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 #9
Lab Title: Simulating impedance in LTSPICE
Date of Experiments: December 5th, 2023
Names: Connor Sorrell

Part 1: Simulate the impedance of an R,L, and C component in LTSPICE:

1) What did you expect the impedance of each component to be at 1 kHz?
For resistor: Z = R, so I expect 1 ohm
For capacitor: Z = 1/Wc = 1/2pifC = 0.16/fC = 0.16/(1000)(0.001) = 0.16 ohms
For inductor: Z = WL = 2pifL = 6.28(1000)(0.001) = 6.28 ohms

2) What values did you actually simulate?
The impedance values obtained from the simulation are as follows:
Resistor: 1 Ohm
Capacitor: 160 milliohms = 0.16 ohms
Inductor: 6.28 ohms

All measurements are exactly what we predicted in question #1 using rule #9.

3) What quantity is really being simulated and plotted?
Technically, the voltage is actually being simulated and plotted.

4) Why is it better to use a log-log scale than a linear scale to display the impedance of a capacitor and an inductor?
Because using a linear scale, the values are extremely hard to interpret. The inductor and capacitor are straight lines on a log-log scale, and the resistor is flat on a log-log scale, compared to the linear scale where the graphs have exponentials and aren't easy to read.

5) What is displayed on the left axis?
The impedance (measured in ohms)

6) What is displayed on the right axis?
The phase angle (measured in degrees)

7) How does the magnitude of the impedance of a capacitor vary with frequency?
Because the equation for the impedance of a capacitor is Z = 1/Wc, as the frequency raises, the impedance will drop.

8) <u>How does the magnitude of the impedance of an inductor vary with frequency?</u>
   Because the equation for the impedance of an inductor is Z = WL, as the frequency rises, the impedance will also rise.

9) <u>If we were to simulate at 1 GHz, what would you expect the impedance of your capacitor to be? And for your inductor?</u>
   If we were to simulate at 1 GHz, I would expect the impedance of my capacitor to be 160 nano ohms, and I would expect the impedance of the inductor to be 6.28 Mega ohms.

10) <u>Take a screenshot of your LTSPICE circuit and simulation showing the correct scales and the correct plots of the R, L, and C elements. Write a brief description.</u>

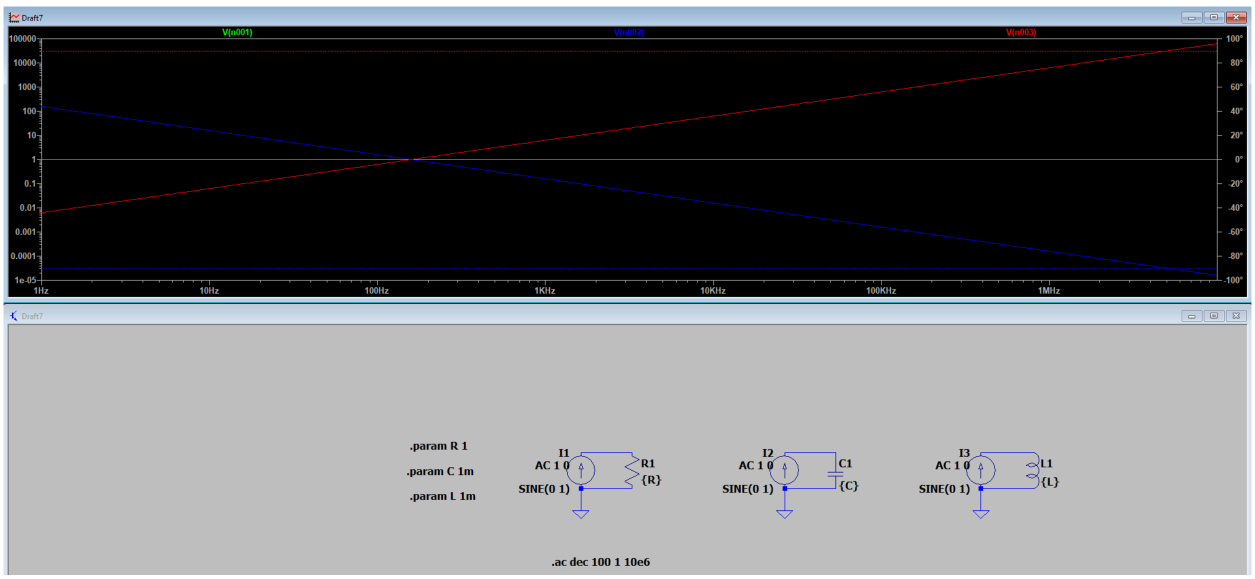

Figure shows the circuit implementation and simulation results of three analyzer circuits, one for an R element (green graph), one for a C element (blue graph), and one for an L element (red graph). All three components impedances are graphed on a log-log scale. Each circuit is made simply with its component and a sine wave current source.

Part 2: Simulate the impedance of four circuits: A series RC, a series RL, a parallel RC, and a parallel RL.

1) What did you expect the impedance of each individual element to be at 1 kHz?
   160 milli Ohms and 6 ohms for the capacitor and inductor, respectively. I also expect the resistance of the resistor to just be that of the circuit, so 1 ohm.

2) What are the time constants for the combinations of the RC and RL elements?
   Time constant of RC = T = RC = 1(.001) = .001
   Time constant of RL = T = L/R = .001/(1) = .001

   In our case, the time constants of both are equal.

3) At what angular frequency and frequency are the impedances of the R and C and L elements equal?
   When w = 1/RC = 1/T = 160 Hz in this case. This is also the frequency in which we will see our transition from “low” to “high”

4) What frequency would be considered “very low” when you analyze these circuits?
   The frequency in which the impedance levels out at a small value as it is dominated by the resistor. Any frequency value below the “transition” which happens at 1/Time constant, which is around 160 Hz in this case.

5) What frequency would be considered “very high” when you analyze these circuits?
   The frequency in which the impedance of the inductor increases linearly. Any frequency value above the “transition” which happens at 1/Time constant, which is around 160 Hz in this case.

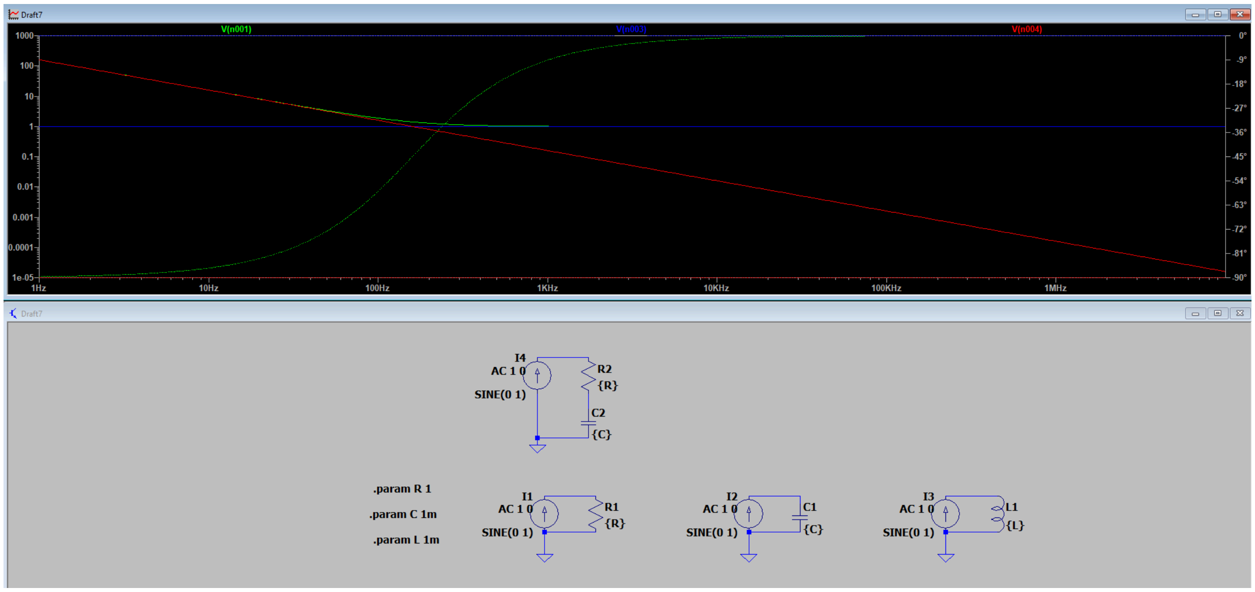

Figure: Shows the simulation results of the series RC circuit.
Impedance of circuit: 1 Ohm
Impedance of capacitor: 160 milliOhms
Impedance of inductor: N/A

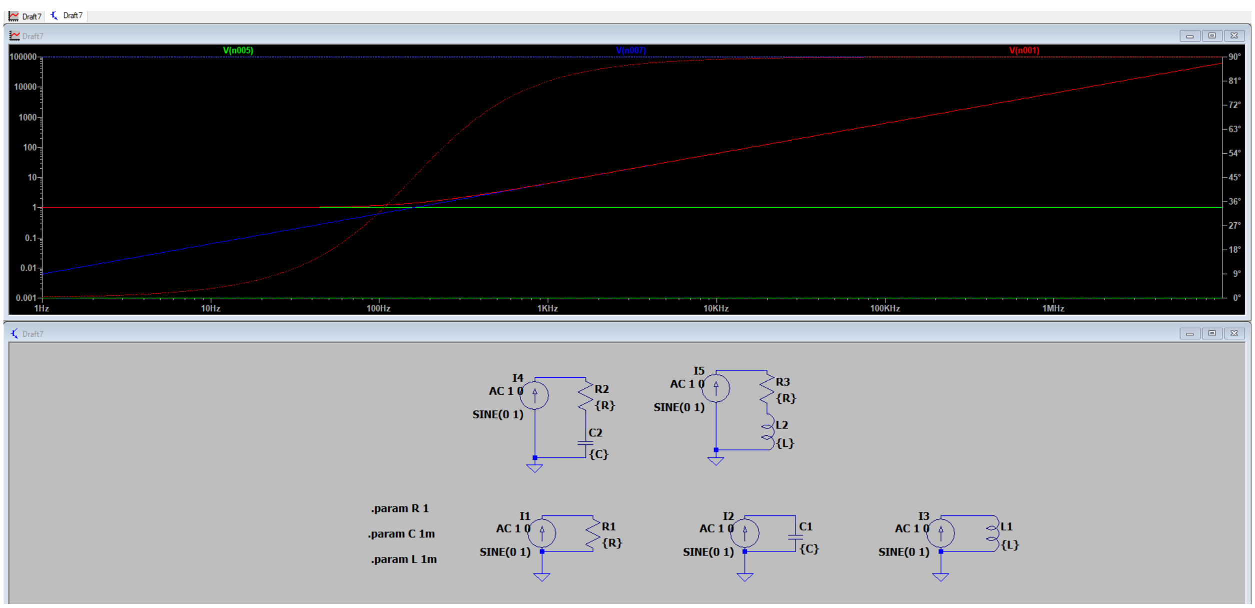

Figure: Shows the simulation results of the series RL circuit.
Impedance of circuit: 1 Ohm
Impedance of capacitor: N/A
Impedance of inductor: 6.3 ohms

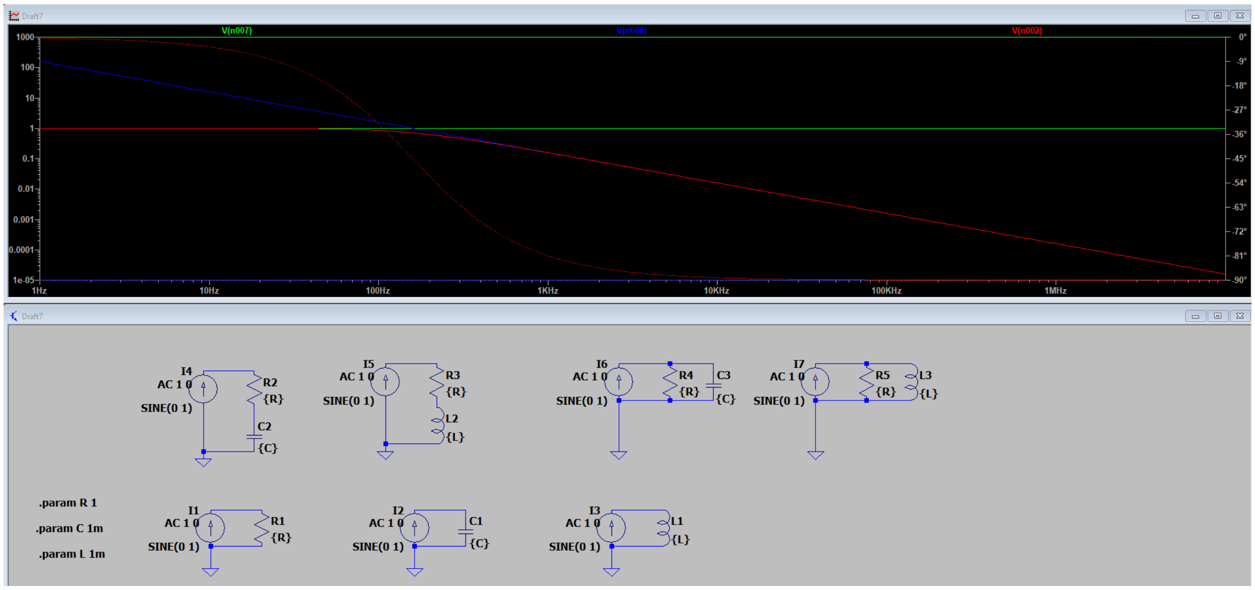

Figure: Shows the simulation results of the parallel RC circuit.

Impedance of circuit: 1 Ohm

Impedance of capacitor: 160 milliOhms

Impedance of inductor: N/A

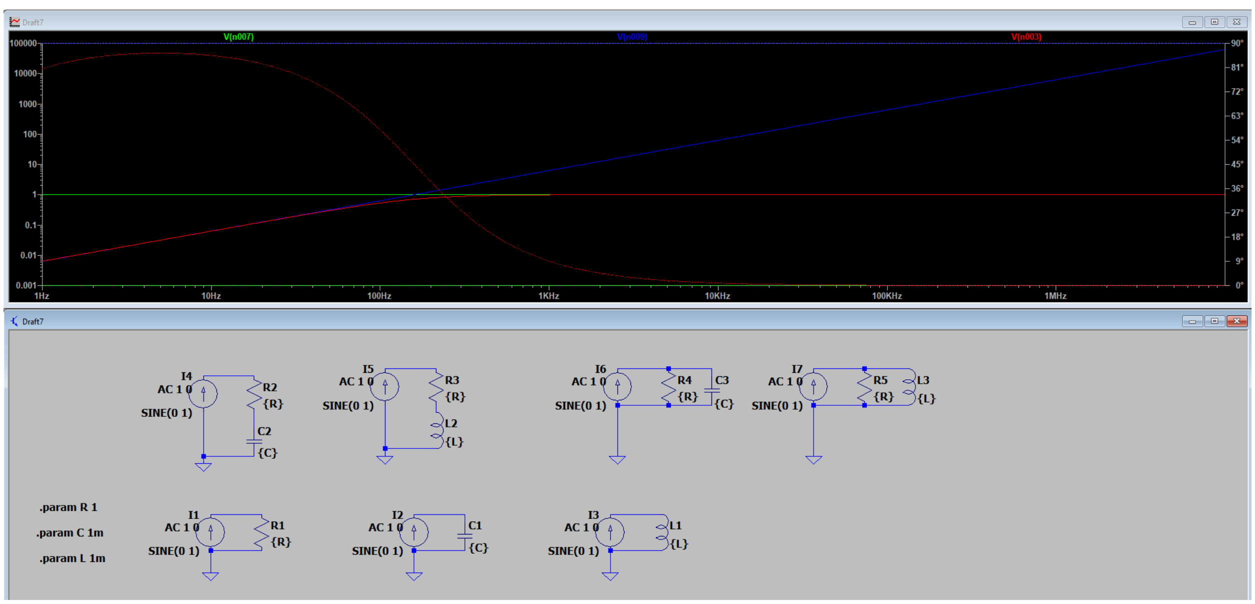

Figure: Shows the simulation results of the parallel RL circuit.

Impedance of circuit: 1 Ohm

Impedance of capacitor: N/A

Impedance of inductor: 6.3 Ohms