Measurements of Capacitance and Inductance
Using Voltage Probes and the LabPro Interface

**Purpose:** To use the equipment and techniques developed in the previous experiment to determine the structure of a hidden series RLC circuit and to measure the values of the various components in that circuit.

**Apparatus:** Circuit Board with hidden series RLC circuit, Vernier LabPro Interface, Dual Voltage Probes, Decade Resistance Box, Voltmeter, Function Generator.

**References:** Refer to your text and to the old write-up for experiment #7 in the lab. manual for a discussion of DC and AC circuits.

**Introduction:** In this lab exercise, you will be given a hidden RLC circuit with connections to the components on top. The three components are connected in series but they may be in any order whatsoever, i.e. RLC, RCL, LRC, LCR, CRL, CLR. Using the equipment available to you in the lab, you will first have to determine which element is which and how the circuit is laid out underneath the board. You will then measure the values of each of the components individually, i.e. determine the values of R, L, and C in your particular board. Remember that any real inductor also has some resistance associated with it such that a real inductor can be considered to be a resistor connected in series with an ideal inductor (which has no resistance). In doing this experiment, you will be encouraged to think things through on your own. You should discuss, first with your lab partner and then perhaps with other groups in the lab, how you plan to figure out the circuit and measure the values of the three components. It will help to know that all of the components are oriented in the direction perpendicular to the long side of the board. If you really get stuck, of course, your lab instructor will be there to give some hints.

**Procedure:**

**I. Determination of Circuit.**

Make note of the number on your circuit board. You will be using this same board again next week!

Using your multimeter and perhaps the voltage probe as well, identify each of the components in your circuit, and make a diagram of the circuit showing how the components are connected in series. You will thereby also identify which are the two ends of the series circuit. [Hint: Note that a direct wire connection between two points will have zero, or very close to zero, resistance.]

Measure the resistance of each of the components in your circuit.

**II. Measurement of C and L.**
1. The computer and interface should already be turned on. Double-click on the Logger Pro icon labeled “Voltage - 1 Probe” to open the software for this part of the experiment.

2. The function generator should be set to the square wave output at a frequency of about 100 Hz. Observe the direct signal from the function generator on the computer and then proceed to the measurements of C and L.

3. You will use the voltage probe and the function generator to observe the transient behavior of the capacitor and the inductor. By measuring the time constant for each, you can determine the values of C and L. The decade box allows you to vary the resistance and make several different determinations of both C and L. For each, you should use at least three different values of R and make sure that your determinations of C and L are fairly consistent. Question: How good is good enough? Some details of the procedure are described below.

You should take repeated scans until you have one that shows the full exponential decay. That is the one you want to analyze.

For the automatic curve fitting, you will need to tell the program what to use for the baseline (parameter “B” in the fitting program). Use the “Examine” feature to manually determine a reasonable value for B, and note that you must enter the minus sign if it turns out to be negative.

Now use the automatic curve-fitting feature, choosing “Exponential” and entering a value of B before clicking on “try fit.” You should not be satisfied with a fit that produces a MSE > 0.001. Try slightly different values of B until you get an acceptable fit.

The value of “C” given by the fitting program is the value of $1/\tau$.
For a capacitor, $\tau = RC$ where R is the total resistance in the circuit.
For an inductor, $\tau = L/R$ where R is the total resistance in the circuit.
Remember that the function generator itself has an internal resistance of 50 Ω. Remember also that the inductor has its own resistance.