

Oscilloscope (Remote Version)

Equipment:

- Computer with modern web browser
- <https://phet.colorado.edu/en/simulation/circuit-construction-kit-dc-virtual-lab>
- https://www.compadre.org/Physlets/circuits/ex31_1.cfm
- https://www.compadre.org/Physlets/circuits/illustration31_7.cfm

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 power supply (socket), the resulting graph of voltage vs. time, takes the form of a sin function:

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

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 an oscilloscope*
- *To compare AC voltages (MAX and RMS) for Resistor and RC circuits*

Part #1: Displaying a DC Signal

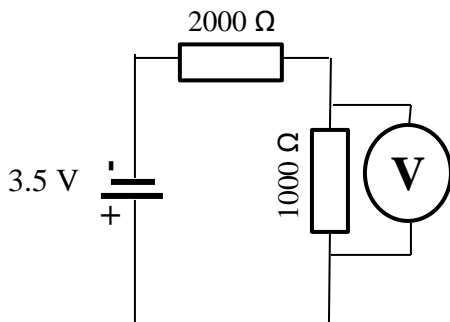



Figure 1. Schematic diagram of series circuit using DC power source.

1. Start the PhET Circuit Construction Kit: DC Virtual Lab
<https://phet.colorado.edu/en/simulation/circuit-construction-kit-dc-virtual-lab>
2. Setup:
 - Change the Show Current option to “Conventional” with the red arrow.
 - Click on the Values option so it is checked
 - Make sure Wire Resistivity is set to lowest value (slider all the way to the left)
3. Construct series circuit with 3.5 V battery, 1000 Ω resistor, & 2000 Ω resistor as shown in Figure 1. You will have to use high capacity resistors () in the circuit. (NOTE: The current flow will not be visible in the circuit.)
4. Measure the voltage across each resistor and the terminal voltage of the battery using a Voltmeter. Record voltage measurements in Table 1. (NOTE: If a voltage measurement is negative, then flip placement of the Voltmeter wires.)
5. Refer to Lab 2 or Lab 3 if you need guidance in constructing the circuit or using a Voltmeter.
6. Provide a screenshot of your circuit from the PhET simulator as a Figure in your report. The image should be cropped so it only shows the circuit with a little bit of blue border around it, not the entire window or your taskbar.
7. How does the ratio of voltages (V_{2000} / V_{1000}) compare against the ratio of resistances (2000 / 1000)?

Component	Voltage (V)
$R_{1000\ \Omega}$	
$R_{2000\ \Omega}$	
Battery	

Table 1. DC Voltage Measurements.

Part# 2: Measuring AC Signals

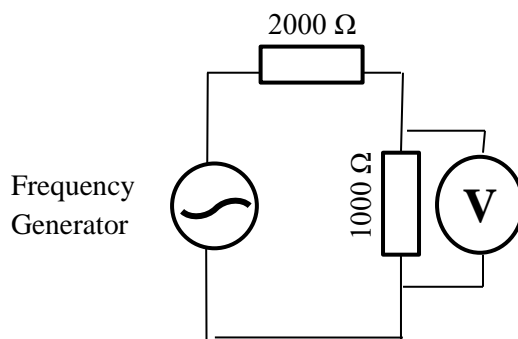




Figure 2. Schematic diagram of series circuit using AC power source.

1. Start Physlet Exploration 31.1
https://www.compadre.org/Physlets/circuits/ex31_1.cfm
2. NOTE: The Physlet simulator is cumbersome to navigate and to use, so follow the instructions in the order that they are listed.
3. Setup #1:
 - Set amplitude = 5 V.
 - Set frequency = 1000 Hz.
 - Set phase angle = 0 **(This value will never change)**
4. Click the Play button (). The graph will begin plotting a graph of voltage across the 1000 Ω resistor. Allow the simulation to run until there are at least 2 complete cycles visible on the graph. Click the Pause button () to Pause the simulation
5. Measure the period of the signal with the Coordinate Tool and record it in Table 2. The period is the time between two consecutive maximums. The Coordinate Tool appears on the graph by holding down the left mouse button. (NOTE: The x-axis (time axis) is listed in milliseconds.)
6. Calculate the frequency of the signal from the measured value of period.
7. Compare the calculated frequency with the set frequency in the simulator.

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

Table 2. Measured and Calculated values of AC frequency.

8. Examine the max voltage (height) of the sine waves. Take note of the amplitude for future comparisons.
9. Change the amplitude to 10 V, but keep the frequency at 1000 Hz. Click Play and allow the simulator to run until there are at least 2 complete cycles visible on the graph. Click Pause to stop.
10. Examine the new max voltage compared to the first run when amplitude = 5 V.

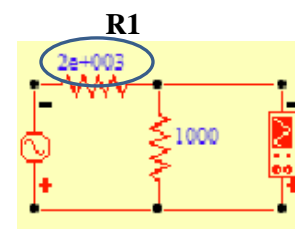
11. Change the amplitude back to 5 V, and change the frequency to 200 Hz. Run the simulation again.
12. Examine new period compared to the first run when frequency = 1000 Hz.
13. Keep the amplitude at 5 V, but change the frequency to 2000 Hz. Run the simulation again.
14. Summarize how changes to frequency and amplitude controls affect the voltage graph.
15. Describe the difference between AC and DC signals.

16. Setup #2:

- Click the [Restart](#) link located in the 2nd paragraph below the circuit diagram.
- Set the resistance of the first resistor to 2000.0 Ω by moving slider all the way to the right.



- The first resistor (R1) in the circuit diagram should read 2e+003.
- Set amplitude = 5 V.
- Set frequency = 1000 Hz.
- Set phase angle = 0 (Don't change this value.)



17. Click the Resume button (). The graph will begin plotting two lines. (Red Line = Voltage of Power Supply and Blue Line = Voltage of 1000 Ω Resistor). Allow the simulation to run until there are 2 complete cycles visible on the graph. Press the Pause button () to Stop the simulation.

Pressing the Play button () will reset your resistor value. Don't do that.

18. Measure the MAX voltage of Voltage Source (Red Line) with Coordinate Tool.
19. Measure the MAX voltage of 1000 Ω Resistor (Blue Line) with Coordinate Tool.
20. **Calculate** the MAX voltage of the 2000 Ω Resistor using the rules for a series circuit.
21. Record the three max voltage values in Table 3.
22. **Calculate** RMS Voltages of both resistors and the EMF along with the Ratios (RMS/MAX).
23. How do voltages in an AC series circuit compare with voltages in a DC series circuit? How do the ratio of AC voltages (V_{2000} / V_{1000}) compare against the ratio of resistances (2000 / 1000)?

Component	MAX Voltage (V)	RMS Voltage (V)	Ratio (RMS / MAX)	$V(t) = \dots \sin(2\pi \dots t)$
$R_{1000 \Omega}$				
$R_{2000 \Omega}$				
EMF				

Table 3. AC Voltage Measurements in a series circuit consisting of a 1000 Ω resistor and a 2000 Ω resistor using an AC Voltage source to provide the EMF.

24. For each element of the circuit, compose a function $V(t)$ using V_{\max} and simulated frequency from Table 2. **Hint:** $V(t) = \dots \sin(2\pi \dots t)$
25. Comment on ratios observed in Table 3.

Part# 3: Displaying different AC Signals

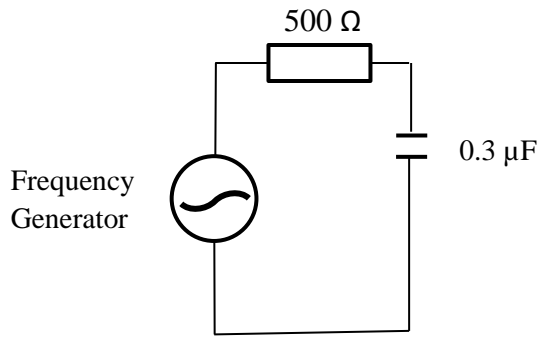


Figure 3. Schematic diagram of an AC circuit with a resistor and capacitor in series.

1. Start Physlet Illustration 31.7
https://www.compadre.org/Physlets/circuits/illustration31_7.cfm
2. Set Frequency to 400 Hz.
3. Click the **Play** button. In the top graph, the simulation will begin plotting 3 lines. (**Red Line** = Voltage of Power Supply, **Green Line** = Voltage of $0.3 \mu\text{F}$ Capacitor, and **Blue Line** = Voltage of 500Ω Resistor). Allow the simulation to run for just over 1 cycle. Press the **Pause** button to stop the simulation. (Stop the simulation soon after the peak of the red and green lines has formed).
4. Choose an instantaneous time on the top graph. Pick a time where the three lines are close together. Measure the instantaneous voltage of the power supply, capacitor, and resistor with the Coordinate Tool at your chosen time. Record the time and three instantaneous voltages in Table 4.
5. Measure the peak voltage of the power supply, capacitor, and resistor in the top graph with the Coordinate Tool. Record the three peak voltages in Table 5.
6. Repeat steps 3 to 5 for frequencies ranging from 600 Hz to 1200 Hz in increments of 200 Hz.
7. For each frequency calculate a regular sum ($V_C + V_R$) and Pythagorean addition ($\sqrt{V_C^2 + V_R^2}$) in Table 4 and Table 5.
8. Discuss which type of addition of V_R and V_C (regular sum or Pythagorean addition) matches better with overall V_{EMF} in Table 4 and Table 5. Why is one type of addition better in each table?
9. Check the effect of the frequency on Peak V_R and Peak V_C by plotting each parameter against frequency on the same graph (Peak V_R vs freq, Peak V_C vs freq). What effect does frequency have on Peak V_R and Peak V_C ?

Frequency (Hz)	400	600	800	1000	1200
Chosen Time t (s)					
V_C at time t (V)					
V_R at time t (V)					
V_{EMF} at time t (V)					
$V_C + V_R$					
$\sqrt{V_C^2 + V_R^2}$					

Table 4. Measurements and calculations for Voltage at chosen time t of an AC circuit consisting of resistor and capacitor in series.

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 5. Measurements and calculations for Peak 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 the ratio of voltages (V_{2000} / V_{1000}) against the ratio of resistances (R_{2000}/R_{1000}) for a DC circuit in Table 1.
 - Describe the differences between DC and AC. How does an AC signal change when you change frequency? Amplitude?
 - In Table 2, how does calculated frequency compare with simulated frequency? Why might there be differences between calculated and simulated frequency?
 - Do resistors behave differently when using an AC source instead of a DC source? Compare the voltages in Table 1 and Table 3. Also, compare the ratio of voltages (V_{2000}/V_{1000}) against the ratio of resistances (R_{2000}/R_{1000}) in Tables 1 and 3.
 - How do ratios in Table 3 (RMS / MAX) compare against expected ratio $V_{RMS}/V_{MAX} = 1/\sqrt{2}$? Discuss reasons for differences between measured and expected ratios, if any.
 - Discuss which type of addition of V_R and V_C (regular sum or Pythagorean addition) matches better with V_{EMF} in Table 4 and Table 5. Why is one type of addition better in each table?
 - What does the data in Table 5 and Graph 1 illustrate about the effect of frequency on peak voltage across the resistor? Capacitor? State the difference in the effect that frequency has on each peak voltage.

Data Section must contain the following:

[Each table and graph should be labeled and descriptively captioned]

- 5 Tables
- 1 Graph (Peak V_R vs freq, Peak V_C vs freq)
- 1 Figure (Screenshot of circuit from Part 1)