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Subject: Convolution in Circuit Analysis

Introduction:

In this lab we set up a circuit and measured the voltages across two capacitors so that we can use convolution and an input response to find out how a circuit will react to a specific input signal.

Circuit Analysis and Calculations:

	2.2kΩ resistor	V_{o1} Capacitor	V_{o2} Capacitor
Expected	2200 Ω	1 µF	1 µF
Measured	2170.03 Ω	1.04 µF	1.04 µF
%Error	1.38%	3.85%	3.85%

The s-domain transfer functions that we generated based on the provided circuit in lab were as follows:

$$H_1(s) = \frac{20 \cdot 10^3(11s + 5000)}{11s^2 + 445 \cdot 10^3 s + 100 \cdot 10^6}$$

$$H_2(s) = \frac{220 \cdot 10^3 s}{11s^2 + 445 \cdot 10^3 s + 100 \cdot 10^6}$$

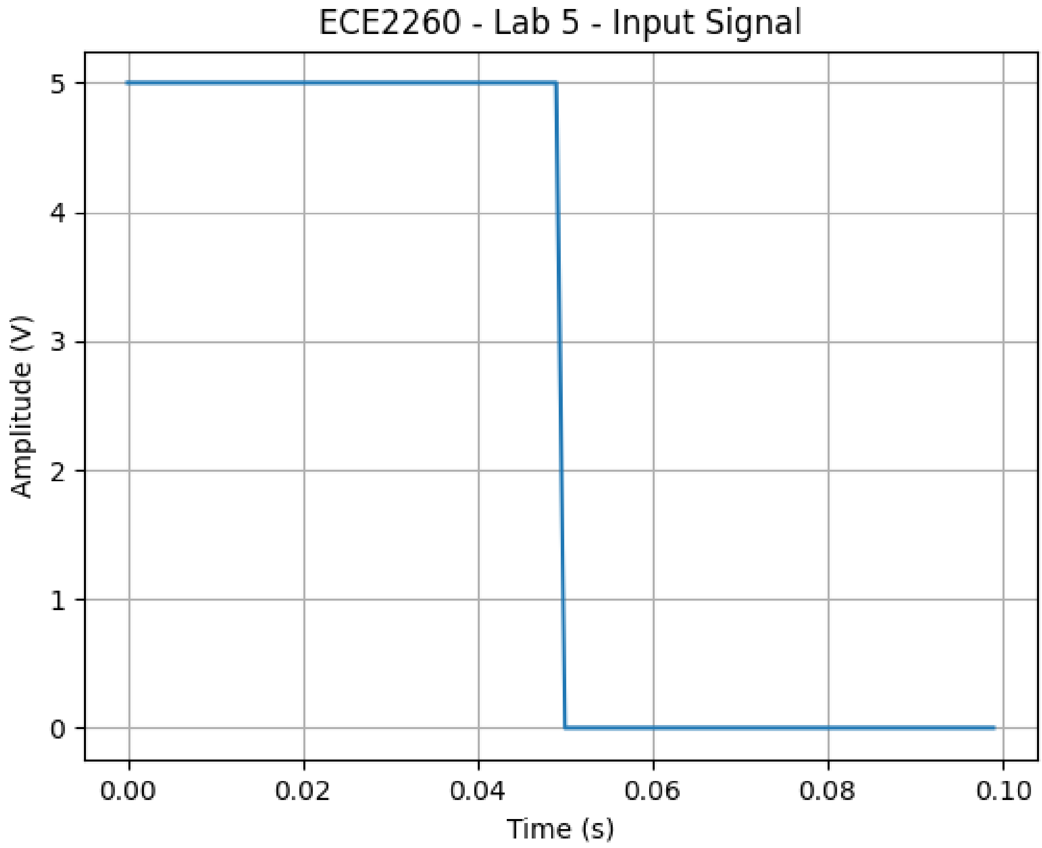
$H_1(s)$ is the transfer function for V_{o1} and $H_2(s)$ is the transfer function V_{o2}.

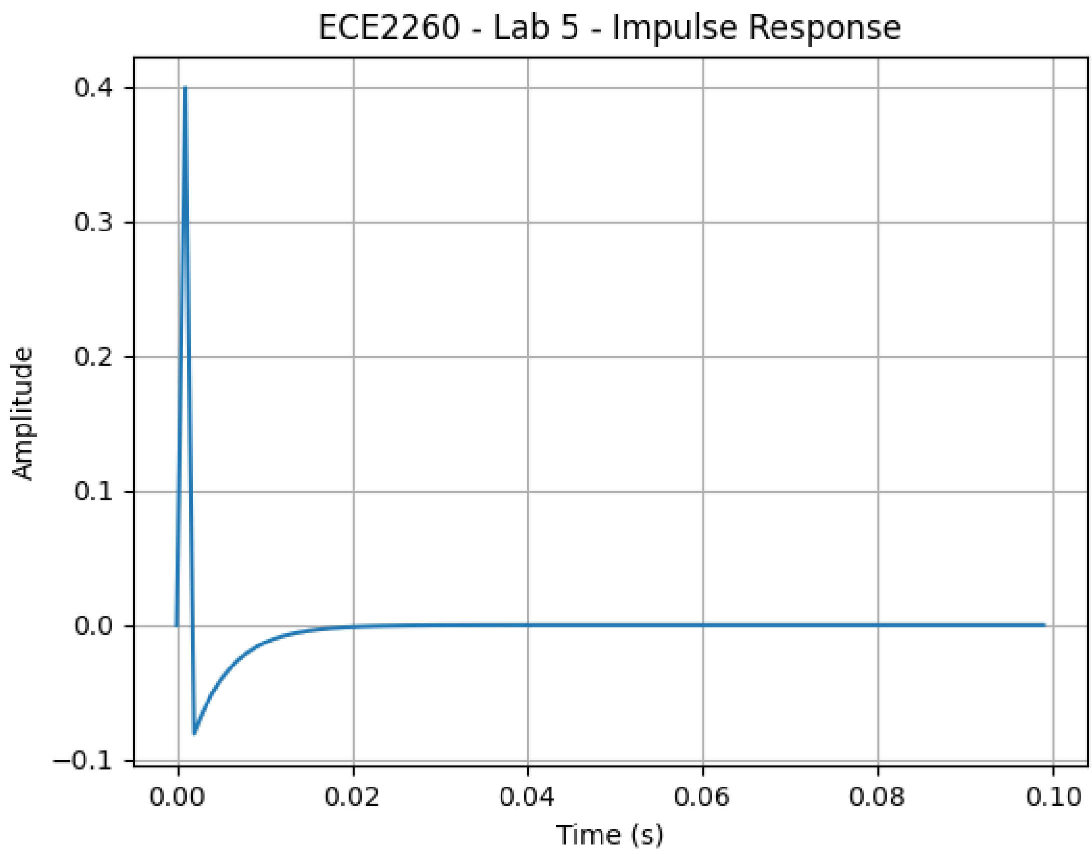
Experimental Procedure and Results:

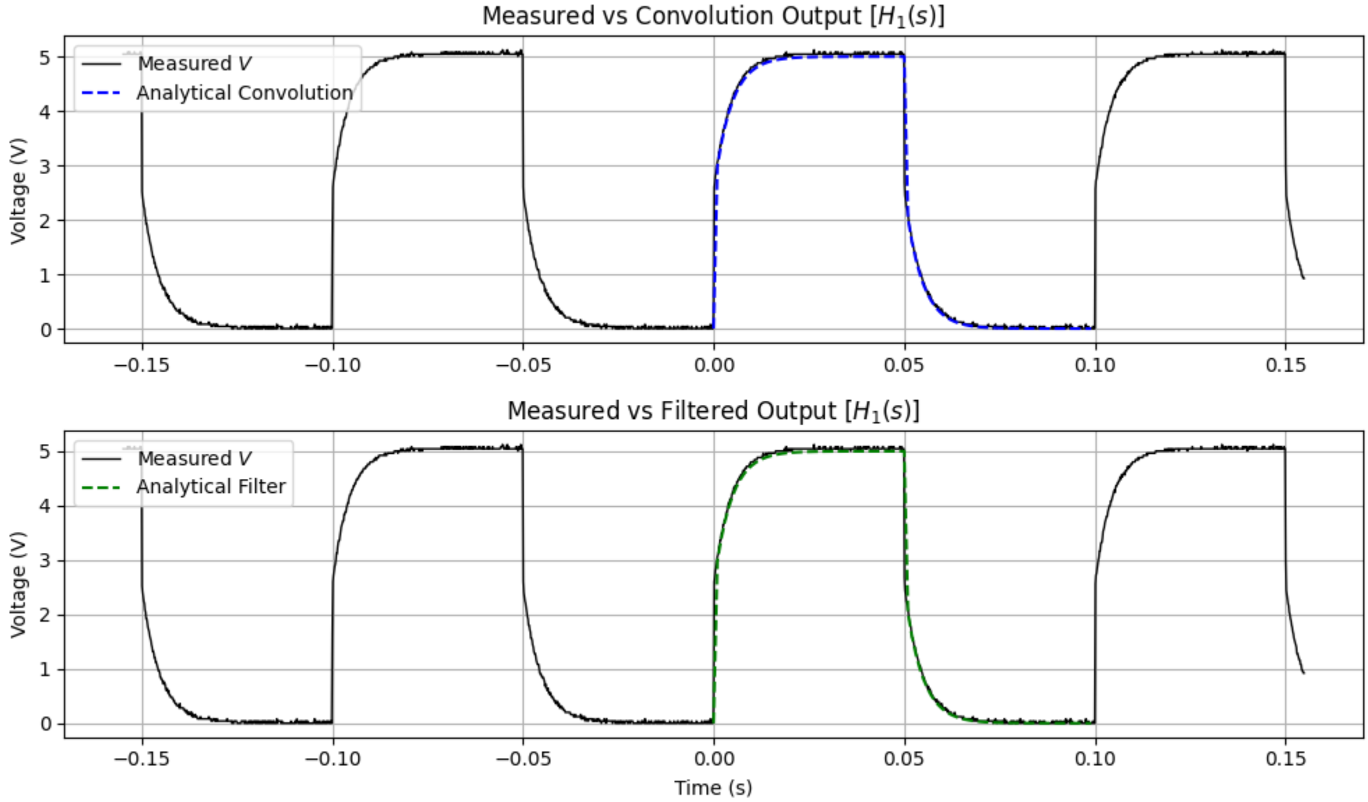
- **Setup Description:** The function generator configured to output two types of waveforms: a 5 V peak-to-peak square wave with a 2.5 V offset at 10 Hz, and a 5 V peak triangle (sawtooth) wave at 50 Hz with no offset. The circuit was set up as described in the lab 5 material.

- **Waveform Plots:**

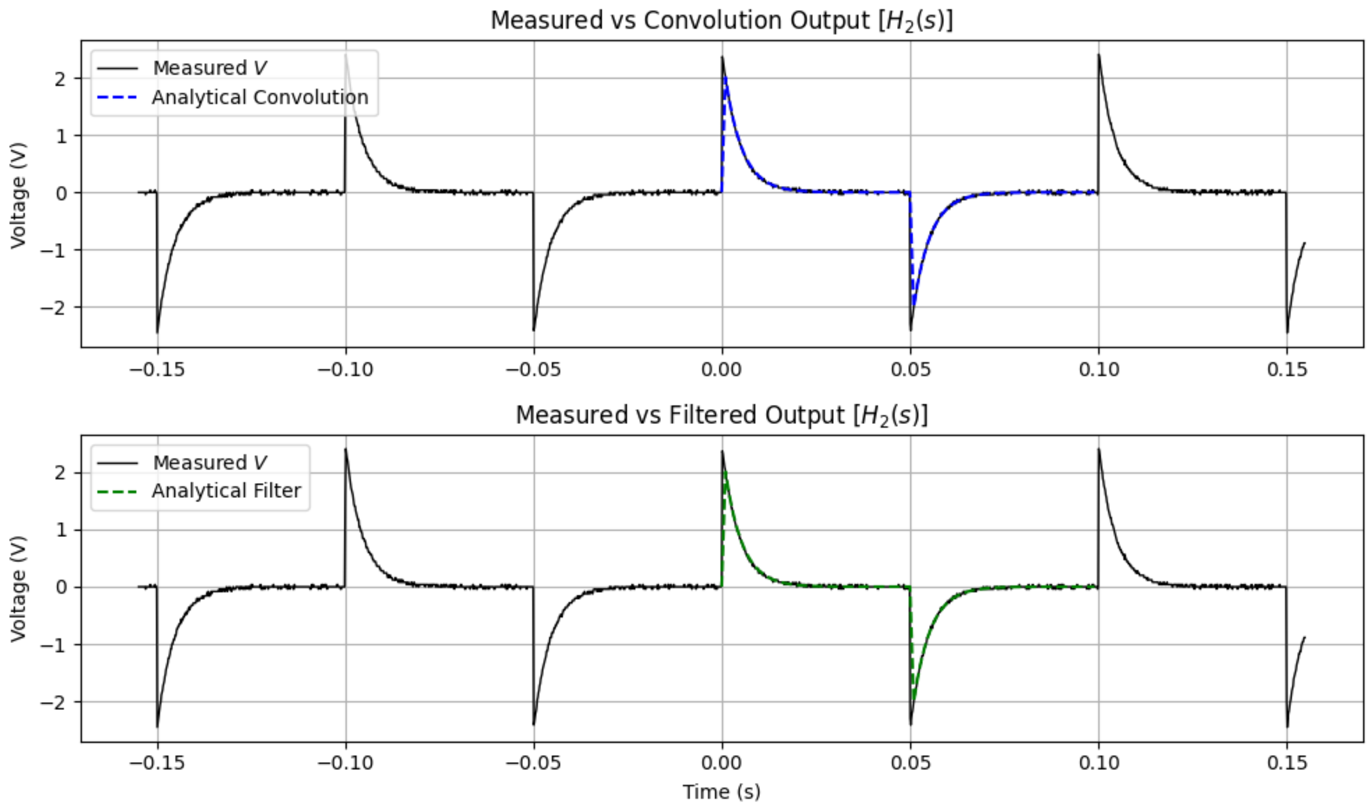
[on the next page]


ECE2260 - Lab 5 - Input Signal
Amplitude (V)
Time (s)
0
1
2
3
4
5
0.00
0.02
0.04
0.06
0.08
0.10

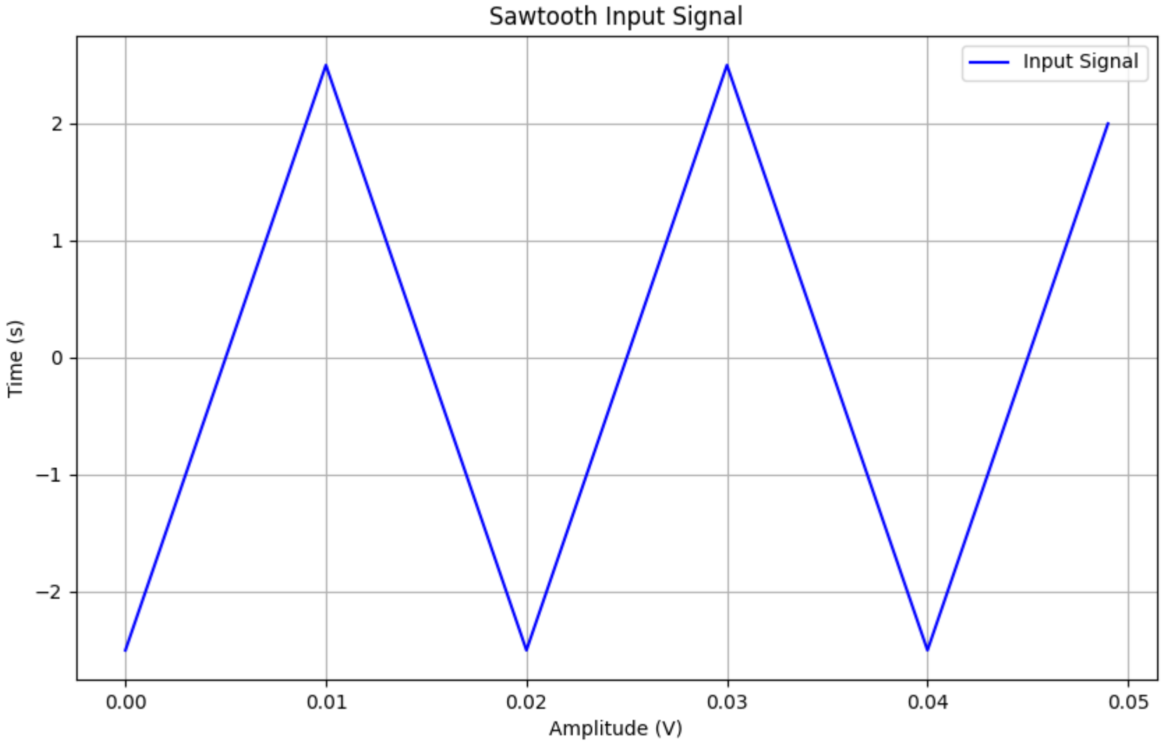

ECE2260 - Lab 5 - Impulse Response
Amplitude
Time (s)
−0.1
0.0
0.1
0.2
0.3
0.4
0.00
0.02
0.04
0.06
0.08
0.10

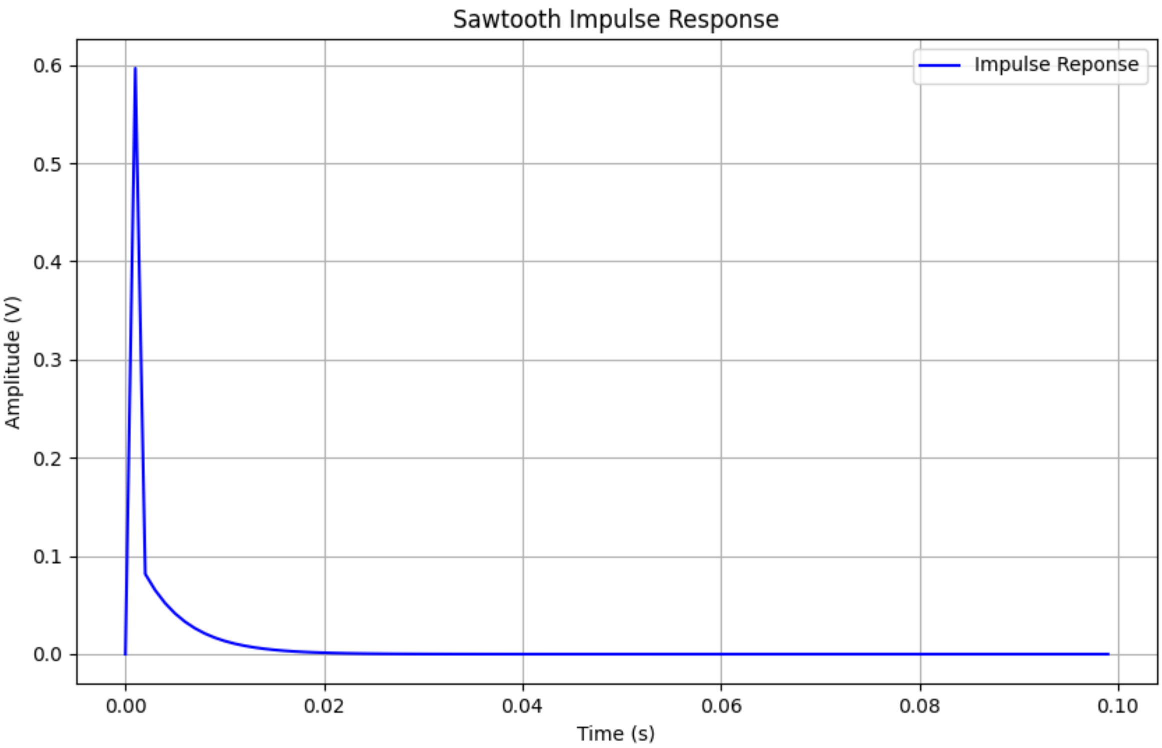


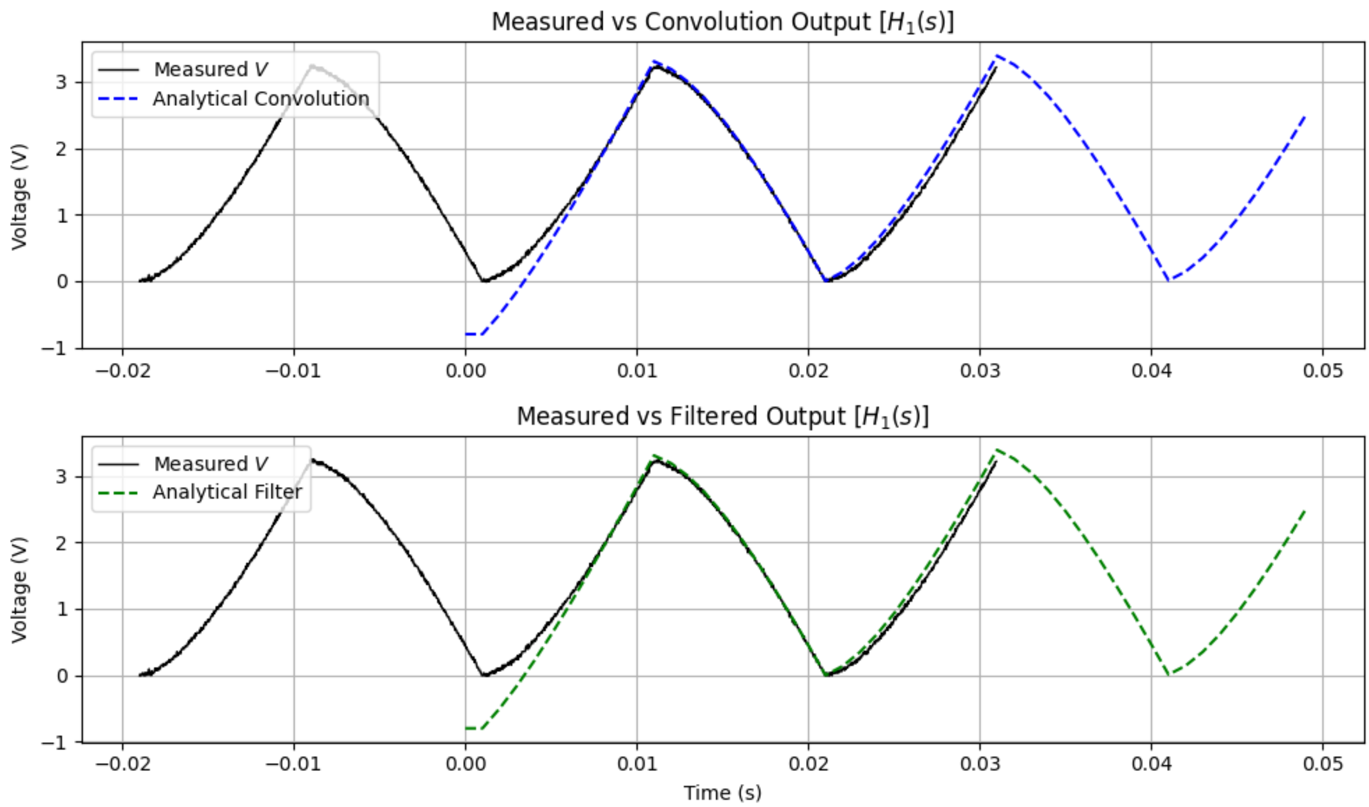
Measured vs Convolution Output $[H_1(s)]$
Measured V
Analytical Convolution
Voltage (V)
Measured vs Filtered Output $[H_1(s)]$
Measured V
Analytical Filter
Voltage (V)
Time (s)

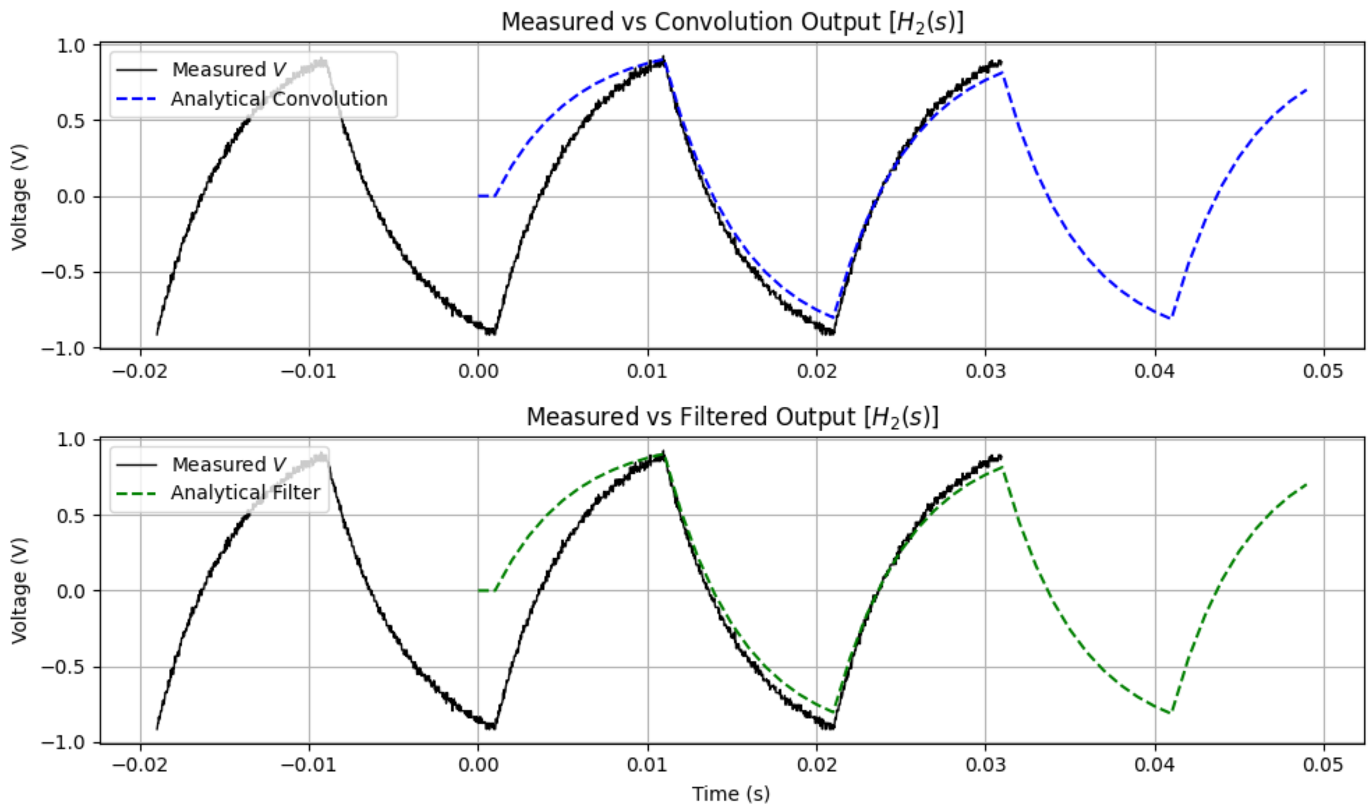


Measured vs Convolution Output $[H_2(s)]$
Measured V
Analytical Convolution
Voltage (V)
Measured vs Filtered Output $[H_2(s)]$
Measured V
Analytical Filter
Voltage (V)
Time (s)


Sawtooth Input Signal
Input Signal
Time (s)
Amplitude (V)
2
1
0
−1
−2
0.00
0.01
0.02
0.03
0.04
0.05


Sawtooth Impulse Response
Impulse Reponse
Amplitude (V)
Time (s)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.00
0.02
0.04
0.06
0.08
0.10





- **Quantitative Comparisons:** Our $H_1(S)$ curve was almost exactly as we had predicted, I was extremely happy with those results. For $H_2(S)$ I noticed that the peak of the analytical curve wasn't rising nearly as high as the data that we gathered in our measurements. I did change my $H_2(S)$ equation to include imperfect component values which did help but the analytical graph itself seems to be going from -2 to 2 Volts instead of -2.5 V to 2.5 V. As for the sawtooth waveforms the $H_1(S)$ prediction was quite close I think maybe the frequency on our oscilloscope was a bit imperfect and drove some odd fluctuations towards the trailing edge of our gathered data. The real interesting part was with $H_2(S)$ where we saw the analytical data did not rise or trough high or low enough to match the measured data although it was also quite close.

Conclusion:

In this lab we used convolution and the impulse response to analyze an RC circuit's behavior in the time domain. We derived transfer functions for V_{o1} and V_{o2} from the provided circuit in lab 5 material. We applied two different wave forms to the circuit (a 5V square wave and a 5V triangle wave). We used python to model the response using a digital filter and convolution. We then compared the simulated results to the measured data we gathered from the oscilloscopes. While we did see matching data in our $H_1(S)$ equations we did see some discrepancies in our $H_2(S)$ equations. If you know the impulse response for a circuit you can use it to find out how a circuit will react to an input signal via convolution.