Impedance and Reactance Lab

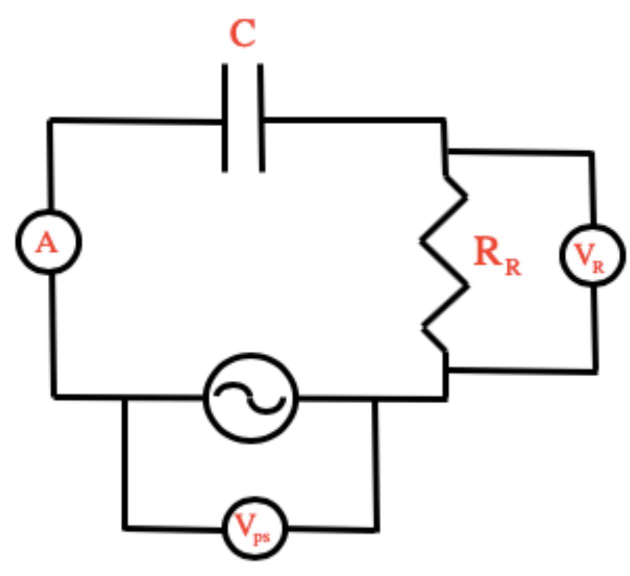
Ohm's Law works perfectly well in an AC circuit as long as you are using RMS values for current and voltage and as long as you know the net resistive nature of the circuit, or the impedance. That is, in an AC setting, Ohm's Law is simply $V_{\text{power supply, RMS}} = i_{RMS}Z$.

You have watched a video that outlines the idea of reactance (the frequency-dependent resistive nature of both inductors and capacitors) and impedance (the net resistive nature of a circuit), so the fact that the impedance is defined as $Z = \left[(R_{net})^2 + \left((X_L)^2 - (X_C)^2\right)\right]^{1/2}$ with the inductive and capacitive reactance being defined as $X_L = 2\pi\nu L$ ohms and $X_C = \frac{1}{2\pi\nu C}$ ohms—this shouldn't be too much of a shock.

This lab is going to give you a chance to see if all of this actually works in an AC circuit.

<u>Procedure:</u>

<u>Part A</u> (general set-up): (NOTE: We could have you set up a general circuit, put an inductor into the circuit, take and record readings, then do the same with a capacitor. That would produce a write-up that would have a section on inductors and a section on capacitors, and it would be on the longish side. To be easy on you time-wise, this lab is only going to ask you to deal with a capacitor circuit.



a.) Wire the circuit shown to the right. Notice the single ammeter in the circuit will be measuring the current through the entire circuit branch, that the voltmeter labeled V_R is measuring the RMS voltage across the resistor, and the voltmeter labeled V_{ps} is measuring the RMS voltage across the power supply (which is to say, the voltage being impressed upon the circuit as a whole by the Function Generator). You will use data from all of these meters during the lab.

b.) Use the Impedance Bridge to measure the resistance of the resistance R_R, the resistance of the overall circuit R_{ckt} (this will be measured at the power supply's terminals) and the capacitance C of the capacitor.

c.) Set the Function Generator so that its output has an amplitude of 1.0 volts (that is the way the generator we have measures output). Additionally set the generator's frequency at 50 Hz.

d.) With the generator turned on and set as specified above, take and record the meter readings. Notice that these are all RMS values.

Calculations:

Being sure to include a blurb with your response to each section:

CONSIDERING JUST THE RESISTOR:

1. Using only the data taken from the resistor (that is, the resistor's value and the voltage across it), determine the current through the circuit.

2. You should have found that the calculated value of the current from Calculation 1 and the observed current from the ammeter are the same (or close to the same). Do a % deviation between the two and comment on your findings. Feel free to be effusive in your joy for how those results turn out.

CONSIDERING THE CIRCUIT AS A WHOLE:

3. We'd like to know the resistive nature of the capacitor. Determine its capacitive reactance at 50 Hz.

4. We'd like to know the circuit's impedance Z at 50 Hz. The only hitch is that there may have been more net resistance in the circuit than just the resistor R_R, so use the value R_{ckt} to include all resistor-like resistance in your calculation.

5. According to Ohm's Law, $V_{ps,RMS} = i_{RMS}Z$. As all the meter readings were RMS readings, we should be able to use this relationship to determine the RMS value of the current being drawn from the power supply (in other words, use your measured V_{ps} and calculated Z to determine i).

   Note that there is no X_L term in this impedance calculation as there are no inductors in the circuit.

6. The value of I determine in Calculation 5 should come somewhat close to matching the current you measured using the ammeter. Do a % comparison between the two and comment.

7. Although this wasn't pointed out in the video, the Function Generator was geared to present its output voltage (amplitude), and according to it as set up during the lab, it believed it was putting out 1.0 volts amplitude, which means .707 volts RMS. Our meter measures a value that was closer to .73 volts. It is possible the meter could have been out of calibration.

   a.) Repeat Calculations 5 and 6 with an input voltage of .707 volts RMS.
   b.) Comment on your findings.