Assignment 4: Part 1

This assignment serves as an introduction to circuit simulation and compact models. The simulation is done using Modified Nodal Analysis (MNA) on circuits. This analysis is done for transient and frequency domain simulations, the two simulations run in SPICE applications. The MNA technique is applied using common node voltages to create a matrix of circuit equations. The nodel equations are created using Kirchoffs current law and voltage law. The Nodal matrix is craeted from the equation $ G_n*V = I_ns$ where V and I are the voltage and currents of the branches. Each device is given a stamp, whereby it's current is defined in terms of an applied voltage. The first part of the assignemnt provides a circuit with a set of components that will be used for nodal analysis. Stamps can be found below:

```
close all;
clear;

R1 =1;
R2 = 2;
R3 = 10;
R4 = 0.1;
R0 = 1000;
cap = 0.25;
L = 0.2;
alpha = 100;

G1 = 1/R1;
G2 = 1/R2;
G3 = 1/R3;
G4 = 1/R4;
G0 = 1/R0;
```

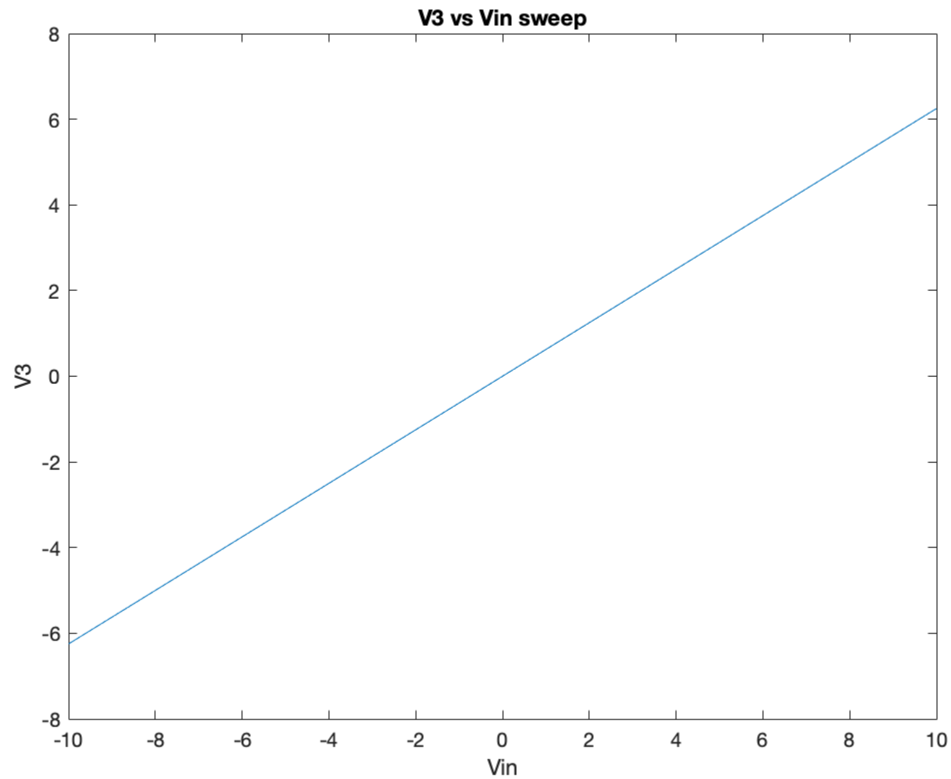
The Matrices are used to satisfy the equation $C(dV/dt) + GV = F$ where C is a capacitive matrix, looking at energy storing devices and G is the conduction matrix, taking into account linear relationships. The G matrix was then created using the nodal equations generated from the stamps above. The G matrix was created based on the number of equations as well as number of unkowns. Initialization of the G matrix can be found below.

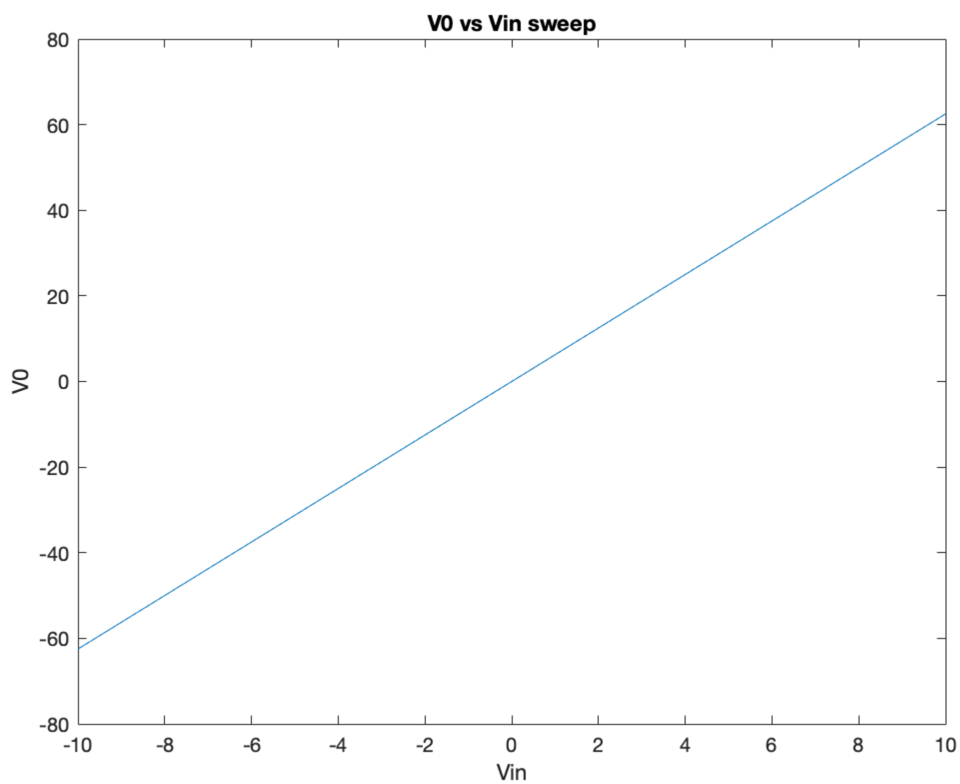
```
G = zeros(8,8);
C = zeros(8, 8);

G(1, 1) = -G1;
G(1, 2) =  G1;
G(2, 1) =  G1;
G(1, 3) =  G1;
G(2, 3) = -G1-G2;
G(3, 4) = -G3;
G(2, 7) = -1;
G(3, 7) = 1;
G(4, 3) = 1;
G(4, 4) = -1;
G(5, 6) = G4;
G(5, 7) = -alpha*G4;
G(5, 8) = 1;
G(6, 6) = -G4-G0;
```

```
G(6, 7) = alpha*G4;
G(7, 1) = 1;
G(8, 5) = 1;
G(8, 7) = -alpha;

C(1, 1) = -cap;
C(1, 3) = cap;
C(2, 1) = cap;
C(2, 3) = -cap;
C(4, 7) = -L;
```

The nodes were then analized in the frequency domain to create similar equations, however taking into account the frequency aspects of the circuit which includes capacitors and inductors. initiliazation of the C matrix can be found below. The F vector was also initilized which would serve as the resulting vector for the simulation.

```
F = zeros(8,1);

% Solve F matrix
Vin = linspace(-10,10,100);
V3 = zeros(length(Vin),1);
V0 = zeros(length(Vin),1);

for i = 1:length(Vin)
    F(7,1) = Vin(i);
    V = G\F;
    V3(i) = V(4);
    V0(i) = V(6);
end

figure(1)
plot(Vin,V3);
xlabel('Vin')
ylabel('V3')
title('V3 vs Vin sweep')

figure(2)
plot(Vin,V0);
xlabel('Vin')
ylabel('V0')
title('V0 vs Vin sweep')
```

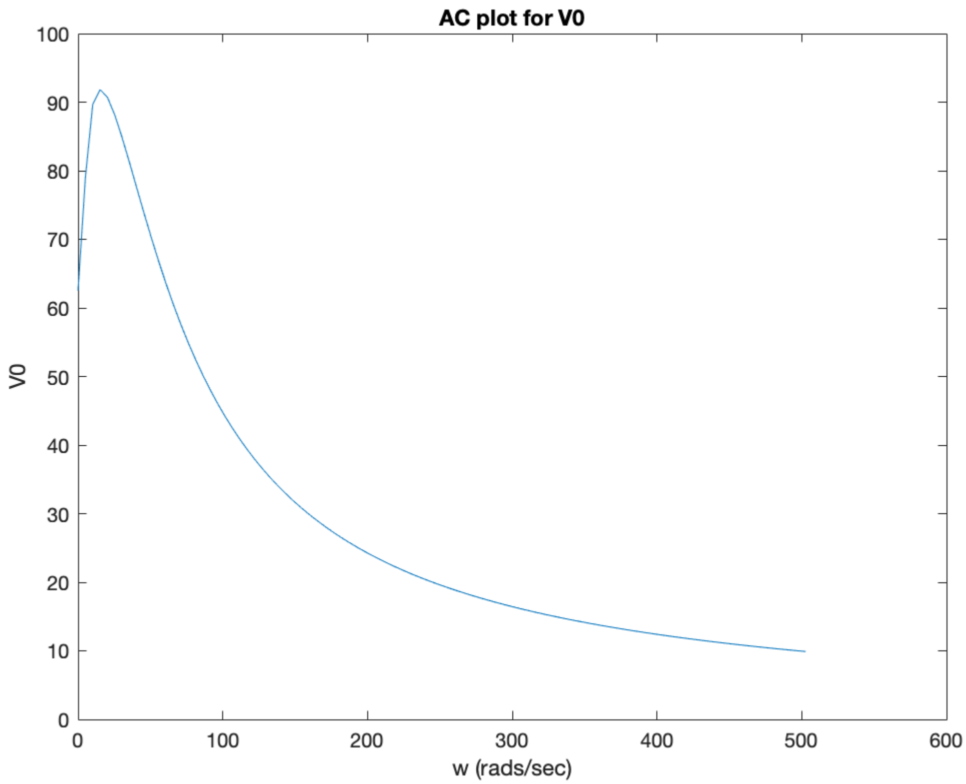

V3 vs Vin sweep
V3
Vin
8
6
4
2
0
-2
-4
-6
-8
-10
-8
-6
-4
-2
0
2
4
6
8
10

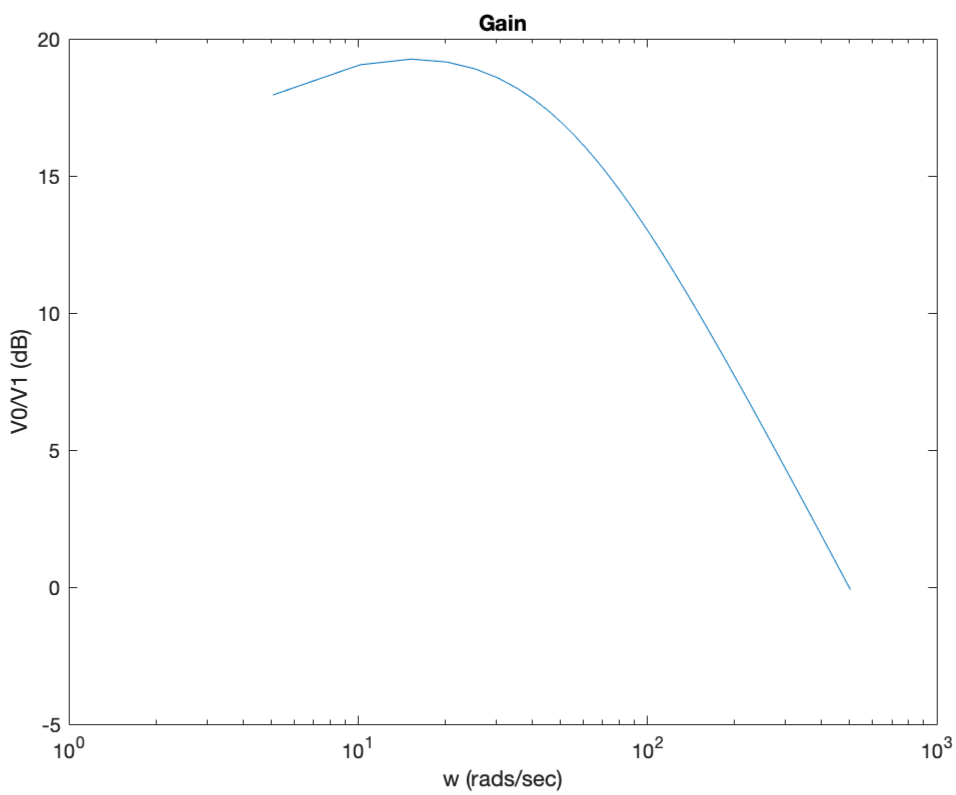

V0 vs Vin sweep
V0
Vin
80
60
40
20
0
-20
-40
-60
-80
-10
-8
-6
-4
-2
0
2
4
6
8
10

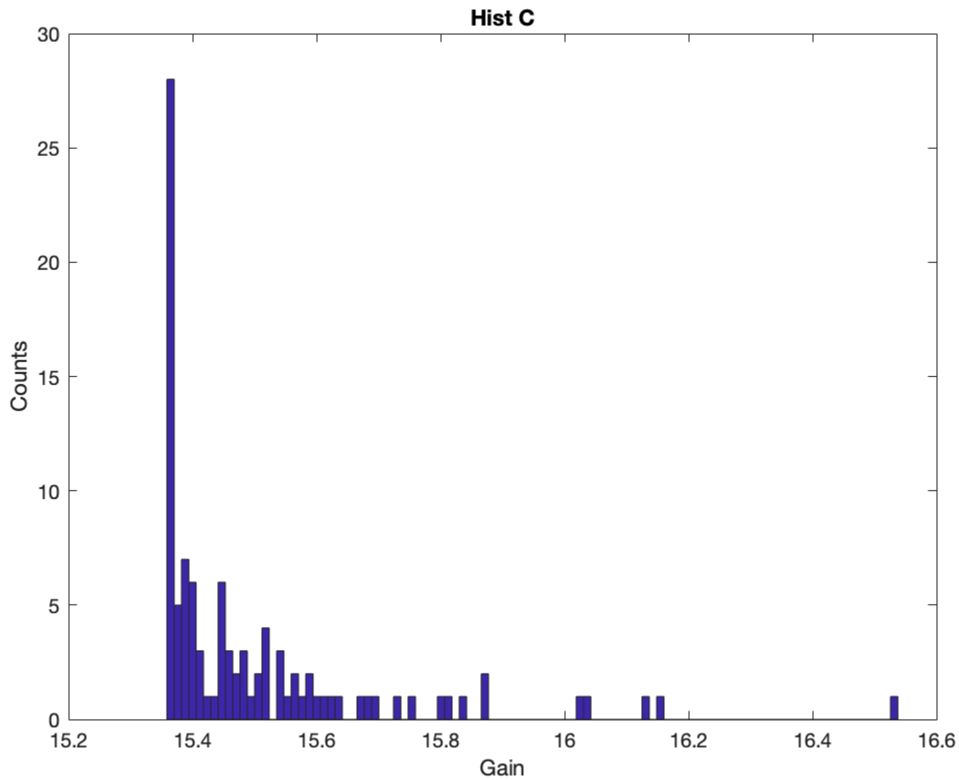
AC Gain Plot

A plot of Vin vs Vo was then plotted for the AC case of the circuit. This involved taking into account the frequency components in the circuit.

```
 w = 2*pi*linspace(0,80,100);
 V0 = zeros(length(w),1);
 gain = zeros(length(w),1);

for i = 1:length(w)
    s = 1i*w(i);
    M = inv((G +((s).*C)))*F;
    V0(i) = abs(M(5));
    gain(i) = 20*log10(abs(V0(i))/abs(M(1)));
end

figure(3)
plot(w,V0);
xlabel('w (rads/sec)')
ylabel('V0')
title('AC plot for V0')


figure(4)
semilogx(w,gain);
xlabel('w (rads/sec)')
ylabel('V0/V1 (dB)')
title('Gain');

V0 = zeros(length(w),1);
gain = zeros(length(w),1);

for i = 1:length(gain)
    pert = randn()*0.05;
    C(1,1) = cap*pert;
    C(1,3) = -cap*pert;
    C(2,1) = -cap*pert;
    C(2,3) = cap*pert;

    s = 1i*2*pi*pi;
    M = inv((G +((s).*C)))*F;
    V0(i) = abs(M(5));
    gain(i) = 20*log10((V0(i))/abs(M(1)));
end

figure(5);
hist(gain,100);
xlabel('Gain')
ylabel('Counts')
title('Hist C')
```


AC plot for V0
100
90
80
70
60
50
40
30
20
10
0
V0
0
100
200
300
400
500
600
w (rads/sec)


Gain
20
15
10
5
0
-5
V0/V1 (dB)
10^0
10^1
10^2
10^3
w (rads/sec)



Published with MATLAB® R2017a