ECE214: Electrical Circuits Laboratory

Lab #7 — RLC Circuits

Week of 24 March 2015

1 Introduction

This lab introduces the inductor. We will construct and analyze an RLC circuit.

2 Pre-Lab

Analyze the RLC circuit in Figure 1 mathematically.
Do not spend too much time on this, if you get stuck continue on with the lab.

1. Is the circuit under-damped, over-damped, or critically-damped?
2. Derive an equation describing the voltage across the capacitor when the input is a 2 Volt peak-to-peak sine wave at a frequency of 100kHz.
3. Derive an equation describing the voltage across the capacitor when the input is a 5 Volt step function.

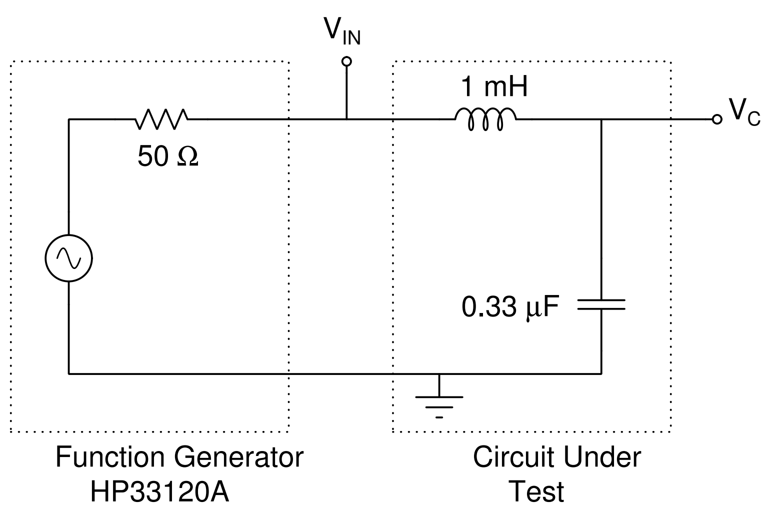

Figure 1: RLC Circuit to build.

3 Lab Procedure

Each group will be supplied with an inductor. Do not lose it; this inductor is to be used in Labs #7 – #10.

1. Component Measurements

   (a) Measure the inductance and quality factor Q for the inductor using the LCR meter at frequencies of 1kHz and 10kHz.

(b) Calculate the series resistance of the inductor from the measured value of Q.

(c) Measure the DC resistance of the inductor using a DVM. Explain the difference in the DC resistance compared to the value obtained in the previous step.

(d) Use whatever (non-destructive) techniques or methods you think are appropriate and measure the number of turns of wire on the inductor. Provide a convincing argument as to the number of turns of wire on one inductor with an estimate of the error.

(e) Measure the capacitance and Q value of the $0.33\mu F$ capacitor at 1kHz and 10kHz.

(f) Calculate the series resistance of the capacitor from the measured value of Q.

2. Simulation. In Micro-cap build the circuit as shown in Figure 2 using the values for the resistors determined in the previous section.

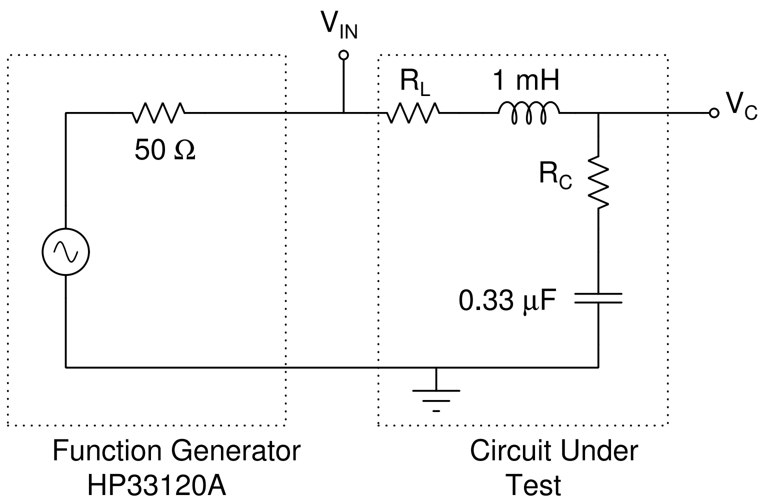

Figure 2: RLC Circuit to simulate.

(a) Use Micro-cap to simulate the expected signals at nodes V_{IN} and V_C when the input signal is sinusoidal. Use AC simulation to examine the response of this circuit in the frequency domain from 100Hz to 1MHz. Plot the node voltages V_{IN} and V_C on one graph and plot the voltage across the inductor, $V_{IN} - V_C$, on a separate graph.

(b) Print the above plot and put it in the post-lab section.

(c) Plot the phase shift across the capacitor. Print this plot and put it in the post-lab.

(d) Simulate using transient analysis a 2 Volt peak-peak sine wave at 100kHz. Does V_C agree with your calculation from the pre-lab?

(e) Simulate the expected signals at nodes V_{IN} and V_C when the input signal is a 5 Volt step function. Use transient simulation to examine the response of this circuit in the time domain (create a 50ms 5V Square pulse). Plot the three node voltages V_{FG}, V_{IN} and V_C on one graph and plot the voltage across the inductor, $V_{IN} - V_C$, on a separate graph. Include these graphs in the post-lab.

3. Build the RLC circuit shown in Figure 1.

(a) Analyze the sinusoidal results.

i. Set the function generator to produce a sinusoidal signal with a peak-to-peak voltage of 2V and a DC offset of 1V. Verify on the oscilloscope that the function generator is producing the correct waveform. Do you need AC or DC input coupling to see the correct signal?
ii. Use the oscilloscope to measure the voltages V_C and V_{IN}.
iii. Use the scope to measure the frequency that produces a phase shift across the capacitor of 45^o with respect to the input signal. (You may use Lissajous or the phase different feature of the scope to find this). Does the voltage across the capacitor lead or lag the input voltage at this frequency? How do the measured results compare to the simulated results?
iv. Determine the frequency that produces a phase shift across the capacitor of 90^o with respect to V_{IN}. Does the voltage across the capacitor lead or lag the input voltage at these frequencies? How do the measured results compare to the simulated results?
v. Measure the voltage across the capacitor V_C at frequencies of 50kHz, 100kHz and 300kHz. Note any problems you encounter.
vi. Connect the "sync" output from the function generator to the external trigger input of the scope. Set the scope to external triggering. Measure the voltage across the capacitor V_C at frequencies of 50kHz, 100kHz and 300kHz. How does this result compare with the measurement in the previous step and your simulated results?

(b) Analyze the step results.

i. Adjust the function generator to output a single pulse with a peak of 5 volts and a pulse width of 50 ms. Make the generator produce only a single pulse when you press the "single" button. Adjust the offset to make the generator's output 0 volts when the pulse is not present.
ii. Now use the single trace and trigger controls on the scope to capture a single event. Capture the signals that appear at V_{IN} and V_C when a single pulse is generated. They should look like simulated step signal. If not (all you see is a big square pulse) you need to zoom in a lot.
iii. Use the Math key (+/-) on the scope to look at the voltage across the inductor (the difference between channel #1 and #2). Is it what you would expect?
iv. Include a picture of the pulse result in your post-lab.

4 Post-Lab

1. Include the plots and graphs as described in the lab section.
2. Do your results match the simulated results?
3. Do your results match your calculated results?
4. If your results do not match, explain why this might be.