ECE 332 Lab 6v

RLC Measurement

Real circuit elements are not ideal–there's never such a thing. But that's not true! Circuit elements in simulation are ideal. For example, this means resistors just resist. They obey Ohm's Law under all conditions. They do not exhibit any parasitic inductance or capacitance. In other words, when you write v = iR, this equation is true for any and all values of v and i.

In the previous lab, you simulated the time-domain operation of an RLC circuit. All three elements were ideal. The responses that you observed were perfect , unhindered by imperfect, non-ideal resistance, capacitance, and inductance. Now we leave that ideal world to see what happens with real, non-ideal circuit elements.

Goals

In this lab, we will:

- Observe the step response of a real RLC circuit.
- Determine the inductance of a lossy inductor.
- Determine the parasitic resistance of the inductor.

Introduction

Inductors, which are generally made of coils of wire, exhibit parasitic resistance. At low frequencies, this resistance can be modeled as an ideal resistor in series with an ideal inductor. The 100-mH inductor we will use in an RLC series circuit has a significant series resistance. If we put this inductor in an RLC circuit, the R must include the resistance of the non-ideal inductor.

The circuit of Figure 1 is a series RLC circuit. The parasitic resistance is shown as part of the inductor. If we excite this circuit with a square wave, we will see a second-order response just as we did in the previous lab. We can use the second-order response and measurement techniques from the previous lab to determine the value of the inductor's resistance.

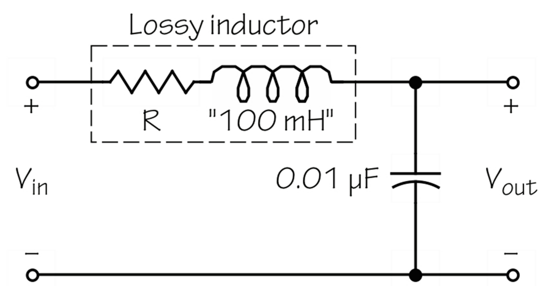

Figure 1: RLC Circuit

You may need to use the lab sheet from the previous RLC lab to guide you through the calculations. The important formulas are repeated at the end of this document.

Procedure

There are four activities in this lab:

- Build an RLC circuit and connect it to myDAQ.
- Display on the scope the time-domain response of this circuit.
- Collect data from the scope so we can determine R and L.
- Calculate R and L for this 100-mH inductor.

A. Build the Circuit

Build the circuit of Figure 1 on your breadboard and connect to myDAQ. The photo in

Figure 2 shows where all the leads go. In general, when we use myDAQ, the pattern of leads is pretty standard:

- Drive the circuit with a signal on AO 0 and AGND.
- Return that input to the scope via AI 0+ and AI 0-.
- Return the output to scope via AI 1+ and AI 1-.

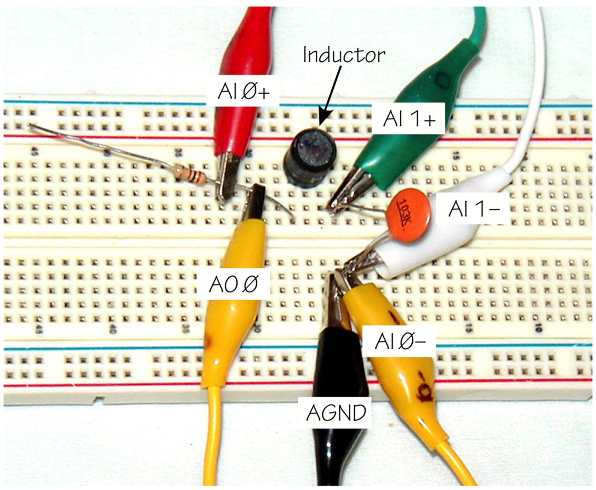

Figure 2: myDAQ Connections

There are two somewhat peculiar things about the circuit shown in Figure 2:

- The inductor is a small can with leads protruding from the bottom. The inductor covers the leads so you can't see the connections. Be sure you know which nodes are the inductor terminals.
- Because the inductor leads are hidden, there is no place to connect AO 0 and AI 0+. By sticking a resistor lead into the node for the hidden inductor terminal, we get a place for the clip leads. The resistor on the left in the picture is doing nothing other than providing this connection.

B. Display the Second-Order Response

1. Launch the Function Generator and set it up as shown in Figure 3.

   A. Click the square-wave button.

   B. Frequency = 100 Hz.

   C. Amplitude = 10 V_{pp} (which is the same as 5 V_P we used in Lab 4s.

   D. DC Offset = -5 V (to position the square wave as it was in Lab 4s).

   E. Duty cycle should default to 50% and the Signal Route should default to AO 0.

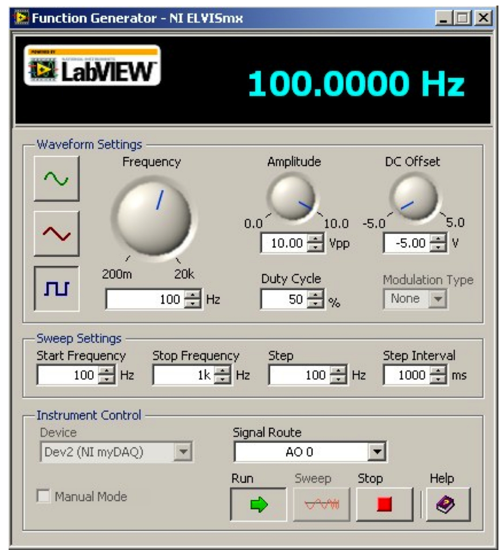

Figure 3: Function Generator Settings

2. Launch the Oscilloscope and set it up as shown in Figure 4.

   A. Enable channel 0 and set Source = AI 0.

   B. Enable Channel 1 and set Source = AI 1.

   C. Set Scale Volts/Div = 2 V for both channels.

   D. Set Vertical Position (Div) = 0 for both channels.

   E. Time/Div = 2 ms (note milli).

   F. Set Trigger to Edge and click the rising-signal button.

   G. change the Horizontal Position (%) = 0.

3. Start the Function Generator and the Oscilloscope by clicking Run on each. You should see a trace like that shown in Figure 4.

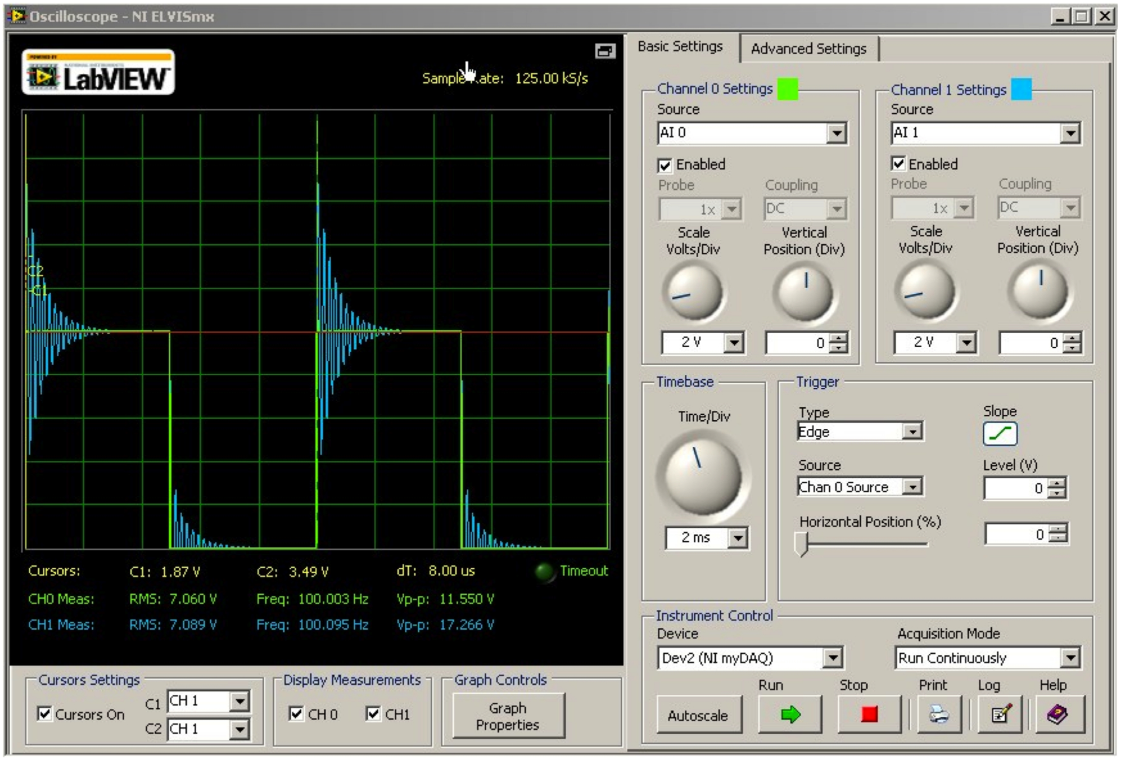

Figure 4: Initial Setup Display

C. Collect Data from the Second Order Response

The measurements we need are the same as those we did in the previous lab, namely, the heights of the first two peaks of the damped sine wave and the time between those peaks.

1. Stop the scope display so it freezes like the waveform in Figure 4. You may need to stop and start several times to get the scope to behave and show you want you want.
2. Change Time/Div to 50 μs (note micro), which will expand the damped sinusoid so you can get data from its peaks.
3. Enable both cursors and set both to read data from CH 1.
4. Position the cursors at the tops of the first two peaks, as shown in Figure 5.
5. The readings from C1 and C2 are the values of x_1 and x_2, measured from the axis on which the damped waveform is settling.
6. The time between these peaks is the value of the period, T.

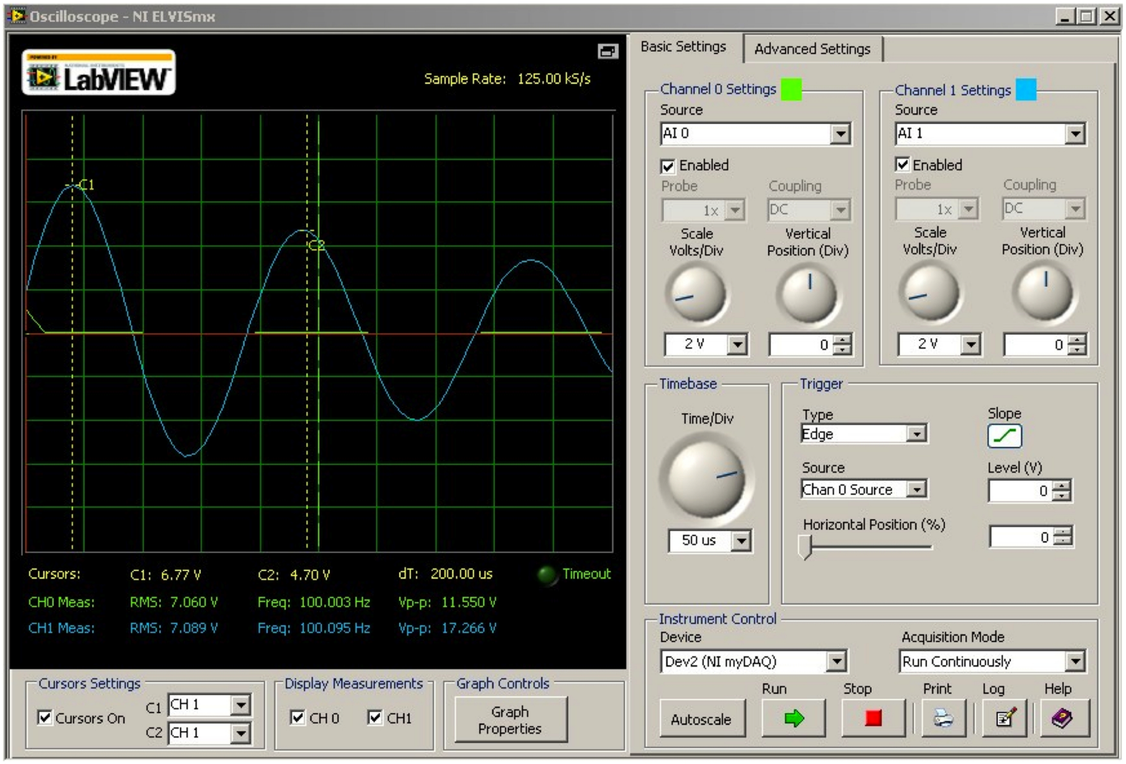

Figure 5: Scope Measurements

D. Calculate L and R

Assume C = 0.01 μF and follow the same procedure that you did before to calculate the values of the inductance L and the parasitic resistance R of the lossy inductor. The pertinent equations are given at the end.

The End

The goals of this lab were to build the RLC circuit, set up myDAQ to collect data, obtain values from the second-order response, and calculate L and R for a lossy inductor. We've accomplished those goals.

Now that you've worked with RLC circuits using both a simulator and an actual circuit, you are ready to design an RLC circuit to meet a given set of specifications.

Relevant Second Order Equations

$$\delta = \ln\left(\frac{x_1}{x_2}\right)$$

$$\zeta = \frac{1}{\sqrt{1+\frac{4\pi^2}{\delta^2}}}$$

$$\omega_d = 2\pi\frac{1}{T} \quad rad/sec$$

$$\omega_d = \omega_o\sqrt{1-\zeta^2}$$

$$\omega_o = \frac{1}{\sqrt{LC}}$$

$$\zeta = \frac{R}{2}\sqrt{\frac{C}{L}}$$

Report of Lab 6v Results

Name ____________________________________

Show Calculations! Show Units!

Scope data:

T __________________ x_1__________________ x_2__________________

Calculated Values:

ω_d __________________ δ__________________ ζ__________________

Calculated element values:

C = 0.01 μF L __________________ R__________________

Draw the series R-L model of the lossy inductor and label the element values.

Use the RLC meter to measure your inductor's inductance and resistance. Record the values below. They should be close to your calculated values. If not, you might have an error.

R = ____________ L = ____________