ELEC 4700 Assignment 4

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Q1 In this part we analyse the circuit , determine G & C matrices. Using nodal analysis to describe the following system of differential equations:

$$V1 = Vin$$

$$G1(V2 - V1) + C1\frac{d(V2 - V1)}{dt} + Il = 0$$

$$G3V3 - Il = 0$$

$$G3V3 - I3 = 0$$

$$G4(Vo - V4) + GoVo = 0$$

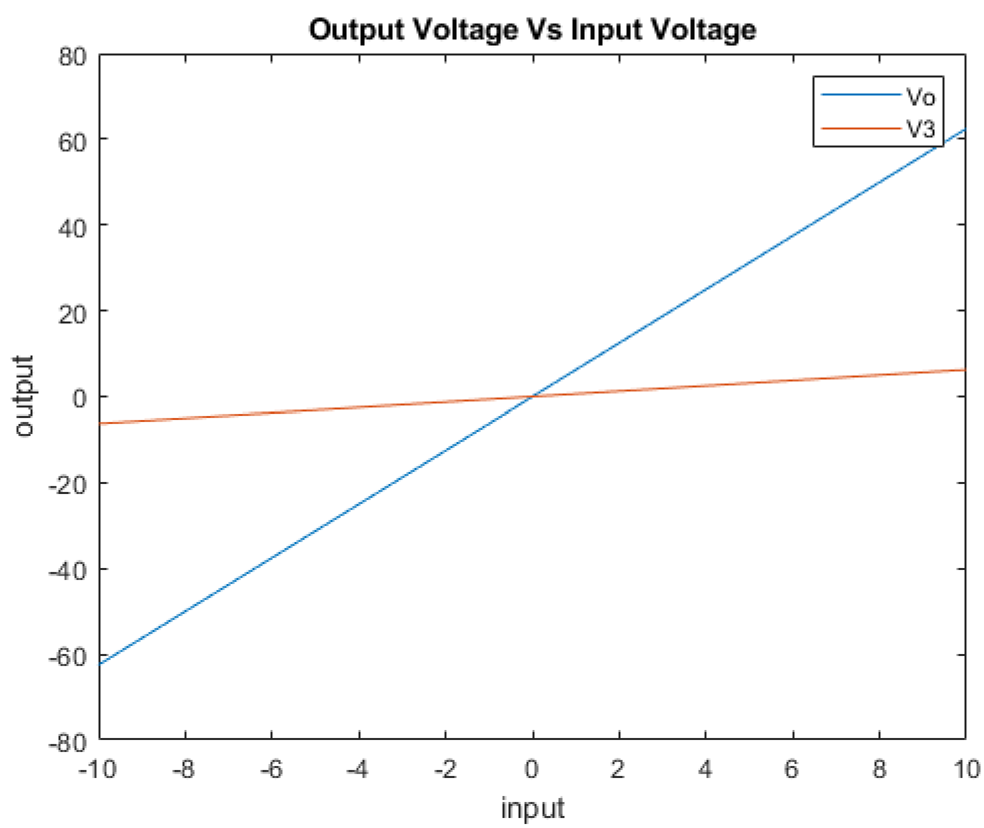
$$V2 - V3 - L\frac{dIl}{dt} = 0$$

$$V4 - aI3 = 0$$

Code : figure 1

```
%%%%%%%%%%%%%%%%%%%%
R1 = 1;
R2 = 2;
C = 0.25;
L = 0.2;  %inductance
R3 = 10;
a = 100;
R4 = 0.1;
R0 = 1000;

G1 = 1/R1;%conductance
G2 = 1/R2;
G3 = 1/R3;
G4 = 1/R4;
C_matrix = [0 0 0 0 0 0 0;
           -C C 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_Matrix = [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 -a 1 0;
            0 0 0 G3 -1 0 0;
            0 0 0 0 0 -G4 G4+G1];

       F = zeros(7,1);V = zeros(7,1);

count = 1;
for i = -10:10
    F(1) = i;
    V = G_Matrix\F;
    Vdc(count) = V(5);
    V3(count) = V(3);
    count = count + 1;
end
figure(1)
plot(linspace(-10,10,21),Vdc)
hold on
figure(2)
plot(linspace(-10,10,21),V3)
title('Output Voltage Vs Input Voltage')
legend('Vo','V3')
```




```
%% AC simulations - (jwC + G)V = F(w)
```

```
j = sqrt(-1);
count = 1;
F(1) = 1;
for w = 0:1000
    Gc = G_Matrix + j*w*C_matrix;
    V = Gc\F;
    Vac(count) =  V(5);
    count = count+1;
end

figure(2)
plot(0:1000,abs(Vac))
title('Ouput Voltage vs Frequency')
xlabel('Frequency (rad/s)')


figure(3)
semilogx(0:1000, log10(abs(Vac)))
title('Gain vs Frequency')
xlabel('Frequncy (rad/s)')
ylabel('Gain (dB)')


plot(linspace(-10,10,21),V3)
title('Output Voltage Vs Input Voltage')
```

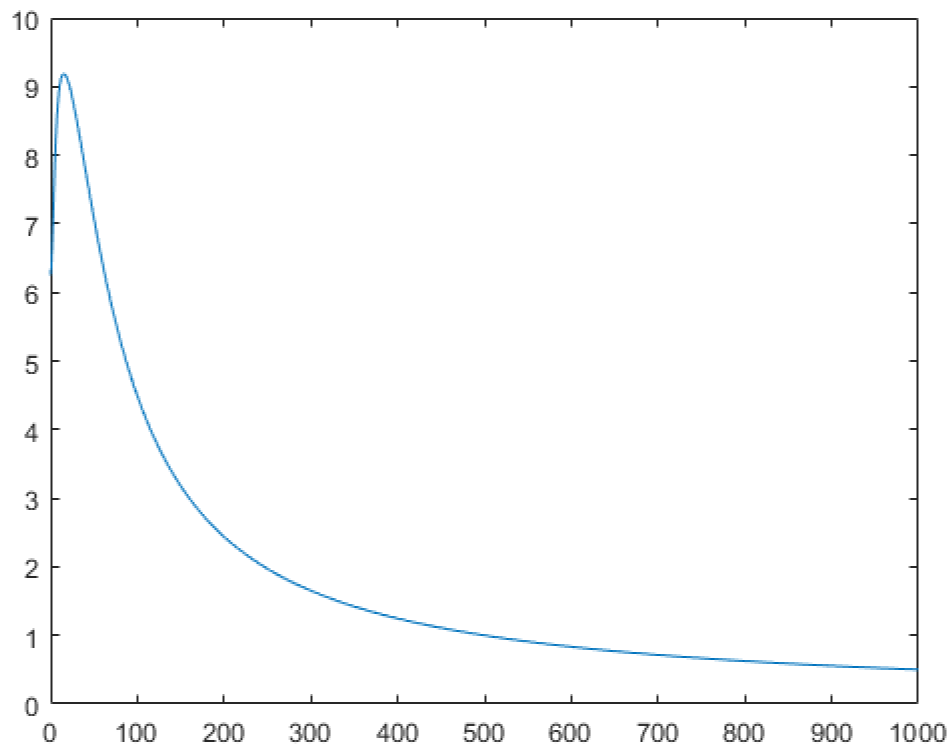
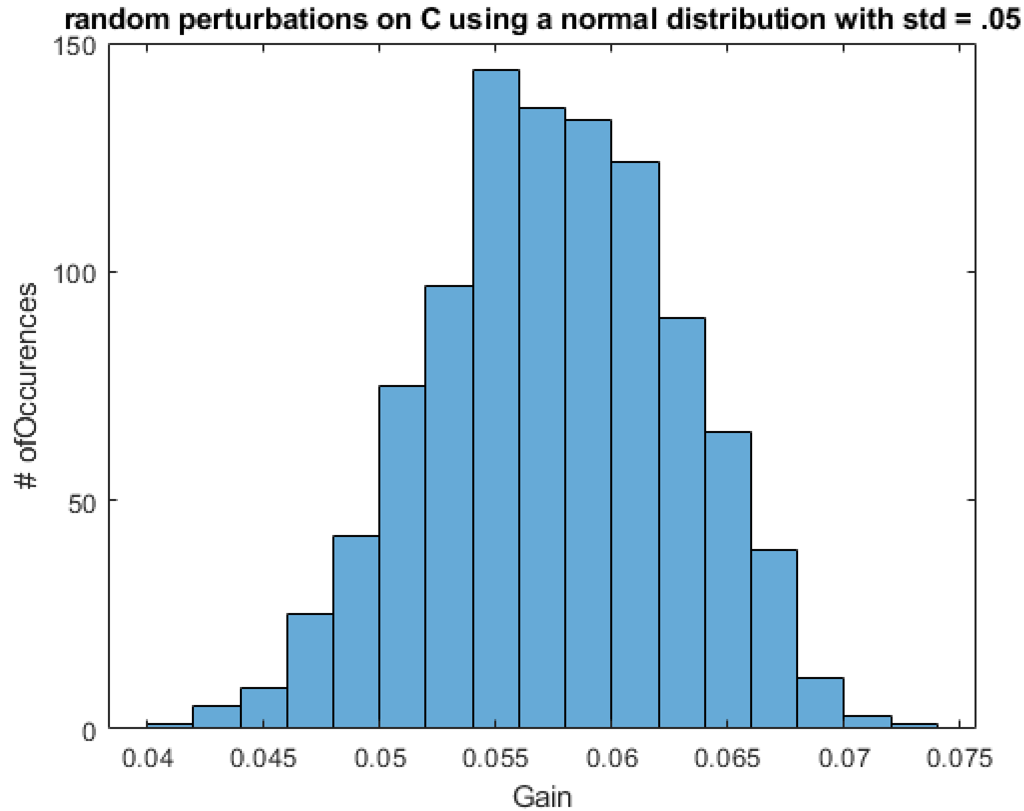
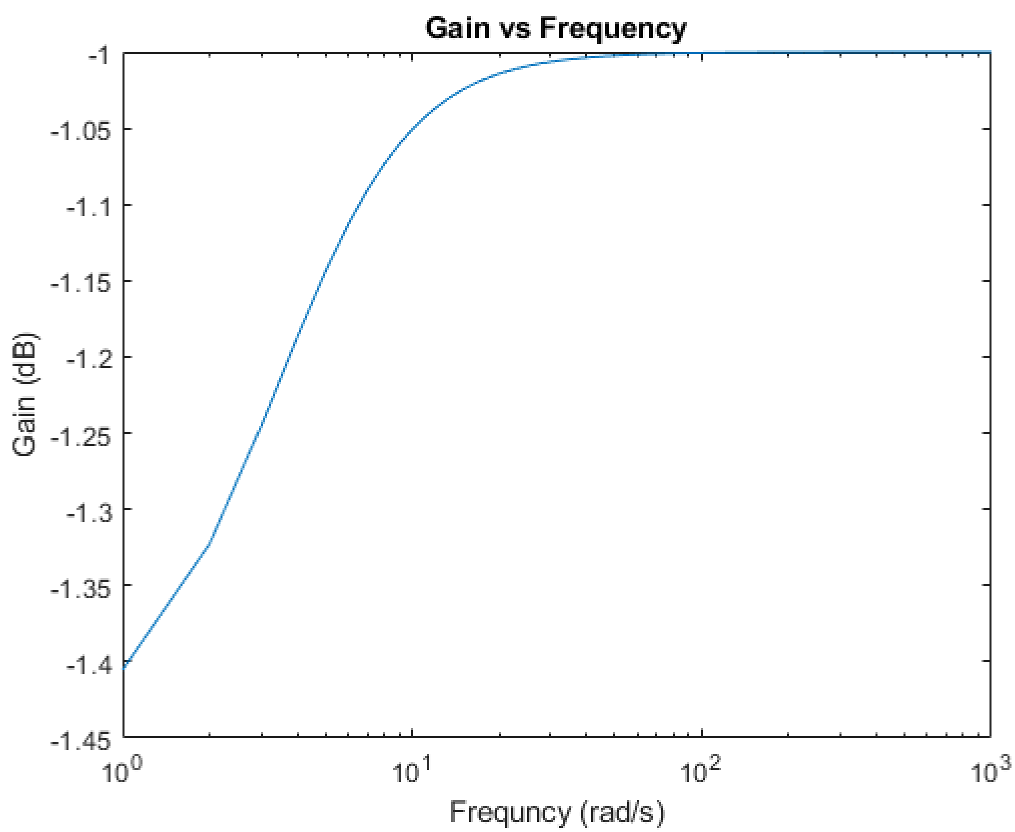


Figure 1 Figure 2

```
plot(linspace(-10,10,21),V3)
```

```
title('Output Voltage Vs Input Voltage')


C_random = C_matrix;
for i = 1:1000
    Cr = normrnd(C,0.05);
    C_random(2,1) = -Cr;
    C_random(2,2) = Cr;
    V = (j*pi*C_random + G_Matrix)\F;
    V_rand(i) = V(5);
end
histogram(abs(V_rand));
title('random perturbations on C using a normal distribution with std = .05')
xlabel('Gain')
ylabel('# ofOccurences')
```

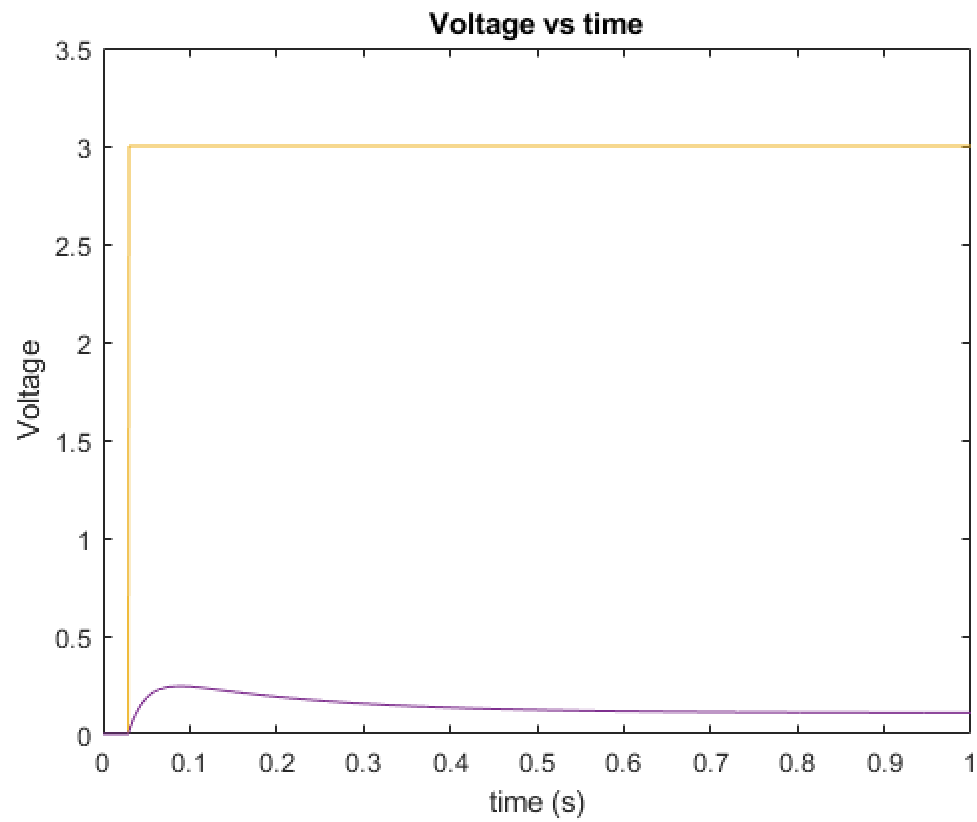

random perturbations on C using a normal distribution with std = .05
ofOccurences
Gain
150
100
50
0
0.04
0.045
0.05
0.055
0.06
0.065
0.07
0.075


Gain vs Frequency
Gain (dB)
Frequncy (rad/s)
-1
-1.05
-1.1
-1.15
-1.2
-1.25
-1.3
-1.35
-1.4
-1.45
10^0
10^1
10^2
10^3

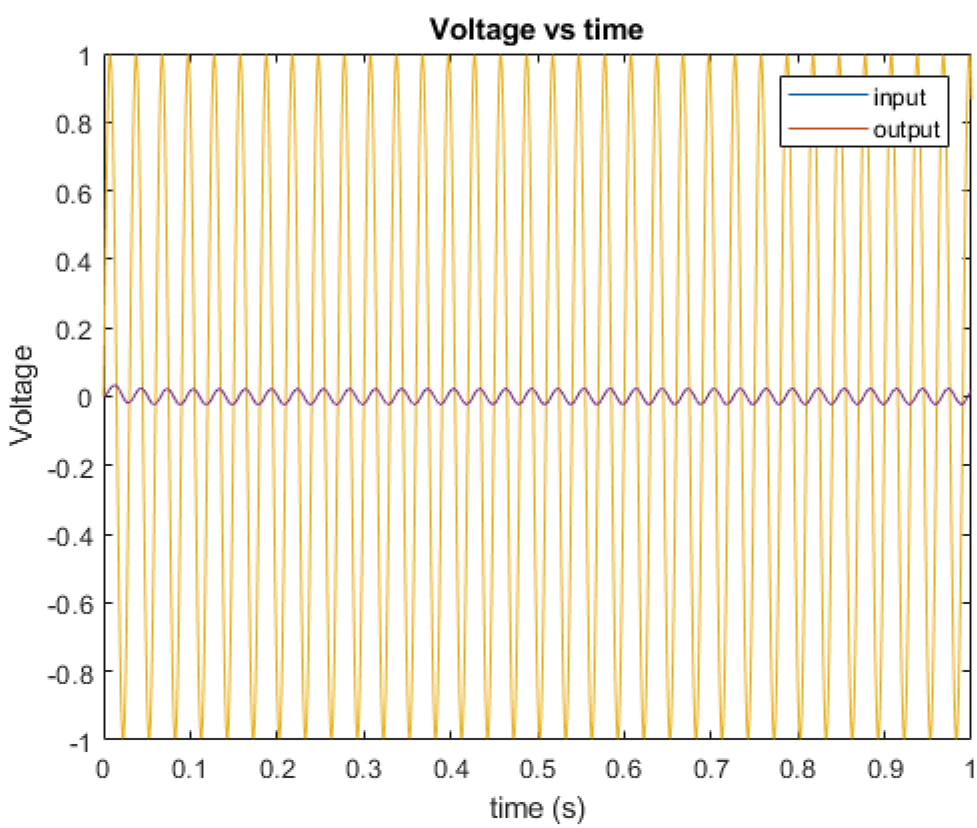
d

Transient

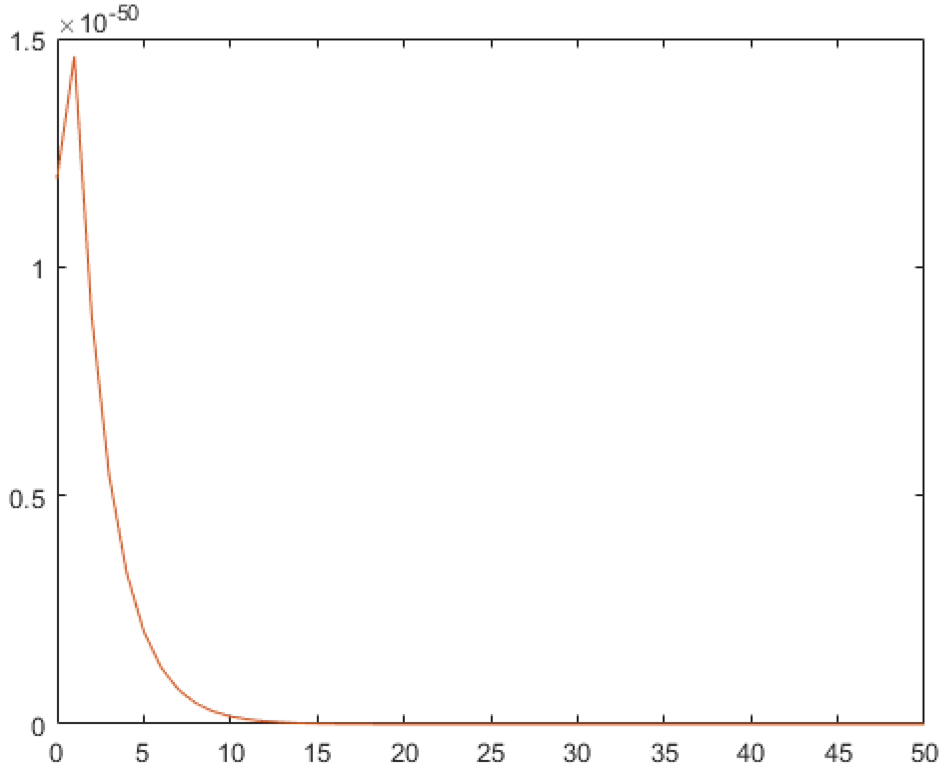
```
%% transient simulation we must solve VdV/dt + GV = F, we must use finite
method.Giving us
%(C/dt + G)V(j) = CV(j-1)/dt + F(t(j))

dt = 0.001;

Atrans =  C_matrix/dt + G_Matrix;

V1 = zeros(7,1);
V2 = zeros(7,1);
V3 = zeros(7,1);
Vo1(1) = 0;
Vo2(1) = 0;
Vo3(1) = 0;
Vi1(1) = 0;
Vi2(1) = 0;
Vi3(1) = 0;
F1 = zeros(7,1);
F2 = zeros(7,1);
F3 = zeros(7,1);
count = 1;
for t = dt:dt:1
    if t >= 0.03
        F1(1) = 3;
    end
    F2(1) = sin(2*pi*t/0.03);
    F3(1) = exp(-0.5*((t - 0.06)/0.03)^2);
    V1 = Atrans\(C_matrix*V1/dt + F1);
    V2 = Atrans\(C_matrix*V2/dt + F2);
    V3 = Atrans\(C_matrix*V3/dt + F3);
    Vi1(count +1) = V1(1);
    Vi2(count +1) = V2(1);
    Vi3(count +1) = V3(1);
    Vo1(count +1) = V1(5);
    Vo2(count +1) = V2(5);
    Vo3(count +1) = V3(5);
    count = count+1;
end
```



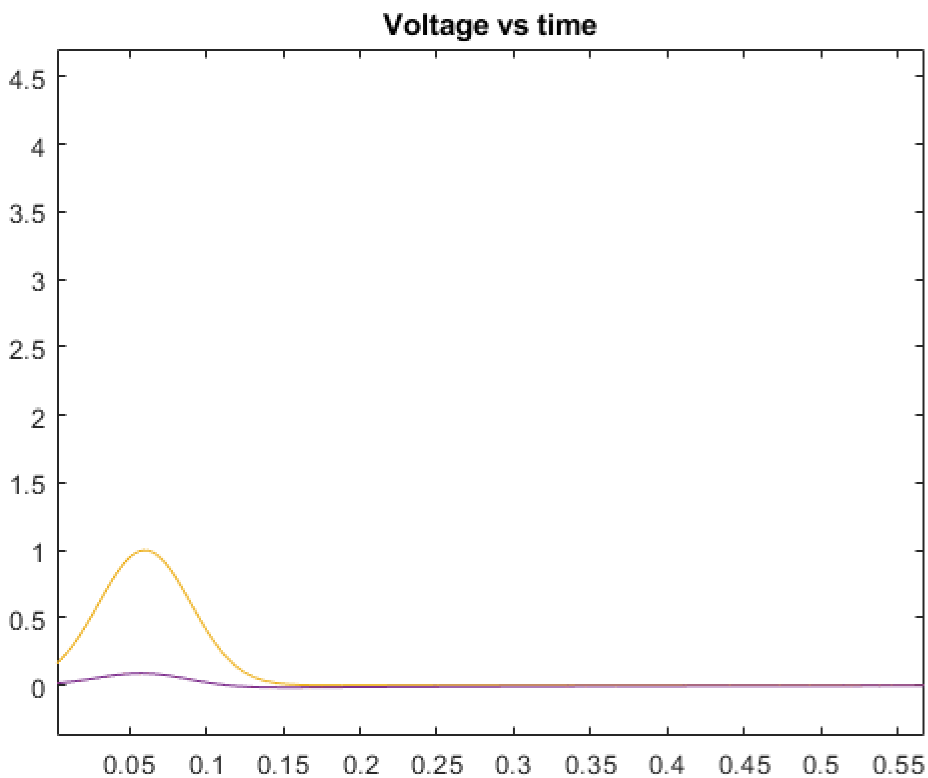
Voltage vs time
Voltage
time (s)



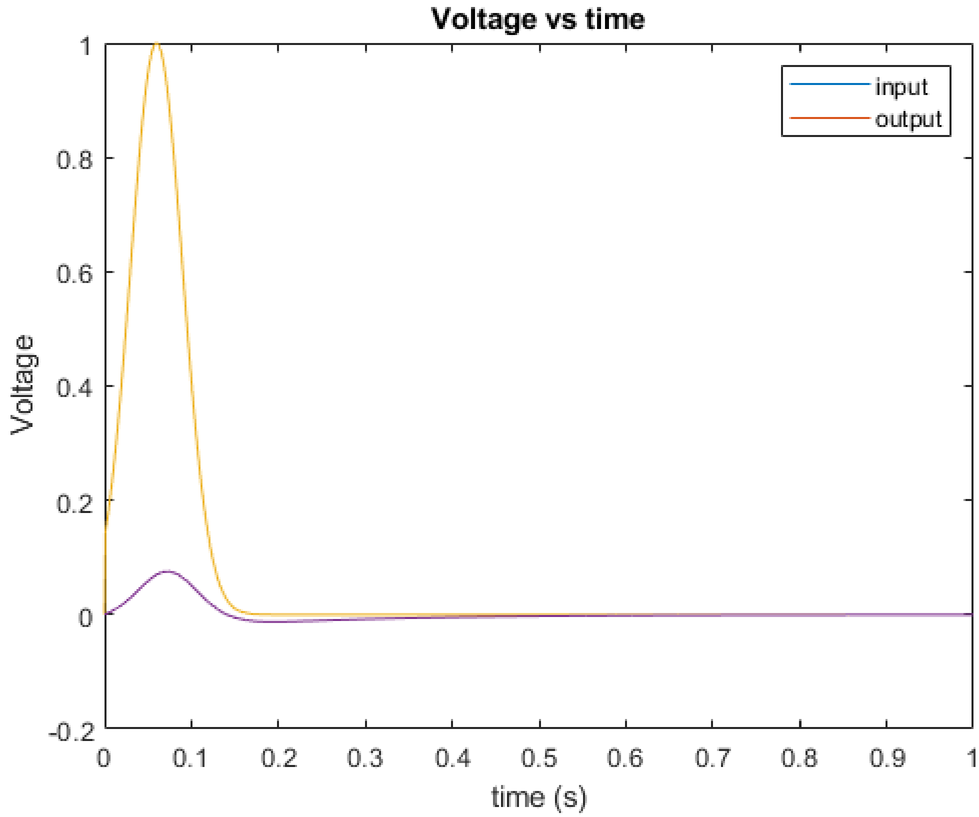
Voltage vs time
input
output
Voltage
time (s)

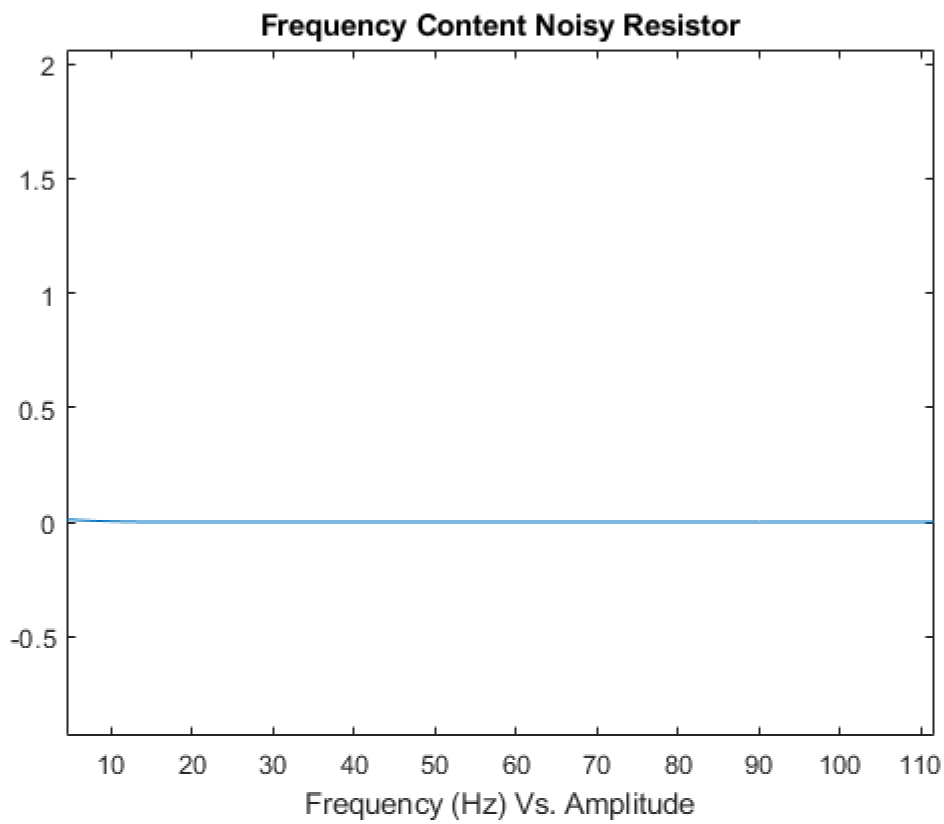


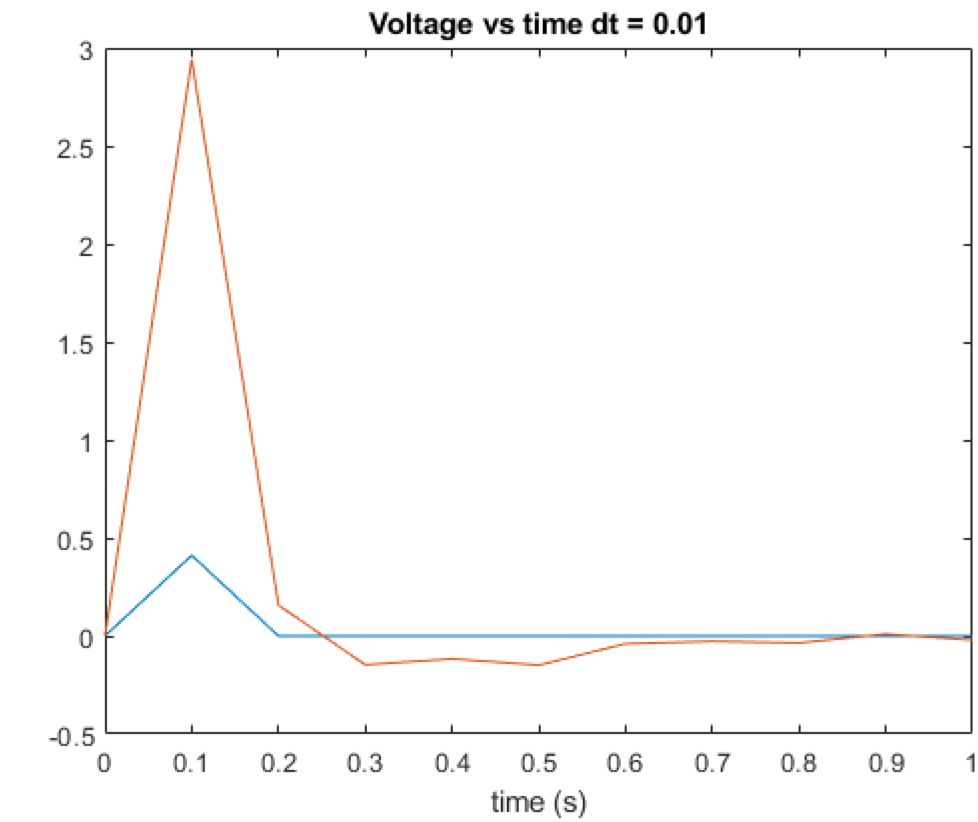
×10^-50
1.5
1
0.5
0
0
5
10
15
20
25
30
35
40
45
50



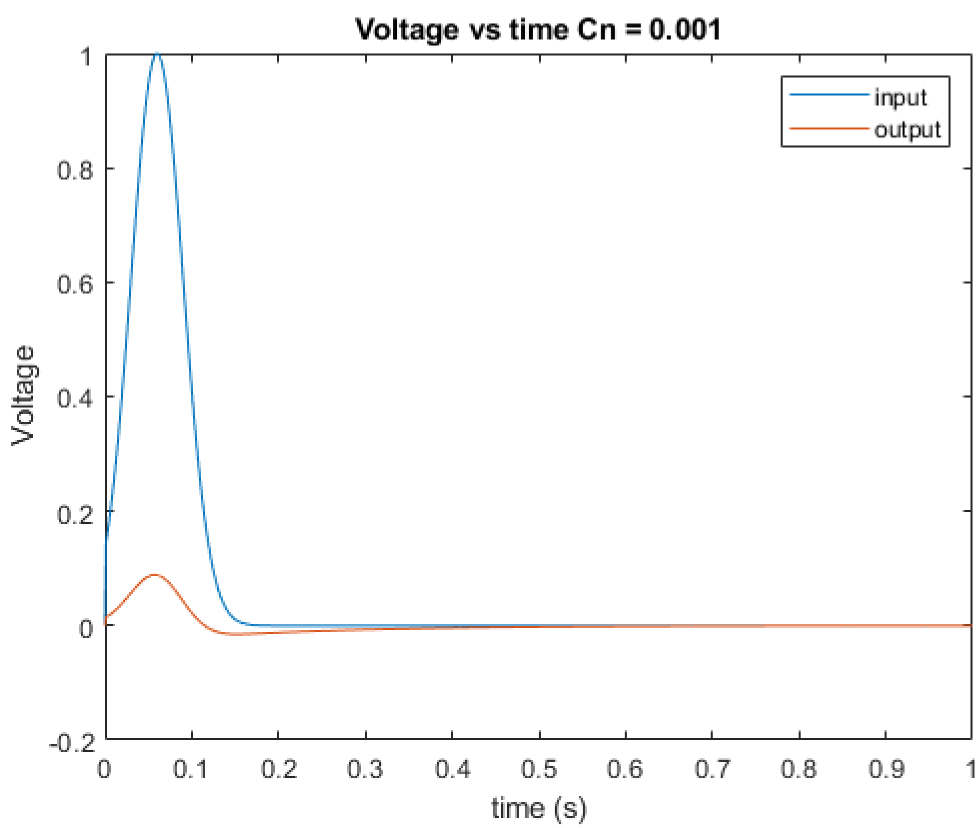
Voltage vs time
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55


Voltage vs time
input
output
Voltage
1
0.8
0.6
0.4
0.2
0
-0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
time (s)


Frequency Content Noisy Resistor
2
1.5
1
0.5
0
-0.5
10
20
30
40
50
60
70
80
90
100
110
Frequency (Hz) Vs. Amplitude



Voltage vs time dt = 0.01
time (s)



Voltage vs time Cn = 0.001
input
output
Voltage
time (s)

These results show that as the step is increased, the results of the simulation can become very erratic / inaccurate. This is because the accuracy of the finite difference approximation is inversly proportional to the step size.

```
figure(10)
plot(0:dt:1,Vi)
hold on
plot(0:dt:1,Vo_2)
title('Voltage vs time Cn = 0.001')
xlabel('time (s)')
ylabel('Voltage')
legend('input','output')

figure(11)
plot(0:dt2:1,ViLargeStep)
hold on
plot(0:dt2:1,VoLargeStep)
title('Voltage vs time dt = 0.01')
xlabel('time (s)')
```