The City College of New York

EE 22100 EE Lab#5

11/01/2017

Experiment 5: RC Circuit Frequency and Time Response

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Purpose

To introduction the student to simple elementary concepts of circuit response in the frequency and time domain.

Introduction

Frequency and time response are importance in value when it comes to the concept of filter design, feedback and communications. These concepts will be introduced in this experiment with the development of high and low pass filters.

Equipments

- ➔ Oscilloscope
- ➔ Function generator
- ➔ Breadboard
- ➔ 2-3.3k resistors
- ➔ 1.5k resistor
- ➔ .1 uF capacitor
- ➔ MATLAB
- ➔ LabView
- ➔ Multisim

Pre Lab

The pre-lab consists of using two different circuit that develops the low pass and high pass filters. The figures are shown below.

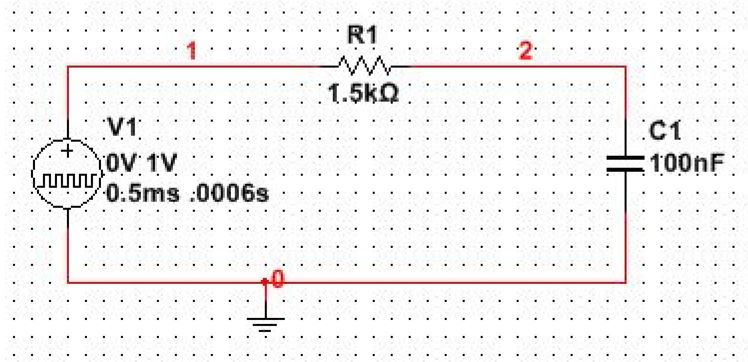

Figure 1: Low Pass Filter

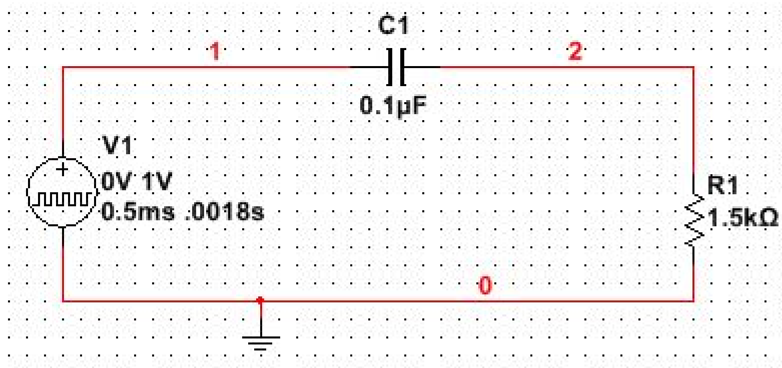

Figure 2: High-pass filter

A-Frequency Domain Response

From those circuits we needed to find the value of gain as a function of w.

- ➔ Low Pass Filter $\left|\frac{V\,out}{V\,in} = \frac{1}{\sqrt{1+(\frac{w^2}{wp^2})}}\right|$ w=2*pi*f wp=1/(RC)

- ➔ High Pass Filter $\left|\frac{V\,out}{V\,in} = \frac{1}{\sqrt{1+(wRC)^2}}\right|$ w=2*pi*f

Then Using Matlab, we plotted the gain vs. frequency using loglog feature. We set the frequency to be equal to 10 Hz to 10 MHz.

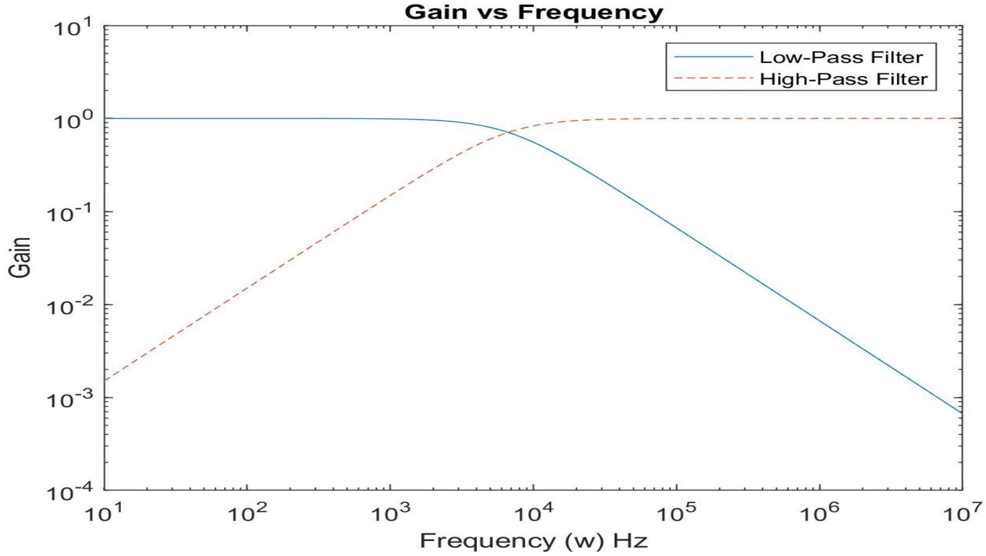

Figure 3-Gain Vs Frequency for both Low and high pass filters

B. Time Domain Response

➔ Low Pass Filter Vout =Vin(1-e^((-t)/(RC)))

➔ High Pass Filter Vout=Vin(e^(-t/(RC))

Then using matlab we plotted the output voltage of these two circuit, with the formula shown above, from time.

➔ t=0, to t=6RC.

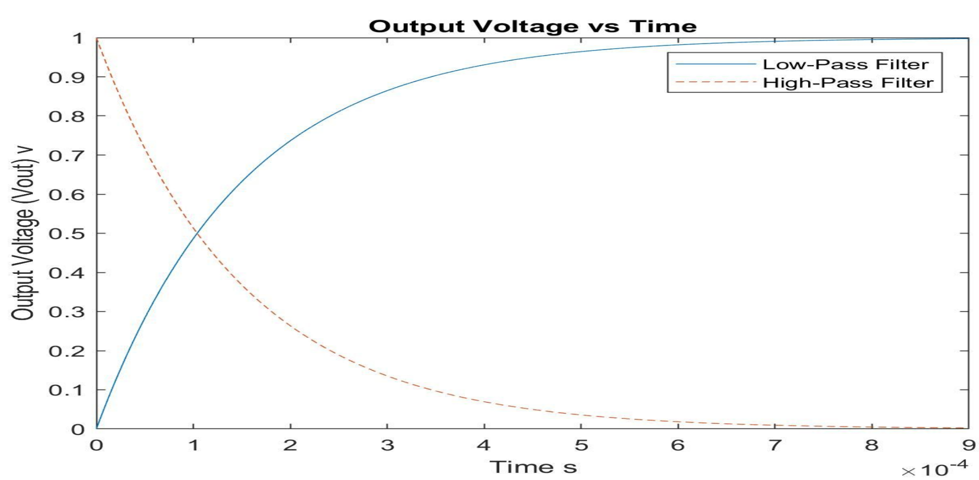

Figure 4: Time Domain Response Pre-lab

Simulation

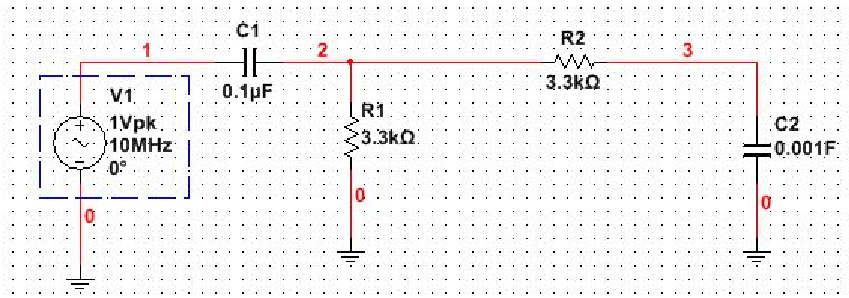

Figure 5: Band-pass filter

Frequency Domain Response:

First, the frequency domain response was simulated using the circuit shown on figure 5. Using AC analysis and log-log scale from 10<f<10MEG.

Time Domain Response:

We simulated the circuits on figure 1 and figure 2 using transient Analysis. We used a pulse voltage source as our voltage source. Setting the initial value to 0V and pulse width to be period/2.

We performed two simulation for figure 1 with the following conditions:

- ➔ Pulse period =12RC; End Time=5mS
- ➔ Pulse period=4RC; End Time=5mS

We performed two simulations for the figure 2 with the following conditions:

- ➔ Pulse period=12RC; End time =5mS
- ➔ Pulse period=(⅔)RC; End time=1mS

Laboratory Measurements

Frequency Domain Response

First we constructed the circuit on figure 1 and figure 2. Using the function generator we set the frequency to 10 Vp-p. We set the channel 1 of the oscilloscope to input and channel 2 to output. We set the trigger to channel 2. Then we verified the circuit is placed correctly by manually checking the gain by setting the frequencies to 100Hz, 300Hz, 1kHz, 10kHz, 100kHz, 300 kHz and 1MHz. Then using the VI, "frequency response", we swept the function generator withe the range between 50<f<2MEG and 40 points. We saved the file as txt file. We repeated this experiment for the figure 2.

Time Domain Response

By constructing the figure 1 and figure 2 on the breadboard, we set the function generator to generate a square wave with VL=0V, VH=1V, and period with the same condition of the simulations onnes. We set channel 1 Vout and channel 2 Vin. Then using the VI, "Save Oscilloscope Data time, ch1 and ch2", we saved the datas using the txt files.

Post-Lab

Frequency Domain Response

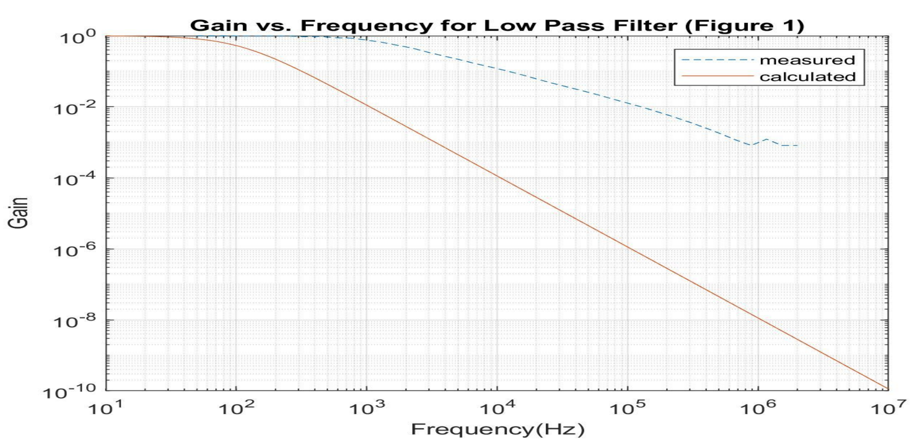

Figure 6: Graph Showing gain vs frequency for circuit 1.

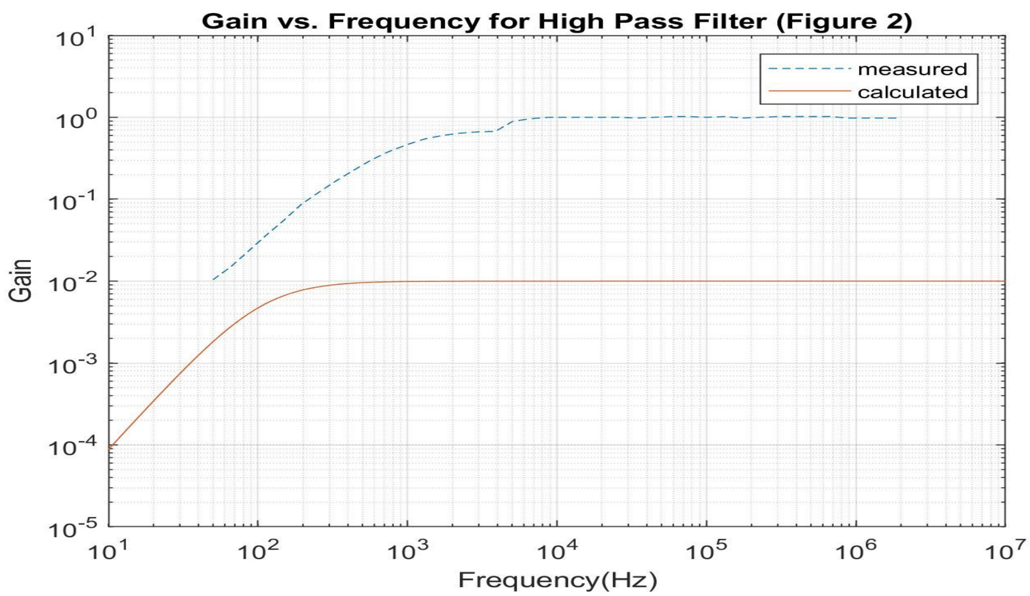

Figure 7: Gain vs Frequency for circuit 2

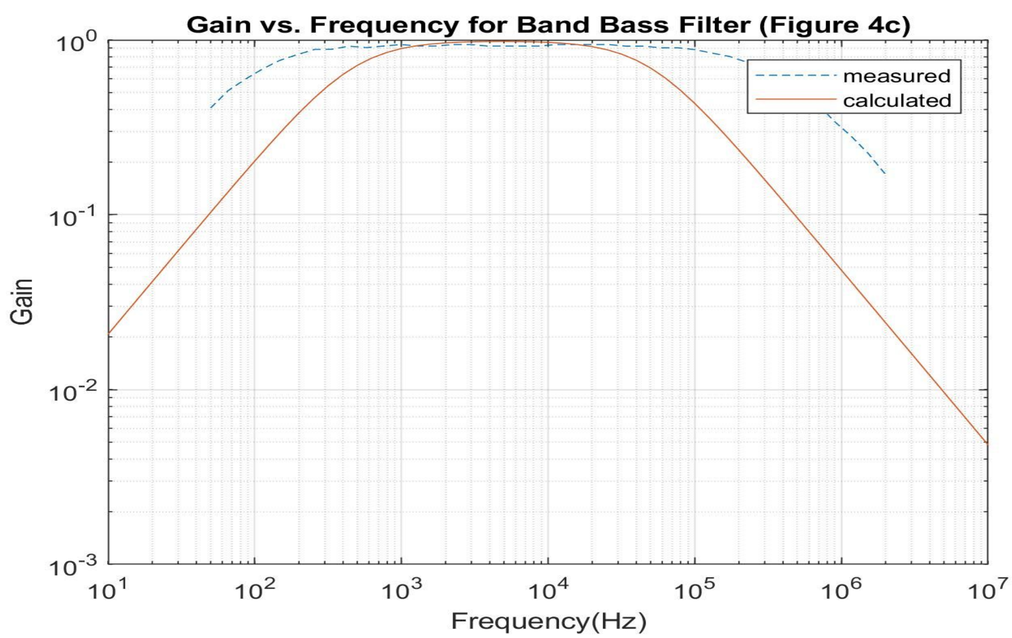

Figure 8: Gain vs Frequency for circuit 4c

Questions

- All of these graphs from the simulations and the measured have the same general shapes. The actual values for the graphs are not the same for the measured one compared to the simulated ones. There are tolerances on the resistors that could be one reason for the difference in the values. Since we also used extra wires to construct the circuit, there could be resistors added to the system because of the wires. Also the resistors, and the capacitors were bent a little when constructing and sometimes the resistors and the capacitors would stick out of the breadboard due to the force created by the oscilloscope and function generator connectors.
- The high-pass frequency would pass frequencies higher than a cutoff frequency while the low-pass filter would pass frequencies lower than a cut-off frequency. The band pass allows frequencies with a specific range to pass. The cutoff frequency for low-pass filter seems to be around 6x10^1 Hz. The cutoff frequency for high-pass filter is around 8x10^2 Hz. The low-pass cutoff for the band pass is around 3x10^2 and high-pass is5x10^4. So the bandwidth would be 41500Hz.

Time Domain Response

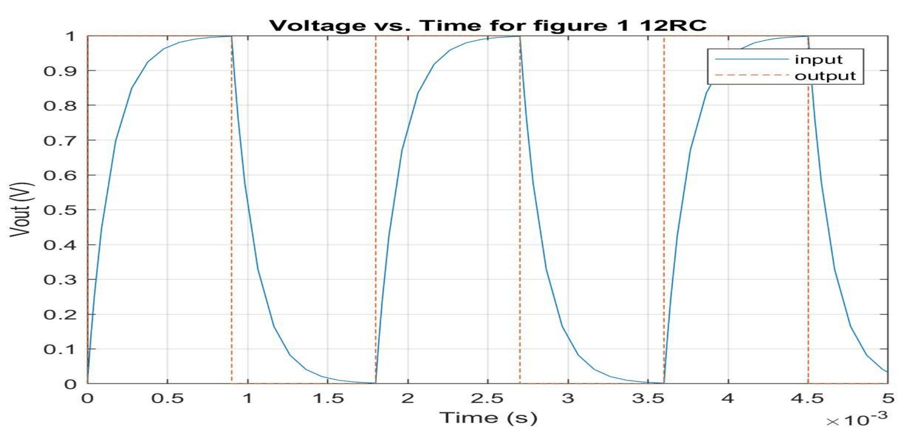

Figure 9: Voltage vs time for circuit 1 using Multisim

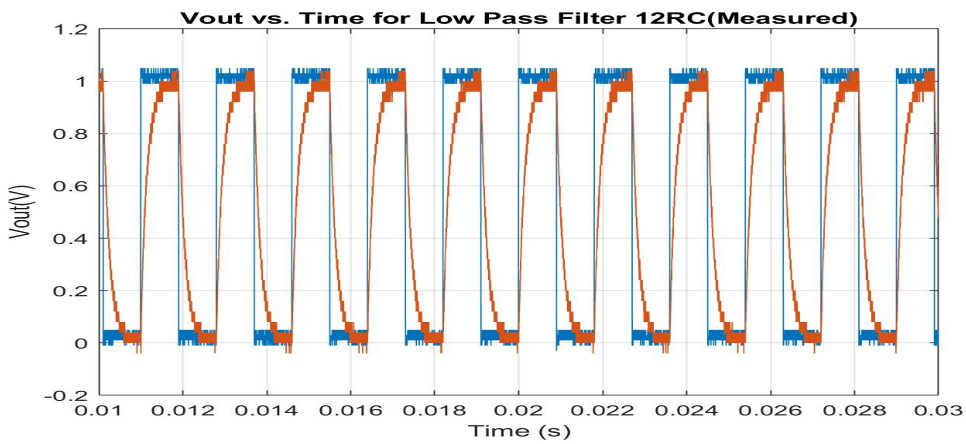

Figure 10: Voltage vs time for circuit 1 using labview

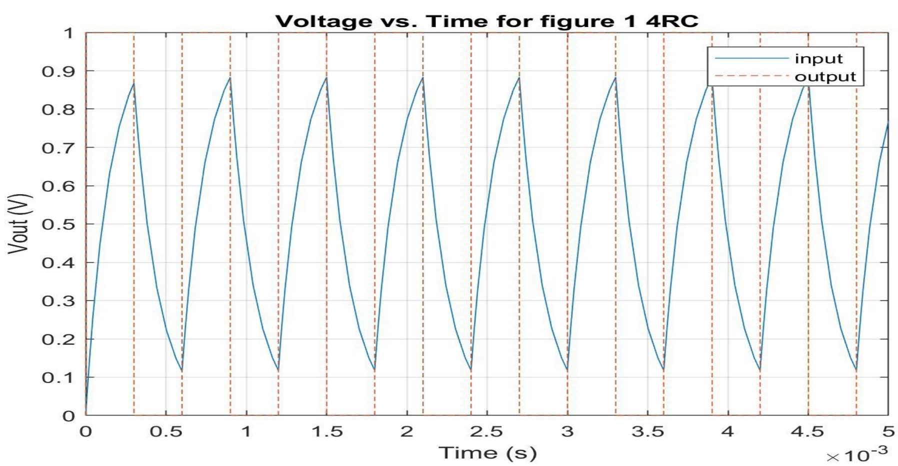

Figure 11: voltage vs time for figure 1 4RC Multisim

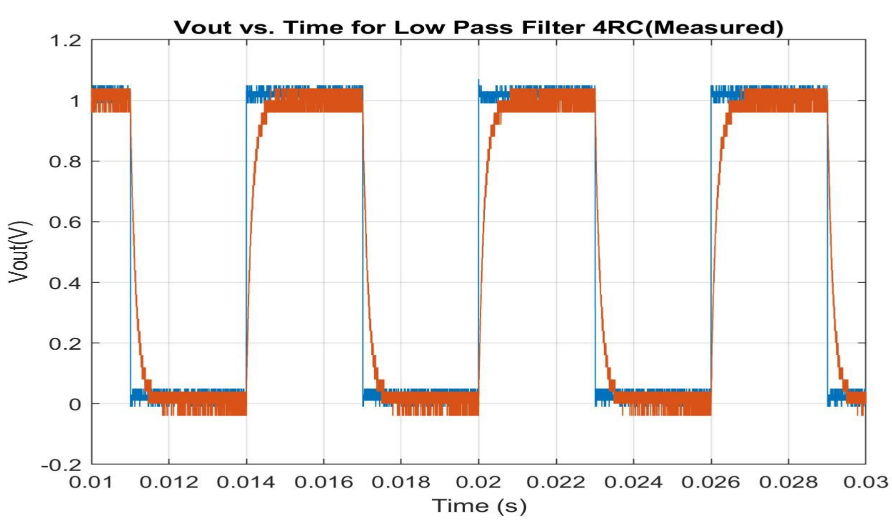

Figure 12: voltage vs time for figure 1 4RC using Labview

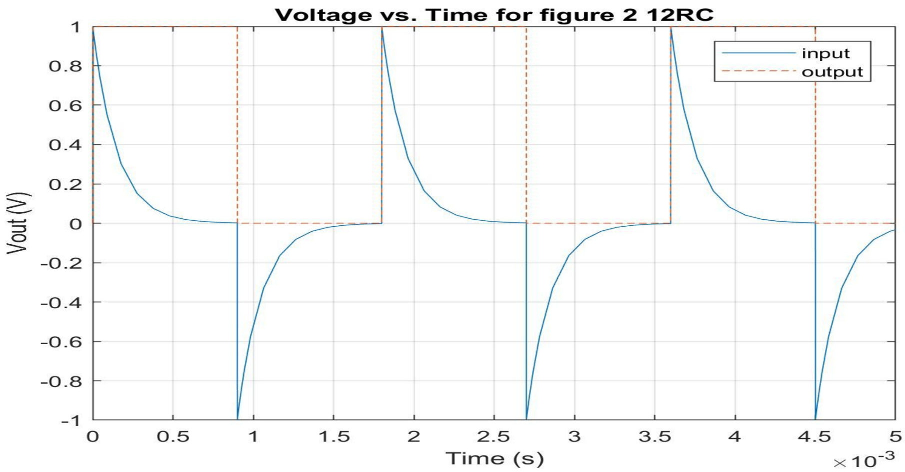

Figure 13: voltage vs time for figure 2 12 RC Multisim

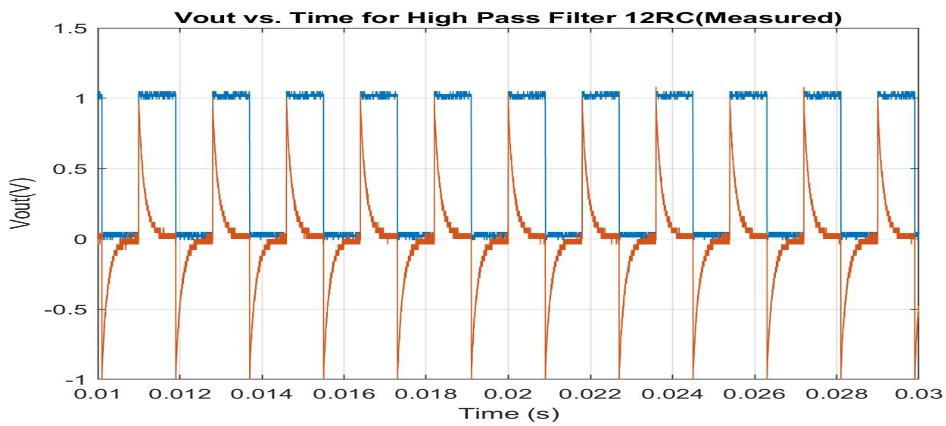

Figure 14: voltage vs time for figure 2 12RC using LabView

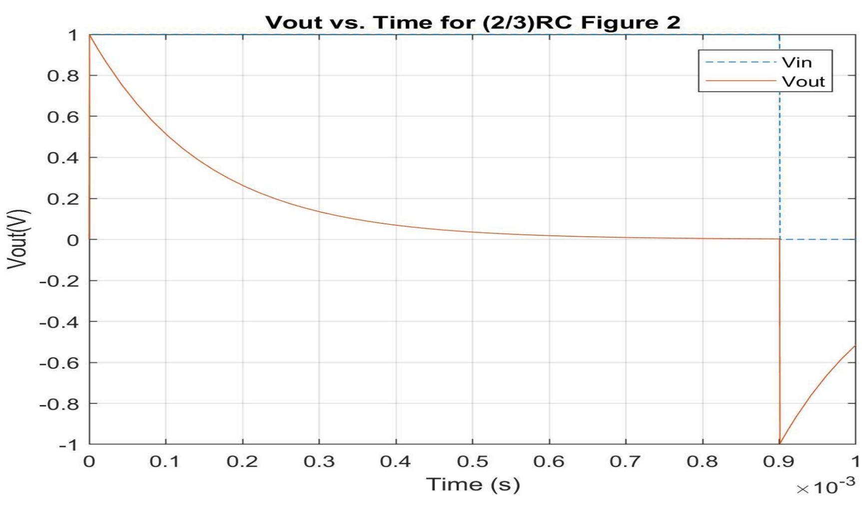

Figure 15: voltage vs time for figure 2 (⅔)RC using Multisim

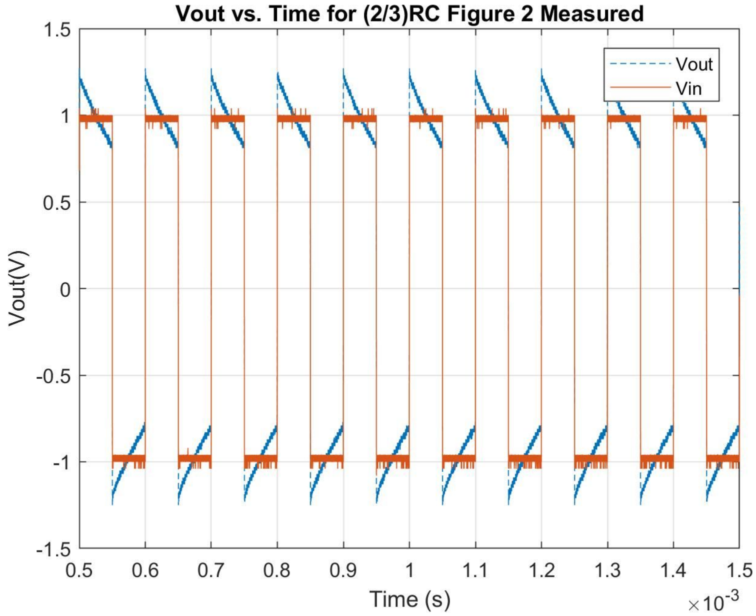

Figure 16: voltage vs time for (⅔)RC on figure 2 using VI

Question

- The graphs from the multisim and the oscilloscope looks pretty similar. When using the 2/3RC for the transient analysis the transient time decreased.
- The rise time for low-pass filter is about 0.45s and fall time is about 0.45s. For the high-pass filter the rise time is .5s, and fall time is 0.65s.
- The time constant it 0.020s

Conclusion

This lab helped us understand the high-pass, low-pass and bandpass filters through the use of multisim, and oscilloscope. The graphs from the simulations and the oscilloscope were not exactly the same. There were errors which could cause the differences.