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)
- 4 alligator wires
- Voltmeter
- 6 V Lantern Battery
- 100 Ω Resistor
- 470 Ω Resistor (Yellow, Purple, Brown, Gold)

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:

\[ V(t) = V_{\text{max}} \sin(2\pi ft) \]

The voltage varies sinusoidally from \( +V_{\text{max}} \) to \( -V_{\text{max}} \) 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 \( V_{\text{max}} \) could be calculated from it

\[ V_{\text{RMS}} = \frac{V_{\text{max}}}{\sqrt{2}} \text{ or } V_{\text{max}} = \sqrt{2}V_{\text{RMS}} \]
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 DC Signal

![Figure 1. Schematic diagram of DC circuit](image)

1. Construct a series circuit with a 6 V battery, a 100 Ω resistor, and a 470 Ω resistor as shown in Figure 1.
2. Set the Multimeter as DC Voltmeter.
3. Measure the voltage across each resistor and the terminal voltage of the battery. (Refer to Lab #2).
4. **Very carefully** insert Voltage Sensor into analog input A.
5. Open “Oscilloscope Set Up” file from Blackboard (Lab#7 folder)
6. In turns, connect the Voltage sensor’s terminals across each resistor and battery to monitor the voltage.
7. Use the Coordinate Tool (cross wire) to measure each voltage.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Voltmeter</th>
<th>Oscilloscope</th>
<th>% Match (ratio of measurements)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{100,\Omega}$ (V)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{470,\Omega}$ (V)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{\text{batt}}$ (V)</td>
<td></td>
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</tbody>
</table>

**Table 1**: DC Voltage Measurements.
Part# 2: Displaying AC Signal

1. Connect the terminals of the Voltage Sensor to the Frequency Generator

2. Set the Frequency Generator to:
   - 1K
   - Sin function (\(^\sim\))
   - 600Ω impedance

3. Monitor the signal; while monitoring, adjust the frequency with the frequency knob.

4. Describe the difference between AC and DC signals. Include this statement in the abstract.

5. Stop monitoring and measure the MAX value of the voltage with the Coordinate Tool.

6. Enter the measured value in Table 2 and use it to calculate RMS value

7. Measure the period of the signal with the aid of Coordinate Tool.
   \textbf{Hint:} 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 Function Generator Display.

\begin{tabular}{|c|c|c|c|}
  \hline
  Measured Period (s) & Calculated frequency (Hz) & Displayed frequency (Hz) & \% difference \\
  \hline
  \end{tabular}

\textbf{Table 2:} Measured and Calculated values of AC frequency.

10. Use the values of \(V_{\text{max}}\) and calculated frequency to compose a function \(V(t)\) – see the introductory

\[ V(t) = \ldots\ldots\sin (2\pi\ldots t) \]

11. Set the Multimeter as AC Voltmeter.

12. Connect the terminals of the Multimeter to the Frequency Generator

13. Measure the RMS value of the voltage

14. Enter the measured value in Table 3 and use it to calculate MAX value

\begin{tabular}{|c|c|c|c|}
  \hline
  \(V_{\text{batt}}\) (V) & Voltmeter & Oscilloscope & \% difference (measured vs calculated) \\
  \hline
  RMS & & & \\
  MAX & & & \\
  \hline
  \end{tabular}

\textbf{Table 3:} Measured and Calculated values of AC Voltage.
Part# 3: Displaying different AC Signals

1. Monitor the AC signal; while monitoring, adjust the frequency to 100 and then to 10K.
2. Describe how the changes affected the appearance of the graph. Include this statement in the abstract.
3. While monitoring the AC signal (1K frequency), change the shape of the signal to square, and then to triangular shape.
4. Disconnect the Voltage Sensor from the Frequency Generator. 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.