Table of Contents


```
clear
clc
```

Question 1 + Question 2

I do not want mistakes from my incomplete Assingmnet 3 to affect this to carry over. R3 was set to 10.

Question 3

```
R1 = 1;
R2 = 2;
C = 0.25;
L = 0.2;
alpha = 100;
R4 = 0.1;
R3 = 10;
Ro = 1000;

G = [
    1   0   0   0   0   0   0;
    -1/R2   (1/R1)+(1/R2)   -1   0   0   0   0;
    0   1   0   -1   0   0   0;
    0   0   -1   1/R3   0   0   0;
    0   0   0   0   -alpha   1   0;
    0   0   0   1/R3   -1   0   0;
    0   0   0   0   0   -1/R4   (1/R4)+(1/Ro)];

C_Mat = [
    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];

% V = [V2; V1; Il; V3; I3; V4; Vo]
```

```
%i DC Sweep
Vin = linspace(-10,10,100);
Vo = zeros(100,1);
V3 = zeros(100,1);

for i = 1:100
    F =[Vin(i); 0; 0; 0; 0; 0; 0];
    V = G\F;
    Vo(i) = V(7);
    V3(i) = V(4);
end

figure(1)
plot(Vin,Vo)
title('Vin vs Vout')
xlabel('Vin (V)')
ylabel('Vout(V)')

figure(2)
plot(Vin,V3)
title('Vin vs V3')
xlabel('Vin (V)')
ylabel('V3 (V)')


%ii AC Sweep

omega = linspace(1,1E4,10000);
Vin = 1;
Vo = zeros(10000,1);
 F =[Vin; 0; 0; 0; 0; 0; 0];
for i = 1:1000
    V = (G +(omega(i)*2*pi*C_Mat *1j)) \F;
    Vo(i) = V(7);
end

figure(3)
semilogx(omega,Vo)
title('Omega vs Vout')
xlabel('omega')
ylabel('Vout(V)')

gain = 20*log10(abs(Vo/Vin));
figure(4)
semilogx(omega,gain)
title('Omega vs gain')
xlabel('Vin (V)')
ylabel('Vout(V)')

%iii AC Sweep2 (with random perturbations on C)

omeega = pi;

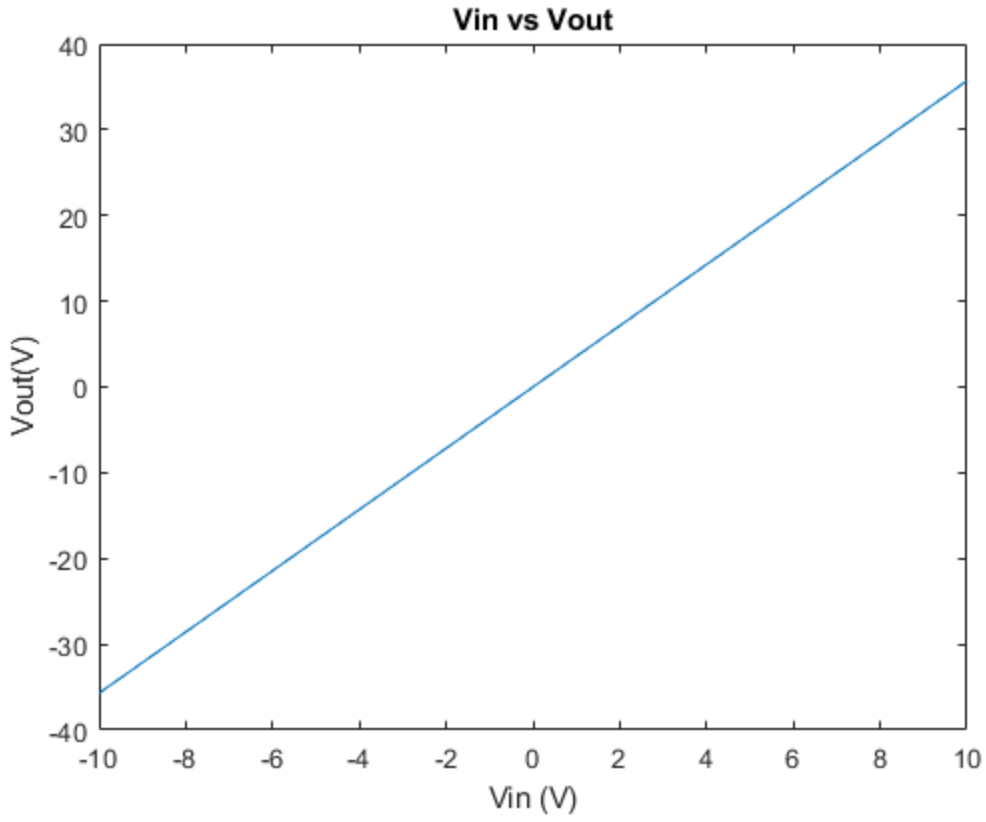
for i = 1:10000
```

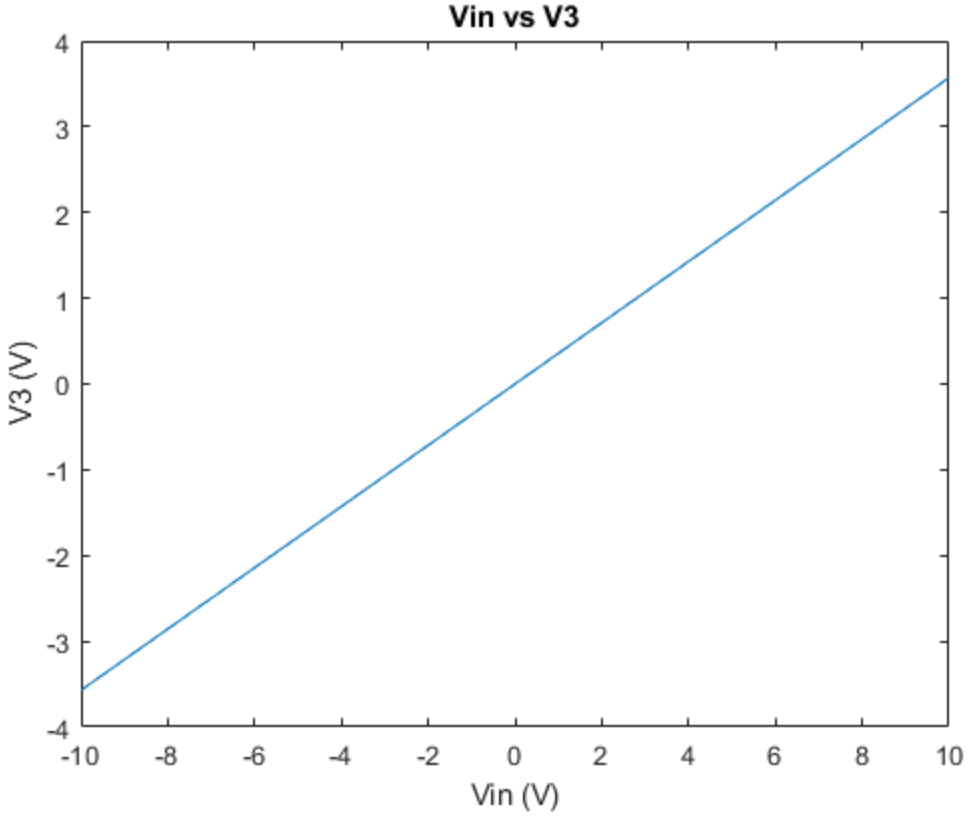
```
    C_dist = normrnd(C,0.05);
    C_Mat = [
        0   0   0   0   0   0   0;
        -C_dist   C_dist   0   0   0   0   0;
        0   0   -L   0   0   0   0;
        0   0   0   0   0   0   0;
        0   0   0   0   0   0   0;
        0   0   0   0   0   0   0;
        0   0   0   0   0   0   0];

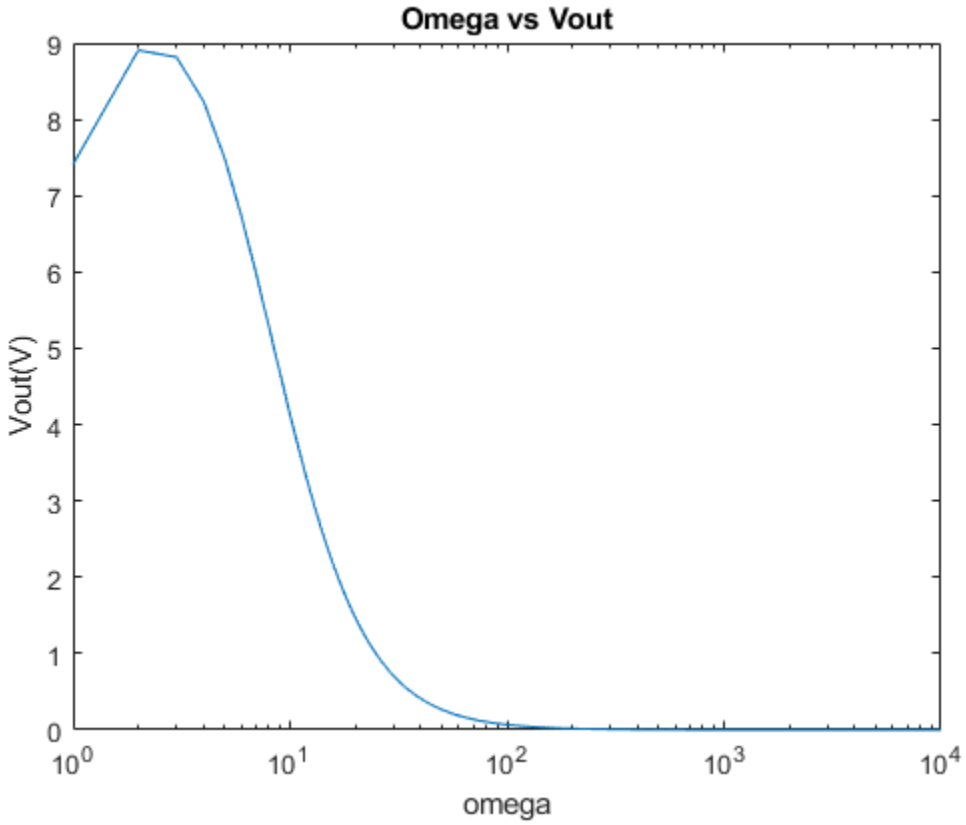
    V = (G +(omega(i)*2*pi*C_Mat *1j)) \F;
    Vo(i) = V(7);
end

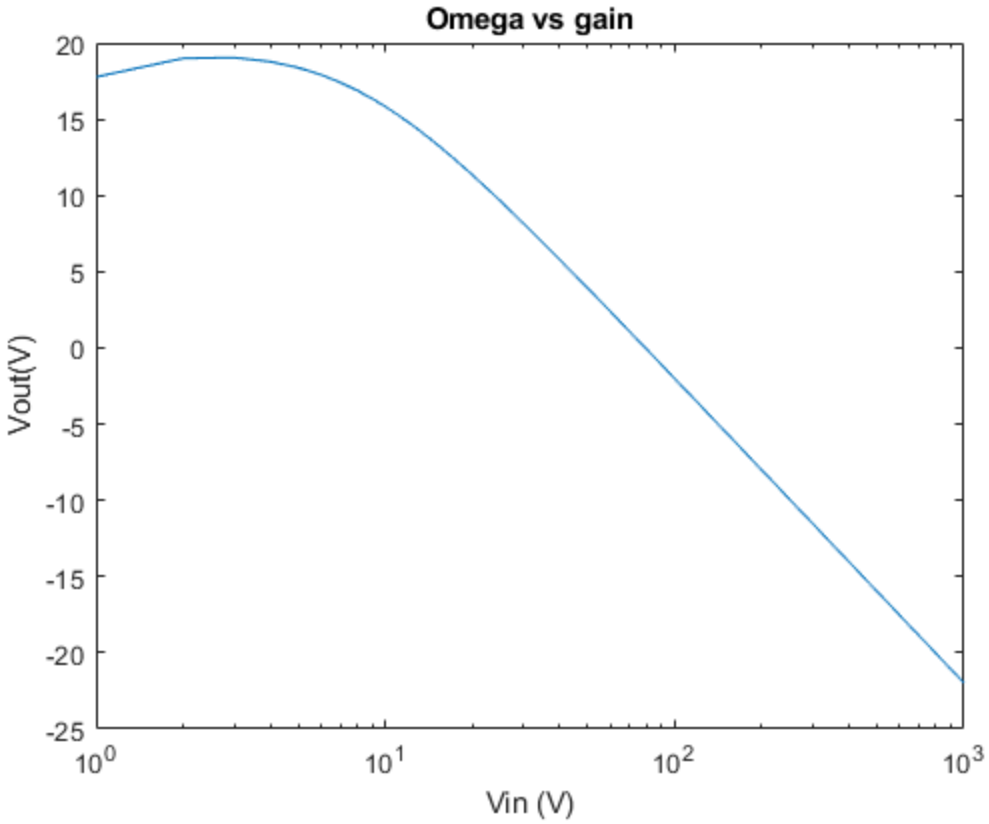
gain = 20*log(abs(Vo/Vin));
figure(5)
histogram(gain)
title('Gain with Capacitor Noise')
xlabel('Gain (dB)');
```

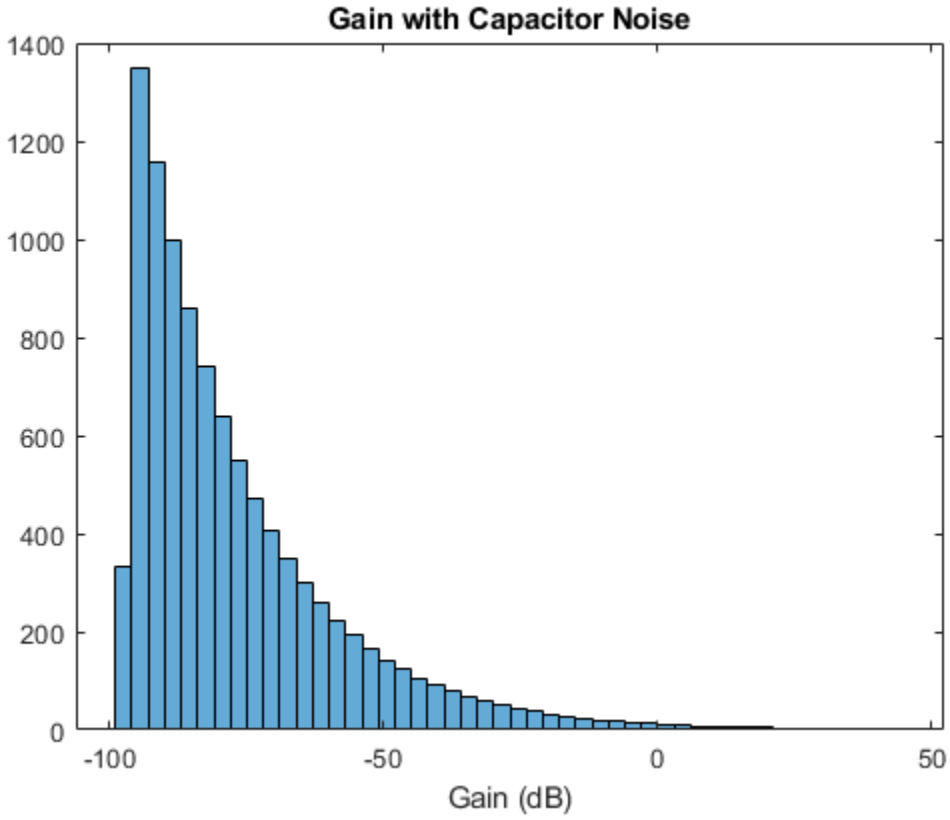
Warning: Imaginary parts of complex X and/or Y arguments ignored




Vin vs V3
V3 (V)
Vin (V)
4
3
2
1
0
-1
-2
-3
-4
-10
-8
-6
-4
-2
0
2
4
6
8
10


Omega vs Vout
Vout(V)
omega
9
8
7
6
5
4
3
2
1
0
10^0
10^1
10^2
10^3
10^4


Omega vs gain
20
15
10
5
0
-5
-10
-15
-20
-25
Vout(V)
10^0
10^1
10^2
10^3
Vin (V)


Gain with Capacitor Noise
1400
1200
1000
800
600
400
200
0
-100
-50
0
50
Gain (dB)

Question 4a

An RLC Circuit

Question 4b

The capacitance and iductance in the cicuit are affected by the frequency. As the frequency is increased, the impedance of the cpacitor (Zc) decreases, while the impedance of the Inductor (Zl) Increases.

Question 4d

Finite difference solution in the Time Domain:

```
simulation_time = 1000; % run simulation for 1 second
dt = 1; % time step

inputA = zeros(1,1000);
Vpre = zeros(7,1); %V(i-1)
% start simulation
for time = dt:dt:simulation_time

    % input A: step that transitions from 0 to 1 at t=0.03s
    if time < 30
        input_A(1,time) = 0;
    else
        input_A(1,time) = 1;
    end

     F =[input_A(1,time); 0; 0; 0; 0; 0; 0];

     Vout = (G +C)\ (C.*Vpre) + F;
     Vout1_store(1,time) = Vout(7);

     Vpre = Vout;
end

Time = linspace(dt,simulation_time,simulation_time);

figure(6)
plot(Time,input_A)
hold on;
plot(Time,abs(Vout1_store))
xlim([0 1000])
ylim([0 1.2])
xlabel('Time (ms)')
ylabel('Voltage(V)')
hold off
legend('Vin','Vout')

  % input B: sin(2?f t) function with f = 1/(0.03)
input_B = zeros(1,1000);
```

```
Vpre = zeros(7,1); %V(i-1)
f = 1/30;

% start simulation
for time = dt:dt:simulation_time

     input_B(time) = sin(2*pi*f*time);

     F =[input_B(1,time); 0; 0; 0; 0; 0; 0];

     Vout = (G +C)\ (C.*Vpre) + F;
     Vout2_store(1,time) = Vout(7);

     Vpre = Vout;
end

Time = linspace(dt,simulation_time,simulation_time);

figure(7)
plot(Time,input_B)
hold on;
plot(Time,abs(Vout2_store))
xlim([0 100])
ylim([-1.1 1.1])
xlabel('Time (ms)')
ylabel('Voltage(V)')
hold off
legend('Vin','Vout')



% input C: A guassian pulse with a magnitude of 1, std dev. of 0.03s
% and a delay of 0.06s
input_C = zeros(1,1000);

% start simulation
for time = dt:dt:simulation_time

    input_C(1,time) = (exp(-2*log(2)*(time-60).^2/
(30)^2)).*cos(-2*pi*f*(time-60));

     F =[input_C(1,time); 0; 0; 0; 0; 0; 0];

     Vout = (G +C)\ (C.*Vpre) + F;
     Vout3_store(1,time) = Vout(7);

     Vpre = Vout;
end

Time = linspace(dt,simulation_time,simulation_time);

figure(8)
plot(Time,input_C)
hold on;
```

```
 plot(Time,abs(Vout3_store))
  xlim([0 200])
%  ylim([-1.1 1.1])
xlabel('Time (ms)')
ylabel('Voltage(V)')
hold off
legend('Vin','Vout')


% Frequncy Plots
A_fin = fftshift(fft(input_A));
B_fin = fftshift(fft(input_B));
C_fin = fftshift(fft(input_C));

A_fout = fftshift(fft(Vout1_store));
B_fout = fftshift(fft(Vout2_store));
C_fout = fftshift(fft(Vout3_store));

figure(9)
plot(Time,A_fin)
hold on
plot(Time,A_fout)
hold off
title('Fourier Transform: Step Input')
xlabel('Frequency')
ylabel('Magnitude')
legend('Input','Output')

figure(10)
plot(Time,B_fin)
hold on
plot(Time,B_fout)
hold off
title('Fourier Transform: Sine Wave Input')
xlabel('Frequency')
ylabel('Magnitude')
legend('Input','Output')

figure(11)
plot(Time,C_fin)
hold on
plot(Time,C_fout)
hold off
title('Fourier Transform: Gaussian Pulse Input')
xlabel('Frequency')
ylabel('Magnitude')
legend('Input','Output')

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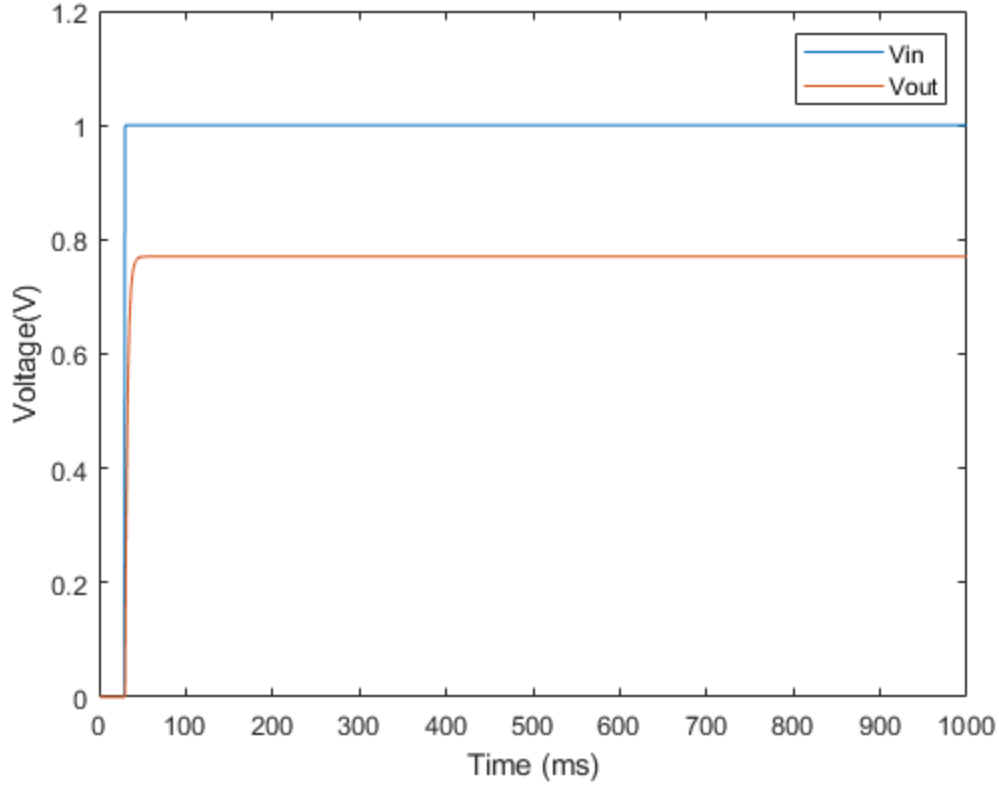
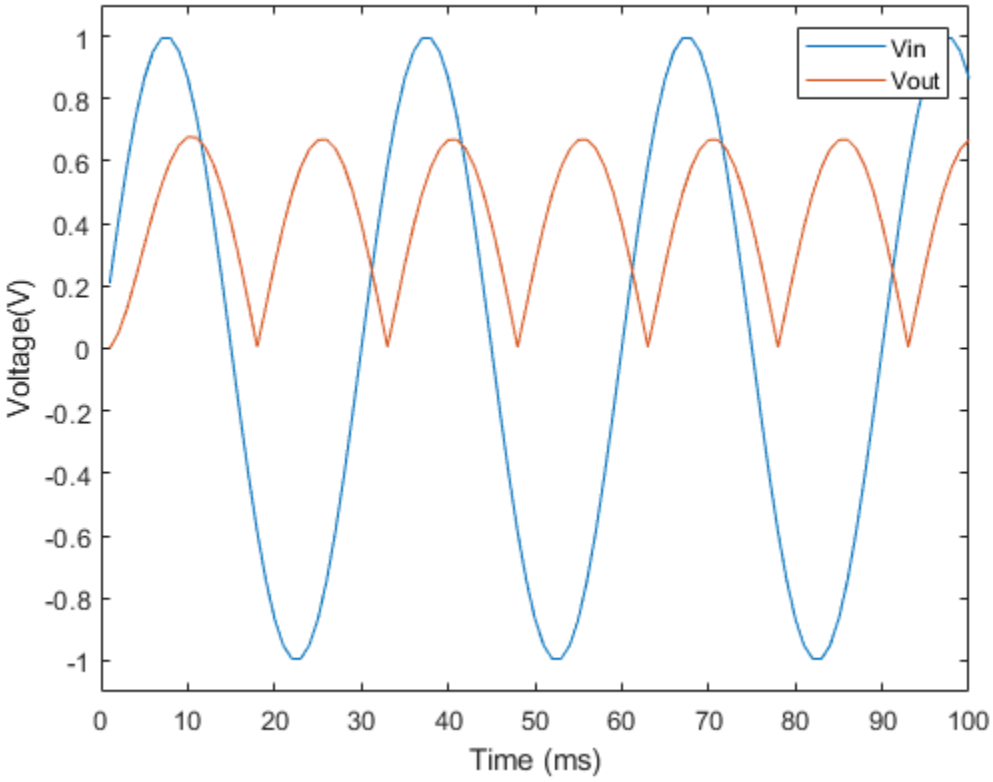
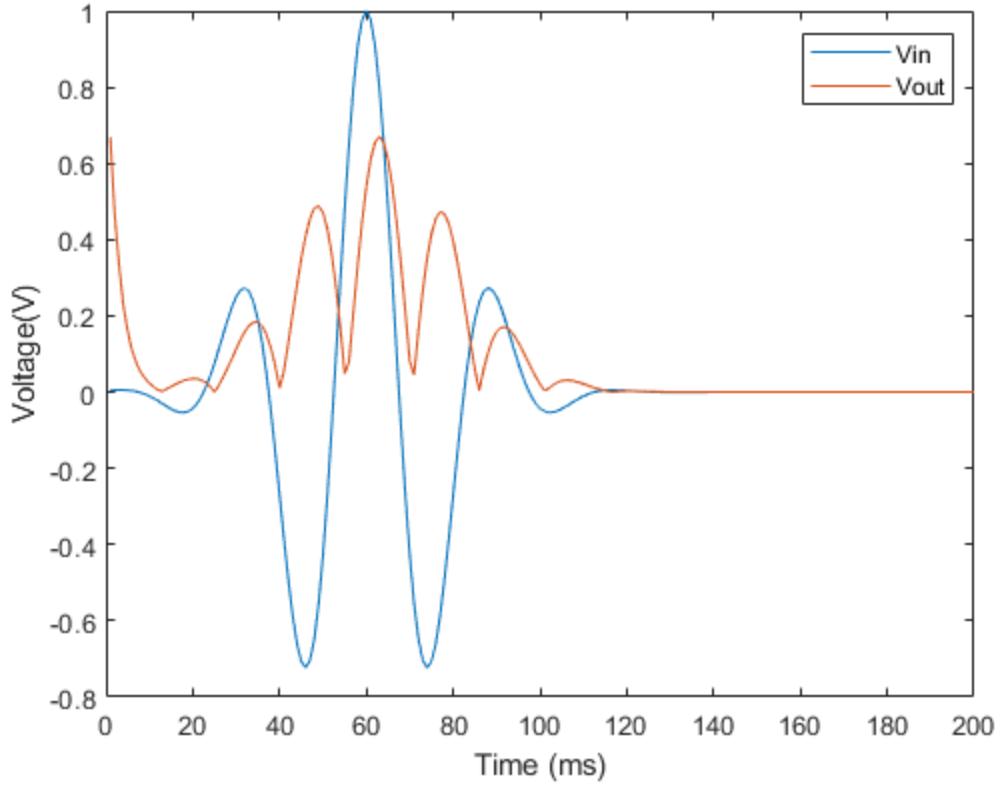
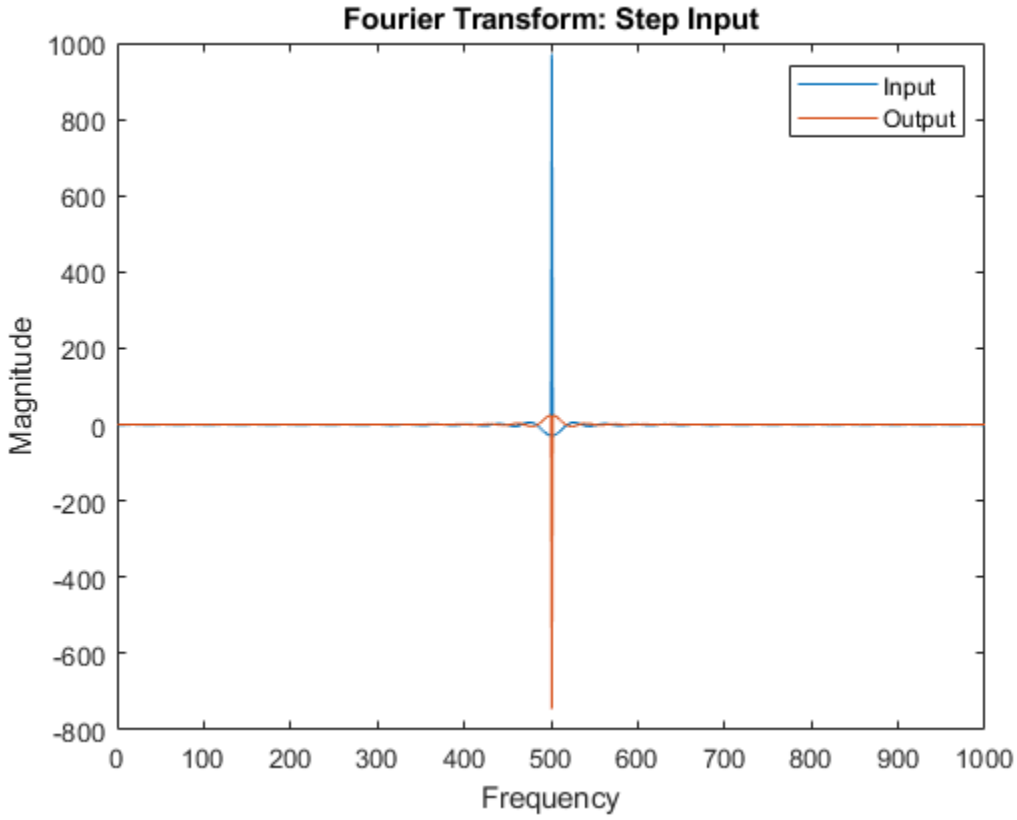
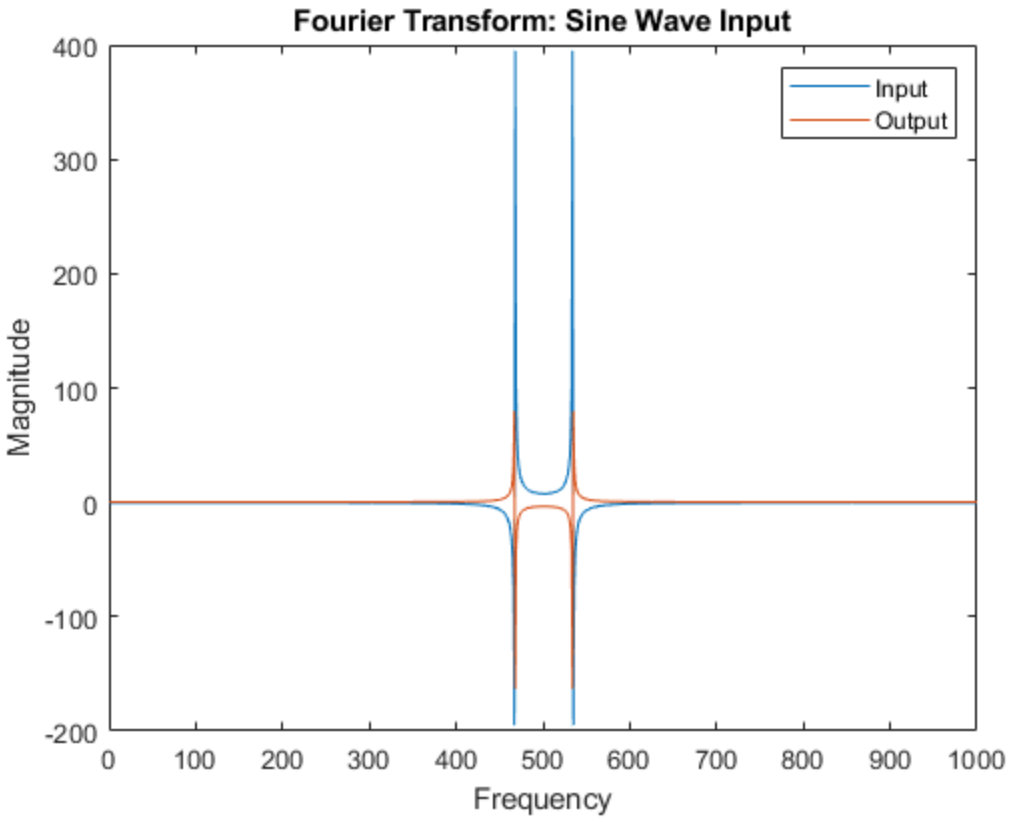
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

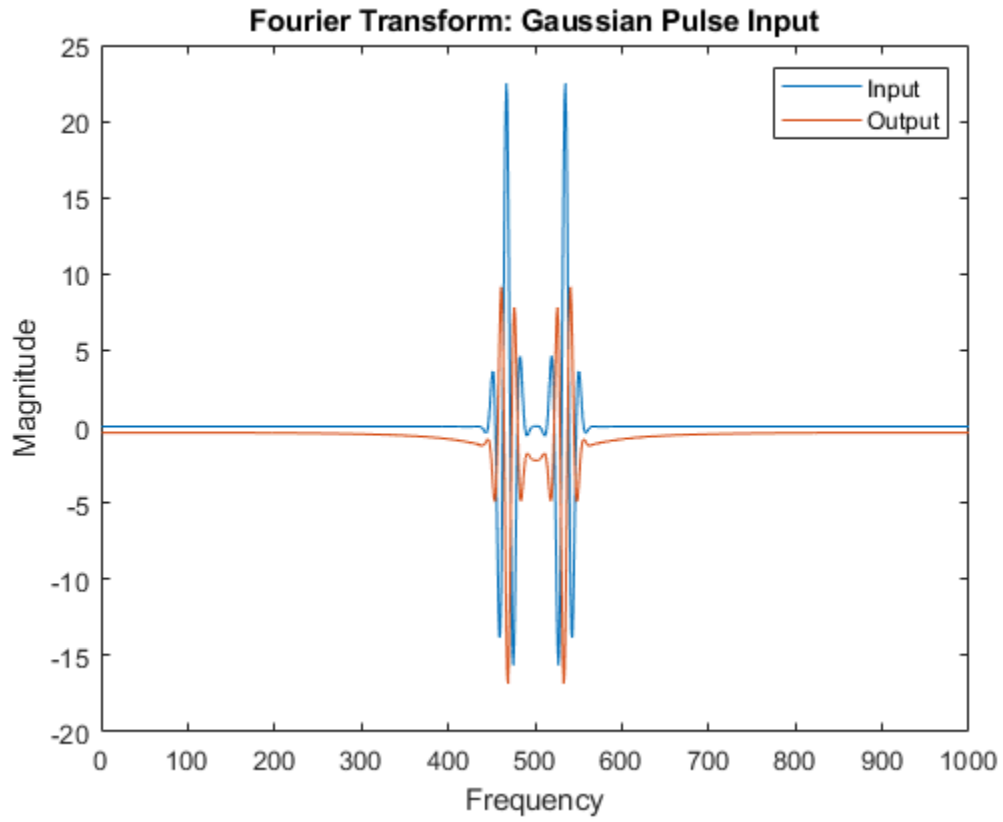

Vin
Vout
Voltage(V)
Time (ms)
0
0.2
0.4
0.6
0.8
1
1.2
0
100
200
300
400
500
600
700
800
900
1000


Vin
Vout
Voltage(V)
Time (ms)
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
70
80
90
100


Vin
Vout
Voltage(V)
Time (ms)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
20
40
60
80
100
120
140
160
180
200


Fourier Transform: Step Input
Input
Output
Magnitude
Frequency
1000
800
600
400
200
0
-200
-400
-600
-800
0
100
200
300
400
500
600
700
800
900
1000


Fourier Transform: Sine Wave Input
Input
Output
Magnitude
Frequency
400
300
200
100
0
-100
-200
0
100
200
300
400
500
600
700
800
900
1000


Fourier Transform: Gaussian Pulse Input
Input
Output
Magnitude
Frequency
25
20
15
10
5
0
-5
-10
-15
-20
0
100
200
300
400
500
600
700
800
900
1000

Question 5

```
Cn = 0.00001
In = 0,001 % initial I0
G = [
    1   0   0   0   0   0   0;
    -1/R2   (1/R1)+(1/R2)   -1   0   0   0   0;
    0   1   0   -1   0   0   0;
    0   0   -1   1/R3   In   0   0;
    0   0   0   0   -alpha   1   0;
    0   0   0   1/R3   -1   0   0;
    0   0   0   0   0   -1/R4   (1/R4)+(1/Ro)];

C_Mat = [
    0   0   0   0   0   0   0;
    -C   C   0   0   0   0   0;
    0   0   -L   0   0   0   0;
    0   0   0   Cn   0   0   0;
    0   0   0   0   0   0   0;
    0   0   0   0   0   0   0;
    0   0   0   0   0   0   0];

% V = [V2; V1; Il; V3; I3; V4; Vo]

for time = dt:dt:simulation_time

    input_C(1,time) = (exp(-2*log(2)*(time-60).^2/
(30)^2)).*cos(-2*pi*f*(time-60));

     F =[input_C(1,time); 0; 0; 0; 0; 0; 0];

     Vout = (G +C)\ (C.*Vpre) + F;
     Vout3_store(1,time) = Vout(7);

     Vpre = Vout;
     In = normrnd(0.001,0.01);
end

Time = linspace(dt,simulation_time,simulation_time);

figure(12)
plot(Time,input_C)
hold on;
plot(Time,abs(Vout3_store))
  xlim([0 200])
%  ylim([-1.1 1.1])
title('Vout and Vin w/ Cn and random In')
xlabel('Time (ms)')
ylabel('Voltage(V)')
hold off
legend('Vin','Vout')

figure(13)
```

```
plot(Time,fft(Vout3_store))
%  ylim([-1.1 1.1])
title('Fourier Transform of Output')
xlabel('Time (ms)')
ylabel('Voltage(V)')
hold off
dt = 100;
for time = 1:dt:simulation_time

    input_C(1,time) = (exp(-2*log(2)*(time-60).^2/
(30)^2)).*cos(-2*pi*f*(time-60));

     F =[input_C(1,time); 0; 0; 0; 0; 0; 0];

     Vout = (G +C)\ (C.*Vpre) + F;
     Vout3_store(1,time) = Vout(7);

     Vpre = Vout;
     In = normrnd(0.001,0.01);
end

Time = linspace(dt,simulation_time,simulation_time);

figure(14)
plot(Time,input_C)
hold on;
plot(Time,abs(Vout3_store))
  xlim([0 200])
%  ylim([-1.1 1.1])
title('Vout and Vin w/ Cn and random In (1/100 time step')
xlabel('Time (ms)')
ylabel('Voltage(V)')
hold off
legend('Vin','Vout')

figure(15)
plot(Time,fft(Vout3_store))
%  ylim([-1.1 1.1])
title('Fourier Transform of Output (1/100 time step)')
xlabel('Time (ms)')
ylabel('Voltage(V)')
hold off
dt = 10;
for time = 1:dt:simulation_time

    input_C(1,time) = (exp(-2*log(2)*(time-60).^2/
(30)^2)).*cos(-2*pi*f*(time-60));

     F =[input_C(1,time); 0; 0; 0; 0; 0; 0];

     Vout = (G +C)\ (C.*Vpre) + F;
     Vout3_store(1,time) = Vout(7);

     Vpre = Vout;
```

```
     In = normrnd(0.001,0.01);
end

Time = linspace(dt,simulation_time,simulation_time);

figure(16)
plot(Time,input_C)
hold on;
plot(Time,abs(Vout3_store))
  xlim([0 200])
%  ylim([-1.1 1.1])
title('Vout and Vin w/ Cn and random In (1/10s step')
xlabel('Time (ms)')
ylabel('Voltage(V)')
hold off
legend('Vin','Vout')

figure(17)
plot(Time,fft(Vout3_store))
%  ylim([-1.1 1.1])
title('Fourier Transform of Output (1/10s Time step)')
xlabel('Time (ms)')
ylabel('Voltage(V)')
hold off
```

```
Cn =

   1.0000e-05


In =

     0


ans =

     1

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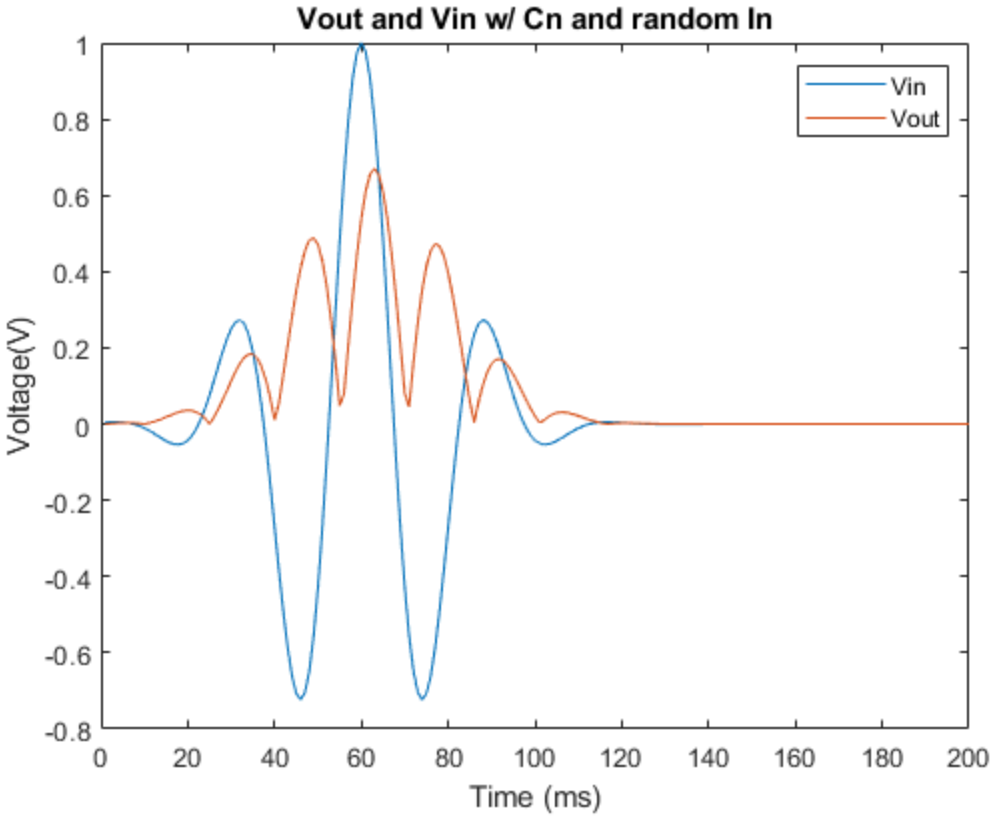
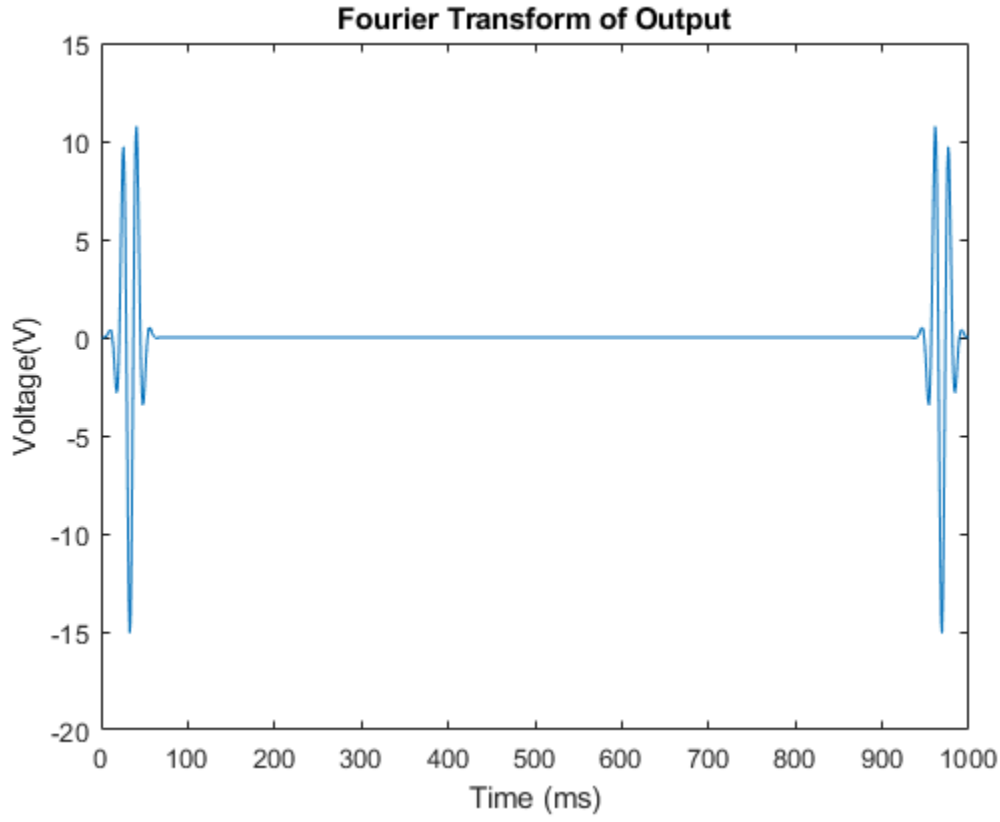
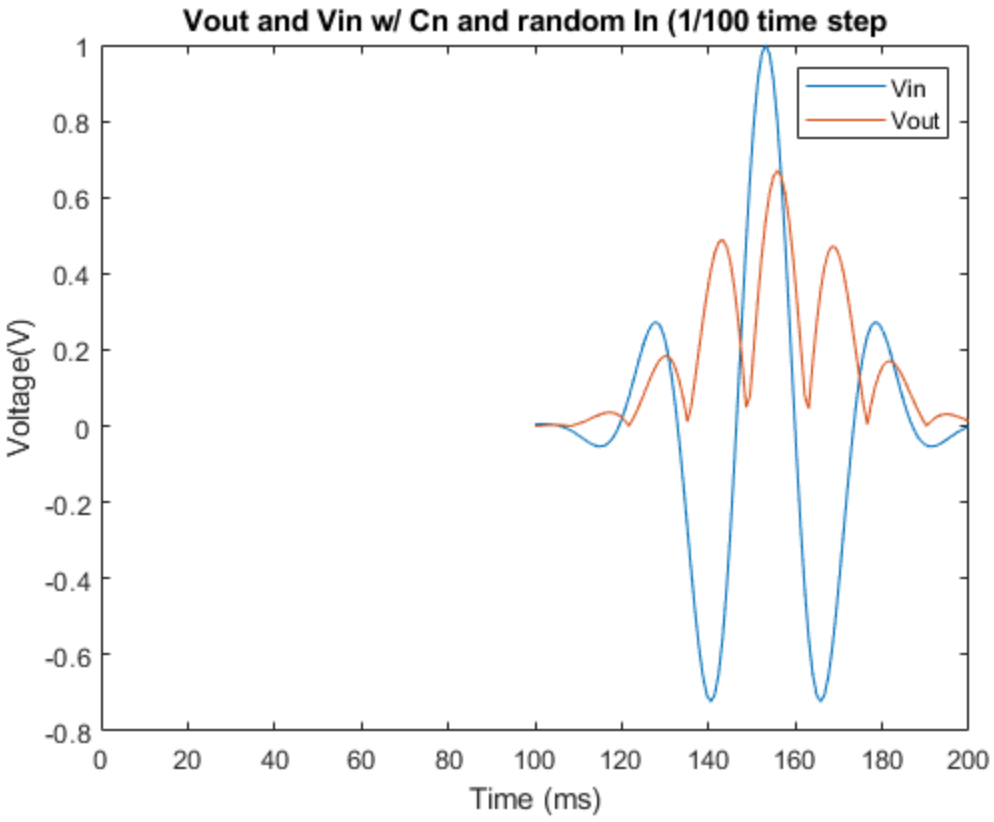
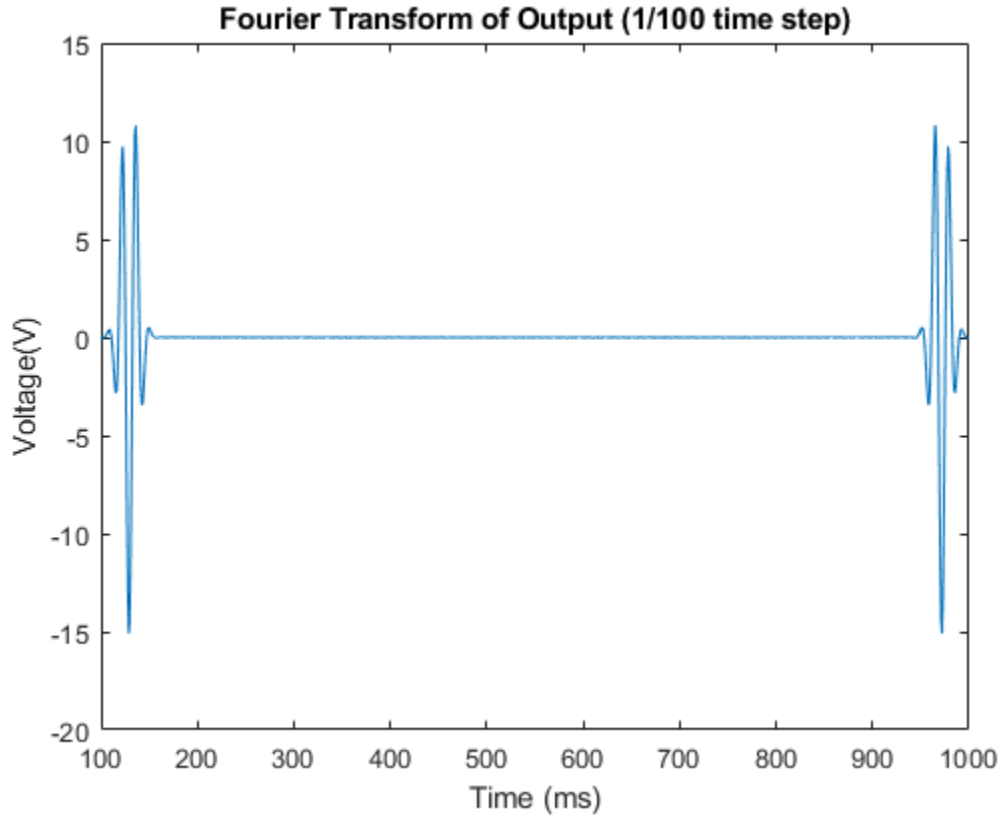
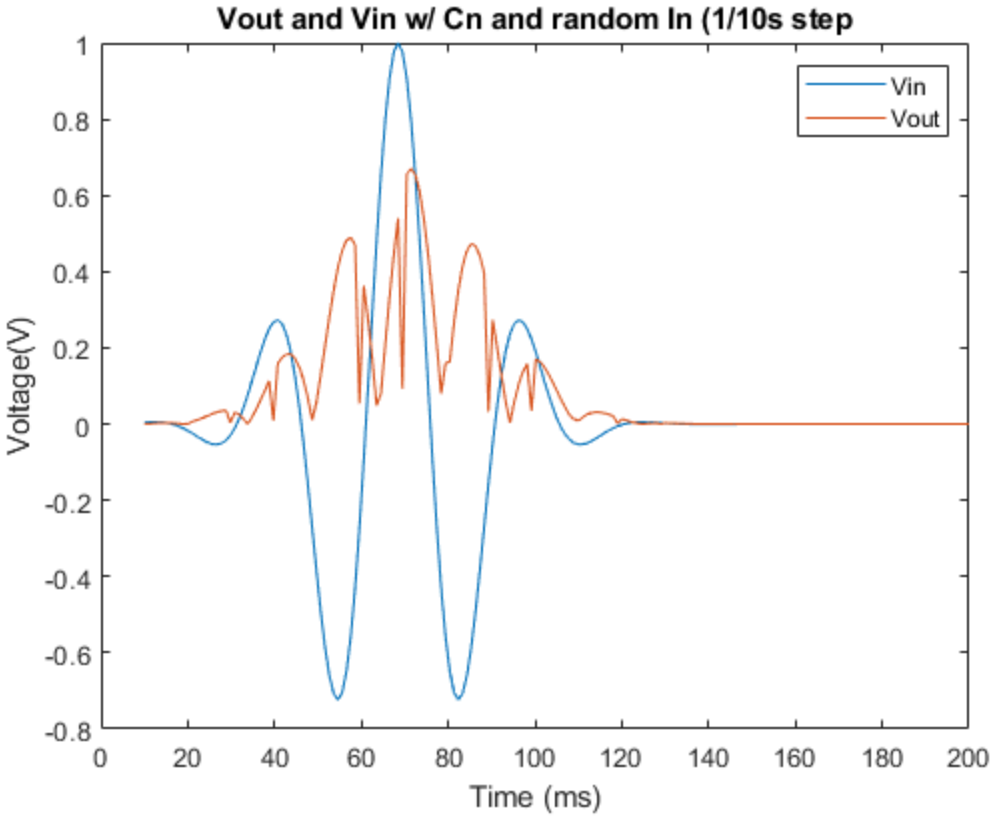
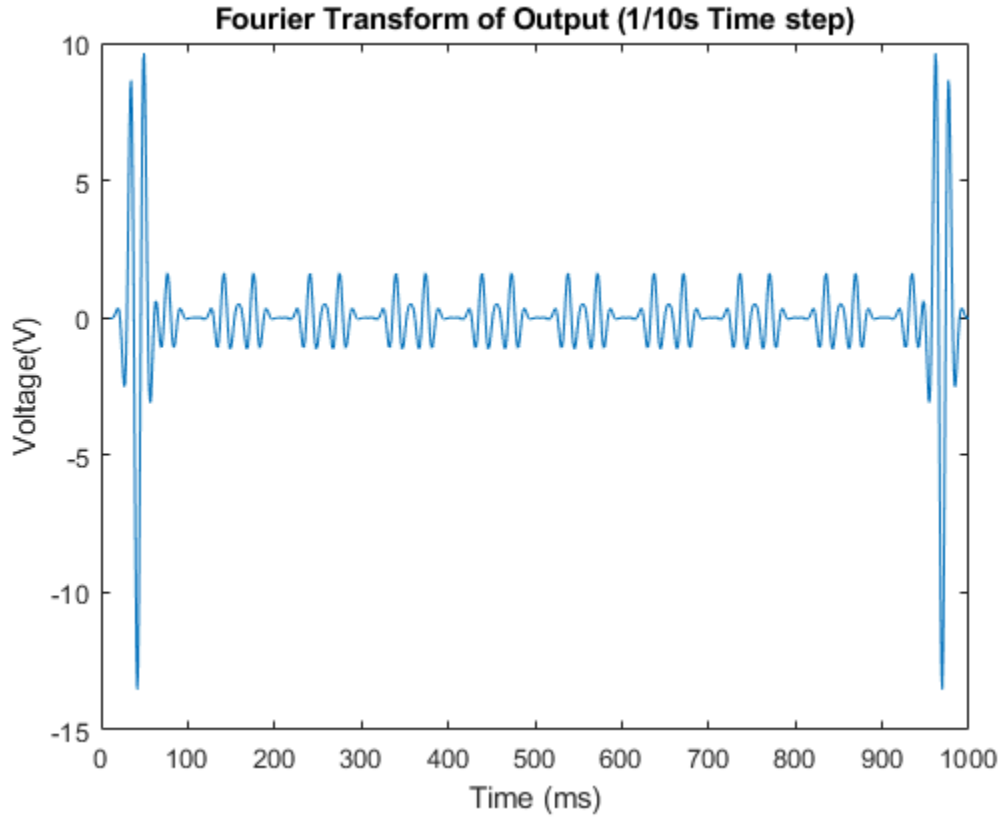

Vout and Vin w/ Cn and random In
Vin
Vout
Voltage(V)
Time (ms)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
20
40
60
80
100
120
140
160
180
200


Fourier Transform of Output
Voltage(V)
Time (ms)
15
10
5
0
-5
-10
-15
-20
0
100
200
300
400
500
600
700
800
900
1000


Vout and Vin w/ Cn and random In (1/100 time step
Vin
Vout
Voltage(V)
Time (ms)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
20
40
60
80
100
120
140
160
180
200


Fourier Transform of Output (1/100 time step)
Voltage(V)
Time (ms)
15
10
5
0
-5
-10
-15
-20
100
200
300
400
500
600
700
800
900
1000


Vout and Vin w/ Cn and random In (1/10s step
Vin
Vout
Voltage(V)
Time (ms)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
20
40
60
80
100
120
140
160
180
200


Fourier Transform of Output (1/10s Time step)
Voltage(V)
Time (ms)
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900
1000

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