CALIFORNIA STATE UNIVERSITY, BAKERSFIELD (CSUB)

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING & COMPUTER SCIENCE

ECE 3320: FIELDS AND WAVES

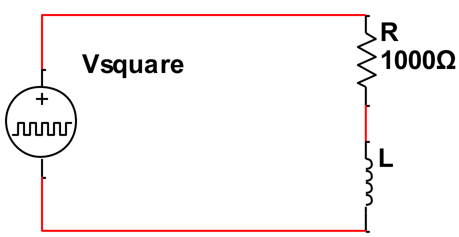
Laboratory 4

Parts List

Part	Unknown	Known	Resistor	Capacitor
A	Blue	1000µH	1000Ω	
B	Red		1000Ω	
C	Green		1000Ω	0.1µF

Note: Two factors that may influence your measurements are that the function generator has 50 Ω and the inductors may have some DC resistance. However, these resistances are small compared to the resistor value of 1000 Ω we are using.

A. Finding the inductance in RL circuit with inductors in parallel and series



In Part A, a square wave simulates a DC source that turns off and on repeatedly. In other words, it is like a battery being connected and disconnected.

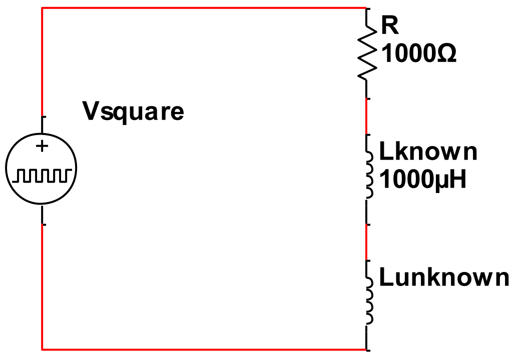
Use a square wave of 3 kHz, 1V peak-to-peak, and a 0.5 VDC offset. Set the Trigger Mode to Auto. The current is $I(t) = I_o [1 - e^{-t/\tau}]$ where $I_o = \varepsilon/R$ is the maximum current and the time constant $\tau = L/R$

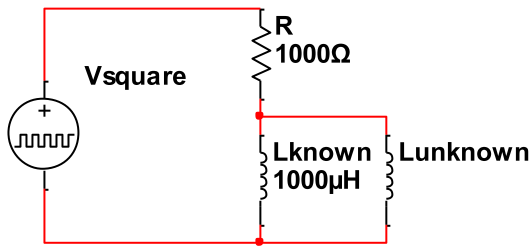
Connect the oscilloscope across the unknown inductor. With the square wave, you will see the voltage of the inductor for when the battery is connected and disconnected.
When the battery is connected, $V_L = \varepsilon e^{-t/\tau}$
When the battery is disconnected, $V_L = -\varepsilon e^{-t/\tau}$
Plug in values for the voltage and time into the equations. Solve for the unknown inductor.

Next, connect the oscilloscope across the resistor. You might need to switch places of the inductor and resistor to get a common ground. You can see the voltage of the resistor for when the battery is connected and disconnected.

When the battery is connected, $V_R = \varepsilon\,[1 - e^{-t/\tau}]$
When the battery is disconnected, $V_R = \varepsilon\, e^{-t/\tau}$
Plug in values for the voltage and time into the equations. Solve for the unknown inductor.

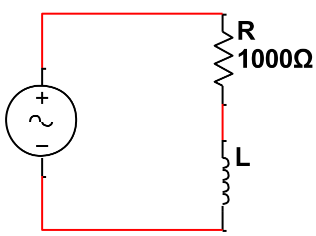
For the unknown inductor by itself, try using oscilloscope settings of 2.5 µs/division and 50-200 mV/div





In this section, you are provided with a known inductor (1000 µH) in series with an unknown inductor. Then, the known inductor (1000 µH) will be in parallel with an unknown inductor. After we solve for the total *L*, we can find the unknown inductor from the parallel or series equation. In series, the inductors are related by the equation: $L_{eq} = L_1 + L_2 + \ldots + L_n$. In parallel, the inductors are related by $1/L_{eq} = 1/L_1 + 1/L_2 + \ldots + 1/L_n$.

B. Finding the inductance in RL circuit with an AC source (1st method)



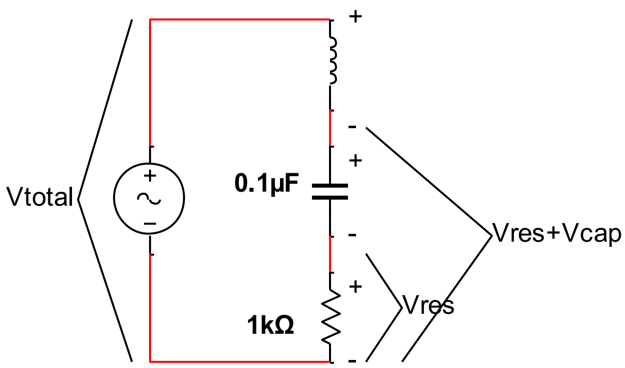
Instead of a voltage or current source, we can use an AC source to obtain the value of an unknown inductor. Similar to the Capacitor Lab, the inductance can be found in a circuit with an AC source via a single measurement. Use the function generator with 1V peak-to-peak sine wave to drive the circuit above. Put the inductor in series with a load resistor, and using a scope, measure the voltage across the resistor and the inductor. Use the RL circuit equations ($R = 2*\pi*f*L$) to find the value of the unknown inductor. The value of the resistor is 1k Ω.

1. You do not need to measure with the probes across the resistor. Only use the probes to measure across the inductor and across the total voltage with the oscilloscope.
2. Use the "Math" button to get subtraction and (Ch1-Ch2). Ch1 is the total voltage. Ch2 is the voltage across the inductor. The Math waveform is the voltage across the resistor.
3. Use "Measure" on the oscilloscope to find the peak-to-peak voltage of the

inductor and the peak-to-peak voltage of the resistor. If it is not giving a value, go to Trig Menu and change the mode from Auto to Normal or try hitting Autoset.

4. Starting from 1 kHz, adjust the frequency until the peak-to-peak voltage of the inductor is equal to the peak-to-peak voltage of the resistor.

C. Finding the inductance in RLC circuit with AC source



Connect an AC source in series with a resistor (1000 Ω), capacitor (0.1 µF), and an *unknown* inductor. The top end of each component is the positive end. The bottom side is the ground. Therefore, the voltage across the source is the total voltage across all three components. Call it V_{total}. Try using a 1V peak-to-peak sine wave as V_{total}. Use the oscilloscopes to obtain the voltage across the three components and use these values in conjunction with the resonant frequency (the impedance of the known capacitor and the impedance of the *unknown* inductor cancel one another at the resonant frequency) to determine the values of the unknown inductor (Hint: refer to the phasors section of Chapter 1).

1. Use one oscilloscope probe to measure across the total voltage. Use the second probe to measure across the voltage of the resistor. Use Math function to get the voltage across the inductor and capacitor. Adjust the frequency until the voltage of the Math waveform is as small as possible.
2. Use the equation for resonant frequency for an RLC circuit to find the value of the inductor.

D. Verify the experimental results with your calculations.

Using Matlab to plot the voltage across the capacitor and inductor for the values you have calculated for the specific frequency and peak-peak voltage you used to carry out the measurements in Section C. Compare these plots against the measurements obtained in Section C.

Plot 1: Voltage Across the inductor as a function of frequency (measurement vs. analytical).

Plot 2: Current in the resistor as a function of frequency (measurement vs. analytical).