Northeast Community College
Diversified Manufacturing Technology

Alternating Current Lab

PURPOSE:

The following experiment demonstrates fundamental characteristics of a sine wave, provides practice in converting the peak value to a peak to peak value, and gain an understanding of Root mean square (RMS) or effective values.

DISCUSSION/PROCEDURE:

In our laboratory experiments so far, you have used direct current (DC) or current in which travels in only one direction. Direct current is used extensively in electricity and electronic equipment. However, the voltage from your AC outlet is very different. The voltage from your household outlet is typically around 110 volts AC. The letters AC stand for "Alternating Current." In Alternating Current, the voltage and current are constantly changing. A detailed explanation is provided in the following paragraph.

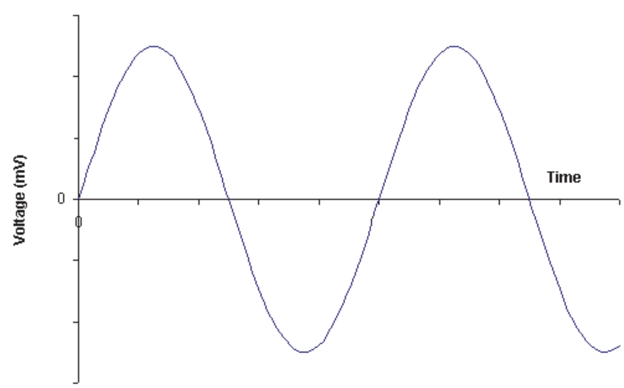

Figure 1

If you plotted AC voltage versus time of a graph, you would end up with the wave shown in figure 1. This waveform is called a sine wave. The vertical axis represents voltage and the horizontal axis represents time. The part of the sine wave that is above the horizontal axis represents a positive voltage. The part of the sine wave that is below the horizontal axis represents a negative voltage. When the voltage switches from positive to negative, the current also switches direction. Note that the part of the wave form below the horizontal axis is the mirror image of the part of the wave form above the horizontal line.

If you plotted the amplitude of current vs. time on a graph, you would have the sine wave shown in figure two. In figure two, I assumed the peak current to be 1 ampere. The complete movement of voltage is called a cycle.

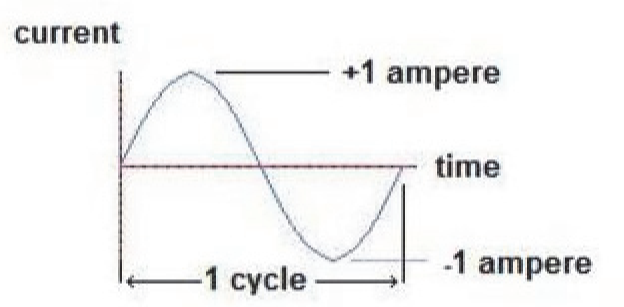

Figure 2

The amount of time required for a waveform, or a series of events that is repeated at regular intervals of time, to complete one cycle is called the period of the wave.

The number of cycles that occur in a unit of time are called the frequency. Frequency is express in hertz (Hz). The frequency of the sine wave is the number of cycles in one second.

For example: If one cycle takes 0.2 seconds to complete, then the frequency is:

Frequency = cycles/second = 1/ (seconds/cycle)
cycles per second = 1 second/ (0.2 seconds/cycle) = 5 cycles per second

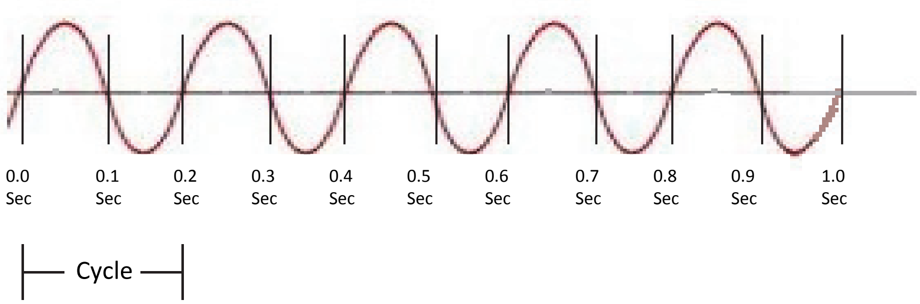

Figure 3

The time required to complete a single cycle is known as the period. In this case, the period is 0.2 seconds.

The period of a waveform = 1/frequency.

period = 1/frequency = 1/ (5 cycles per second) = 0.2 seconds

1. Define “period” as applied to an AC waveform. ____

2. Define “frequency” as applied to an AC waveform. ____

3. What is the period of a sine wave that has a frequency of 500 hertz?

4. Sine wave in Figure 4 below has a period of 0.002 second. What is the frequency? ______________

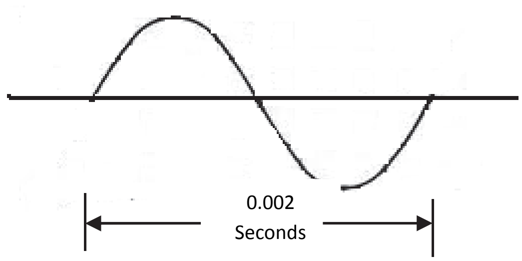

Figure 4

5. What is the frequency of waveform in Figure 5? ______________________________

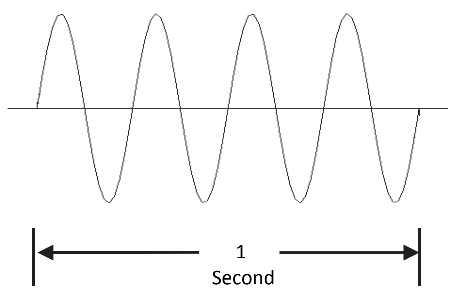

Figure 5

All waveforms are not sine waves. The sine wave is the basic waveform and all complex waves are composed of sine waves having different frequencies and amplitudes. A sine wave has its own unique characteristics.

The maximum instantaneous voltage of a sine wave is called the peak value (Vpk). The complete swing between the maximum positive and maximum negative is the peak to peak value (Vp-p).

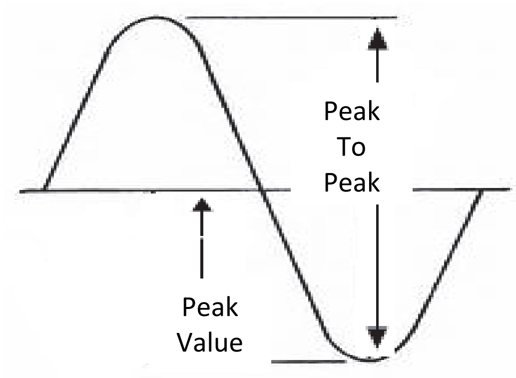

Figure 6

As you can see in Figure 6, the peak to peak value is twice the peak value.

Peak to Peak Value (Vp-p) = Peak Value (Vpk) x 2

Peak Value (Vpk) = Peak to Peak Value (Vp-p)/2

When measuring the peak voltage, a special peak to peak AC voltmeter is required. If one is not available, you can simply complete a simple calculation to convert the voltage (known as the RMS or effective voltage) reading of a regular AC voltmeter to peak voltage.

Peak Voltage (Vpk) = Effective Voltage (Vrms) x 1.414

This means that the peak voltage can be determined by multiplying the RMS value by 1.414. Peak to peak values can then be determined by multiplying the peak voltage by 2, as previously discussed. The average value of a basic sign wave is zero because the positive and negative alterations have equal amplitudes.

The majority of meters used to measure AC voltage are calibrated to display the effective (RMS) voltage. You therefore need to complete the calculation.

Note: the **root mean square** (abbreviated **RMS** or **rms**), is a statistical measure of the magnitude of a varying quantity. In the case of a circuit, the effective voltage would be the same as the voltage applied by the power source.

6. Using the PHET AC Circuit Simulation set up the circuit as shown in Figure 7.

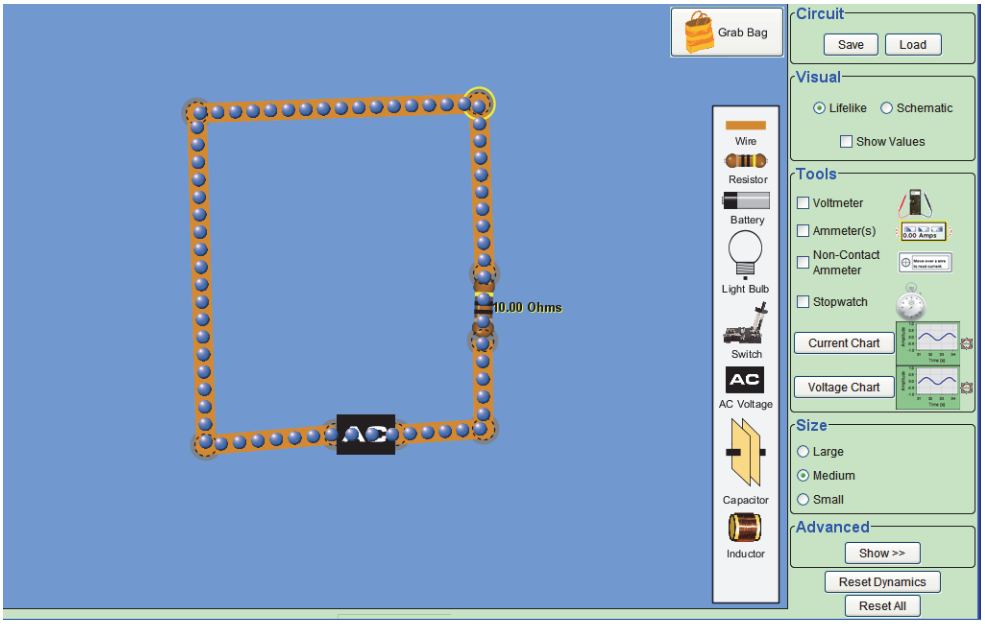

Figure 7

7. What would happen to this circuit if the resistor were removed?

8. Explain your answer to question 7.

9. Next select the Current Chart and the Voltage Chart and place the measuring leads from each device in the circuit as shown in figure 8.

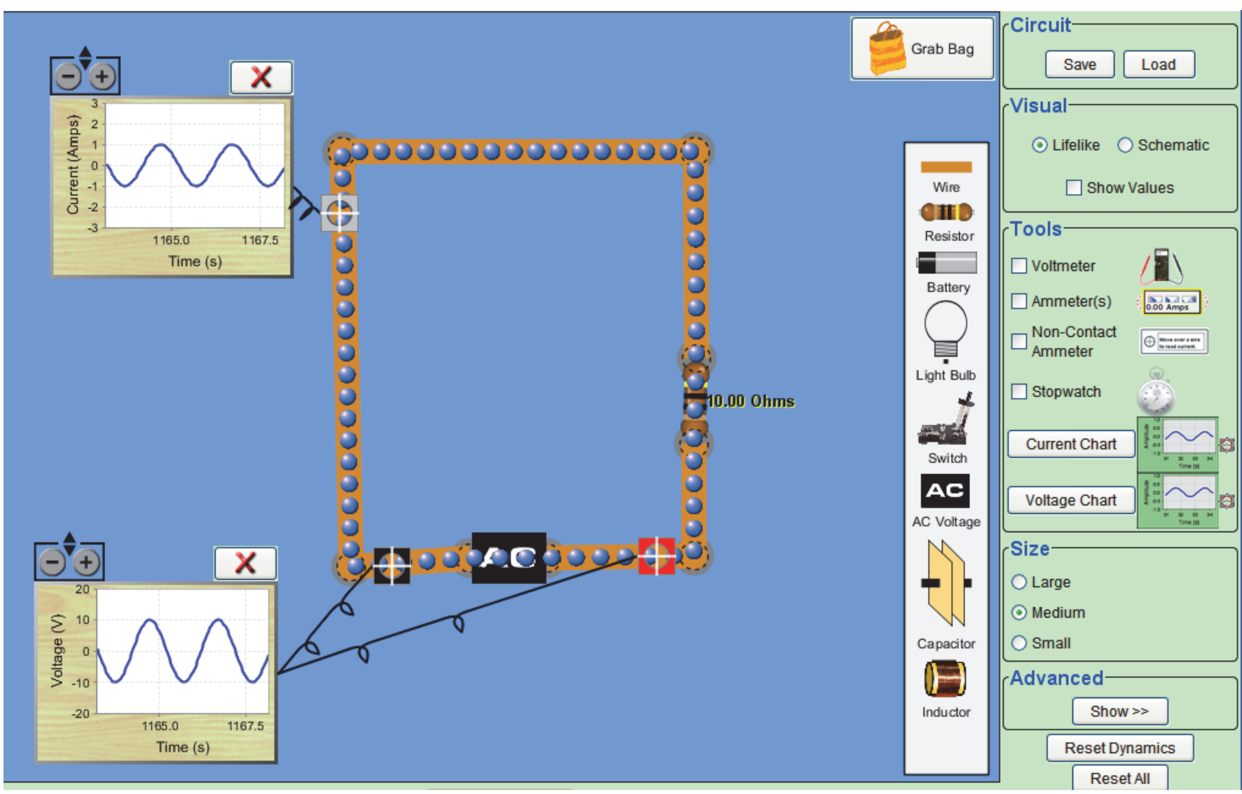

Figure 8

10. Read the voltage across the AC Voltage block using the voltmeter. You will have to select the voltmeter from the tools list on the right side of the simulation screen.

11. Does the voltage on the voltage chart and the voltage on the voltmeter match. _________

12. Change the resistance across the AC Voltage course by right clicking on the AC Voltage block and increasing the resistance to 2.25.

13. How did increasing resistance in AC circuit affect the voltage?

14. How did increasing the resistance in an AC circuit affect the current? If you have difficulty in reading the chart, you can insert the ammeter in the circuit.

15. How does changes in resistance in AC circuits compare to DC circuits in terms of voltage and current? You can test your theory by replacing the AC Voltage with a 10 volt battery. You will have to set your battery voltage and internal resistance by right clicking the battery and selecting the correct settings.

16. With the AC Voltage source in place, reset the internal resistance to 0. Increase the voltage to 20, to 30, to 40, to 50. You may need to adjust the charts by clicking on the "-"sign so that the entire waveform is visible.

17. How does increasing the voltage in an AC circuit affect the current?

18. With the voltage reset to 10, increase the frequency from 0.5 to 1.0, to 1.5, to 20. How does the change in frequency affect voltage and current?

19. How does the change in frequency affect the flow of electrons?

20. Based upon the laboratory discussion(s), calculate the peak value of a sine wave with a peak-to-peak voltage of 120 volts of alternating current (AC)? ____

21. Bases upon the laboratory discussion (s), calculate the peak-to-peak value of a sine wave with a peak voltage of 80 volts of alternating current (AC)?

22. Calculate the peak-to-peak value of a sine wave with an effective voltage (RMS voltage) of 120 volts of alternating current (AC).

23. What is the average value, in volts, of a complete sine wave with equal amplitude for each of the positive and negative alterations?

The alternating voltages and currents are usually expressed in RMS or effective values. Unless otherwise noted, an AC value is considered to be the RMS value. The AC voltage in the power lines in our homes is rated at 110-120 volts. This means the effective voltage (RMS voltage) to our homes would be 110-120 volts.

In a more practical sense, the RMS voltage is the amount of heat that can be generated. Thus the RMS voltage or current produces the same amount of heat as a direct current voltage and current electrical stream.

The effective (RMS) value can be determined by multiplying the peak value (Vpk) by 0.707.

Vrms = Vpk x 0.707

When the effective (RMS) value is known, the peak value can be determined by:

Vpk = Vrms/0.707   or Vpk = Vrms x 1.414.

Here is an example:

A peak to peak AC voltmeter shows a reading of 50 volts. Solve for the RMS value.

From our earlier discussions, you know:

Peak Value (Vpk) = Peak to Peak Value (Vp-p)/2, so
Vpk = 50/2
Vpk = 25

You also know:

Vrms = Vpk x 0.707, so
Vrms = 25 x 0.707
Vrms = 17.68 volts

The average voltage or current of a complete AC cycle is zero. The average amplitude of only one alternation (Figure 9) is 0.636 of the peak amplitude.

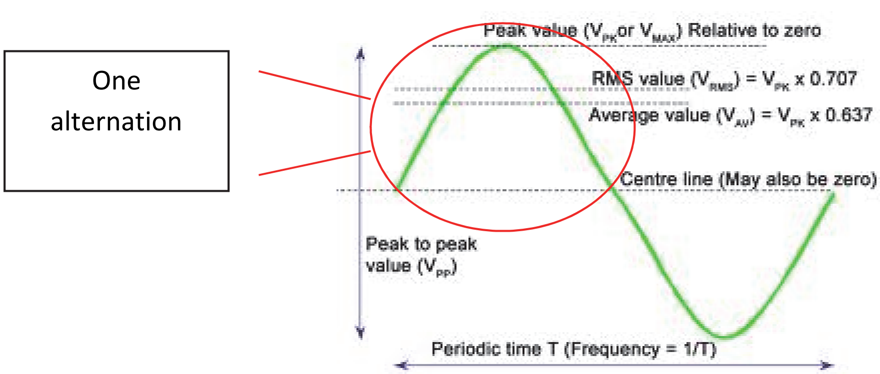

Figure 9
Figure 9 Source: Learnabout-electronics.org

$$V_{avg} = V_{pk} \times 0.636.$$

When the average value is known, the peak value can be determined by

$$V_{pk} = V_{avg} \times 1.57$$

The relationship between the effective voltage (RMS) and the average voltage is as follows.

$$V_{rms} = V_{avg} \times 1.11$$

$$V_{avg} = V_{rms} \times 0.9$$

When you are talking about average voltage in alternating current, the average voltage is assumed to be of only one alternation, not a complete sine wave. As mentioned earlier, the average value of a complete sine wave is zero.

24. What is the effective voltage (Vrms) of a sine wave that has been measured as being 160 volts peak-to-peak?

25. What is the average voltage (Vavg) of a sine wave that has been measure as being 160 volts peak-to-peak?

26. If the average voltage of a sine wave is measured at 10.8 volts what is effective voltage (Vrms).

27. A sine wave was measured by an AC voltmeter as having an amplitude of 12 volts RMS. What is it peak to peak value?

Resources:

1. Learnabout-electronics.org (n.d.). Sine Wave Peak Voltage. Retrieved from http://www.bing.com/images/search?q=Peak+to+Peak+Value&view=detailv2&&id=8DA4EB89D0F569463C4758FDFFB0DEF3035D8367&selectedIndex=5&ccid=JxCjvh18&simid=608008383454317307&thid=OIP.M2710a3be1d7c170a601bae82b299afcao0&ajaxhist=0

2. University of Colorado Boulder (n.d.). PhET - Circuit Construction Kit.

Founded in 2002 by Nobel Laureate Carl Wieman, the PhET Interactive Simulations project at the University of Colorado Boulder creates free interactive math and science simulations. PhET sims are based on extensive education research and engage students through an intuitive, game-like environment where students learn through exploration and discovery.

3. Grant Statement

This document was developed as part of Trade Adjustment Assistance Community College and Career Training (TAACCCT) Grant Program Round 2 Grant, Innovations Moving People to Achieve Certified Training (IMPACT): TC-23752-12-60-A-31.