PHY–134 Lab # 9: Resonance[1]
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Last lab we determined the inductance of LC(R) circuits. This lab will build upon that to find additional properties of such LRC circuits. This lab is very similar to the previous lab except we are given *frequency counters* to get a more accurate measurement of the frequency of our signals.

1. Connect the circuit as shown in the lab write up with $R = 50\Omega$ and $C = 0.1\mu F$. This portion is measuring the voltage across the resistor in the LRC circuit. Connect the signal from the signal generator to channel 1 of the scope and connect the voltage across the resistor to channel 2 of the scope. With the scope displaying both signals at the same time (dual mode) adjust the frequency of the signal generator. When you do this the voltage of the signal from the generator will increase to a maximum value and then start decreasing again. The circuit is said to be at resonance when this voltage is at its maximum value. When you obtain this maximum value, read the frequency off of the frequency counter.

Q1. *At what frequency should the maximum occur? Use the value obtained last week for L to answer this question.* Since you probably do not remember your value for L from last week, use the value of the frequency you measured to obtain a new value for L. Recall, at resonance

$$\omega_o = \frac{1}{\sqrt{LC}} \rightarrow f_o = \frac{1}{2 * \pi\sqrt{LC}} \tag{1}$$

where f_o is the resonance frequency. When you have calculated this **DO NOT** change the frequency until step 5.

2. Now we simply interchange the positions of the resistor and the capacitor in the circuit. Now, channel 2 of the scope should display the voltage across the capacitor. Information for the following questions can be found on or near page 1190 of your textbook.

Q2. *What is the phase of the capacitor voltage relative to the input voltage at resonance?*
Recall that by phase they mean an angle; i.e. say the period of both signals is $4ms$ but on the scope you notice that one signal is *ahead* of the other by $1ms$. Then we can determine an angle by noting that there are 2π radians in one period and therefore our separation or *phase* between the two signals is

$$\phi = \frac{1ms}{4ms} * 2\pi = \frac{\pi}{2}$$

or 90^o out of phase.

Q3. *What is the amplitude of the capacitor voltage at resonance? Is it larger than the input voltage?*

3. Now we want to measure the voltage across inductor so just interchange the positions of the inductor and capacitor.

Q4. *What is the phase of the inductor voltage relative to the input voltage at resonance?*

[1] This is a supplement to the lab write up.

Q5. *What is the phase of the inductor voltage relative to the capacitor voltage at resonance?* You won't have a direct measurement of this, but just use your information from part 2.

Q6. *What is the amplitude of the inductor voltage at resonance? Is it larger than the input voltage?*

Q7. *Explain how it is possible for the inductor and capacitor voltages to be larger than the input.*
This is definitely in your book around the page listed above. It has to do with the phase diagrams.

4. Now we want to measure the voltage across the inductor *and* capacitor in series. Just interchange the capacitor and inductor once more but connect the scope to the outside of the LC combination.

Q8. *At resonance, what is the voltage and phase across the LC combination relative to the input voltage? What connection does this have to Q7?*
Again, phase diagrams.

5. Now we want to measure the voltage across the resistor as a function of frequency. Simply interchange the LC combination and the resistor positions and hook the scope up so that you are reading the voltage across the resistor. Now, vary the frequency and take measurements of the voltage. Take 4 measurements at a frequency less than the resonant frequency and 4 measurements above the resonant frequency, for a *total* of 8 measurements.

Q9. *Plot the voltage across the resistor as a function of frequency. This is called a resonance curve.*

6. Repeat step 5, but now with $R = 10\Omega$ and $C = 0.1\mu F$.

Q10. *Make a similar plot as in Q9 and comment on any difference you may observe.*