was used to determine the resistance value of the device. (R3=10)



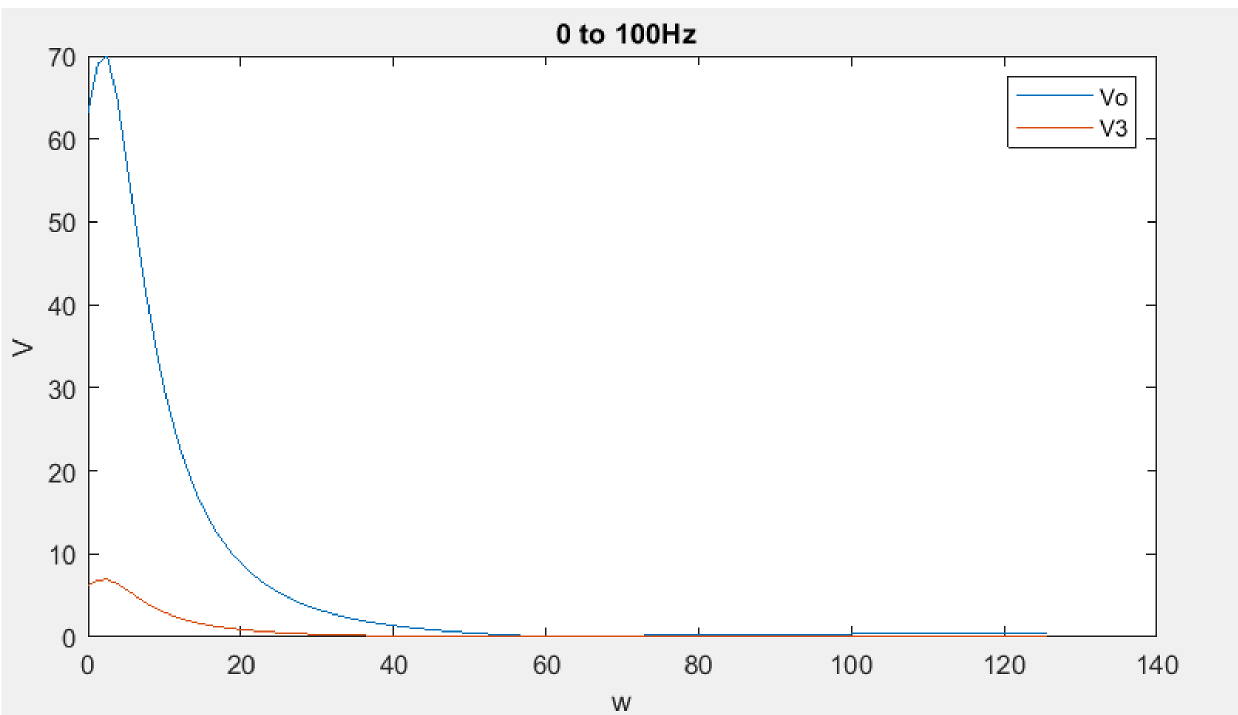
The current vs voltage sweep plot is the average current at each voltage.

B: (plot of Dc sweep)

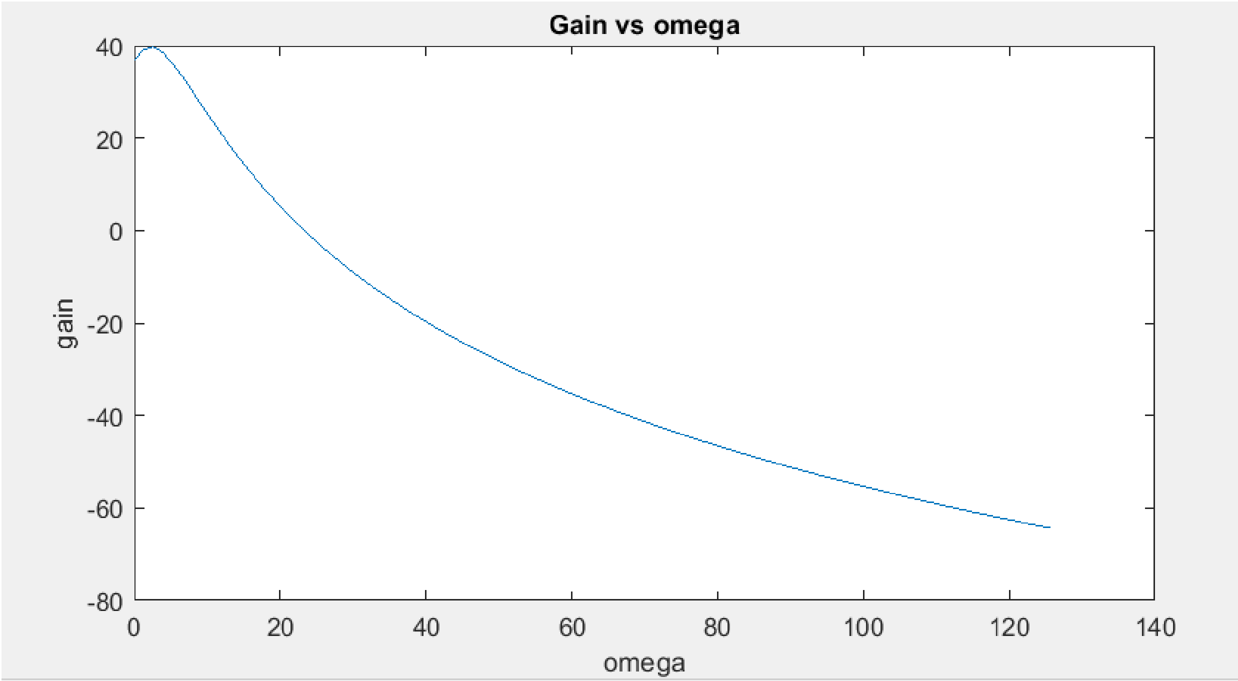


The plot was gotten by performing a voltage sweep of the device from 0.1 V to 10 V

C: (The AC case plot VO as a function of ω)

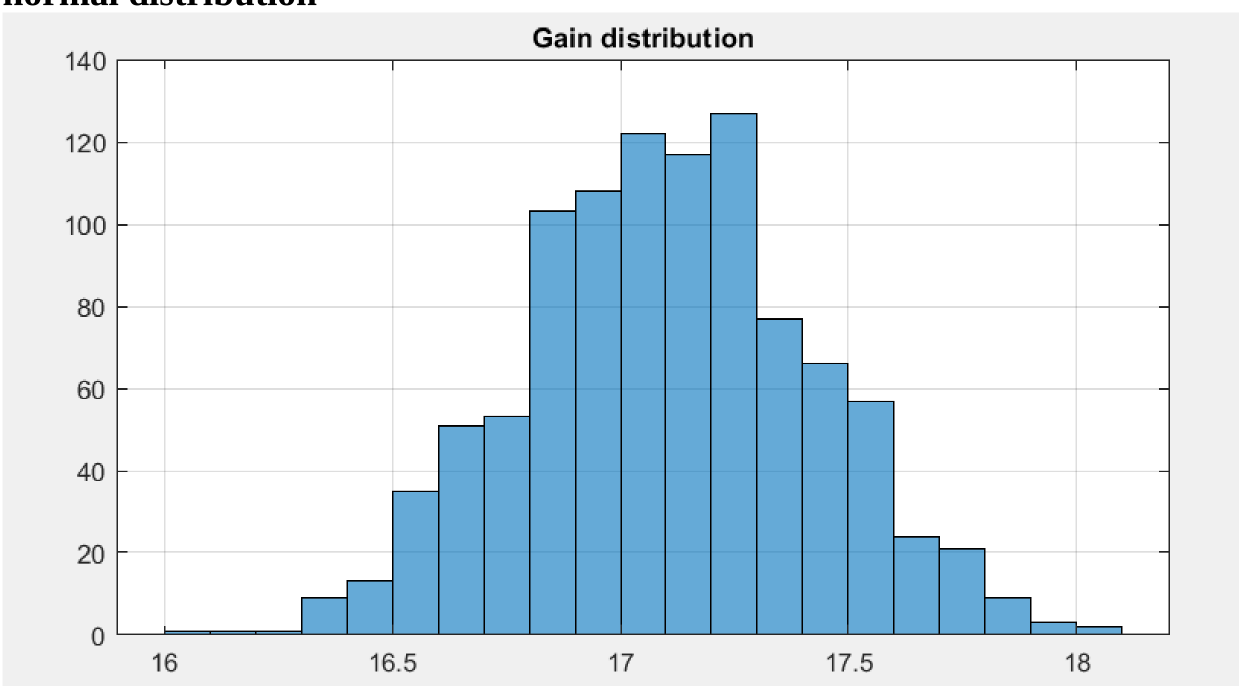


The plot is based on AC case plot VO as a function of ω(omega).



This plot is an AC case plot where the gain is a function of random perturbations on C

The case plot the gain as function of random perturbations on C using a normal distribution



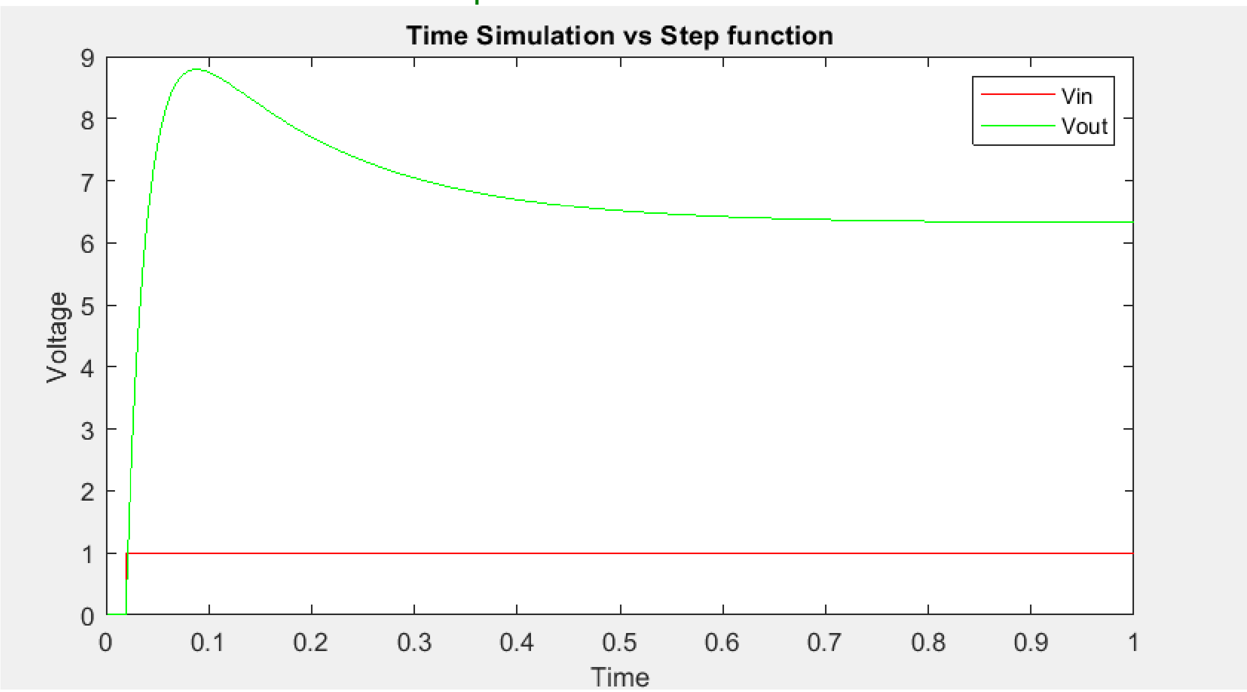
Question:4

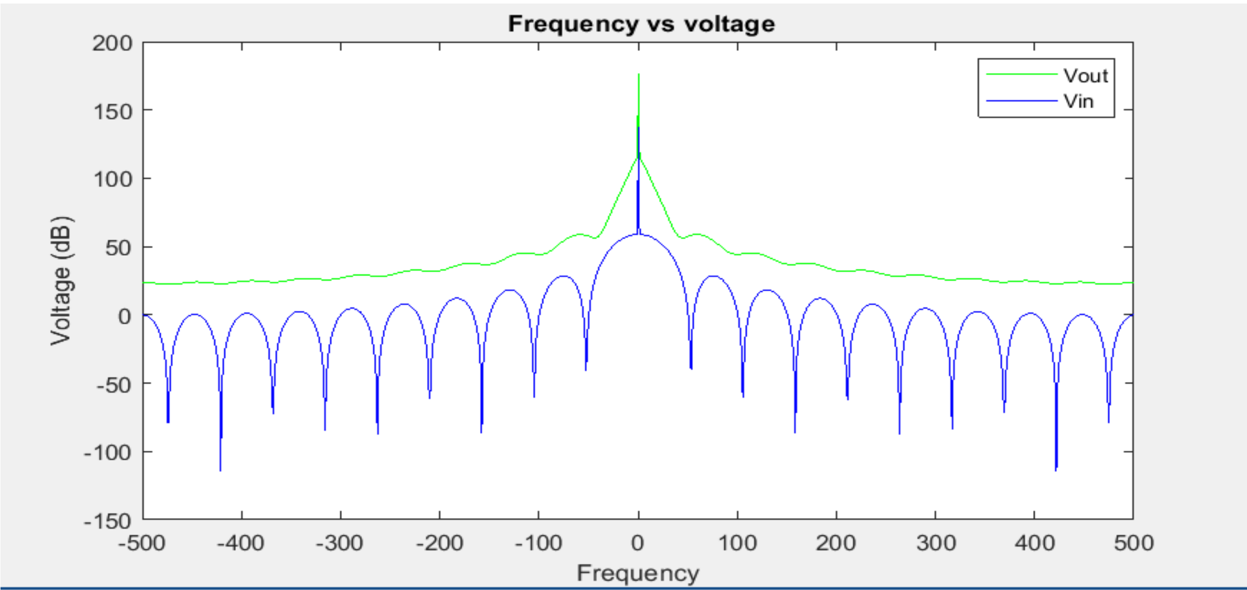
This part focus was based on determining the transient response of the same circuit.

a.) it is a low pass filter

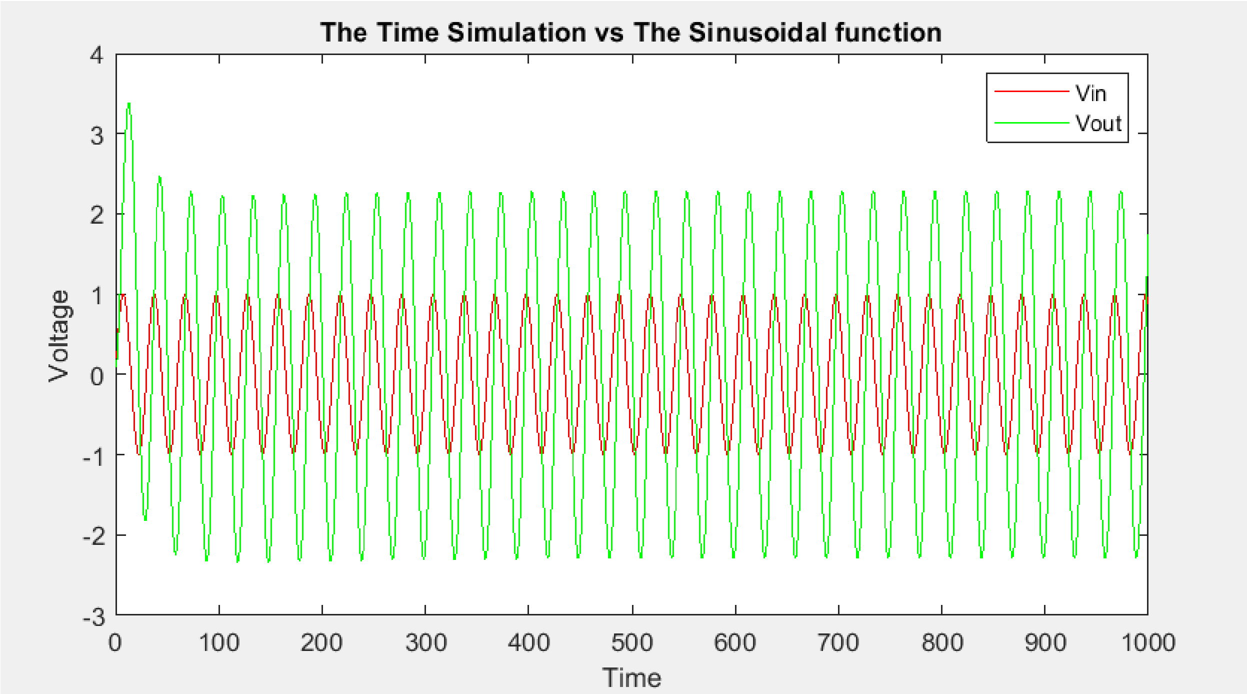
b.) Basically, the frequency response is expected to cut off the high frequencies, then the low frequencies will then go through.

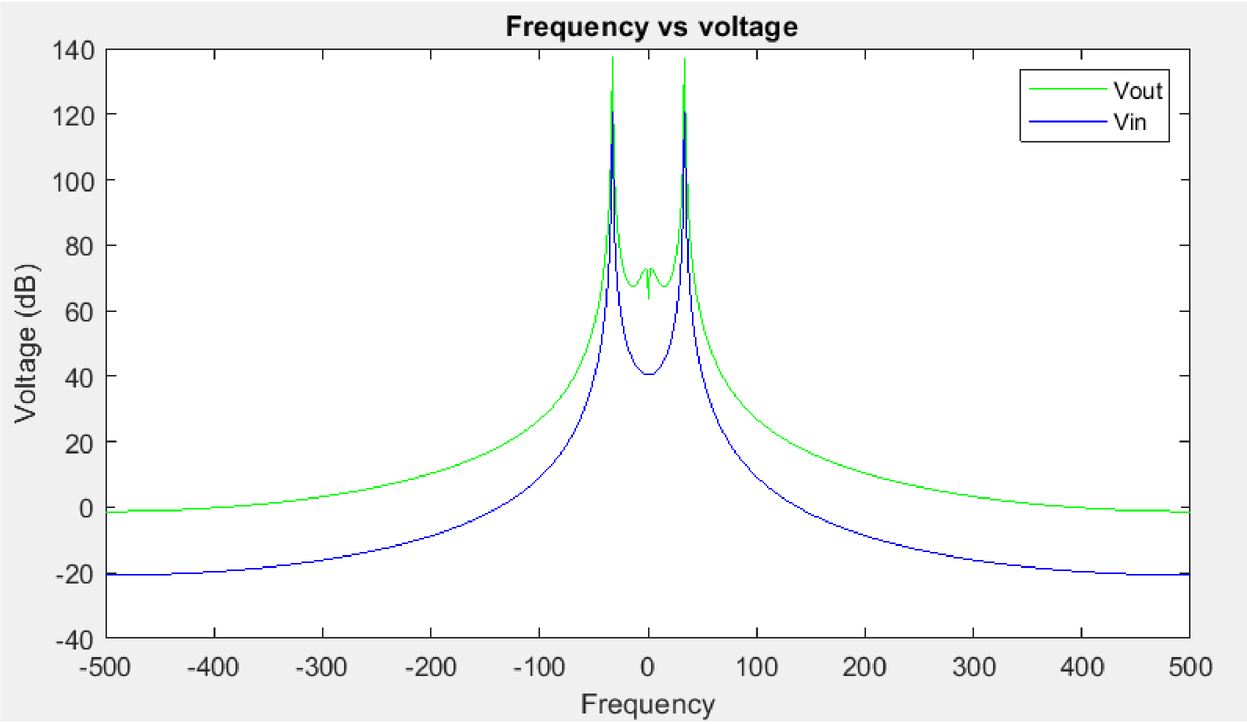
```
% Time simulation - step function
```





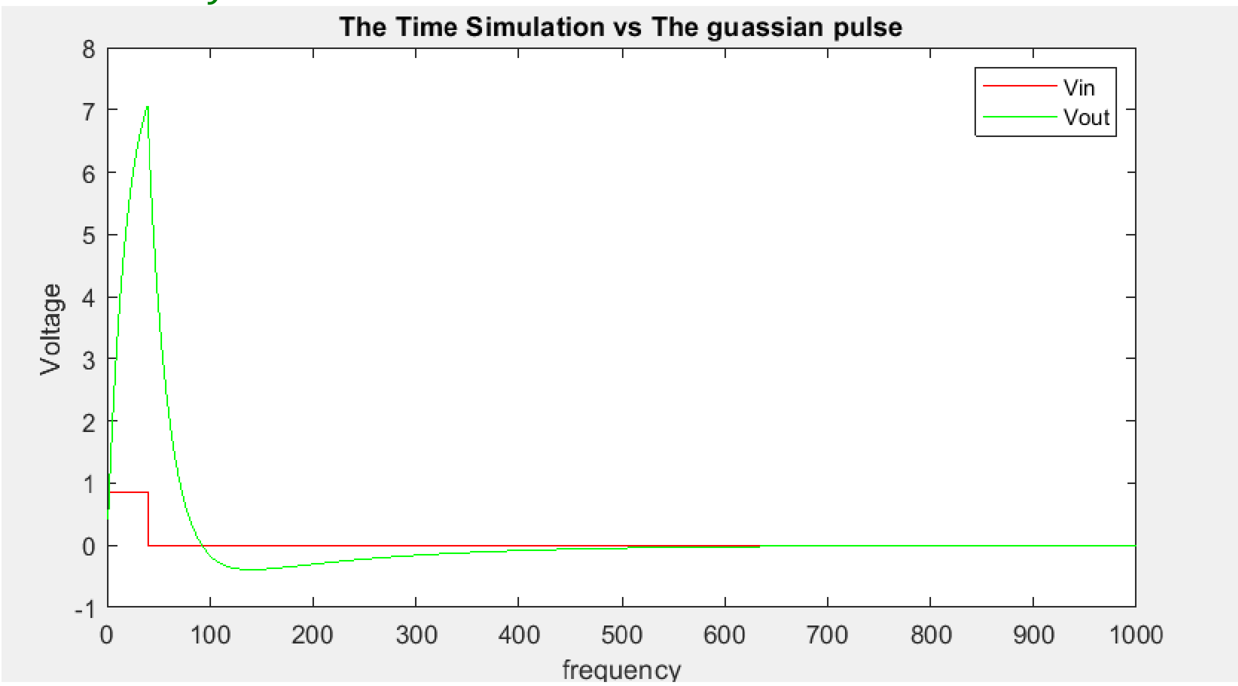
```
% Time simulation - sinusoidal function
```

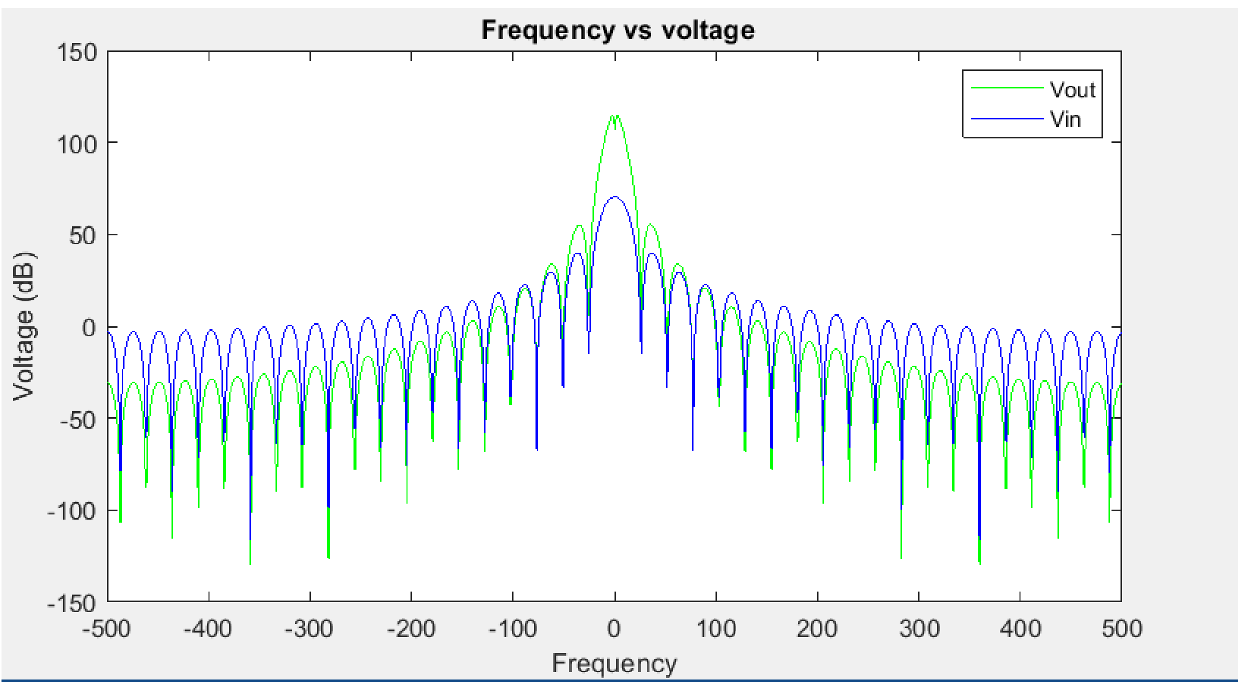




Based on the plot above when the frequency was lower it resulted to a larger period of the sine response. At the peak of the plot the frequency was approximately 33 Hz

```
%A guassian pulse with a magnitude of 1, std dev. of 0.03s
and a delay of 0.06s.
```





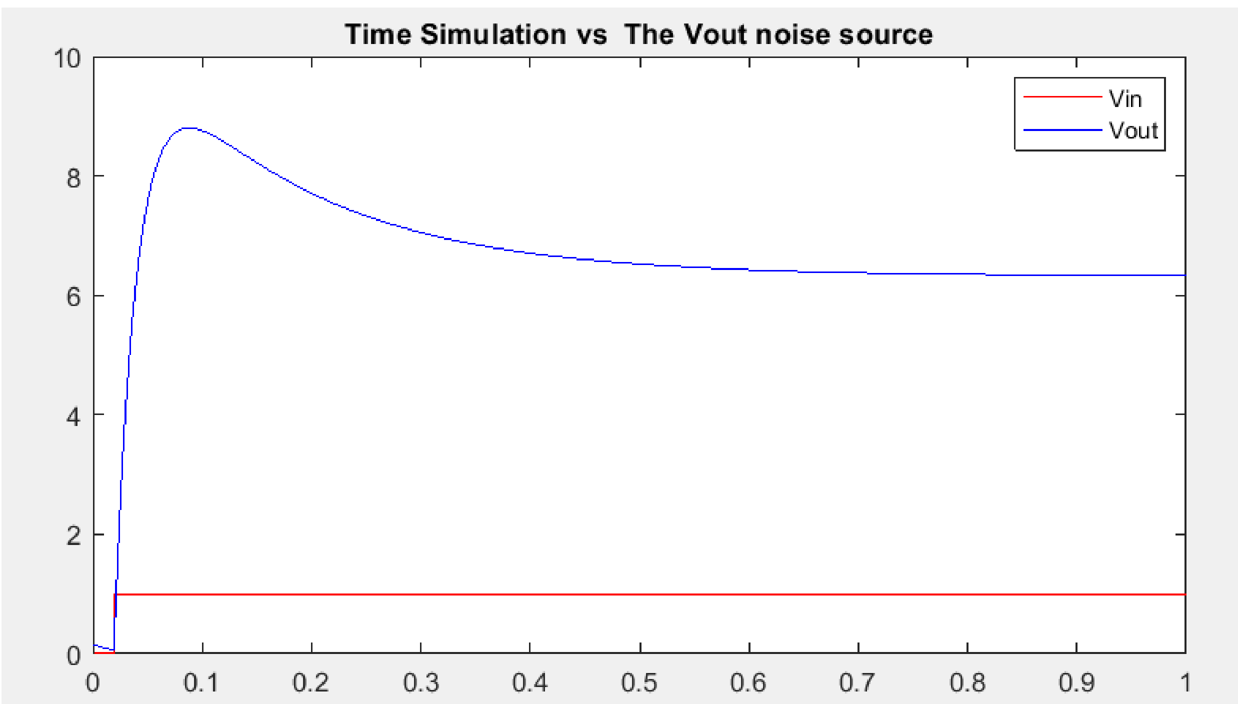
PART2

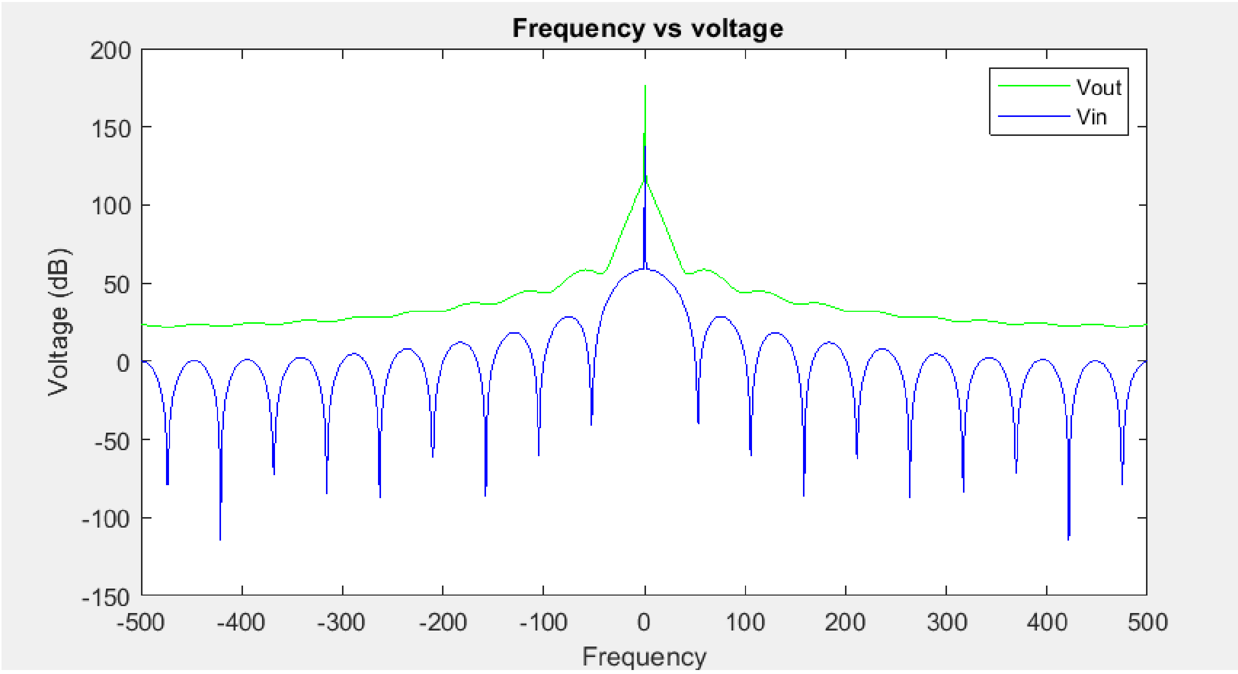
C

6x6 double

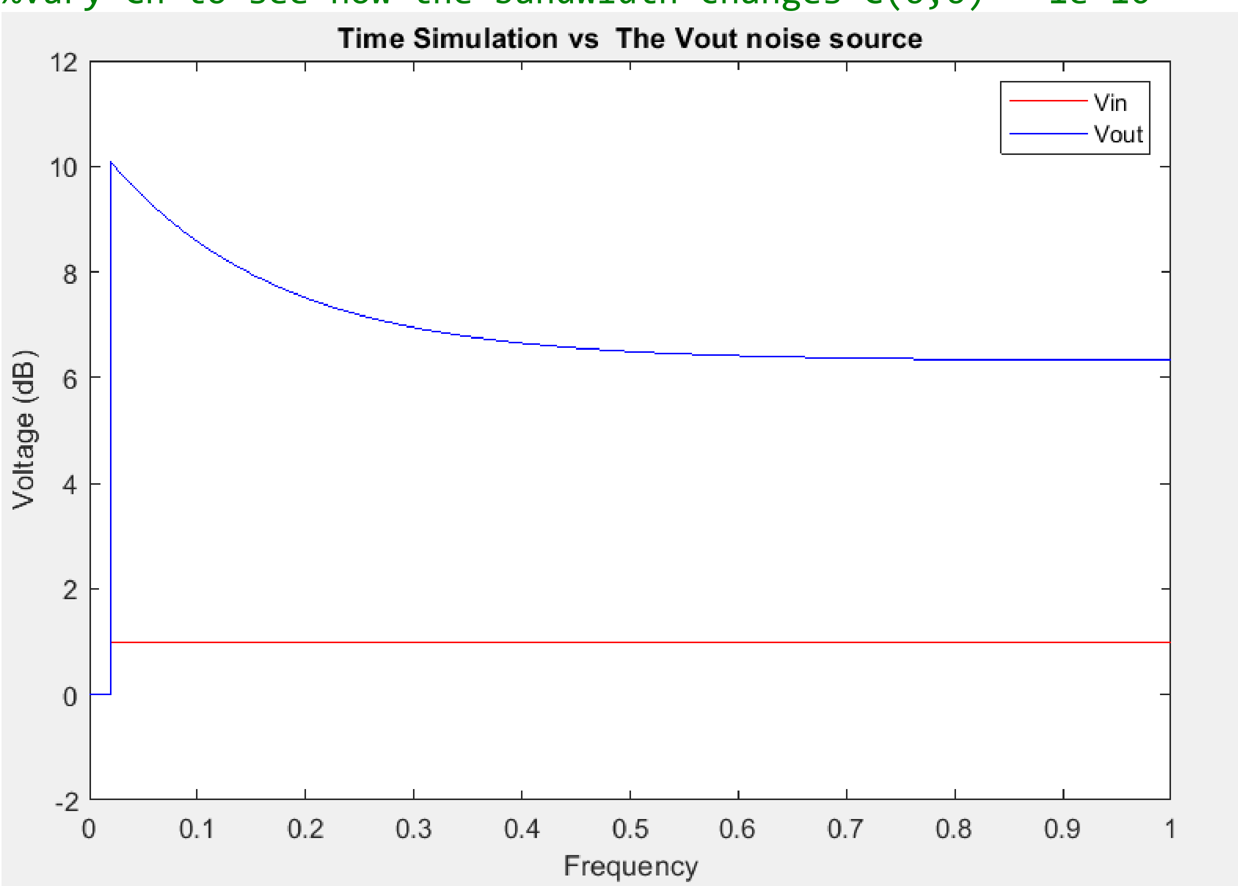
	1	2	3	4	5	6
1	0	0	0	0	0	0
2	-0.2500	0.2500	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	1.0000e-04

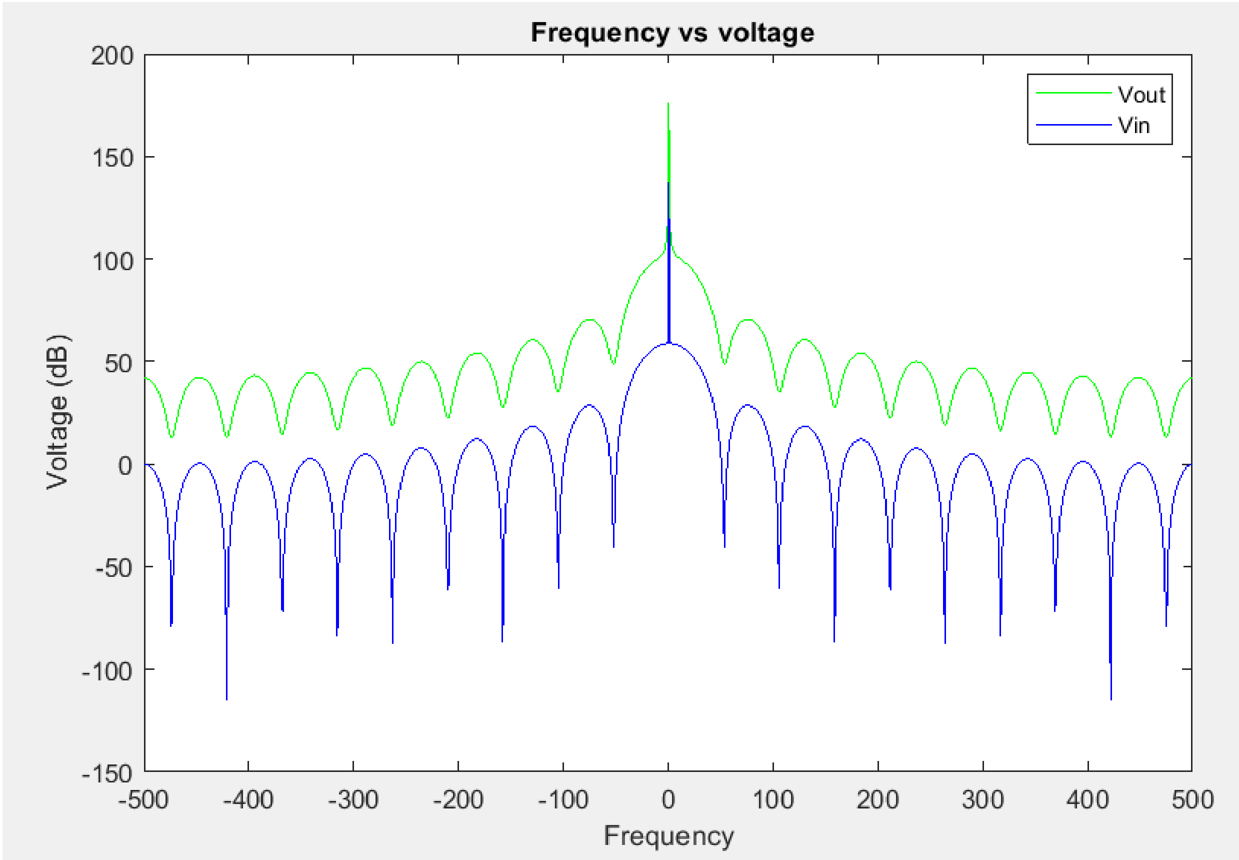
Plot of Vout with noise source



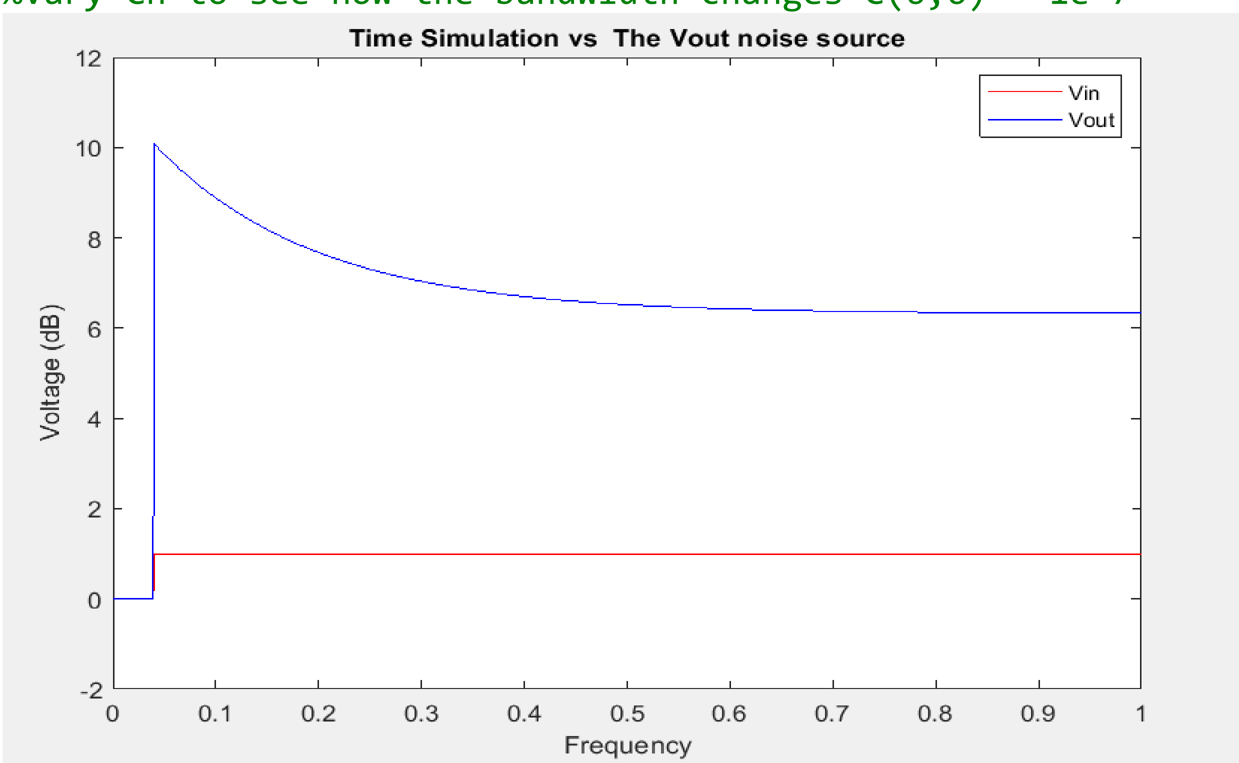


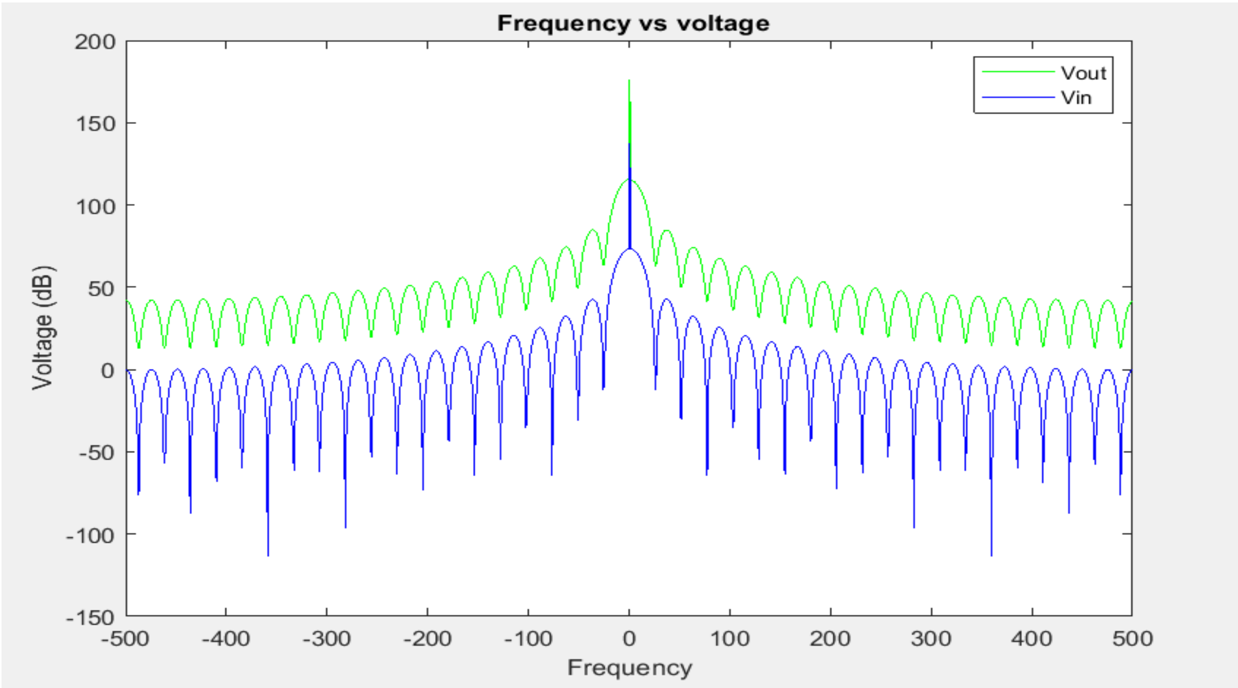

```
%vary Cn to see how the bandwidth changes C(6,6) = 1e-10
```



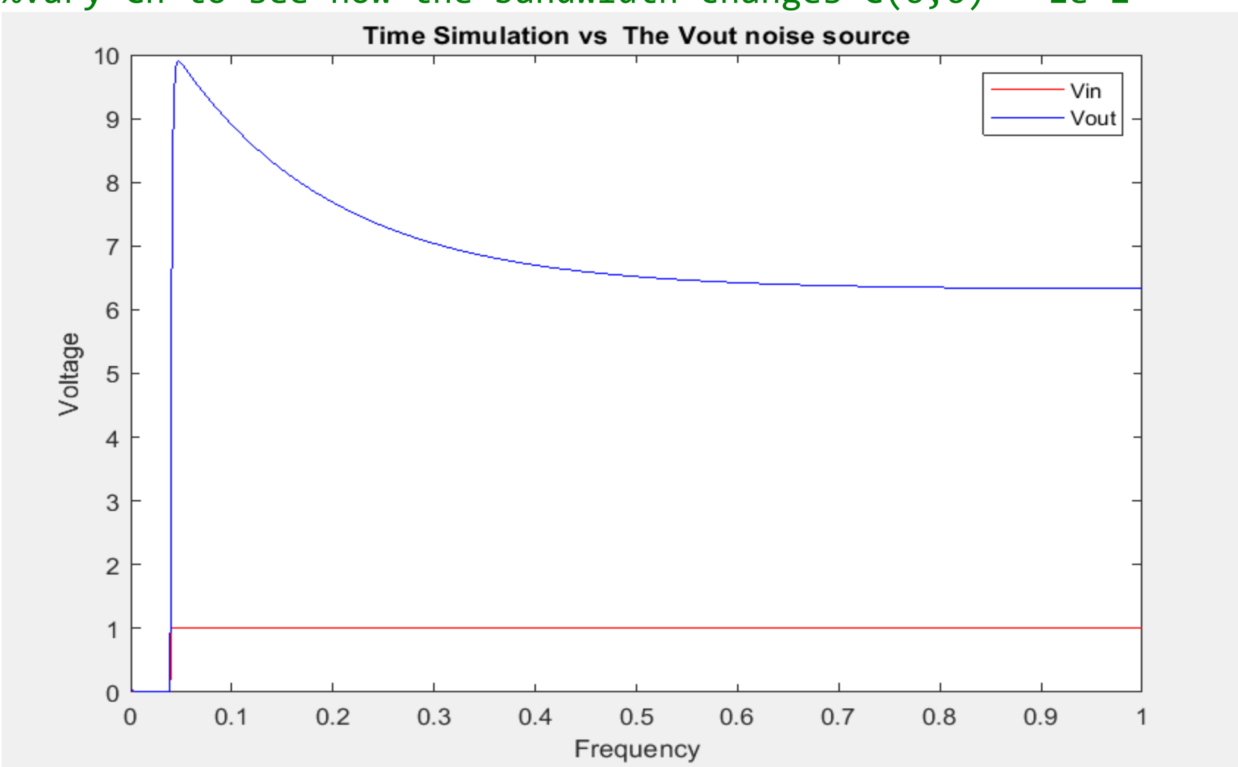


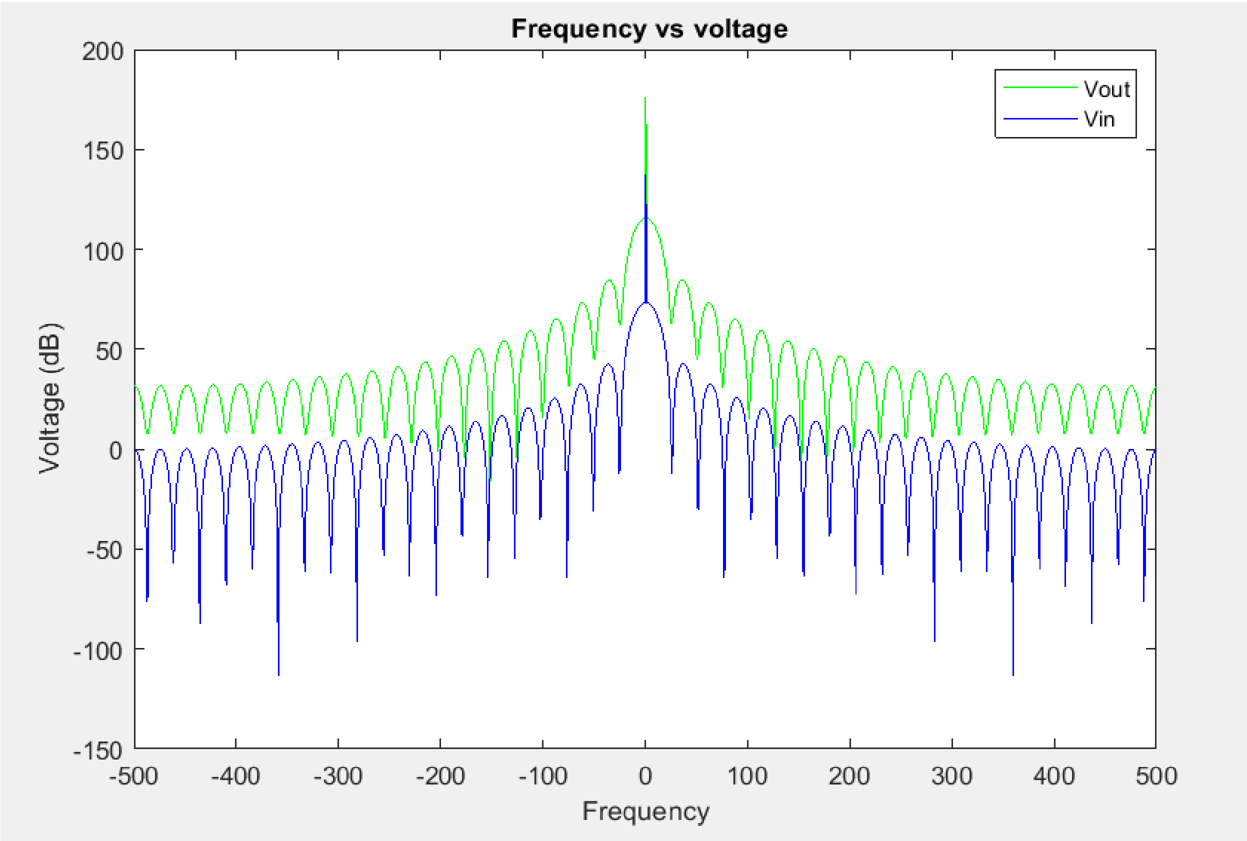

```
%vary Cn to see how the bandwidth changes C(6,6) = 1e-7
```





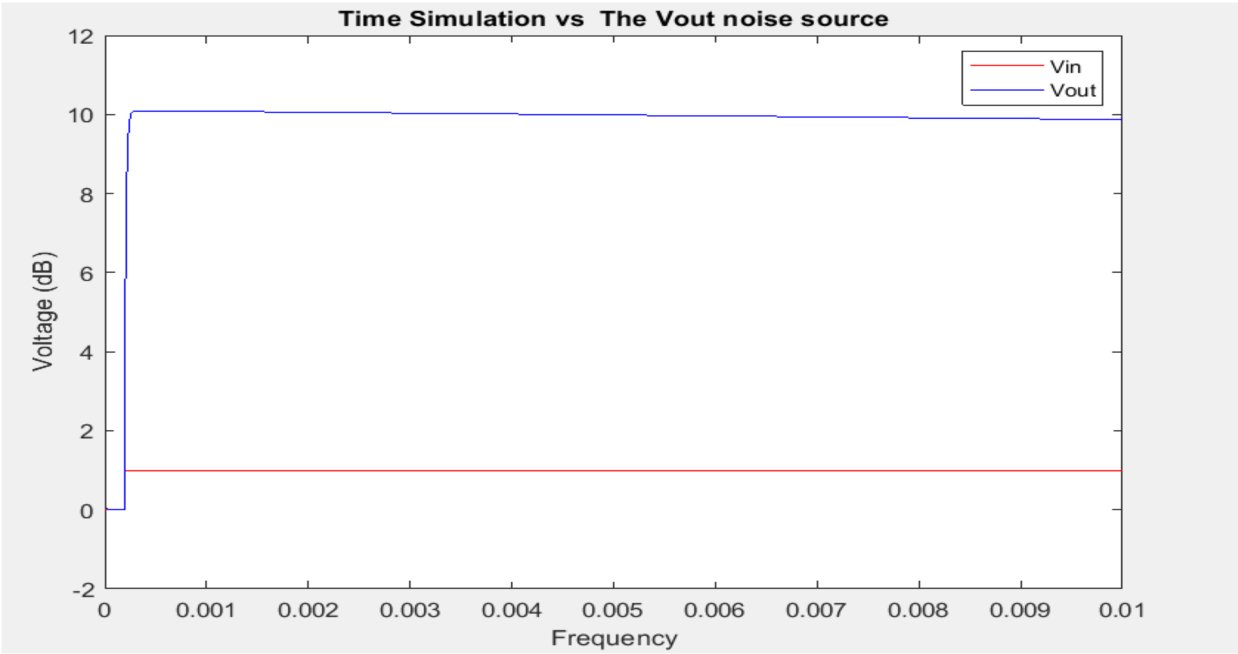
%vary Cn to see how the bandwidth changes C(6,6) = 1e-2

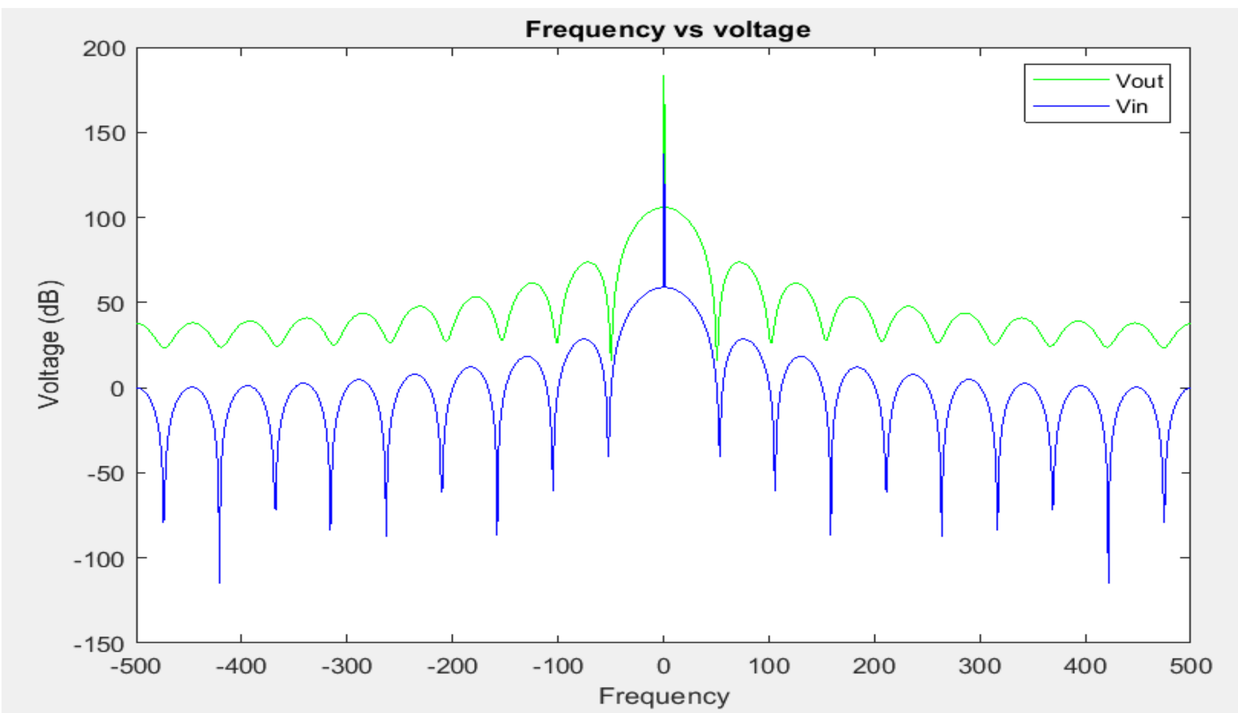




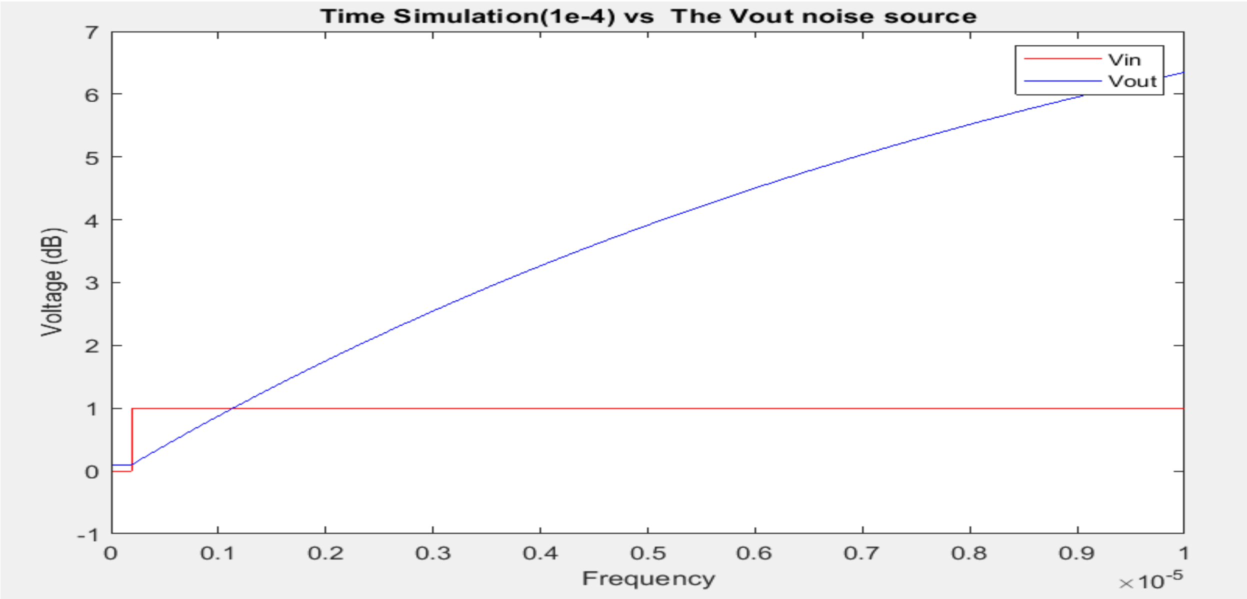
Based on the plots(vary Cn to see how the bandwidth changes) above as cn gets larger the bandwidth tends to get smaller.

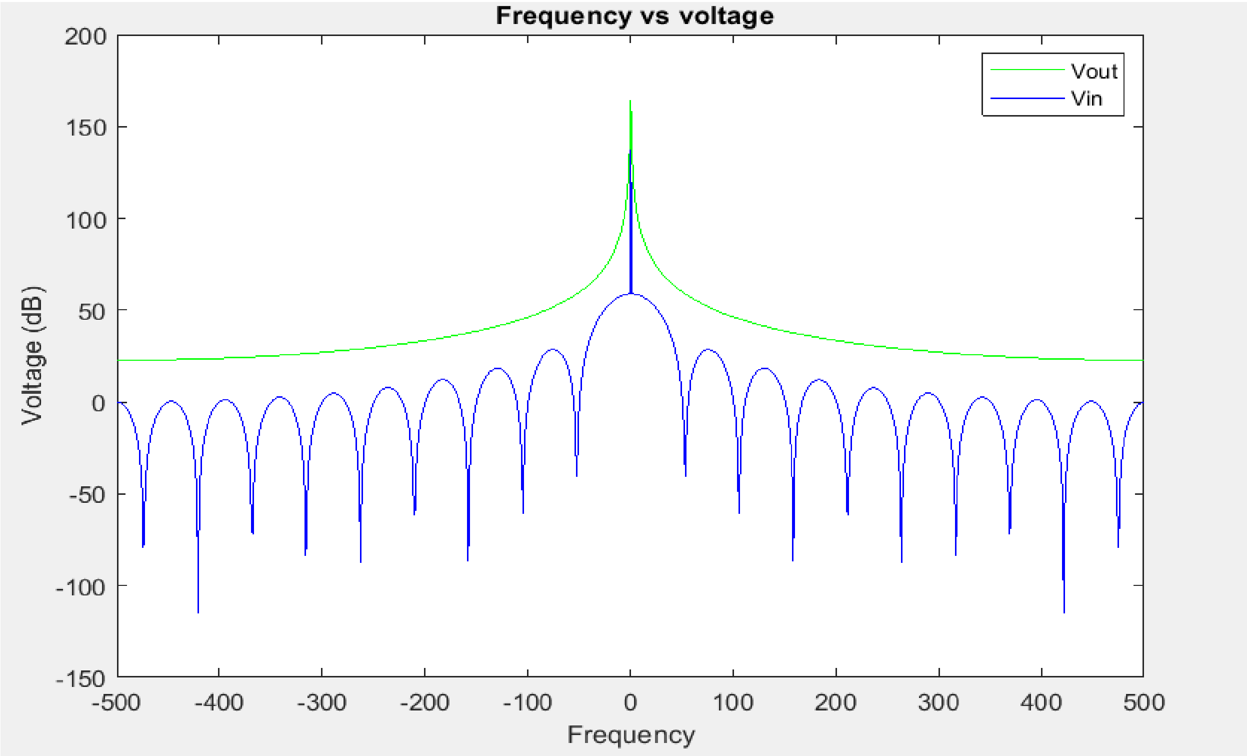
Vary the time step (Time step increased from 1000 to 100000)





Vary the time step (Time step increased from 100000t to 100000000)





Based on the plot(Vary the time step) as the time step is increased the simulation correctness decreases.

Question:6

Addition of another matrix to represent the non-linear elements. “B(V)” a non-linear vector will be added. This addition makes the system to be nonlinear, newton Raphson numerical method will come in useful. Also, backwards Euler implementation can be used.

MATLAB CODE(PART1)

```
%% Part 1
%
clearvars
clearvars -GLOBAL
close all
set(0,'DefaultFigureWindowStyle', 'docked')

meshsizex = 6;
meshsizey = 6;



vinlow = 0.1;
vinhigh = 10;

% Components

Cap = 0.25;
R1 = 1;
R2 = 2;
L = 0.2;



R3 = 10;
alpha = 100;
R4 = 0.1;
Ro = 1000;
omg = 10;

% C Matrix
%C=zeros(6,6);
C = zeros(meshsizex,meshsizey);
C(2,1) = -Cap;
C(2,2) = Cap;
C(6,6) = L;

% G Matrix
```

```
G = zeros (meshsizex, meshsizey);
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;
%%
% The  C and G matrix
C;
G;
%%
F=zeros(6,1);
Vv1 = zeros(10,1);
Vv2 = zeros(100,1);
gain = zeros(10,1);
vin = linspace(-10,10,100);
for i=1:100
   %F(6) = i;
   F(1) = vin(i);
   V=G\F;

   Vv1(i) = V(5);
   Vv2(i) = V(3);
end
figure (1)
plot(vin,Vv1)
title('DC SWEEP');
xlabel('voltage sweep');
ylabel(' output Voltage');
hold on
plot(vin,Vv2)
```

```
%THE AC
Vv1 = zeros(10,1);
Vv2 = zeros(100,1);

step=100;
omg = 2*pi*linspace(0,20,step);

for i=1:100
omg =2*pi*linspace(0,20,step);
F(1) = vin(i);

s=i*omg(i);
    x = G + (s.*C);
    V = x\F;

     Vv1(i) = V(5);
    Vv2(i) = V(3);
     gain(i) = 20 * log(abs(Vv1(i))/abs(V(1)));
end
figure (2)
plot (omg,abs(Vv1))
title(' 0 to 100Hz');
hold on;
figure (2)
plot(omg,abs(Vv2))
legend('Vo', 'V3');
xlabel('w');
ylabel('V');
figure(3)
plot(omg, gain);
title('Gain vs omega');
xlabel('omega');
ylabel('gain');

s = 1i*pi;

%C case plot the gain as function of random perturbations on
C using a normal distribution
for i = 1:1000
```

```
    randomcap = Cap + 0.05*randn(); % random perturbations
on C
    C(2, 1) = randomcap;
    C(2, 2) = -randomcap;
    C(6, 6) = L;

    H = G +(s.*C);
    V = H\F;
    Vv1(i) = abs(V(5));
    gain(i) = 20*log10(abs(Vv1(i))/abs(V(1)));
end

figure(4)
histogram(gain)
title('Gain distribution');
grid on


% C dV/dt + GV = F
% C*(V_i - V_(i-1))/delta t + G*V_i = F
% (C/delta t + G) * V_i + C/delta t*V_(i-1) = F
% C/delta t * V_(i-1) - F = (C/delta t + G)*V_i
% (C/delta t + G)  \ (C/delta t * V_(i-1) - F) = V_i  <-


Simtime = 1;
numSteps = 1000;
deltaT = Simtime/numSteps;
% H vector

% C Matrix
%C=zeros(6,6);
C = zeros(meshsizex,meshsizey);
C(2,1) = -Cap;
C(2,2) = Cap;

C(6,6) = L;

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

```
 V = zeros(6,1);
 Vp = V;


% F vector
F = zeros(1,6);

Vv1 = zeros(10,1);
Vv2 = zeros(100,1);
% Time simulation - step function

newtime = linspace(1,numSteps,numSteps);

for i = 1:numSteps

    % F vector

    if (i == 20)
        F(1) = 1;
    end
    newtime(i) = i*deltaT;
    V = H\(((C * Vp)./deltaT) + F');

    Vv1(i) = V(1);
    Vv2(i) = V(5);

    Vp = V;
end

 figure(5)
   plot(newtime,Vv1,'-r');
    hold on
   plot(newtime,Vv2,'g');
pause(0.01);
legend('Vin', 'Vout');
title('Time Simulation vs Step function');
xlabel('Time');
ylabel('Voltage');
```

```
figure(6)
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv2)))),'-g');
hold on
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv1)))),'-b');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage (dB)');
title(' Frequency vs voltage');


% Time simulation - sinusoidal function

Simtime = 1;
numSteps = 1000;
deltaT = Simtime/numSteps;
% H vector
H = (C./deltaT) + G;

Vv1 = zeros(10,1);
Vv2 = zeros(100,1);
Vp = zeros(6,1);

newtime = linspace(1,numSteps,numSteps);
for i = 1:numSteps

    % F vector

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

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



   Vv1(i) = V(1);
    Vv2(i) = V(5);
    Vp = V;
end
```

```
 figure(7)
    plot(newtime,Vv1,'r');
    hold on
   plot(newtime,Vv2,'g');
pause(0.01);
legend('Vin', 'Vout');
title('Time Simulation vs Step function');
xlabel('Time');
ylabel('Voltage');
legend('Vin', 'Vout');
title('The Time Simulation vs The Sinusoidal function');
xlabel('Time');
ylabel('Voltage');

figure(8)
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv2)))),'g');
hold on
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv1)))),'b');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage (dB)');
title(' Frequency vs voltage');


% plot(ti,g)
% g = exp(-(ti-0.3).^2/0.1^2)
%A guassian pulse with a magnitude of 1, std dev. of 0.03s
and a delay of 0.06s.

Simtime = 1;
numSteps = 1000;
deltaT = Simtime/numSteps;
% H vector
H = (C./deltaT) + G;

Vv1 = zeros(10,1);
```

```
Vv2 = zeros(100,1);
Vp = zeros(6,1);

gp=sin(2*pi*0.03)*exp(-(newtime-0.06-0.5).^2/(2*0.03^2));
newtime = linspace(1,numSteps,numSteps);
for i = 1:numSteps

    % F vector
    if (i == 40)
        F(1) = gp(i);
    end



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



   Vv1(i) = V(1);
    Vv2(i) = V(5);
    Vp = V;
end

 figure(9)
    plot(newtime,Vv1,'r');
    hold on
   plot(newtime,Vv2,'g');
pause(0.01);
legend('Vin', 'Vout');
title('Time Simulation vs guassian pulse');
xlabel('Time');
ylabel('Voltage');
legend('Vin', 'Vout');
title('The Time Simulation vs The guassian pulse');
xlabel('frequency');
ylabel('Voltage');

figure(10)
```

```
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv2)))),'g');
hold on
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv1)))),'b');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage (dB)');
title(' Frequency vs voltage');
```

MATLAB CODE(PART2)

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

meshsizex = 6;
meshsizey = 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;
omg = 10;
```

```
% Noise components
In = 0.001;
Cn =  0.00001;

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

% G Matrix
G = zeros (meshsizex, meshsizey);
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;

Simtime = 1;
numSteps = 1000;
deltaT = Simtime/numSteps;
% H vector
H = (C./deltaT) + G;

 V = zeros(6,1);
 Vp = V;
```

```
% F vector
F = zeros(1,6);
%F(3)=In;
 F(3) = In*randn();

Vv1 = zeros(10,1);
Vv2 = zeros(100,1);
newtime = linspace(1,numSteps,numSteps);

for i = 1:numSteps

    % F vector

    if (i == 20)
        F(1) = 1;
    end
    newtime(i) = i*deltaT;
    V = H\(((C * Vp)./deltaT) + F');

    Vv1(i) = V(1);
    Vv2(i) = V(5);

    Vp = V;

end

 figure(1)
  plot(newtime,Vv1,'-r');
    hold on
   plot(newtime,Vv2,'-b');
pause(0.01);
legend('Vin', 'Vout');
title('Time Simulation vs  The Vout noise source');
figure(2)
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv2))))),'-g');
hold on
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv1))))),'-b');
```

```
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage (dB)');
title(' Frequency vs voltage');


%vary Cn to see how the bandwidth changes C(6,6) = 1e-10
C = zeros(meshsizex,meshsizey);
C(2,1) = -Cap;
C(2,2) = Cap;
C(6,6) = 1e-20;
Simtime = 1;
numSteps = 1000;
deltaT = Simtime/numSteps;
% H vector
H = (C./deltaT) + G;

 V = zeros(6,1);
 Vp = V;

% F vector
F = zeros(1,6);
F(3)=In;
 %F(3) = In*randn();

Vv1 = zeros(10,1);
Vv2 = zeros(100,1);
newtime = linspace(1,numSteps,numSteps);

for i = 1:numSteps

    % F vector

    if (i == 20)
        F(1) = 1;
    end
    newtime(i) = i*deltaT;
    V = H\(((C * Vp)./deltaT) + F');
```

```
    Vv1(i) = V(1);
    Vv2(i) = V(5);

    Vp = V;



end

 figure(3)
  plot(newtime,Vv1,'-r');
    hold on
   plot(newtime,Vv2,'-b');
pause(0.01);
legend('Vin', 'Vout');
xlabel('Frequency');
ylabel('Voltage (dB)');
title('Time Simulation vs  The Vout noise source');
figure(4)
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv2)))),'-g');
hold on
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv1)))),'-b');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage (dB)');
title(' Frequency vs voltage');

%vary Cn to see how the bandwidth changes C(6,6) = 1e-7

C(6,6) = 1e-7;
Simtime = 1;
numSteps = 1000;
deltaT = Simtime/numSteps;
% H vector
H = (C./deltaT) + G;

 V = zeros(6,1);
```

```
 Vp = V;

% F vector
F = zeros(1,6);
F(3)=In;
 %F(3) = In*randn();

Vv1 = zeros(10,1);
Vv2 = zeros(100,1);
newtime = linspace(1,numSteps,numSteps);

for i = 1:numSteps

    % F vector

    if (i == 40)
        F(1) = 1;
    end
    newtime(i) = i*deltaT;
    V = H\(((C * Vp)./deltaT) + F');

    Vv1(i) = V(1);
    Vv2(i) = V(5);

    Vp = V;

end

 figure(5)
  plot(newtime,Vv1,'r');
    hold on
   plot(newtime,Vv2,'b');
pause(0.01);
legend('Vin', 'Vout');
xlabel('Frequency');
ylabel('Voltage (dB)');
title('Time Simulation vs  The Vout noise source');
figure(6)
```

```
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv2))))),'g');
hold on
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv1))))),'b');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage (dB)');
title(' Frequency vs voltage');

%vary Cn to see how the bandwidth changes C(6,6) = 1e-2

C(6,6) = 1e-2;
Simtime = 1;
numSteps = 1000;
deltaT = Simtime/numSteps;
% H vector
H = (C./deltaT) + G;

 V = zeros(6,1);
 Vp = V;

% F vector
F = zeros(1,6);
F(3)=In;
 %F(3) = In*randn();

Vv1 = zeros(10,1);
Vv2 = zeros(100,1);
newtime = linspace(1,numSteps,numSteps);

for i = 1:numSteps

    % F vector

    if (i == 40)
        F(1) = 1;
    end
    newtime(i) = i*deltaT;
```

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

    Vv1(i) = V(1);
    Vv2(i) = V(5);

    Vp = V;

end

 figure(8)
  plot(newtime,Vv1,'r');
    hold on
   plot(newtime,Vv2,'b');
pause(0.01);
legend('Vin', 'Vout');
xlabel('Frequency');
ylabel('Voltage');
title('Time Simulation vs  The Vout noise source');
figure(9)
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv2)))),'g');
hold on
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv1)))),'b');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage (dB)');
title(' Frequency vs voltage');

%vary the time step

C(6,6) = 1e-4;
% Simtime = 1;
% numSteps = 1000;
% deltaT = Simtime/numSteps;
deltaT=1e-5;
% H vector
H = (C./deltaT) + G;
```

```
 V = zeros(6,1);
 Vp = V;

% F vector
F = zeros(1,6);
F(3)=In;
 %F(3) = In*randn();

Vv1 = zeros(10,1);
Vv2 = zeros(100,1);
newtime = linspace(1,numSteps,numSteps);

for i = 1:numSteps

    % F vector

    if (i == 20)
        F(1) = 1;
    end
    newtime(i) = i*deltaT;
    V = H\(((C * Vp)./deltaT) + F');

    Vv1(i) = V(1);
    Vv2(i) = V(5);

    Vp = V;

end

 figure(10)
  plot(newtime,Vv1,'r');
    hold on
   plot(newtime,Vv2,'b');
pause(0.01);
legend('Vin', 'Vout');
xlabel('Frequency');
ylabel('Voltage (dB)');
title('Time Simulation vs  The Vout noise source');
figure(11)
```

```
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv2))))),'g');
hold on
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv1))))),'b');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage (dB)');
title(' Frequency vs voltage');

%vary time
C(6,6) = 1e-4;
% Simtime = 10000;
% numSteps = 1000;
% deltaT = Simtime/numSteps;
deltaT=1e-8;
% H vector
H = (C./deltaT) + G;

 V = zeros(6,1);
 Vp = V;

% F vector
F = zeros(1,6);
F(3)=In;
 %F(3) = In*randn();

Vv1 = zeros(10,1);
Vv2 = zeros(100,1);
newtime = linspace(1,numSteps,numSteps);

for i = 1:numSteps

    % F vector

    if (i == 20)
        F(1) = 1;
    end
    newtime(i) = i*deltaT;
```

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

    Vv1(i) = V(1);
    Vv2(i) = V(5);

    Vp = V;

end

 figure(12)
  plot(newtime,Vv1,'r');
    hold on
   plot(newtime,Vv2,'b');
pause(0.01);
legend('Vin', 'Vout');
xlabel('Frequency');
ylabel('Voltage (dB)');
title('Time Simulation(1e-4) vs  The Vout noise source');
figure(13)
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv2)))),'g');
hold on
plot(linspace(-
500,500,1000),fftshift(20*log(abs(fft(Vv1)))),'b');
legend('Vout', 'Vin');
xlabel('Frequency');
ylabel('Voltage (dB)');
title(' Frequency vs voltage');
```