University of Colorado Boulder
ECEE Department

ECEN 2250 - Introduction to circuits and electronics - Fall 2023
Location: Engineering Center, ECCR 1B40, MWF 2:30PM - 3:20PM
Instructor: Professor Eric Bogatin, Dr. Mona ElHelbawy
Lab #8
Lab Title: Measurement simulation of transient response of RLC
Date of Experiments: November 14th, 2023
Names: Connor Sorrell

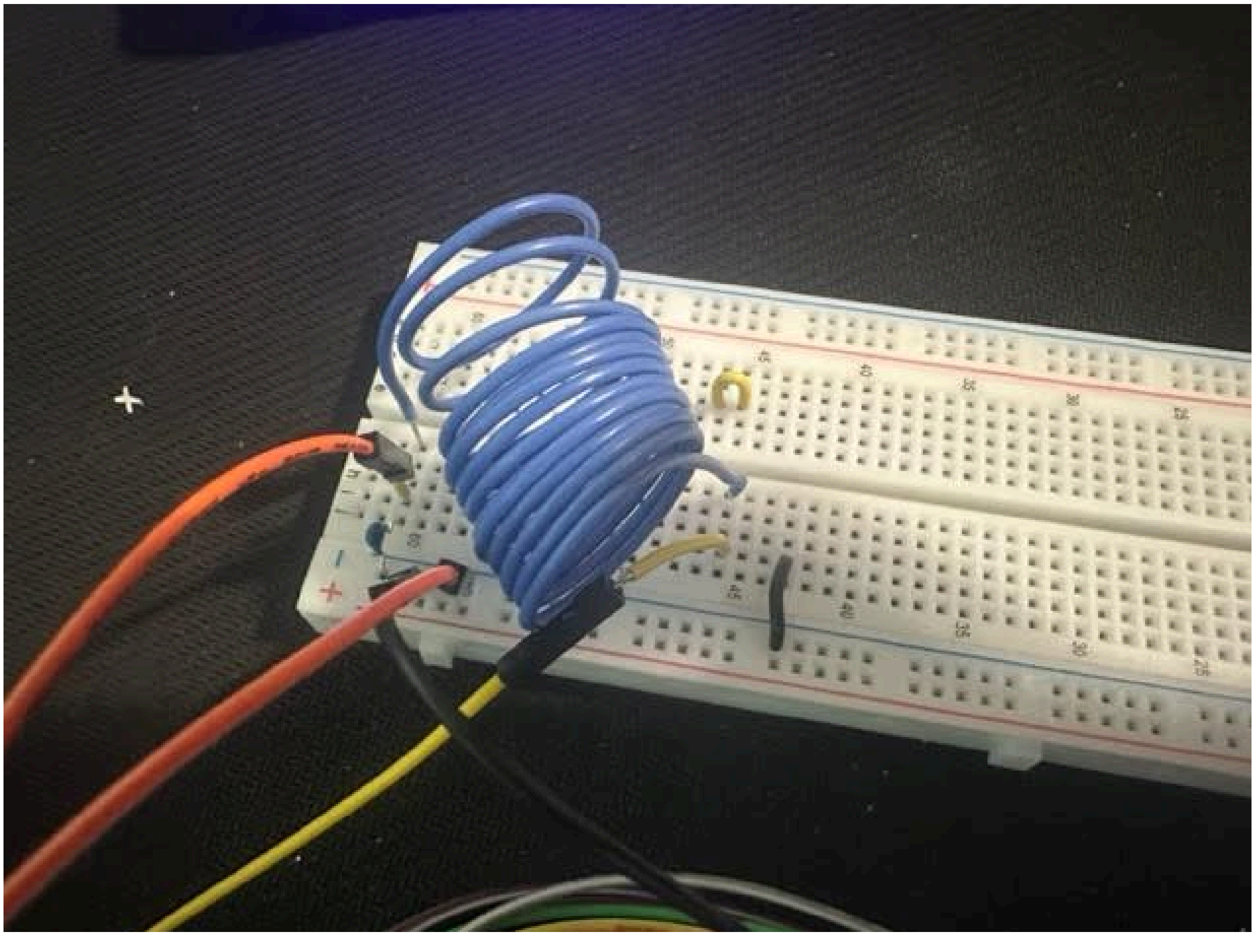

Figure 1.0.1: Picture of the solderless breadboard showing the inductor and the circuit connected to the AD2 scope.

I expect my inductor to have an inductance of roughly 1.22 uH because it has a coil radius of 0.8cm, (wrapped around chapstick), a 6 cm length, and 16 turns.

I expect the ringing frequency ($f = \frac{w}{2\pi} = \frac{0.16}{\sqrt{1\mu H * 0.01\mu F}}$) to be ~1.6 MHz.

I expect characteristic impedance, ($Z = \sqrt{\frac{L}{C}} = \sqrt{\frac{1\ \mu H}{0.01\mu F}}$) to be about 10 ohms. These values are obtained by using nominal values for inductance and capacitance that make sense in this scenario and serve as accurate guesses.

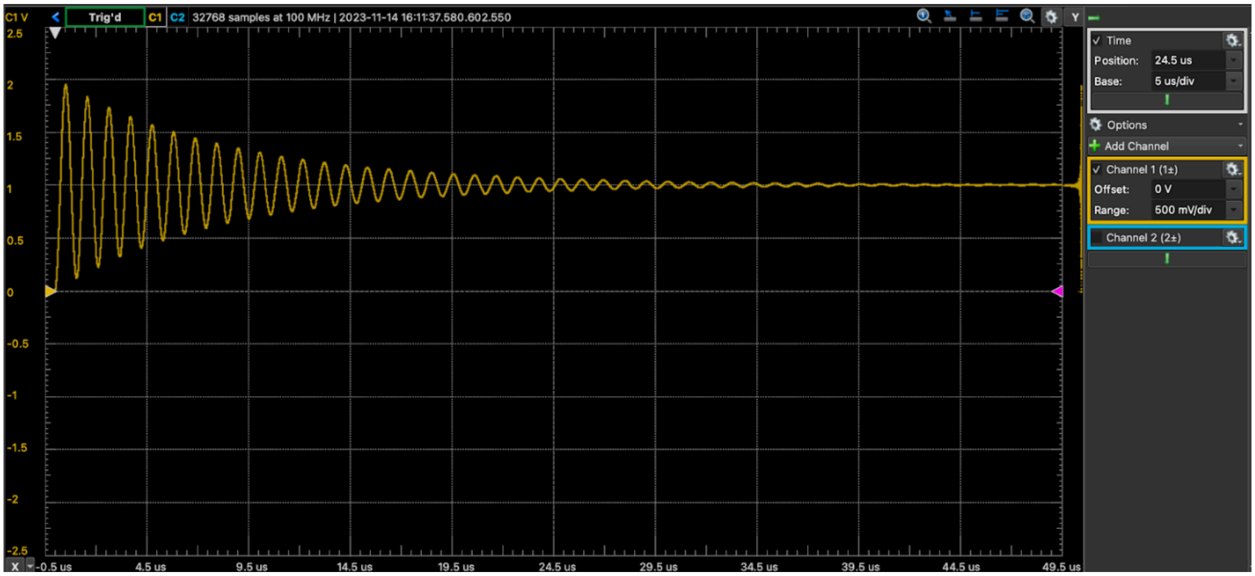

Figure 1.0.2: Shows a screen capture of the measured waveform on the AD2 scope.

The waveform shows roughly a little less than a 1 microsecond period, which means a little bit more than a 1 MHz frequency, exactly what we expected to see.

We can see that where we trigger (t=0), the wave starts. This is because we are triggering the wavegen, so the waveform starts only when it starts to transition. In this instance, this is the most useful because it shows us our entire waveform.

The waveform makes sense because it shows the oscillations starting off with a high amplitude, then slowly becoming smaller due to the damping.

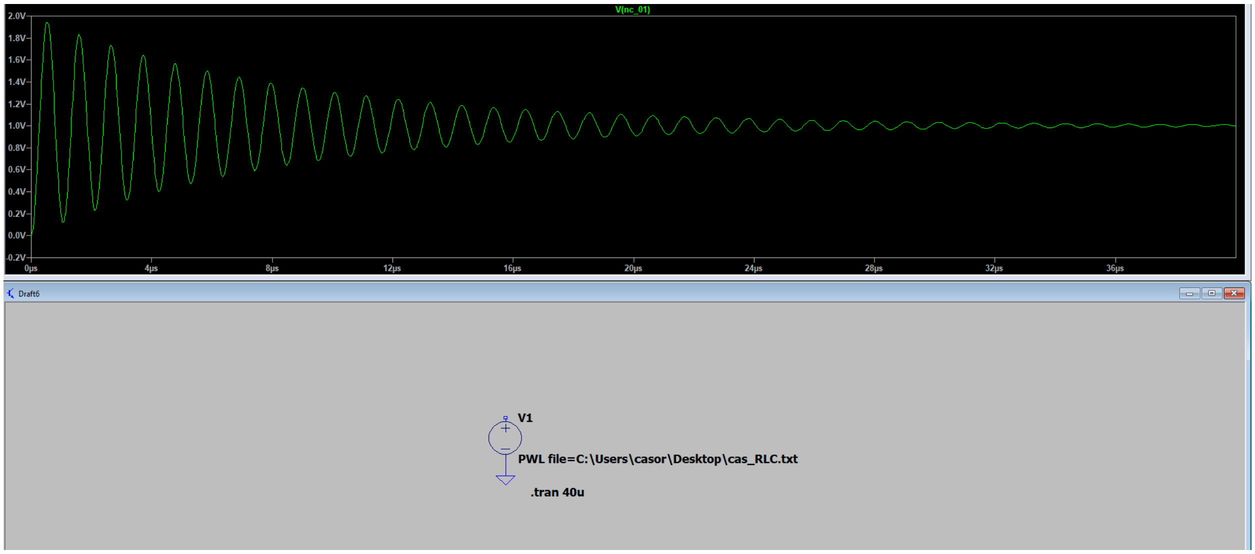

Figure 1.0.3: Shows a screen capture of the LTSPICE circuit and the simulation for the measurements obtained from the inductor I made via AD2 scope.

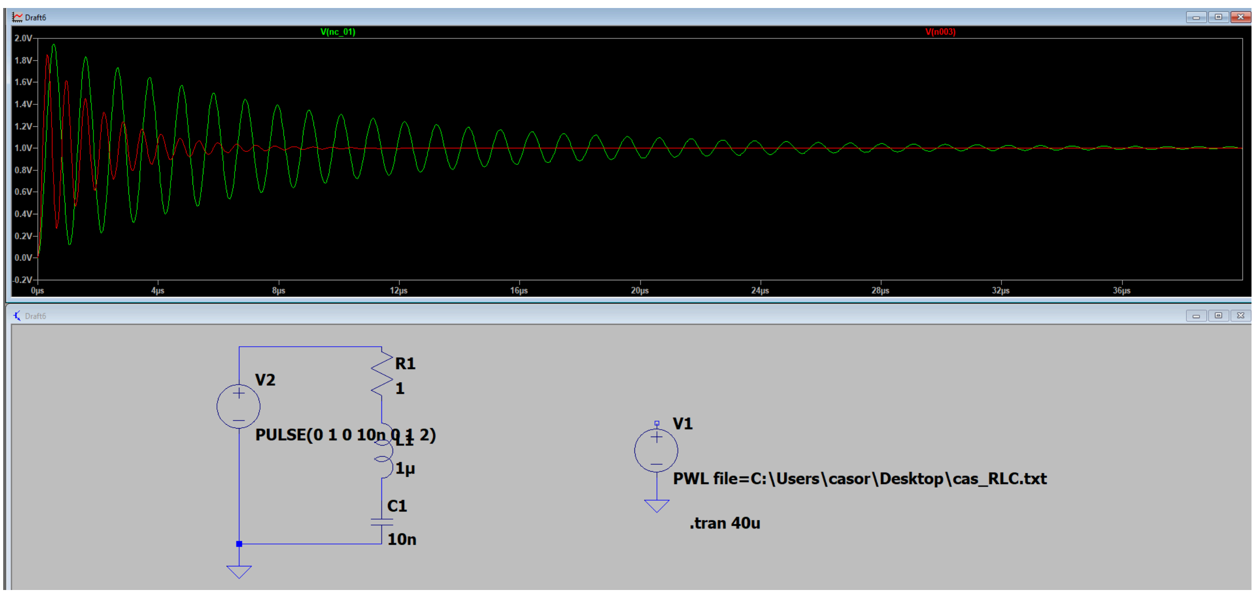

Figure 1.0.4: Shows a screen capture of the simulated transient response (red wave) before any hacking was done, using nominal values.

I started with nominal values: 1 Ohm, 1 uH, and 10nF. I started 10nF capacitance because that was the only value that was expected, and could remain unchanged. I started with 1 uH for my inductor because I knew it had to be much smaller than 10uH, but didn't know much besides that. Similarly, I started with 1 ohm of resistance for the same reasons; we know there is internal resistance everywhere, but an accurate estimate can't really be made, so 1 ohm is a good starting point.

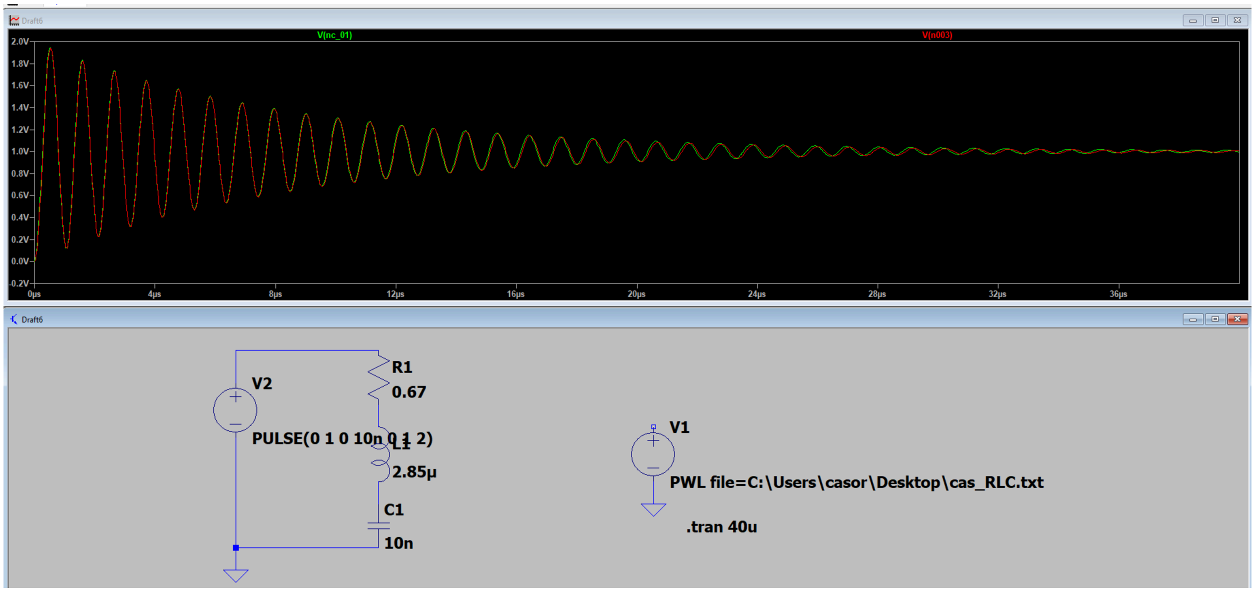

Figure 1.0.5: Shows a screen capture of the transient simulation after hacking (red wave) compared to the measured waveform (green wave)

To hack the waveform, I needed to change the period and the damping. To change the period, which is $f \;=\; \sqrt{LC}$, I only needed to raise the inductance and keep the capacitance the same. To achieve less damping, I simply decreased the resistance of R until the waveforms matched up.

After hacking my values, the transient simulation looks exactly as it should. However, this was only obtained after changing the inductor to a value of 2.85 uH, and a R of 0.65. The resistance value in this case makes sense, because there is small internal resistance across every part of this lab. However, the large inductance of 2.85 uH is pretty far off from the 1uH I was shooting for. This is probably because of several reasons, however I think it is almost solely because my inductor did not stay tight enough after plugged into the circuit. This means that the inductor had the same number of loops, but a significantly larger coil radius and coil length, which drove the inductance up quite a bit.