1.0 PA 9 Work

1.1 C and G Matrices

```
C = zeros(7,7);
C(2,1) = -c;
C(2,2) = c;
C(3,3) = -L;

G = [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+Go];
```

Figure 1: C and G Matrices for the MNA Circuit

1.2 DC Sweep for V_{in}

Below you will find the plot for a DC sweep of V_{in} from -10V to 10V to produce V_{out} versus V_3.

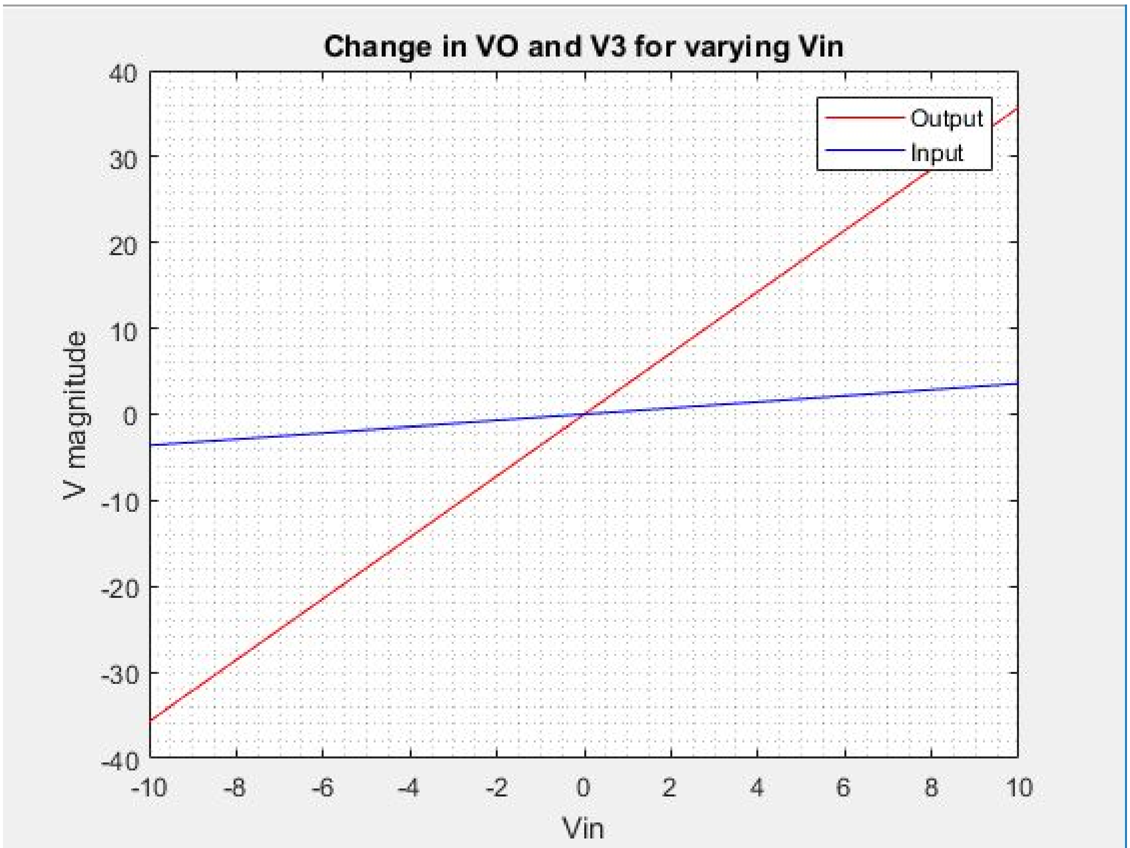

Figure 2: Change in Vo and V3 for varying Vin

1.3 AC Case

Below is a plot for V_o as a function of ω with the gain in dB.

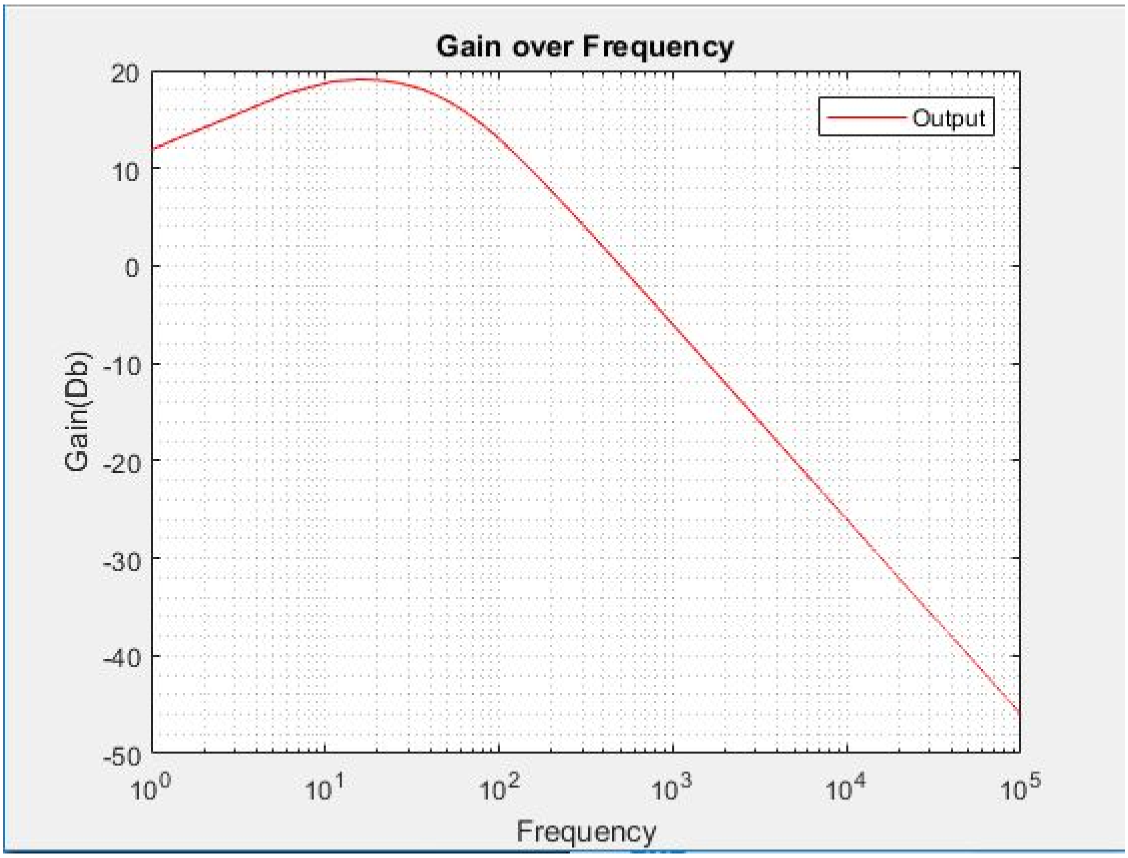

Figure 3: Plot of Gain versus frequency in dB

1.4 Varying the Capacitor C

Below is a histogram of the gain with random values of capacitor C.

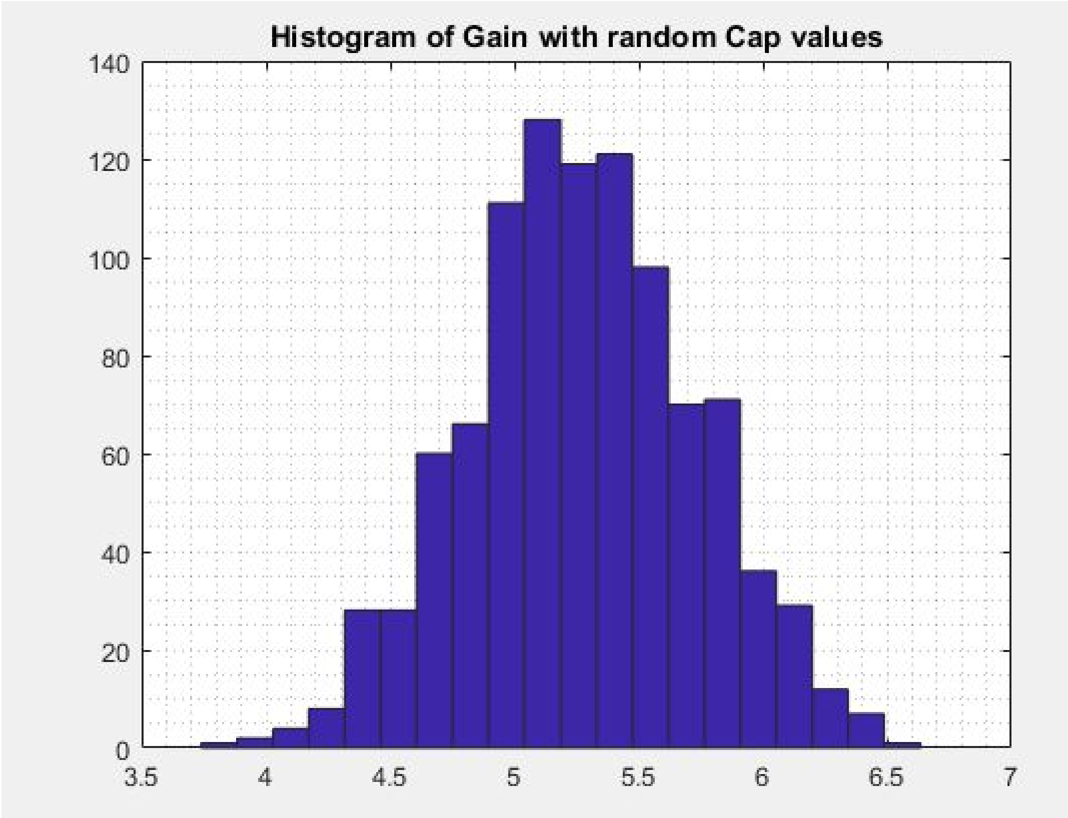

Figure 4: Histogram of Gain with Varying Capacitances.

2.0 Transient Circuit Simulation

2.1 Step Function Response

Below in the following figures will be a step function response in time domain as well as the response in frequency domain.

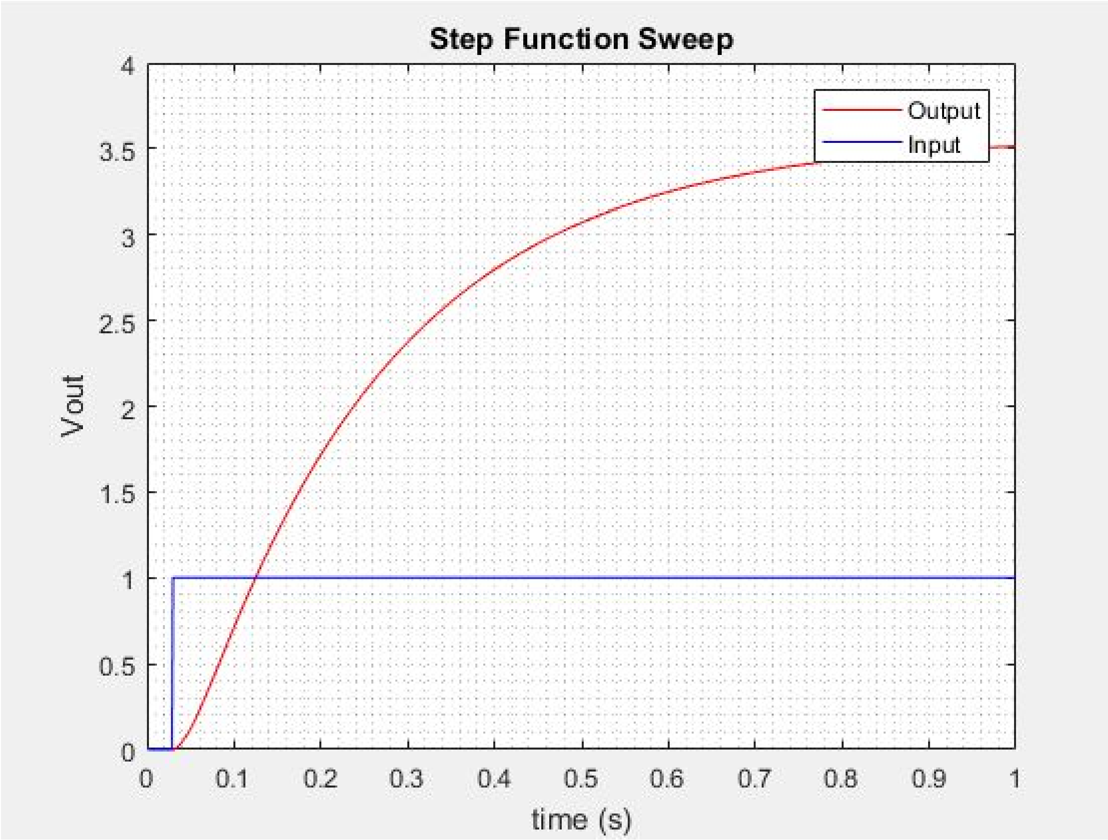

Figure 5: Step Response in Time Domain

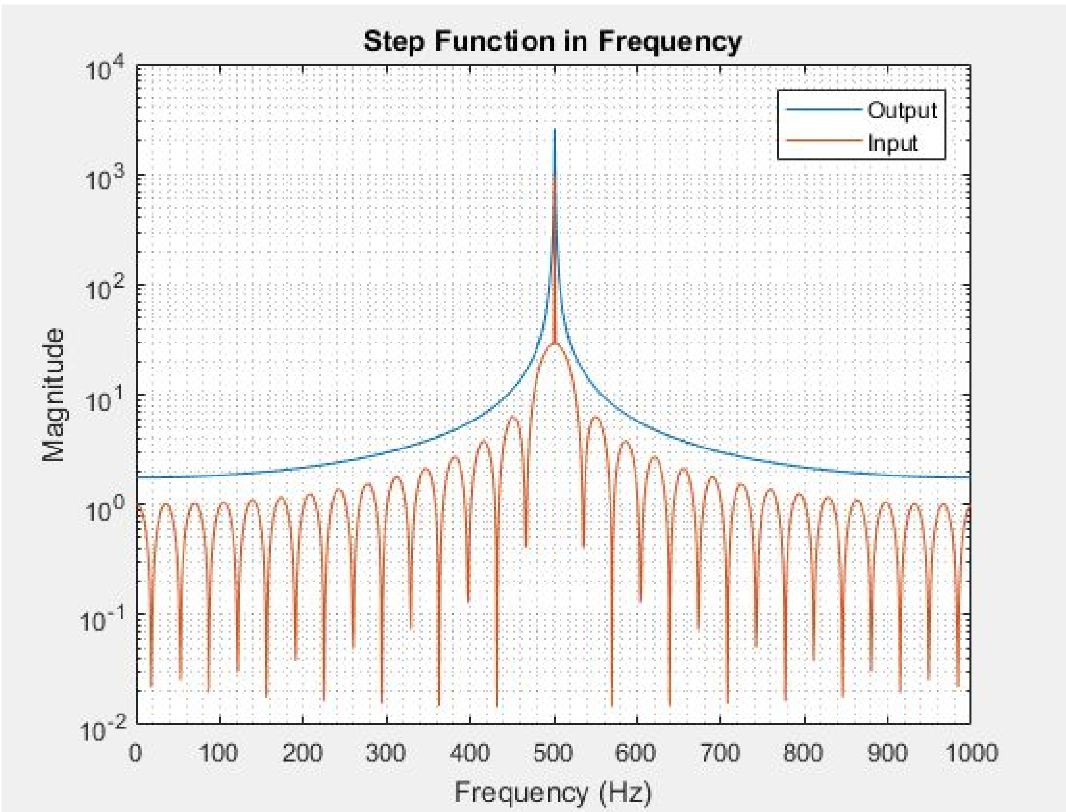

Figure 6: Step Function Response in Frequency Domain

2.2 Sine Function Input

Below is the response to the system with a sine function input in time domain and frequency domain.

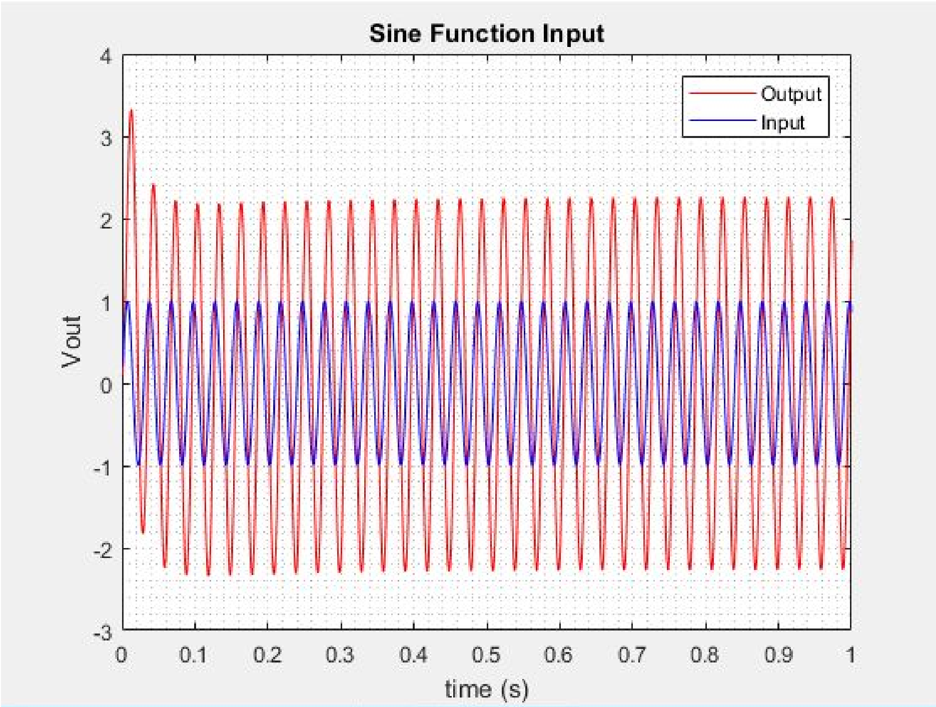

Figure 7: Sine Function Response in Time Domain

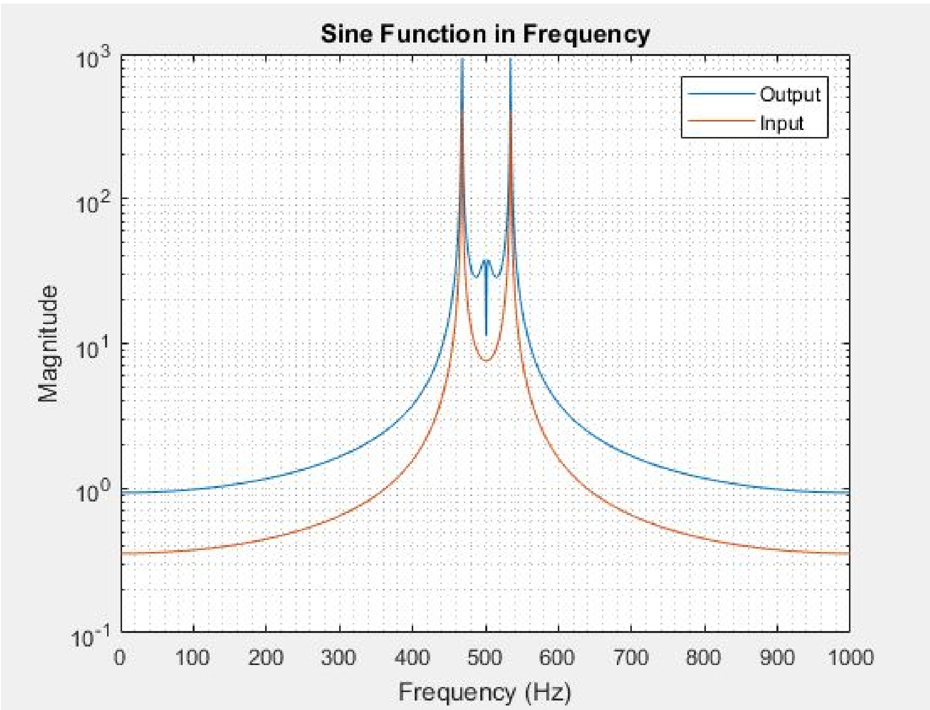

Figure 8: Sine Function Response in Frequency Domain

2.3 Gaussian Pulse Response

Below is the plots for the response with a Gaussian pulse input in frequency and time domain.

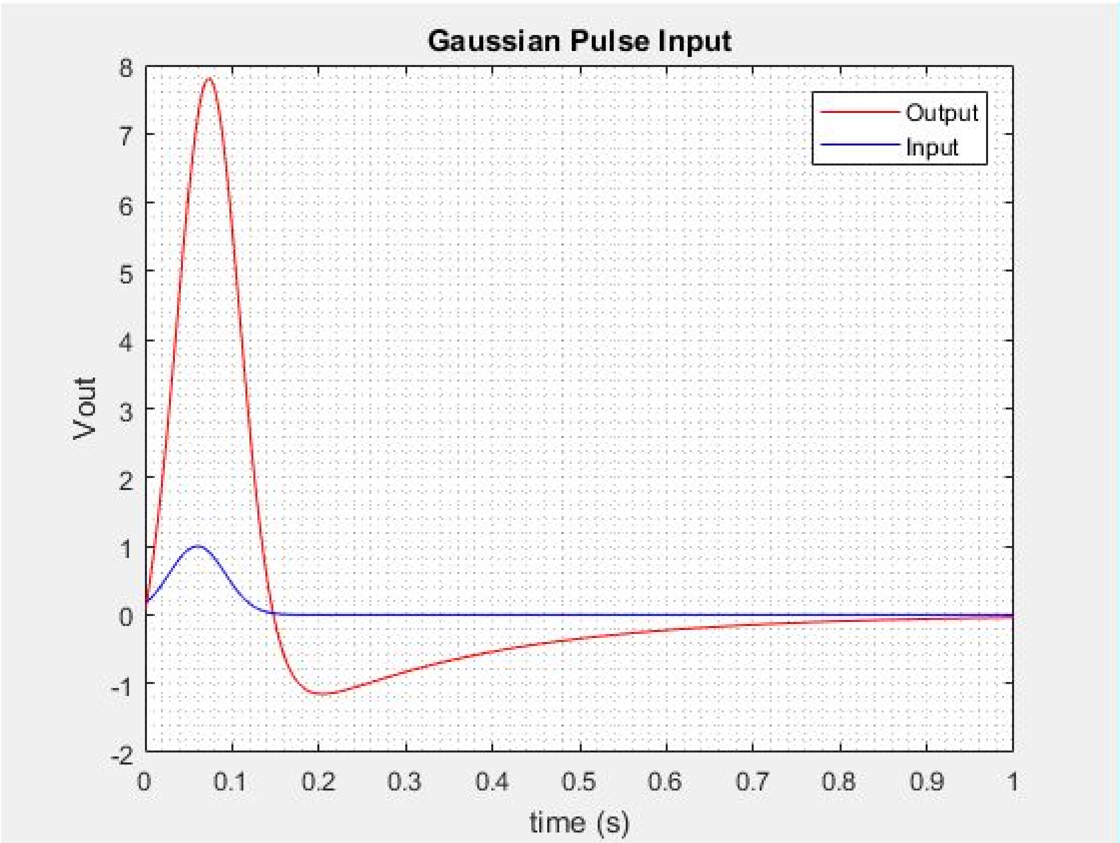

Figure 9: Gaussian Pulse Response in Time Domain

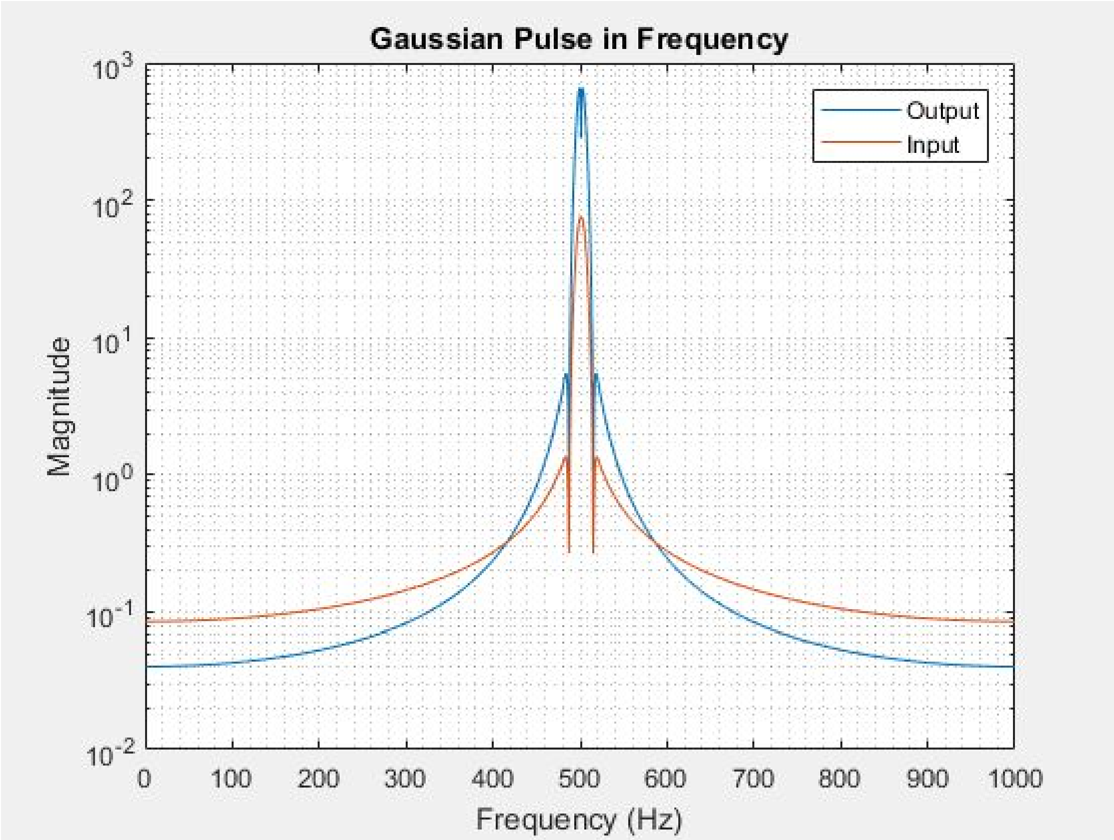

Figure 10: Gaussian Pulse Response in Frequency Domain

3.0 Circuit with Noise

3.1 Updated C Matrix

Since the circuit now has a capacitor in parallel with a varying current source, the equation changes. More specifically,

$$-I_L + G_3V_3 = 0$$

Will change to;

$$C\ dV_3/dt - I_L + G_3V_3 = I_N$$

This will change our C matrix to be:

```
C = zeros(7,7);
C(2,1) = -c;
C(2,2) = c;
C(3,3) = -L;
C(4,4) = -Cn;
```

Figure 11: Updated C Matrix

3.2 Plot of Vout with a noise source using a Gaussian Pulse

Now we add a Gaussian pulse with a random value of I_n. This will add noise to the circuit which is demonstrated below in time domain and Frequency Domain.

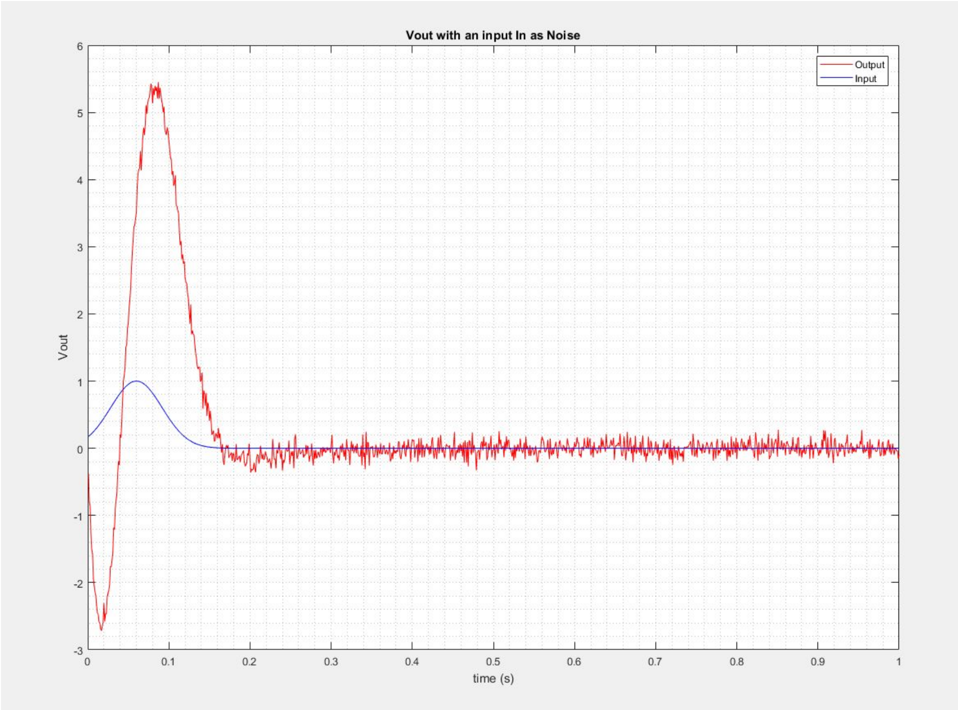

Figure 12: Plot of Vout in Time Domain with a Gaussian Pulse and Noise

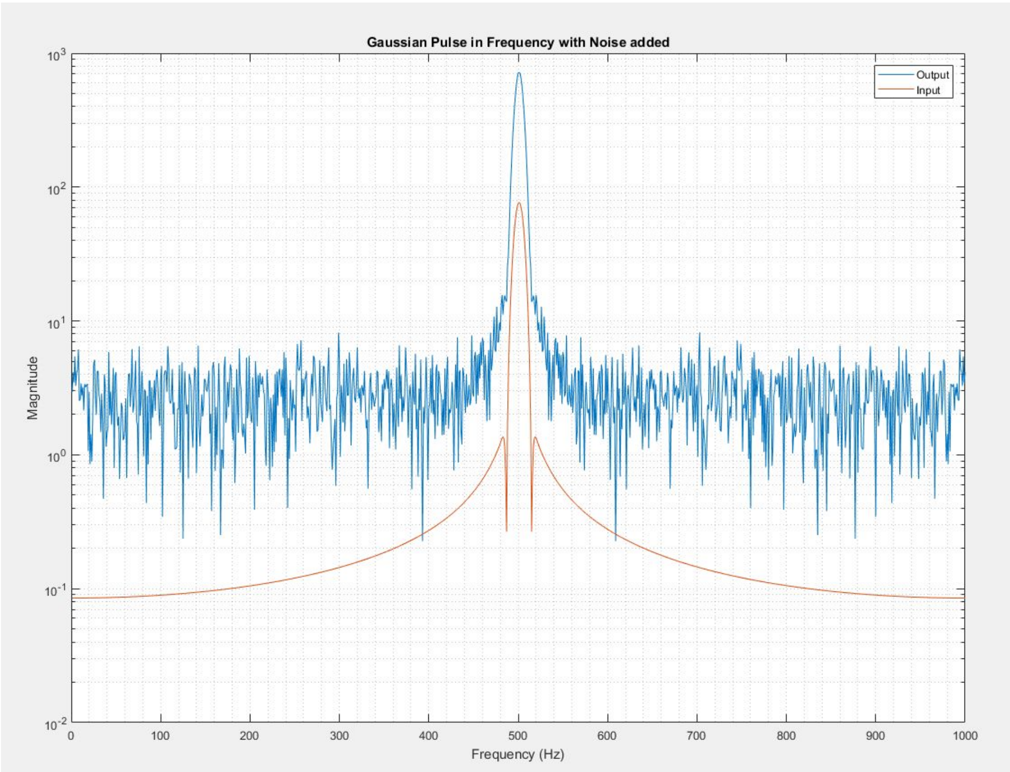

Figure 13: Plot of Vout in Frequency Domain with a Gaussian Pulse and Noise

3.3 Varying the Values of C

Below in figure 14 you will find a Frequency Domain plot with a larger value of C. When adding a larger value of C you should see a decrease in the noise.

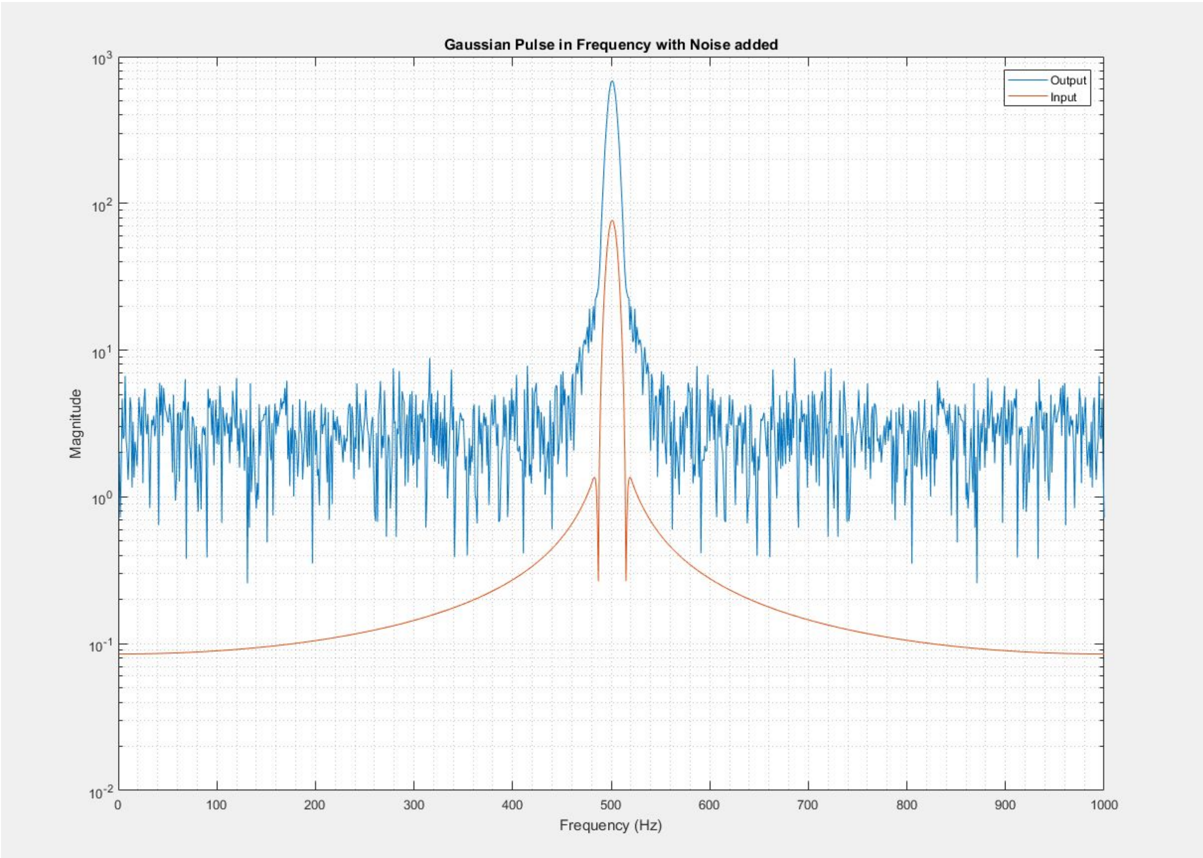

Figure 14: Noise Response in Frequency Domain With a Larger C

We can see from figure 14, that a larger value of C will produce less noise in comparison to figure 13. Next, we will examine a smaller value of C and see the results.

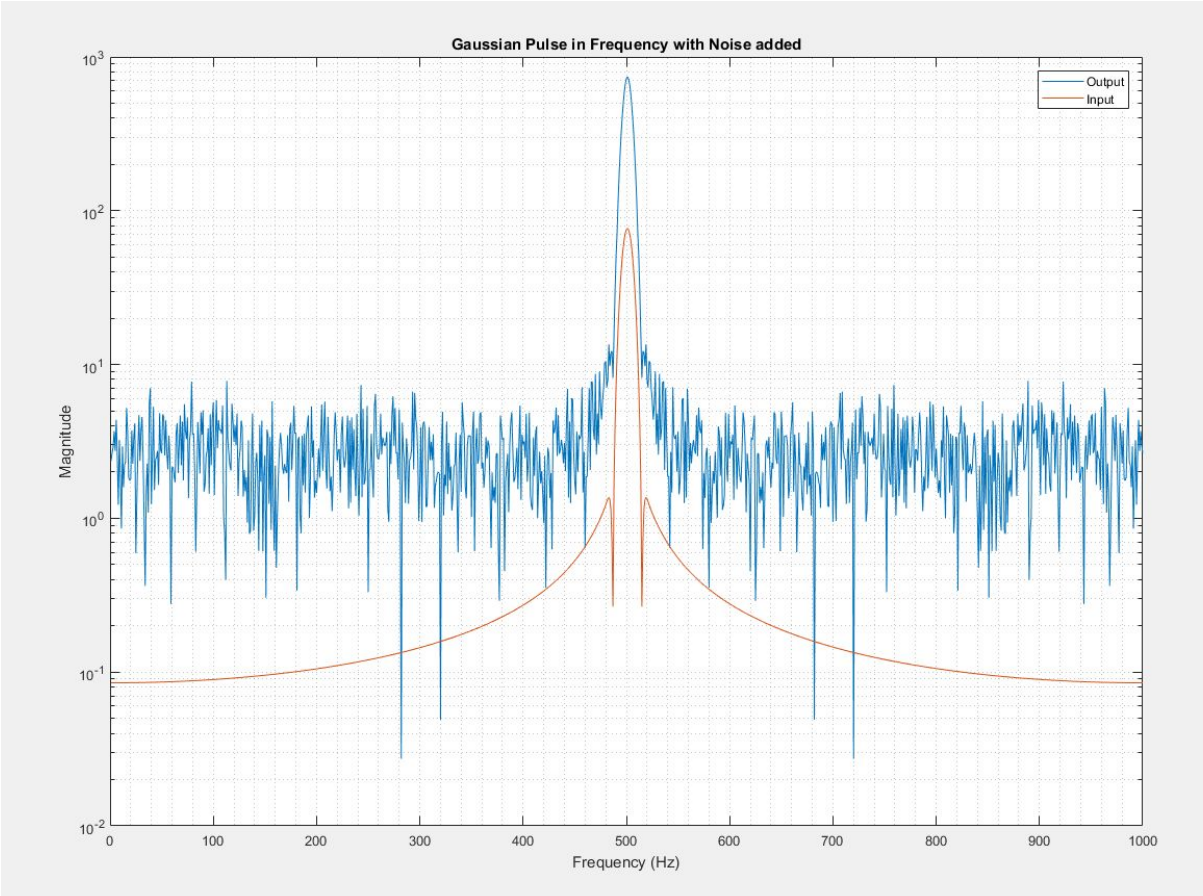

Figure 15: Noise Response in Frequency Domain With a Smaller C

Now we can see that with a smaller capacitor, it will produce more noise in the circuit. This is confirmed by comparing figure 15 to figures 14 and 13.

2.4 Changing the Time Step

Below you will find the V_{out} response with a larger timestep.

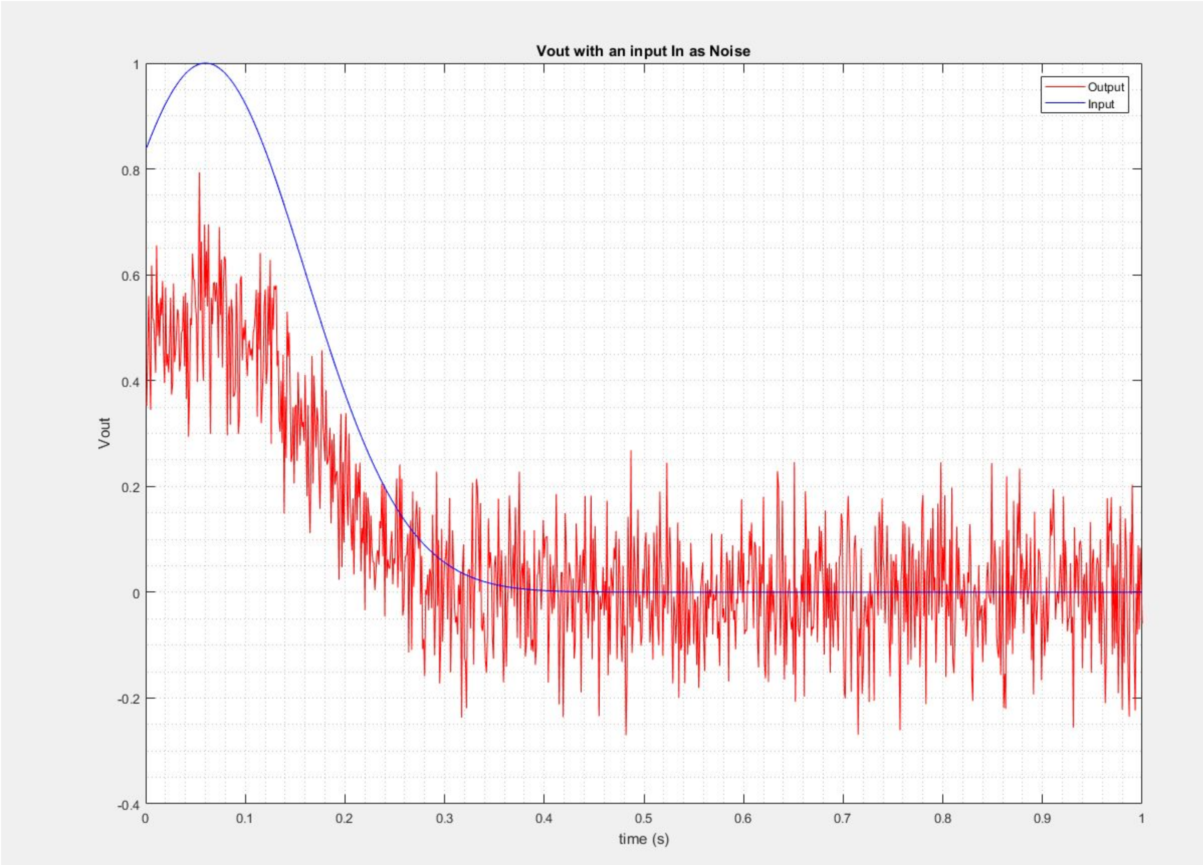

Figure 16: Vout Response with Noise and a Larger Time Step

4.0 Non - Linearity

If the voltage source on the the output stage was modeled by:

$$V = \alpha I_3 + \beta I_3^2 + \gamma I_3^3$$

This produces non-linearity, and if we wish to implement this, a few things would need to change. Firstly, you would need to formulate a Jacobian Matrix to find the non-linear solution. Then we use the equation with the B matrix shown below.

$$V^j = \hat{A}^{-1}\left[C\frac{\hat{V}^{j-1}}{\Delta t} + \hat{F}(t^j) - \hat{B}(\hat{V}^j)\right]$$

This equation will allow us to solve the nonlinear equation by using iteration.