Oscilloscope

Equipment:

- Computer with PASCO ScienceWorkshop 850 Interface and PASCO Capstone
- Signal Generator
- Voltage Sensor (Round DIN to two Banana plugs)
- Signal Generator cable (BNC plug to Alligator clips)
- 3 alligator wires
- Multimeter
- 6 V Lantern Battery
- 100 Ω Resistor
- 470 Ω Resistor (Yellow, Purple, Brown, Gold)
- 2.2 μF mylar Capacitor

Introduction

A traditional instrument to display the electrical signals is the oscilloscope. Capstone software allows the PASCO Interface to function as an oscilloscope. When PASCO Voltage sensor is connected to the source of an electrical signal, the Interface monitors the voltage, while the Capstone software displays the values of voltage as a function of time.
Voltage of DC source doesn't change with time; therefore, when Voltage Sensor is connected to DC power supply (battery), the software displays a flat line either below or above the time axis depending on the direction of the voltage.
However, when Voltage Sensor is connected to AC powers supply (socket), the resulting graph of voltage vs. time, takes the form of a sin function:

$$V(t) = V_{max} \sin(2\pi f t)$$

The voltage varies sinusoidally from $+V_{max}$ to $-V_{max}$ with frequency f. Because of this oscillation, the direction of the voltage, and hence the direction of the current, changes back and forth.

Oscilloscope displays instant values of the AC voltages but not RMS values of the voltage needed to assess energy provided by the AC power supply. RMS values of the voltage should be measured with a voltmeter. The biggest difference between an oscilloscope and an AC voltmeter is that the oscilloscope displays the variations the voltage, while the voltmeter measures the RMS voltage. With the oscilloscope, a "peak voltage" or max magnitude of the voltage could be measured and RMS value could be calculated from it.
Alternatively, with the voltmeter, RMS value could be measured and V_{max} could be calculated from it

$$V_{RMS} = \frac{V_{max}}{\sqrt{2}} \text{ or } V_{max} = \sqrt{2}V_{RMS}$$

. Objective:

- *To compare AC and DC voltage signals displayed by the oscilloscope*
- *To compare AC voltages (MAX and RMS) measured with a Multimeter and an Oscilloscope*

Part #1: Displaying a DC Signal

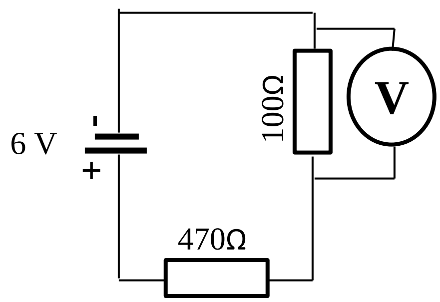

Figure 1. Schematic diagram of series circuit using DC power source.

1. Construct a series circuit with the 6 V battery, a 100 Ω resistor, and a 470 Ω resistor as shown in Figure 1.
2. Set the Multimeter as a DC Voltmeter.
3. Measure the voltage across each resistor and the terminal voltage of the battery. (Refer to Lab #2).
4. Place alligator clips on the end of the voltage sensor cable. ***Very carefully*** insert Voltage Sensor cable into analog input A of the PASCO interface. (Make sure the notch is at the top.)
5. Open "Oscilloscope Set Up" from http://physlab.tamucc.edu/ (Lab 7 line).
6. For each resistor, and then for the battery, connect the Voltage Sensor's clips across the component, take data briefly in Capstone, stop Capstone, then use the Coordinate Tool (cross wire) to measure the voltage.
7. How do voltage measurements compare between the two instruments?

Voltage	Voltmeter	Oscilloscope	% Difference
$V_{100\,\Omega}$ (V)			
$V_{470\,\Omega}$ (V)			
V_{batt} (V)			

Table 1. DC Voltage Measurements.

Part# 2: Measuring AC Signals

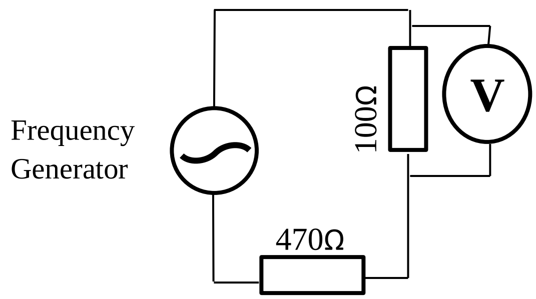

Figure 2. Schematic diagram of series circuit using AC power source.

1. Construct a series circuit with the Frequency Generator, a 100 Ω resistor, and a 470 Ω resistor as shown in Figure 2. (It's the same circuit, with the frequency generator replacing the battery.)
2. Connect the Voltage Sensor's clips across the 100 Ω resistor.
3. Set the Frequency Generator to:
   - 1.2 KHz = 1200 Hz
   - Sin function (~)
   - 600Ω impedance
   - Output or Amplitude: maximum
4. Monitor the signal using Capstone's virtual oscilloscope. While monitoring the signal, adjust the frequency knob from its lowest setting to its highest setting. Similarly, adjust the amplitude knob. Return the amplitude to the max setting and the frequency to 1.2 kHz.
5. Describe how changes to frequency and amplitude affected the appearance of the graph.
6. Describe the difference between AC and DC signals.
7. Stop monitoring. If the display doesn't look like a nice sine wave, you may have to stretch or compress the time axis, then monitor again for a brief time. Measure the period of the signal with the aid of Coordinate Tool. **Hint:** The period is the time between two consecutive maximums.
8. Calculate the frequency of the signal from the measured value of period.
9. Compare the calculated frequency with the one shown on Frequency Generator Display.

Measured Period (s)	Calculated frequency (Hz)	Displayed frequency (Hz)	% difference

Table 2. Measured and Calculated values of AC frequency.

10. Measure MAX voltage of signal with Coordinate Tool. Record MAX in Table 3 for 100 Ω resistor.
11. Connect the Voltage Sensor across the 470 Ω resistor measure the MAX voltages of that circuit element. Do the same for the Frequency Generator. Record the values in Table 3.
12. How do voltages in an AC series circuit compare with voltages in a DC series circuit? Check the ratio of voltages (V_{470} / V_{100}) against the ratio of resistances (470 / 100).

Voltage	Voltmeter (RMS Voltage)	Oscilloscope (MAX Voltage)	Ratio (Voltmeter / Oscilloscope)	*V(t) = ... sin (2π....t)*
$V_{100\,\Omega}$ (V)				
$V_{470\,\Omega}$ (V)				
V_{EMF} (V)				

Table 3. AC Voltage Measurements in a series circuit consisting of a 100 ohm resistor and a 470 ohm resistor, using a frequency generator to provide the EMF.

13. Set the Multimeter as an AC Voltmeter.
14. Measure the voltage across each resistor and the terminal voltage of the Frequency Generator. Record the values in Table 3.
15. For each element of the circuit, compose a function V(t) using V_{max} and displayed frequency from Table 2. **Hint:** *V(t) = ... sin (2π....t)*
16. Comment on ratios observed in Table 3.
17. Disconnect the Voltage Sensor from the circuit. While monitoring the AC signal, adjust the scale to millivolts (click on the vertical axis and scroll). What signal do you think is displayed now? Include this statement in the abstract.

Part# 3: Displaying different AC Signals

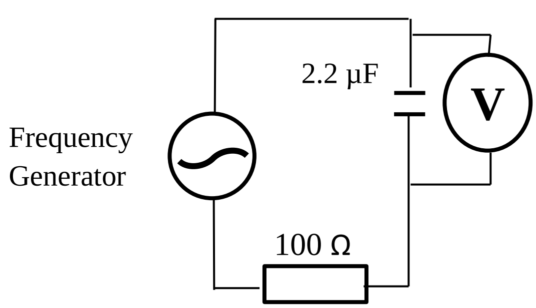

Figure 3. Schematic diagram of an AC circuit with a resistor and capacitor in series.

1. Set up the circuit depicted in Figure 3. (One resistor has been replaced by a capacitor.)

2. Make sure the Frequency Generator is set for 1.2 kHz, maximum amplitude as before.
3. Connect the Voltage Sensor across the capacitor and monitor the AC signal. Stop monitoring and record the MAX voltage of the capacitor.
4. Using the same technique, record the MAX voltage of the resistor and the Frequency Generator.
5. Repeat all 3 measurements for frequencies ranging from 0.4 – 1.2 kHz in increments of 0.2 kHz.
6. For each frequency calculate the sum ($V_C + V_R$) and Pythagorean addition ($\sqrt{V_C^2 + V_R^2}$) of the voltages.
7. Check the effect of the frequency on the values V_R and V_C by plotting each parameter against frequency on the same graph (V_R vs freq, V_C vs freq).
8. Discuss which type of addition of V_R and V_C (regular sum or Pythagorean addition) matches better with the overall V_{EMF}.

Frequency (Hz)	400	600	800	1000	1200
Peak V_C (V)					
Peak V_R (V)					
Peak V_{EMF} (V)					
$V_C + V_R$					
$\sqrt{V_C^2 + V_R^2}$					

Table 4. Measurements and calculations for voltage of an AC circuit consisting of resistor and capacitor in series.

Requirements for the Report:

The report must contain a **Header** at the top (Title of Lab, Authors, and Date)

Abstract Section must contain the following in paragraph form:

- Brief Introduction that includes objectives and basic theory of the lab.
- Methodology describing broadly what was done, using what tools, and what was measured/recorded.
- Data Summary including quantities worked into sentences. Describe the importance of each Table and Graph.
    - Compare DC voltage measurements between multimeter and oscilloscope in Table 1.
    - Describe difference between DC and AC. How does AC signal change when you change frequency? Amplitude?
    - In Table 2, how does calculated frequency compare with frequency displayed on Function Generator?
    - Do resistors behave differently when using AC source instead of DC source? Compare ratio of voltages (V_{470}/V_{100}) against ratio of resistances (R_{470}/R_{100}) in Tables 1 and 3.
    - How do ratios in Table 3 (Voltmeter/Oscilloscope) compare against expected ratio $V_{RMS}/V_{MAX} = 1/\text{sqrt}(2)$? Discuss reasons for differences between measured and expected ratios, if any.
    - What signal is displayed when the voltage sensor is disconnected from the circuit?
    - What does data in Table 4 and graph illustrate about the effect of frequency on voltage across the resistor? Capacitor? State the difference in the effect that frequency has on each voltage.
    - Discuss which type of addition of V_R and V_C (regular sum or Pythagorean addition) matches better with the V_{EMF}.
- The lab manual contains questions and/or imperatives throughout that will guide you with the conclusions. **Always incorporate the questions and/or imperatives from the lab manual**.

Data Section must contain the following:
[Each table and graph should be labeled and descriptively captioned]

- 4 Tables
- 1 Graph (Resistor Voltage vs. Frequency, Capacitor Voltage vs. Frequency)