Physics 251 Laboratory

AC Circuits Part 1 - Implementation

<u>Pre-Lab: Please do the lab prep exercise on the web.</u>

Introduction

This week we will set up a series RLC circuit driven by an ac voltage source, and use an oscilloscope and a digital voltmeter to study its behaviors. For reference, here are the equations we have discussed in lecture.

$$V = V_{max}\cos(\omega t) \qquad I = I_{max}\cos(\omega t - \varphi) \qquad I_{max} = V_{max}/Z$$

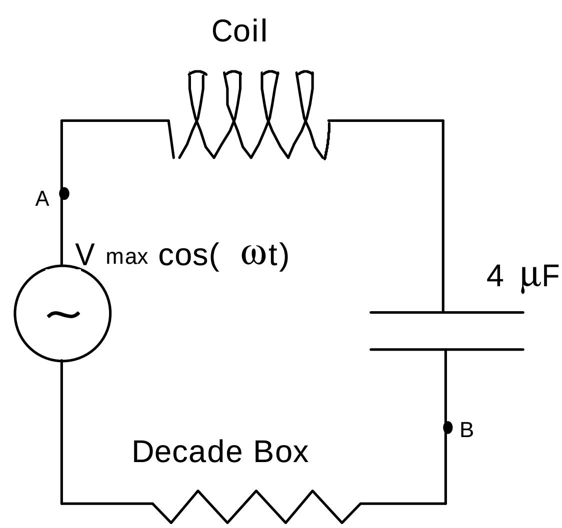
$$Z = \sqrt{R^2 + (X_L - X_C)^2} \qquad \tan\varphi = \frac{X_L - X_C}{R}$$

$$V_L = I_{max}X_L\cos\left(\omega t + \frac{\pi}{2}\right) \qquad V_R = IR \qquad V_C = I_{max}X_C\cos\left(\omega t - \frac{\pi}{2}\right)$$

$$P = \frac{I_{max}V_{max}\cos\varphi}{2} = \frac{I_{max}^2 Z\cos\varphi}{2} = \frac{I_{max}^2 R}{2}$$

You will be supplied with the following equipment:

1. Signal generator
2. Large coil with removable iron core
3. 4 μF capacitor
4. Resistance decade box
5. Cables, clips, connectors, etc.
6. Oscilloscope
7. Digital voltmeter (DVM)



Section 1

Set up the circuit as it is shown in the figure. Because of the way we will make measurements, **it is important that the resistance box be "last" attached to the ground side of the signal generator**.

Initially, set the decade resistance box for 50 Ω, and set the signal generator to produce a 2500 Hz sine wave. Set the amplitude of the sine wave to its maximum value. Do not use the iron core in the coil.

Once everything is set up, do a few measurements.

1. Use the DVM to measure the voltage produced by the signal generator.
2. Set up the oscilloscope and look at the voltage waveform (measure at point A). Does the voltage you see agree with what the DVM said?

3. Try varying the frequency and amplitude; make sure you understand what the oscilloscope is doing.
4. Now, move the DVM to measure the voltage across the resistor. Set the scope to measure at point B. Do these voltages agree? Should they?

Section 2

In this section, we will measure the inductance of the coil both with and without the iron core in place. This can be done because we know the capacitance of our capacitor and we can measure the resonant frequency of the circuit. The amplitude of the current (and hence of V_R) is a maximum at resonance.

1. With the circuit set up as above, turn the frequency adjust knob all the way down (to 0.3) while staying on the 1 kHz scale.
2. Measure the voltage across the resistor (point B) vs. the frequency all the way to the top of the scale. You may wish to "scan" the frequency range first and plan to take more closely spaced data near resonance.
3. Plot your results and determine the resonance frequency as best you can. Is it easier to use the oscilloscope or the voltmeter to find resonance?
4. Calculate the inductance of the coil.
5. Repeat this process with the iron core in place. You may need to go to a different frequency range.

Section 3

Now, get a second set of leads and use the scope to measure at points A and B simultaneously. Use Channel 1 to measure at A and Channel 2 at B. You should be able to see the phase angle φ directly with this setup. Can you? Try setting the frequency far below resonance then scanning the frequency through resonance. Does the phase behave as you expect? We can also find resonance by looking for the frequency where $\varphi = 0$.

1. With the iron core removed set the signal generator to 3 kHz. Measure the phase shift.
2. Calculate what phase shift you expect. Does your result make sense?
3. Set your 'scope to trigger on channel 1 at zero voltage. Your waveform should cross zero in the middle of the screen (indicated by a little "T"). Shift this waveform up from the center, and shift channel 2 down so they don't overlap.
4. Look at channel 2. Does it cross its own x-axis (indicated at the left of the screen) at the trigger point? This is your phase shift again.
5. Watch the phase shift as you cross resonance. Determine the resonant frequency with and without the core using this method. Do your results agree with the ones from before? Which way is more accurate?

Name ________________________________ Data ________________________

Lab Partners ____

AC Circuits Part 1 - Implementation Results

Please use the back of this page or attach another sheet if you need more room.

Section 1

1. Source voltage as measured by DVM ____
2. Source voltage as measured by oscilloscope ___________________________________
3. Do your voltage measurements agree? If not, why? ____________________________

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4. Voltage across resistor as measured by DVM __________________________________
5. Voltage across resistor as measured by oscilloscope ___________________________
6. Do your voltage measurements agree? If not, why? ____________________________

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Section 2

Without Core		With Iron Core	
f(Hz)	V_R (Volts)	f(Hz)	V_R (Volts)

Resonance frequency will be at the maximum of the graph.

Plot Results in Excel and attach to this sheet.
Using your plotted results, find:

Without Iron Core
Resonance frequency ______________
L= ________________________________
Calculated Impedance _____________

With Iron Core
Resonance frequency _______________
L= _________________________________
Calculated Impedance ______________

Section 3

Without Core
Phase shift ________________________ Resonance frequency _____________________

With Core
Phase shift _________________________ Resonance frequency _____________________

How closely do the results for resonance frequency in section 2 and section 3 agree? Which method do you think is most accurate______________________________________

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Overall

Why is the resonant frequency important in electric circuits? How does the inductance of the coil change when the iron core is in place?____

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What was good about this lab and what would you do to improve it?

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