# Experiment: AC Circuits

## OBJECTIVES:

1. To observe the behavior of AC circuits containing resistors, capacitors and inductors
2. To measure the AC response of a resistor, capacitor and inductor
3. To measure the impedance of a series RLC circuit

## EQUIPMENT:

- Universal Breadboard (Archer 276-169)
- Vernier Current & Voltage Probe
- LoggerPro software & LabPro Interface
- Analog Out Cable
- Resistor (between 50 Ω and 200 Ω, ¼ watt)
- Capacitor (between 10 and 100 μF)
- Inductor (between 5 and 200 mH)

## INTRODUCTION

In this lab, you will observe the AC behavior of electrical components, by applying time-varying voltages, using the LabPro interface as an AC voltage source, to a resistor, capacitor and inductor, measuring the resulting current. The topic gets complex, because there are many variables to keep straight, but it is very important. All large-scale electrical power is AC, as are all non-digital electrical communication systems. AC voltages and currents are constantly varying. We will use V and I to represent the voltage and current at any particular instant. $V_{peak}$ and $I_{peak}$ represent the peak voltage and peak current. Voltmeters and ammeters (unless they tell you otherwise) measure $V_{rms}$ and $I_{rms}$, where "rms" stands for "root mean square." This is also known as the "effective voltage," $V_{eff}$, and "effective current," $I_{eff}$. This lab will concentrate on the instantaneous and peak values in AC circuits using computer-based current & voltage probes.

## Part I. VOLTAGE VS. CURRENT

For each of the 3 electrical components, use the circuit shown in Figure 1 to determine if $V_{rms}$ is proportional to $I_{rms}$ when AC voltages are applied to the component.

1. Record the manufacturer's specifications for the resistor, capacitor and inductor.

   **Manufacturer's Specifications:**

   Resistor: __________ Ω

   Capacitor: __________ μF

   Inductor: __________ mH

2. Connect the following:
   a. current probe to CH 1 of the LabPro interface
   b. differential voltage probe to CH 2 of the LabPro interface
   c. Analog Out cable to CH 4 of the LabPro.

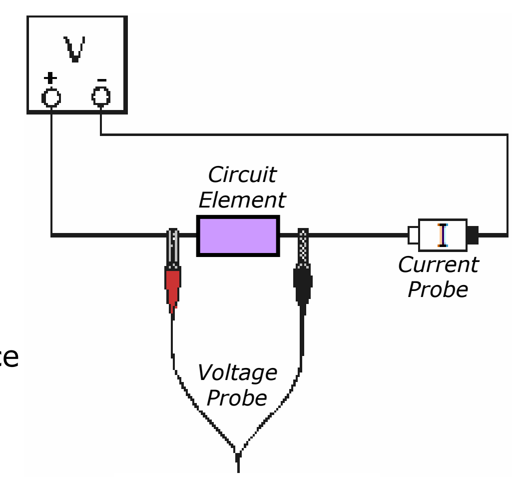


*Figure 1*

3. Turn on the computer and open the LabPro software.
4. Open the experiment file "AC-Circuits". *Before collecting data be sure to zero the probes appropriately.*
5. Initially, set the "Amplitude" to 0.2 V and the "Frequency" to 50 Hz.

6. Collect a 1s record of current vs time data for $V_{peak}$ = 0.2 V.
7. Click and drag the mouse over the current vs time graph. Use the "Statistics" function to obtain the minimum and maximum current values. Add the two values together and calculate the average value. Record this value ($I_{peak}$) in the table below.
8. Click and drag the mouse over the voltage vs time graph. Use the "Statistics" function to obtain the minimum and maximum voltage values. Add the two values together and calculate the average value. Record this value ($V_{peak}$) in the table below.
9. Repeat steps 5 through 8 in voltage steps from 1.0 to 4.0 V corresponding to the table below.
10. Using Graphical Analysis, create a graph of $V_{peak}$ vs. $I_{peak}$.
11. Fit the graph to the simplest model that agrees with data. If the graph is not linear, the device is not "Ohmic". Enter the slope value (if fit is linear) in the table below.
12. In LoggerPro, change the "Frequency" to 200 Hz.
13. Repeat steps 5 through 11.
14. Repeat steps 5-13 for the capacitor and the inductor, for both 50 Hz and 200 Hz.

| | **$I_{peak}$** | | | | | |
|---|---|---|---|---|---|---|
| **Applied $V_{peak}$ (V)** | **Resistor 50 Hz (mA)** | **Resistor 200 Hz (mA)** | **Capacitor 50 Hz (mA)** | **Inductor 50 Hz (mA)** | **Capacitor 200 Hz (mA)** | **Inductor 200 Hz (mA)** |
| 0.5 | | | | | | |
| 1.0 | | | | | | |
| 1.5 | | | | | | |
| 2.0 | | | | | | |
| 2.5 | | | | | | |
| 3.0 | | | | | | |
| 4.0 | | | | | | |
| **Slopes from graphs (or enter "not ohmic"):** | | | | | | |
| | | | | | | |
| **Theoretical values for slopes (or enter "not ohmic"):** | | | | | | |
| | **R** | | **$X_C$** | **$X_L$** | **$X_C$** | **$X_L$** |
| | | | | | | |
| **Percent difference:** | | | | | | |
| | | | | | | |

***File Name:*** *Ph203_Lab-AC-Circuits-Labpro-sum08.doc*

## *Analysis*

1. For the resistor, the slope of $V_{peak}$ vs $I_{peak}$ is, of course, called the "resistance." For the capacitor, the slope is called "capacitive reactance" and symbolized by $X_C$.

Calculate the capacitive reactance for each frequency from the manufacturer's specified capacitance, using the formula below.

$$X_C = 1/(2\pi fC)$$

**$X_C$ (50 Hz) = ________________**

**$X_C$ (200 Hz) = ________________**

Record values in the data table above.

2. Similarly, for the inductor, the slope of $V_{peak}$ vs $I_{peak}$ is called the "inductive reactance" and symbolized by $X_L$. Calculate the inductive reactance for each frequency from the manufacturer's specified inductance, using the formula below.

$$X_L = 2\pi fL$$

**$X_L$ (50 Hz) = ________________**

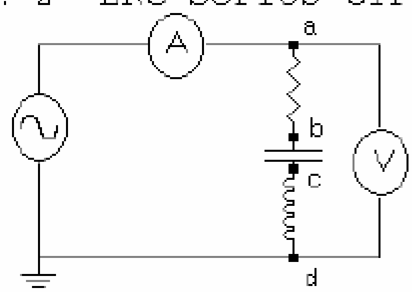
**$X_L$ (200 Hz) = ________________**

Record values in the data table above.

3. Compare each of these calculated values to the slope of the corresponding graph. Also compare the manufacturer's value for the resistor to the slope of that graph. Calculate the % Error for these values and record in the above table.

**Part II. LRC CIRCUIT**

Fig. 2 LRC Series Circuit




Connect the resistor, capacitor and inductor in series to the LabPro function generator, as shown. Set the Frequency to 100 Hz and Amplitude to 4 V.

1. Measure the peak current for this circuit.

**$I_{peak}$ = _______________ mA**

2. Connect the voltage probe leads at points a and d to measure the total voltage, $V_{peak}$, for the circuit.

**$V_{peak}$** (or $V_{ad}$ for the 3 elements combined) **= ______________ V**

3. Measure the peak voltage ($V_{Rpeak}$) between points a and b of the circuit.

**$V_{Rpeak}$** ($V_{ab}$) **= ______________ V**

4. Measure the peak voltage ($V_{Cpeak}$) between points b and c of the circuit.

**$V_{Cpeak}$** ($V_{bc}$ for the capacitor) **= ______________ V**

5. Measure the peak voltage ($V_{Lpeak}$) between points c and d of the circuit.

**$V_{Lpeak}$** ($V_{cd}$ for the inductor) **= ______________ V**

## Analysis

1. Find the value of R within the LRC circuit using $V_{Rpeak} = I_{peak} R$.

   **R = _______________**

2. Similarly, find the value of $X_C$ within the LRC circuit using $V_{Cpeak} = I_{peak} X_C$.

   **$X_C$ = _______________**

3. Find the value of $X_L$ within the LRC circuit using $V_{Lpeak} = I_{peak} X_L$.

   **$X_L$ = _______________**

4. Find the total impedance, Z using $V_{Rpeak} = I_{peak} Z$.

   **Z (measured) = _______________**

5. Calculate the value of Z using the formula below:

$$Z = [ R^2 + (X_L - X_C)^2 ]^{1/2}$$

   **Z (calculated) = _______________**

6. Find the phase angle from the formula: $\tan ø = \frac{(X_L - X_C)}{R}$.

   **ø = ______________**

7. Does the sum of the peak voltages on each component in the LRC circuit equal the total peak voltage? Can you explain why or not?