Agberien Stephen 101047160 Assignment 4

Part 1: Diff. Eq & Matrix Formulation

```
%{
N1:    i1 + i2 = 0
       i1 + [(V1-V2)/R1 + C(d(V1-V2)/dt)] = 0
       V1 = Vin (1)
N2:   i2 + i3 + i4 = 0
      [(Vin-V2)/R1 + C(d(Vin-V2)/dt)] + V2/R2 + iL (2)
N3:   iL + i3 = 0
      iL + V3/R3 = 0 (3)
N4:   alpha*i3 + i4 = 0
      alpha*i3 + (V4-V5)/R4 = 0 (4)
      V4 = alpha*i3 (5)
N5:   i4 + i0 = 0
      (V5-V4)/R4 + V0/R0 = 0 (6)
N1:
      i1 + [(V1-V2)G1 + (V1-V2)sC] = 0 (1)
      V1 = Vin (2)
N2:
      [(V2-V1)G1 + (V2-V1)sC] + V2G2 + (V2-V3)sL (3)
N3:
      (V3-V2)sL + V3G3 = 0 (4)
N4:
      alpha*i3 + (V4-V5)G4 = 0 (5)
      V4 = alpha*i3 (6)
N5:
      (V5-V4)G4 + V0G0 = 0 (7)
Where s = jw
    V1,     V2, IL,    V3,       V4,    Vo  <-- V matrix
G:
      1,     0,  0,     0,        0,     0
    -G1, G1+G2,  0,     0,        0,     0
      0,     1,  0,    -1,        0,     0
      0,     0, -1,    G3,        0,     0
      0,     0,  0, -a*G3,        1,     0
      0,     0,  0,     0,      -G4, G4+GO

C:
      0,       0,  0,  0,     0,   0,
     -C,       C,  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,

%}

clear all
close all
clc
```

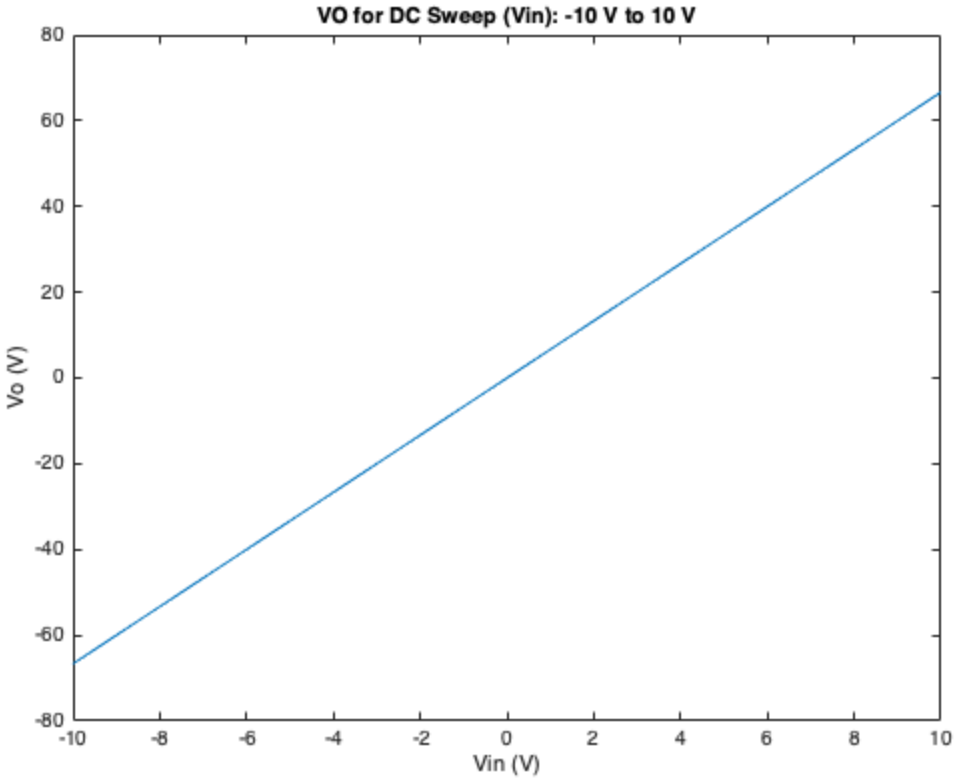
```
G = zeros(6, 6);

%Conductances(1/R):
G1 = 1;
G2 = 0.5;
G3 = 0.1;
G4 = 10;
G0 = 0.001;

%Additional Parameters:
alpha = 100;
Cval = 0.25;
L = 0.2;
vin = zeros(1, 20);
vo = zeros(1, 20);
v3 = zeros(1, 20);

G(1, 1) = 1;                                    % 1
G(2, 1) = -G1; G(2, 2) = G1 + G2;               % 2
G(3 ,2) = -1; G(3, 4) = 1;                      % iL
G(4, 3) = -1; G(4, 4) = G3;                     % 3
G(5, 5) = 1; G(5, 4) = -alpha*G3;               % 4
G(6, 6) = G4 + G0; G(6, 5) = -G4;               % 5

C = zeros(6);

C(2, 1) = -Cval; C(2, 2) = Cval;
C(3, 3) = L;
```

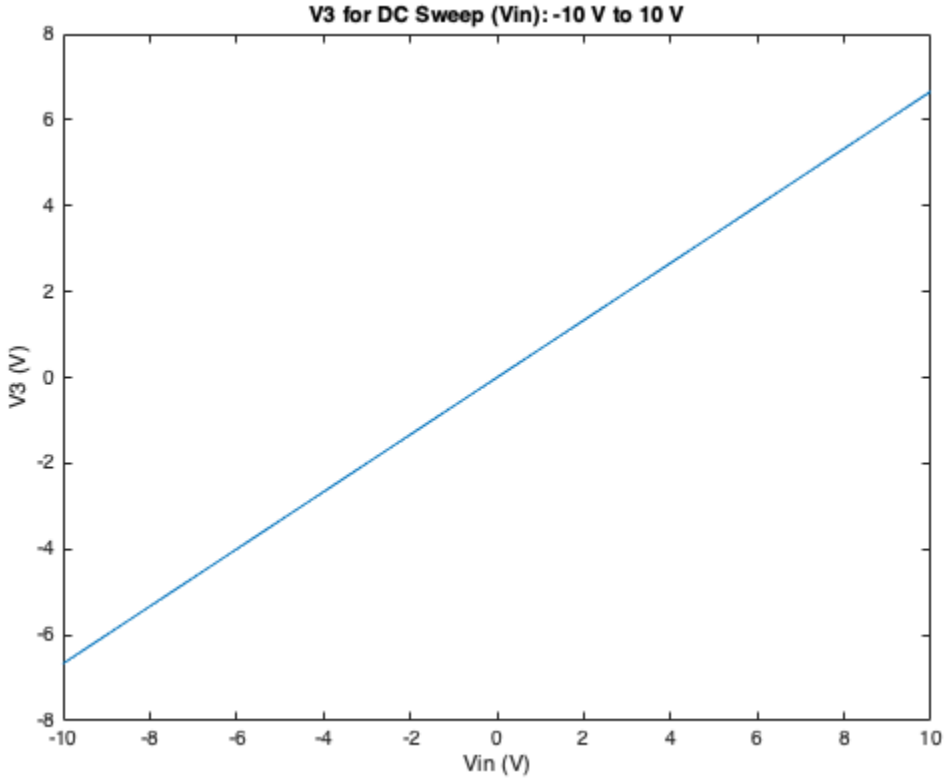
The C and G matrices were set as follows:

```
C
G


C =

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


G =

    1.0000         0         0         0         0         0
   -1.0000    1.5000         0         0         0         0
         0   -1.0000         0    1.0000         0         0
         0         0   -1.0000    0.1000         0         0
         0         0         0  -10.0000    1.0000         0
         0         0         0         0  -10.0000   10.0010
```

The input was swept as a DC input from -10V to 10V. Both the output voltage and the voltage, V3, were plotted over this DC sweep.

```
F = zeros(1, 6);
v = -10;

for i = 1:21
    vin(i) = v;
    F(1) = vin(i);

    Vm = G\F';

    vo(i) = Vm(6);
    v3(i) = Vm(4);
    v = v + 1;
end


figure(1)
plot(vin, vo);
title('VO for DC Sweep (Vin): -10 V to 10 V');
xlabel('Vin (V)')
ylabel('Vo (V)')

figure(2)
plot(vin, v3)
title('V3 for DC Sweep (Vin): -10 V to 10 V')
xlabel('Vin (V)')
ylabel('V3 (V)')
```


VO for DC Sweep (Vin): -10 V to 10 V
Vo (V)
Vin (V)
80
60
40
20
0
-20
-40
-60
-80
-10
-8
-6
-4
-2
0
2
4
6
8
10


V3 for DC Sweep (Vin): -10 V to 10 V
V3 (V)
Vin (V)
8
6
4
2
0
-2
-4
-6
-8
-10
-8
-6
-4
-2
0
2
4
6
8
10

Next, Vo was analyzed for an AC case. Therefore, the output was plotted against the angular frequency, and the dB gain was plotted.

```
F(1) = 1;
vo2 = zeros(1, 1000);
freq = linspace(0, 1000, 1000); % note: in radians
Av = zeros(1, 1000);
Avlog = zeros(1, 1000);

for i = 1:1000
    Vm2 = (G+1i*freq(i)*C)\F';
    vo2(i) = Vm2(6);
    Av(i) = vo2(i)/F(1);
    Avlog(i) = 20*log10(Av(i));
end
figure(3)
plot(freq, Av)
title('Vo(w) (part C)')
xlabel('w (rad)')
ylabel('Av (V/V)')

figure(4)
semilogx(freq, Avlog)
xlim([0 1000])
title('Vo(w) dB (part C)')
xlabel('w (rad)')
ylabel('Av (dB)')
```

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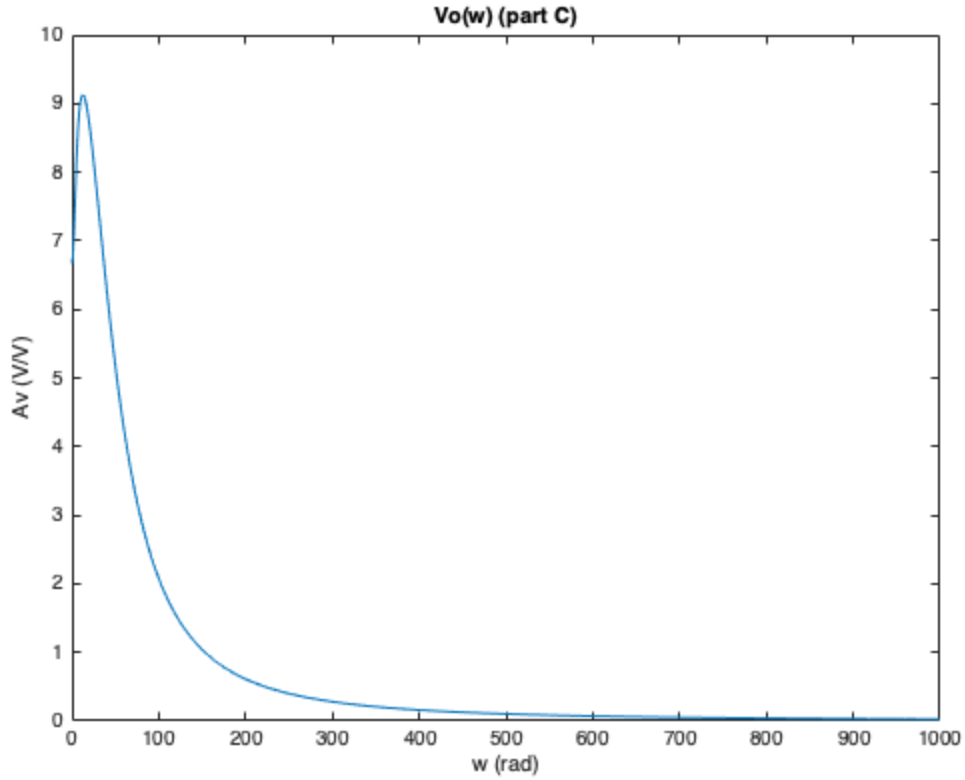
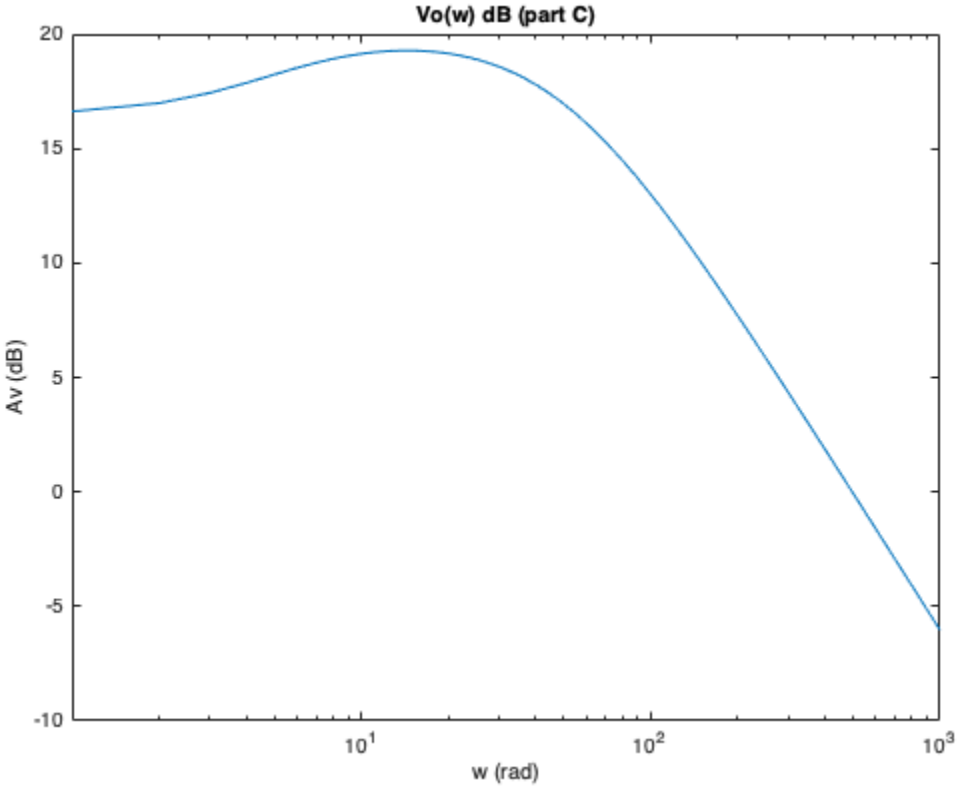
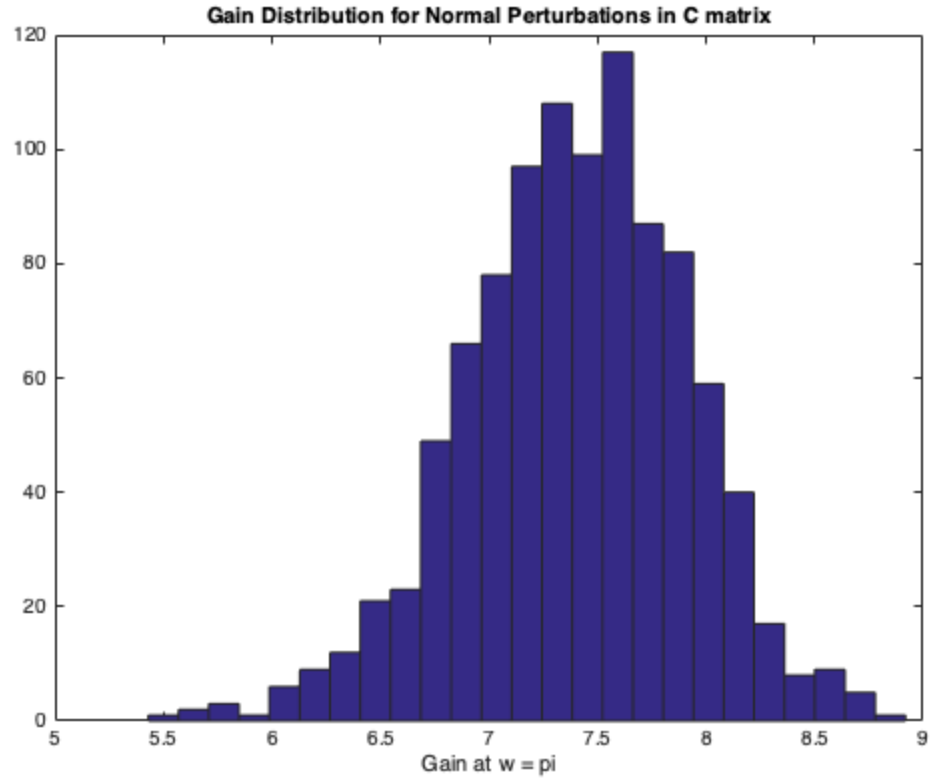


Vo(w) (part C)
Av (V/V)
w (rad)
0
1
2
3
4
5
6
7
8
9
10
0
100
200
300
400
500
600
700
800
900
1000

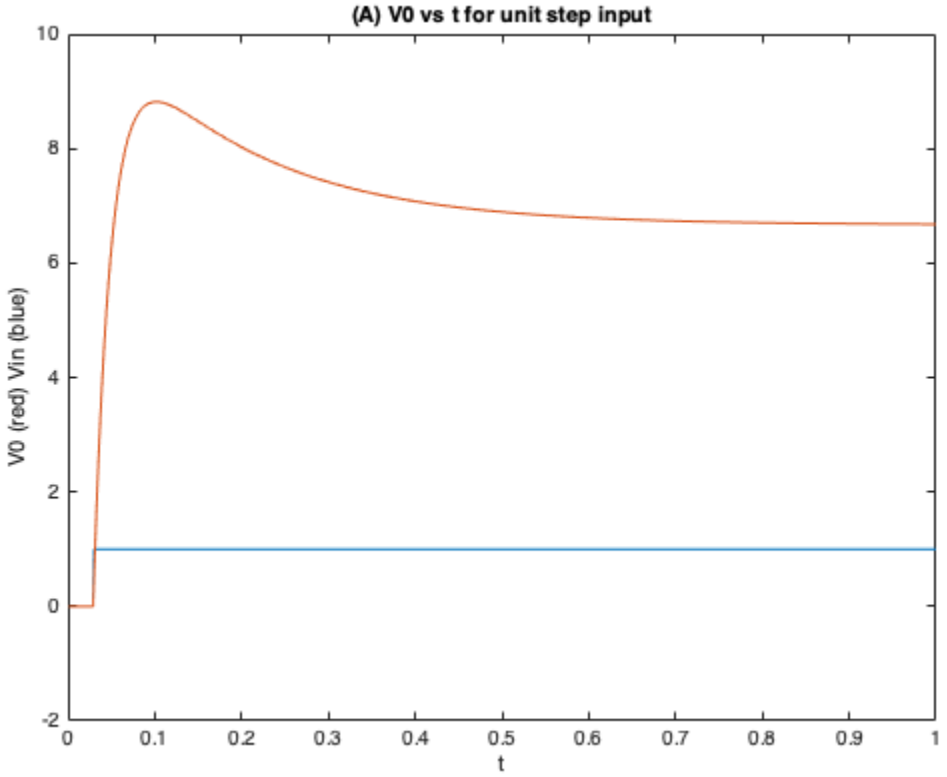

Vo(w) dB (part C)
Av (dB)
w (rad)
20
15
10
5
0
-5
-10
10^1
10^2
10^3

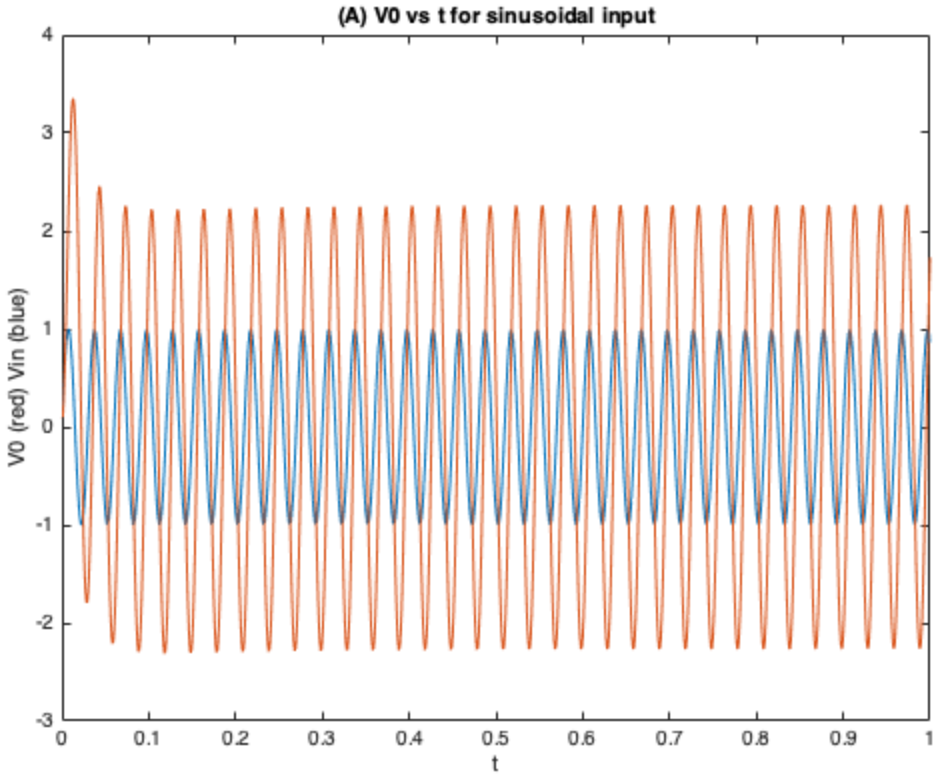
The AC case was plotted again where the gain was plotted as function of random perturbations on C using a normal distribution with std = .05 at w = pi. A histogram was made to demonstrate the changes in the gain.

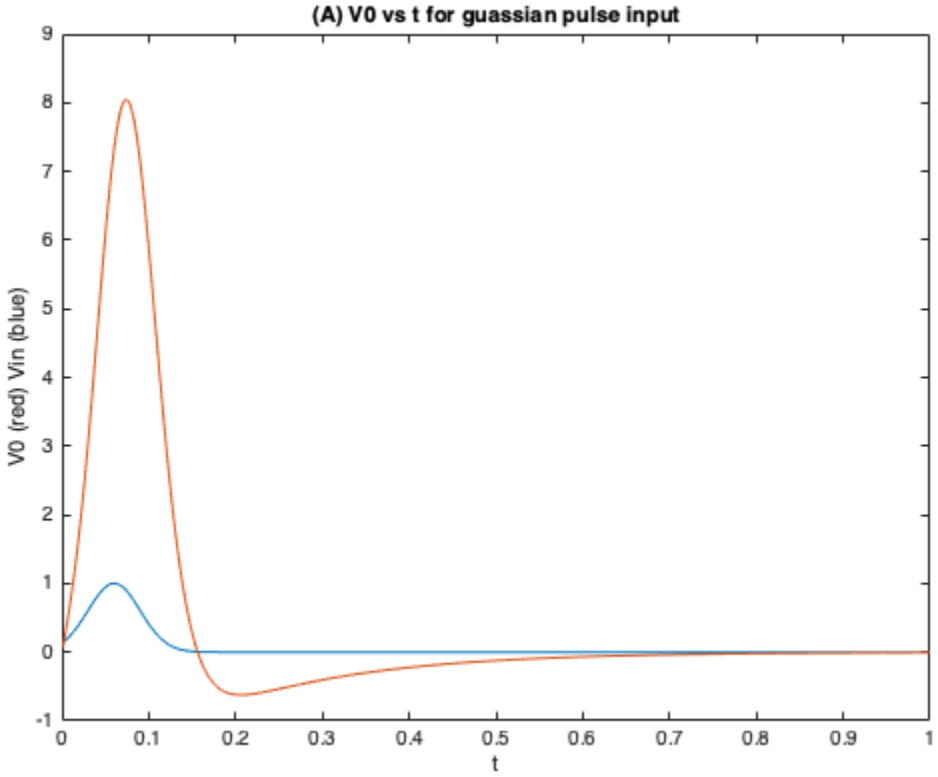
```
w = pi;
Av2 = zeros(15, 1);
Cper = zeros(15, 1);
vo3 = zeros(1, 15);

for i = 1:1000
    C(2, 1) = normrnd(-Cval, 0.05);
    C(2, 2) = normrnd(Cval, 0.05);
    C(3, 3) = normrnd(L, 0.05);
    Vm3 = (G+1i*w*C)\F';
    vo3(i) = Vm3(6);
    Av2(i) = vo3(i)/F(1);
end

figure(5)
hist(real(Av2), 25)
title('Gain Distribution for Normal Perturbations in C matrix')
xlabel('Gain at w = pi')
```

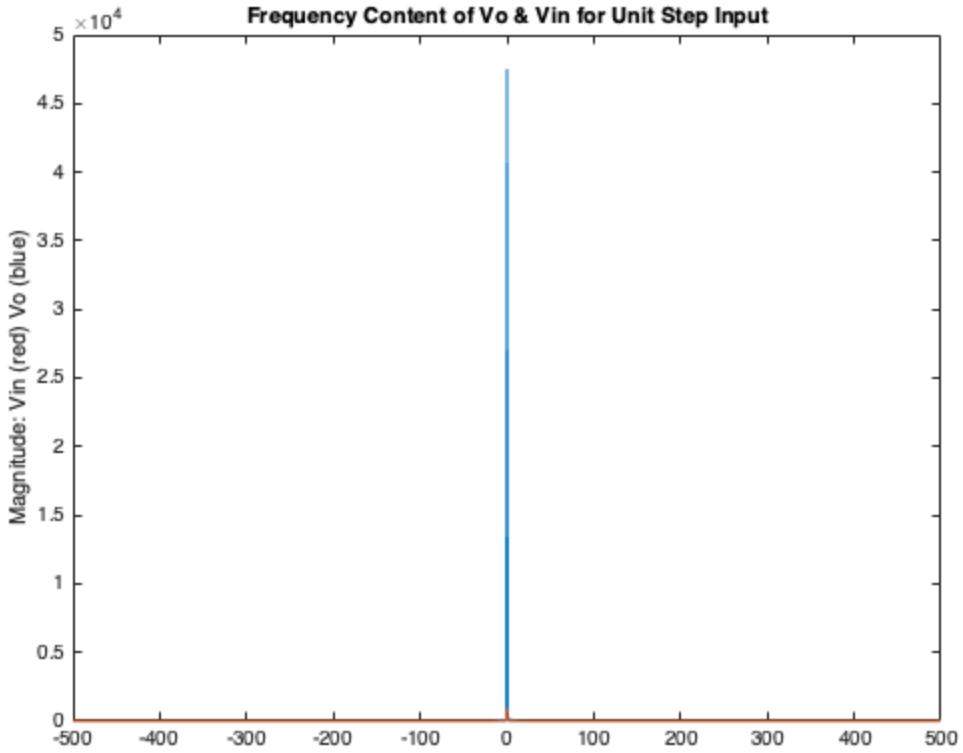
```
Assignment4Transient
Assignment4Noiseandnon


C =

         0         0         0         0         0         0         0
   -0.2500    0.2500         0         0         0         0         0
         0         0    0.2000         0         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         0         0         0
```

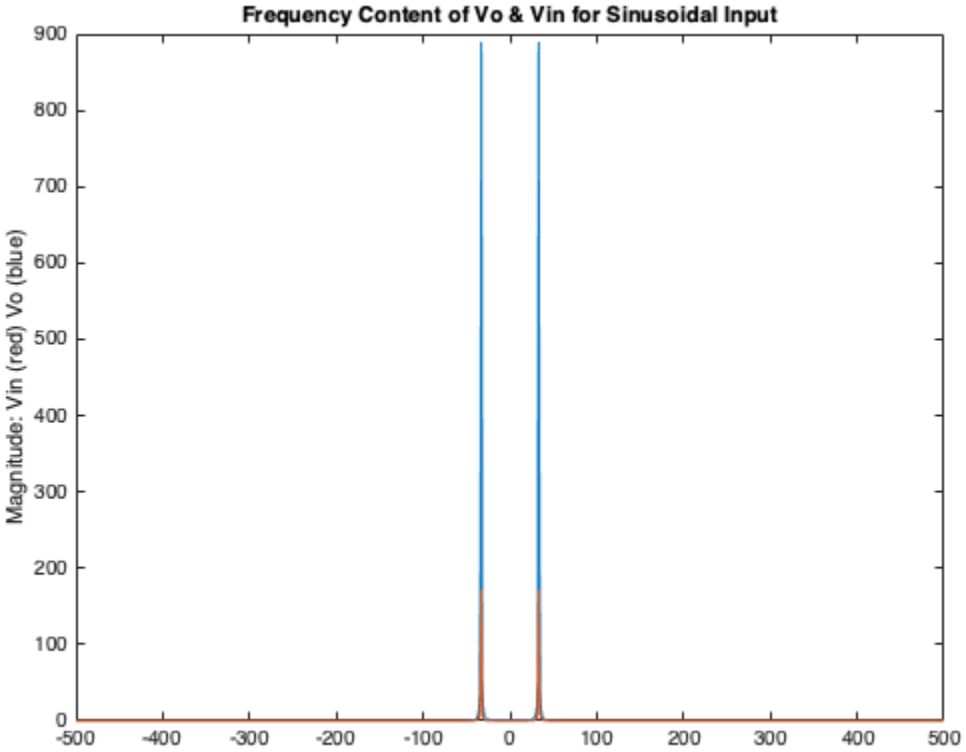

Gain Distribution for Normal Perturbations in C matrix
120
100
80
60
40
20
0
5
5.5
6
6.5
7
7.5
8
8.5
9
Gain at w = pi

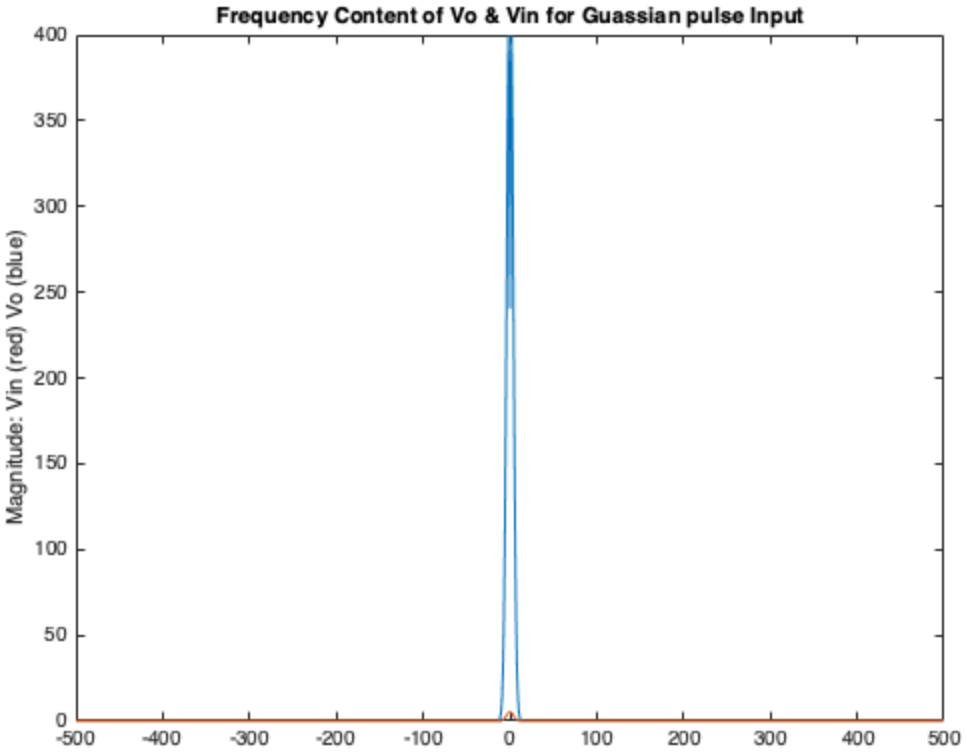

(A) V0 vs t for unit step input
10
8
6
4
2
0
-2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
t
V0 (red) Vin (blue)

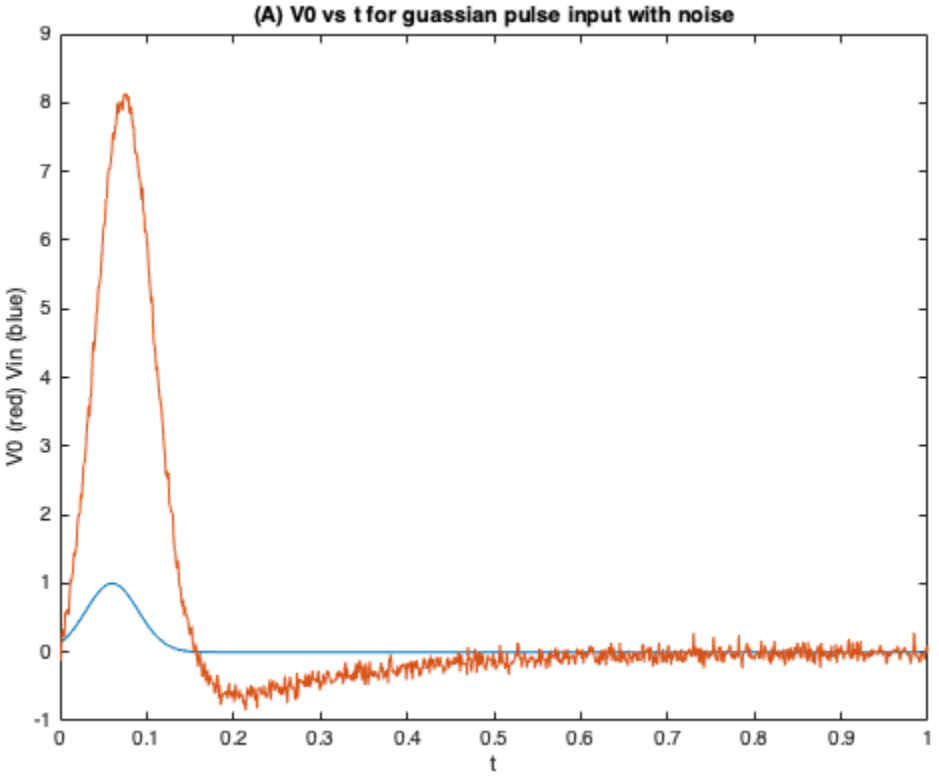

(A) V0 vs t for sinusoidal input
V0 (red) Vin (blue)
t
4
3
2
1
0
-1
-2
-3
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


(A) V0 vs t for guassian pulse input
V0 (red) Vin (blue)
t
9
8
7
6
5
4
3
2
1
0
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

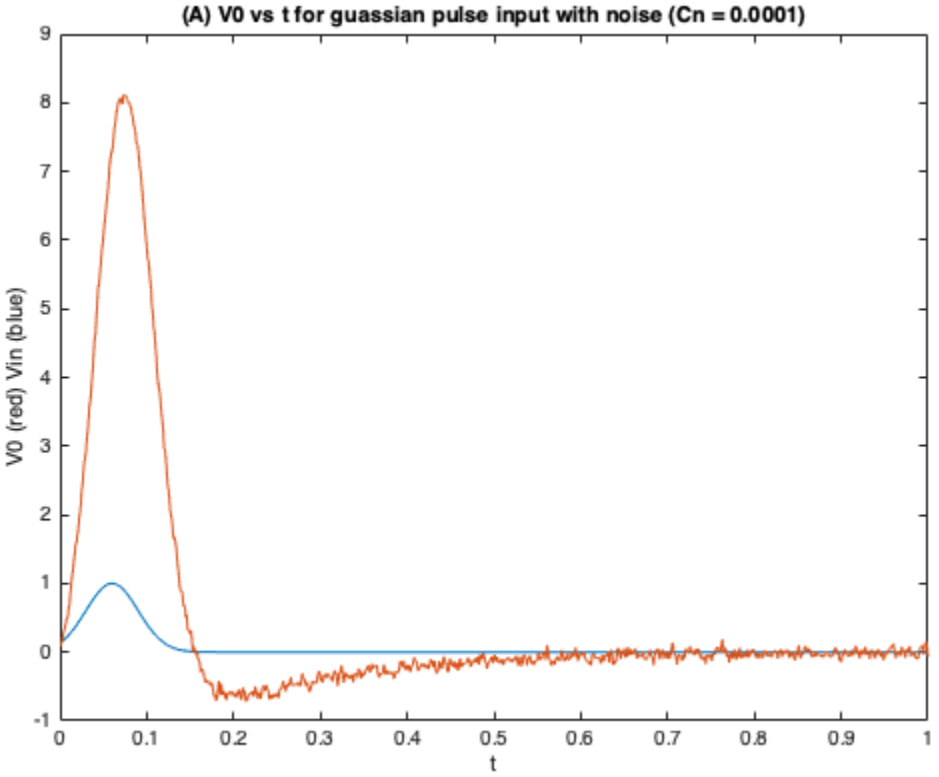

Frequency Content of Vo & Vin for Unit Step Input
×10^4
Magnitude: Vin (red) Vo (blue)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Frequency Content of Vo & Vin for Sinusoidal Input
Magnitude: Vin (red) Vo (blue)
900
800
700
600
500
400
300
200
100
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

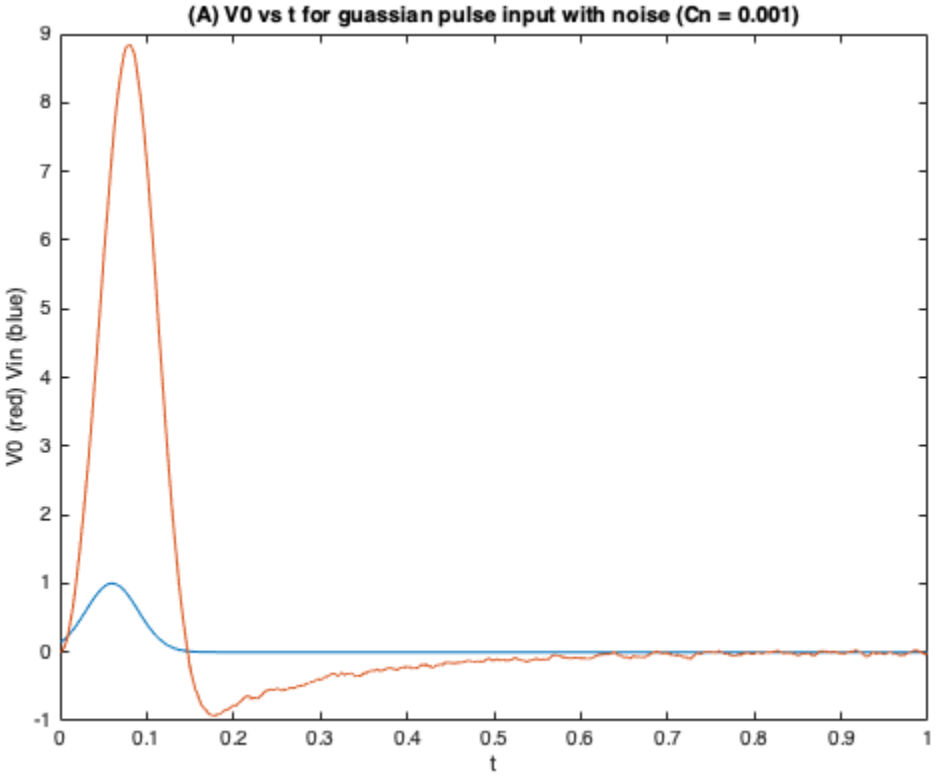

Frequency Content of Vo & Vin for Guassian pulse Input
Magnitude: Vin (red) Vo (blue)
400
350
300
250
200
150
100
50
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

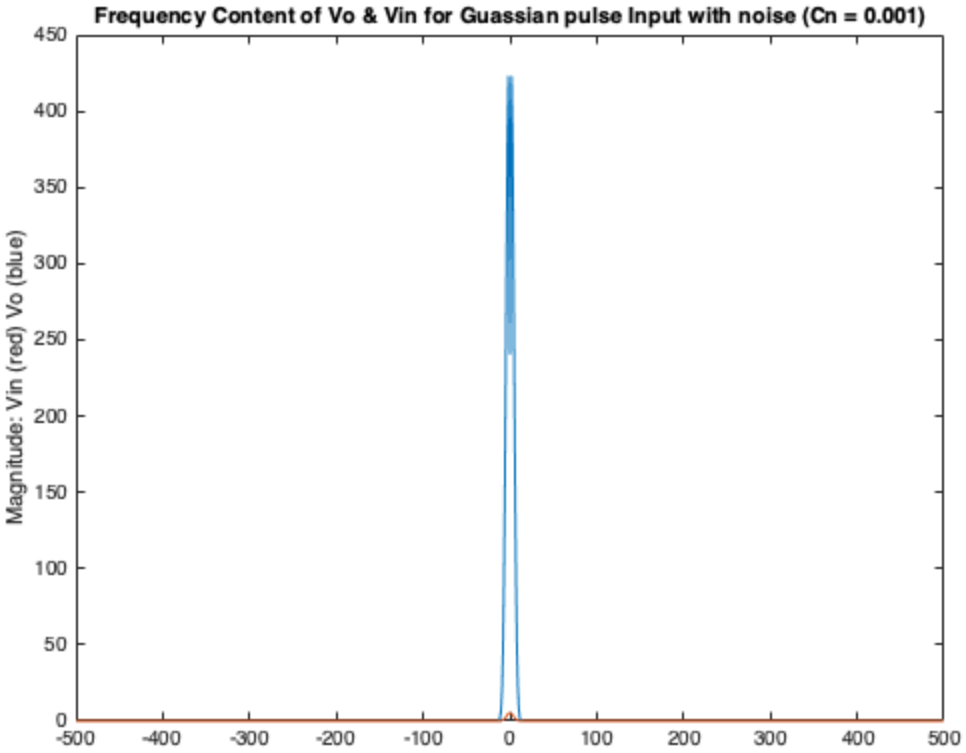

(A) V0 vs t for guassian pulse input with noise
V0 (red) Vin (blue)
9
8
7
6
5
4
3
2
1
0
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
t

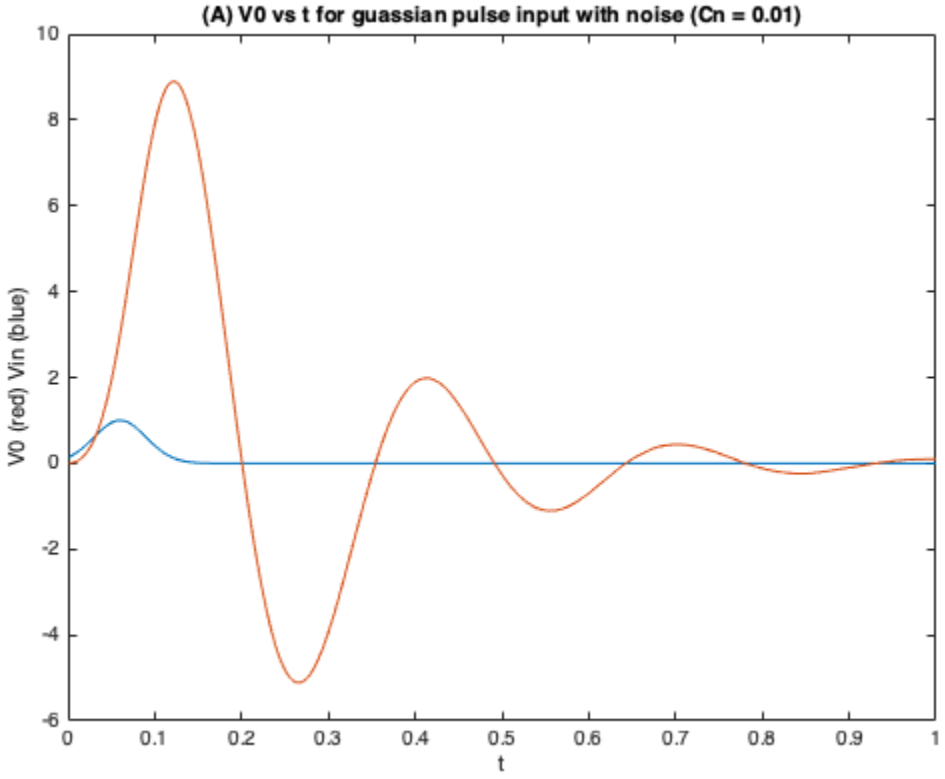

Frequency Content of Vo & Vin for Guassian pulse Input with noise
Magnitude: Vin (red) Vo (blue)
400
350
300
250
200
150
100
50
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

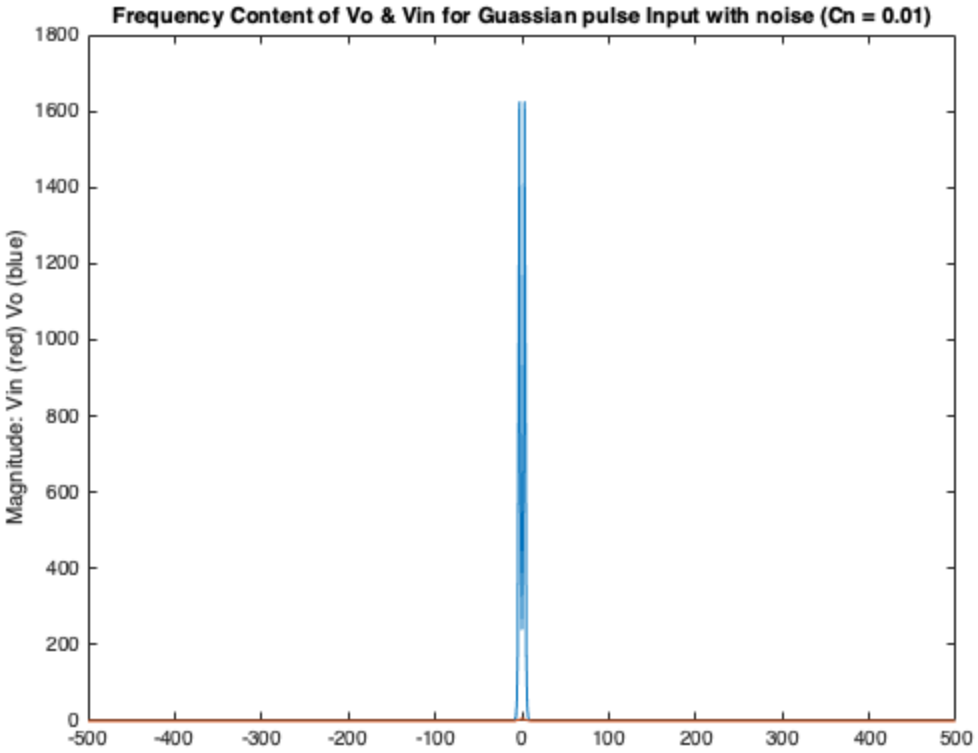

(A) V0 vs t for guassian pulse input with noise (Cn = 0.0001)
V0 (red) Vin (blue)
9
8
7
6
5
4
3
2
1
0
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
t

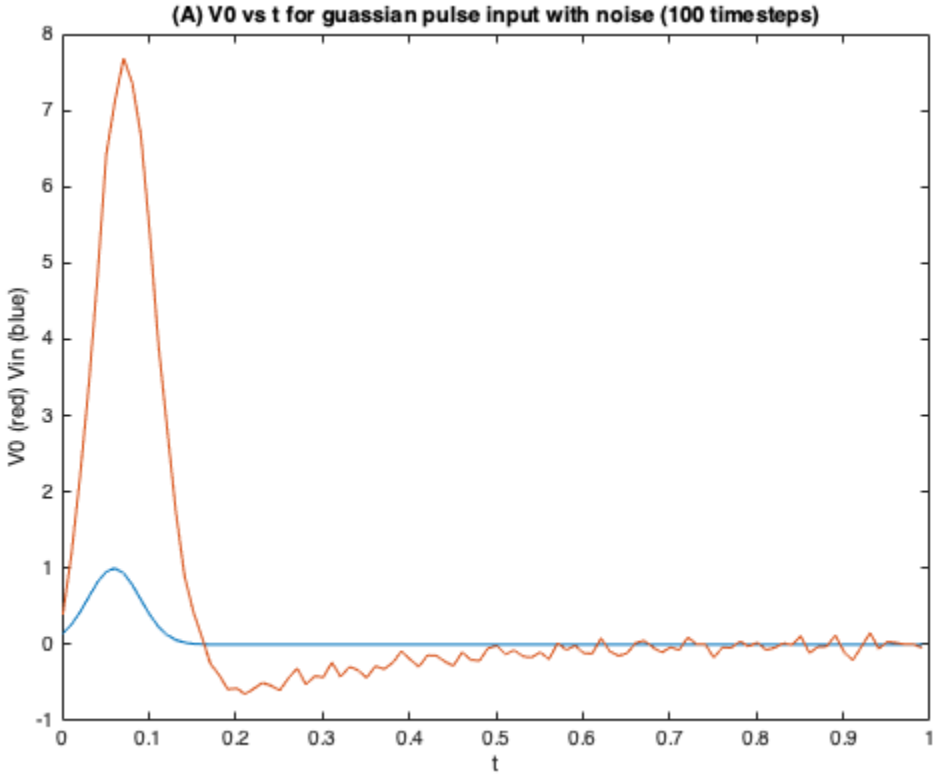

Frequency Content of Vo & Vin for Guassian pulse Input with noise (Cn = 0.0001)
Magnitude: Vin (red) Vo (blue)
450
400
350
300
250
200
150
100
50
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

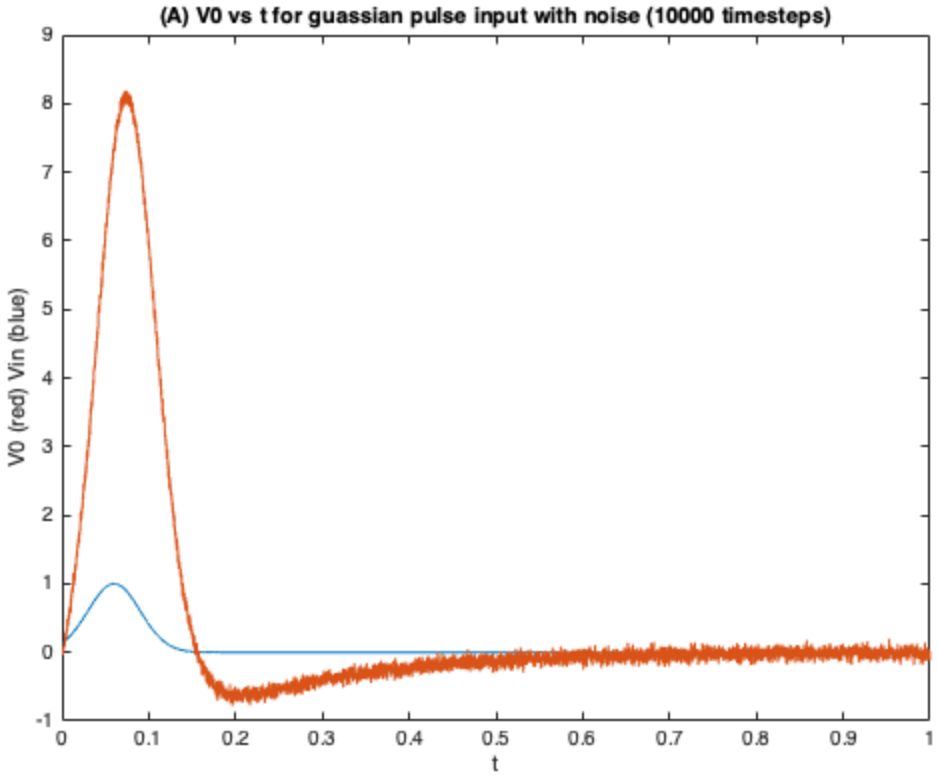

(A) V0 vs t for guassian pulse input with noise (Cn = 0.001)
V0 (red) Vin (blue)
9
8
7
6
5
4
3
2
1
0
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
t


Frequency Content of Vo & Vin for Guassian pulse Input with noise (Cn = 0.001)
Magnitude: Vin (red) Vo (blue)
450
400
350
300
250
200
150
100
50
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


(A) V0 vs t for guassian pulse input with noise (Cn = 0.01)
V0 (red) Vin (blue)
10
8
6
4
2
0
-2
-4
-6
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
t


Frequency Content of Vo & Vin for Guassian pulse Input with noise (Cn = 0.01)
Magnitude: Vin (red) Vo (blue)
1800
1600
1400
1200
1000
800
600
400
200
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


(A) V0 vs t for guassian pulse input with noise (100 timesteps)
V0 (red) Vin (blue)
8
7
6
5
4
3
2
1
0
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
t



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