Lab Experiments for AC Circuits

Wayne M. Hope

Formulations Media Inc
Edmonton / Alberta / Canada

Cover Art Created By

Brian Dyke

Library and Archives Canada Cataloguing in Publication

Hope, Wayne M., 1944-
Lab experiments for AC circuits / Wayne M. Hope.

ISBN 978-1-894848-13-8

1. Electric circuits--Alternating current--Laboratory manuals.
2. Electronic circuits--Laboratory manuals. I. Title.

TK7818.H6752 2009 621.3815078 C2009-902486-1

ISBN: 9781894848138

Created and Printed in Canada

Table of Contents

1 Oscilloscope Voltage Measurements

Objectives

1. To measure peak to peak voltages with an oscilloscope.
2. To convert peak to peak voltage measurements into RMS measurements.
3. To measure dc voltages with an oscilloscope.
4. To measure combined dc and ac voltages with an oscilloscope.
5. To operate vertically-related oscilloscope controls.

Equipment

Dual trace oscilloscope with x 1 and x 10 probes, dc power supply
Sinewave oscillator or waveform generator, ac voltmeter
1/4 W resistors: 15 kΩ 27 kΩ 56 kΩ

Information

Voltage measurement with a scope is concerned with the vertical deflection of the display, although the settings of some horizontal controls can affect the ease and accuracy of the resulting vertical measurements.

Vertical measurements are most often made in units of peak to peak volts, and expressed, for example, as 33.0 Vpp. The measurement is accomplished by measuring the vertical deflection of the waveform from one peak to the other, in units of "divisions peak to peak." This vertical distance is then multiplied by the vertical sensitivity, which is in units of "volts per division." When divisions peak to peak is multiplied by volts per division, the resulting number has units of "volts peak to peak," since the division terms cancel. An example is shown on the next page and illustrated in Figure 1-1.

Example: 6.60 divisions peak to peak x 5 V / division = 33.0 volts peak to peak = 33.0 Vpp

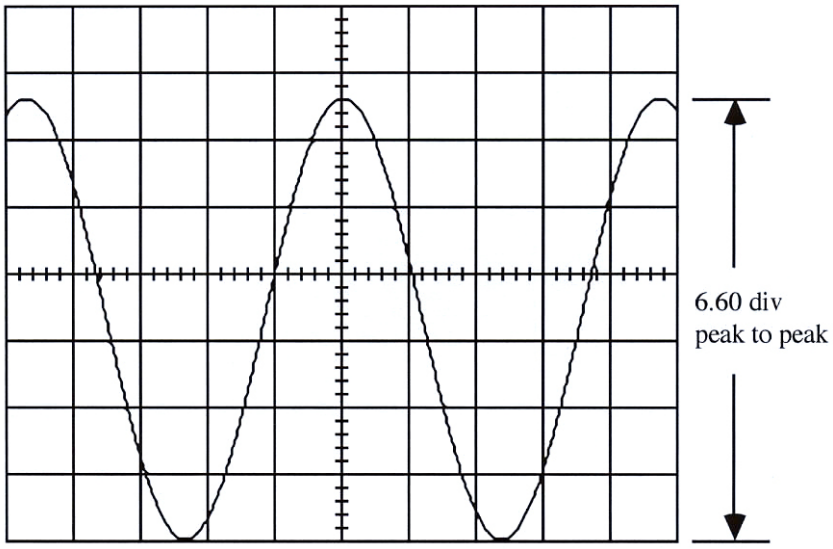


Figure 1-1. Oscilloscope Voltage Measurement

The resulting measurement can now be converted into peak volts by dividing by two, therefore 33.0 Vpp is equal to 16.5 Vp. This peak voltage can be converted to RMS voltage by dividing by √2, or 1.41, which calculates to 11.7 V. These are all the same voltages, they are only expressed differently, thus, 33.0 Vpp = 16.5 Vp = 11.7 V.

Some users prefer measuring peak voltage. This can be accomplished by measuring the number of peak divisions from the vertical centre of the waveform to either peak, then multiplying by volts per division, resulting in units of volts peak. In the case of Figure 1-1, this would demand that the user position the waveform in the centre of the screen vertically.

DC voltages can also be measured with a scope. A dc voltage appears as a horizontal line on the scope, since the voltage does not vary with time. To measure a dc voltage, first position the trace to a convenient horizontal graticule line as a reference with vertical COUPLING set to 0, then switch the COUPLING to DC, measure the vertical displacement of the line, and multiply by the vertical sensitivity. Combined dc and ac voltages can also be measured in this fashion.

When the VERT MODE is set to BOTH, two waveforms may be measured independently of each other, and their settings of the VOLTS/DIV switches can be different from each other.

Two independent waveforms can be added algebraically by setting VERT MODE to ADD and the POLARITY on CH 2 to NORM; this is often referred to as “CH 1 + CH 2.” Two waveforms can also be subtracted by setting VERT MODE to ADD and the POLARITY on CH 2 to INV; this is often referred to as “CH 1 - CH 2.” When either of these functions are used, it is important to realize that the settings of the VOLTS/DIV switch on each channel must be identical in order to have meaningful results.

Note that the use of a MAGNIFIER switch increases the vertical sensitivity and will enlarge the display. As an example, a vertical setting of 200 mV/DIV combined with a x10 MAGNIFIER setting, results in a vertical sensitivity of 20 mV/DIV.

Lab Prep

1. For the scope display shown in Figure 1-2, determine the voltages required in Table 1-1. Record your answers on the Prep Sheet as well.

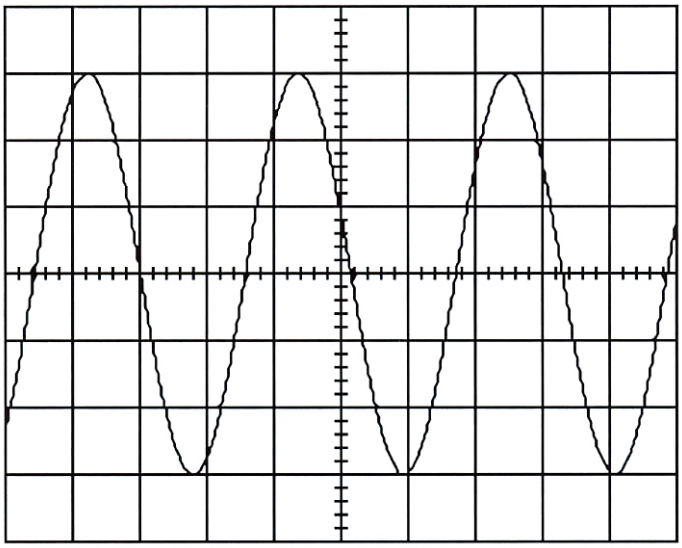


Figure 1-2. Oscilloscope Display

Table 1-1. Scope Readings

VOLTS/DIV MAGNIFIER	0.2 V/DIV x 1	5 V/DIV x 10	10 mV/DIV x 1	20 V/DIV x 10
Desired Measurement	Peak to Peak Voltage	RMS Voltage	Peak Voltage	Peak to Peak Voltage
Measurement				

2. For the scope display shown in Figure 1-3, determine the voltages required in Table 1-2. Record your answers on the Prep Sheet as well.

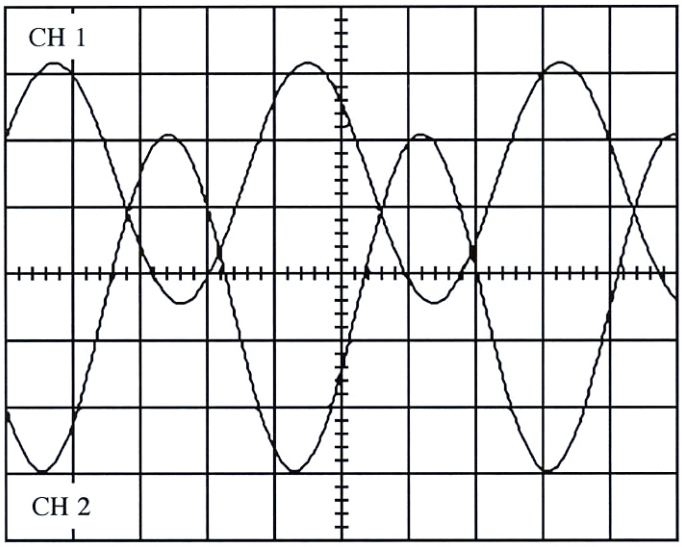


Figure 1-3. Oscilloscope Display

Table 1-2. Scope Readings

MODE VOLTS/DIV MAGNIFIER	CH 1 0.1 V/DIV x 1	CH 2 20 mV/DIV x 10	CH 1 10 V/DIV x 10	CH 2 0.5 V/DIV x 1
Desired Measurement	Peak Voltage	Peak to Peak Voltage	RMS Voltage	Peak to Peak Voltage
Measurement				

Procedure

Oscilloscope AC Voltage Measurements

1. Use an ac voltmeter to set your sinusoidal output of the signal generator to 3.0 V at a frequency of 1.0 kHz. (Remember that 3.0 V, in the context of AC, means 3.0 VRMS)

2. Measure the peak to peak voltage of the generator with each channel, one at a time, of your scope. Record your measurements in Table 1-3.

3. Using your peak to peak measurements, calculate the RMS value of each measurement for Table 1-3.

Table 1-3. Generator Measurements and Calculations

CH 1 Measured	CH 2 Measured	CH 1 Calculated	CH 2 Calculated

4. Connect the circuit of Figure 1-4, grounding one side of the generator. After the circuit is connected, use the scope to set the generator to 8.0 Vpp at a frequency of 2.0 kHz.

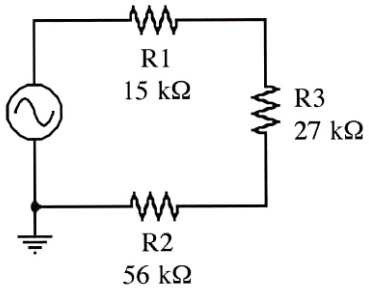


Figure 1-4. Series Circuit Measurements

5. With the resistors fixed in their positions in the circuit, measure the peak to peak voltage across each resistor and record in Table 1-4. Note that this will cause some erroneous measurements because the ground leads will not always be in the same place. This is intentional.

6. Repeat the resistor voltage measurements, but this time move the resistors around such that when each resistor's voltage is measured, it is in the location of R2 in Figure 1-4 Keep both the generator and the scope ground leads together. Record in Table 1-4.

Table 1-4. Oscilloscope Measurements

Resistors	Scope voltages with resistors fixed	Scope voltages moving resistors
R1		
R2		
R3		

Oscilloscope DC Voltage Measurements

7. With no input connected, adjust the scope for a horizontal trace centered vertically on the graticule. Set the vertical sensitivity at 2 V/DIV, and the COUPLING to DC.

8. Connect a dc power supply, set to about 5 V, to the scope input and observe the vertical movement of the scope trace. Measure the dc voltage with the scope and assure that it agrees with the setting of the power supply. Confirm the voltage measurement with a dc meter if you wish.

9. Reverse the scope connections to the power supply and observe that the vertical movement of the scope trace is opposite to that observed in step 8.

10. Switch the COUPLING from DC to the AC position and observe the results.

Oscilloscope Combined DC and AC Voltage Measurements

11. Set the scope to a vertical sensitivity of 1.0 V/DIV, with the trace centered 2 divisions below the centre of the graticule, and the VERTICAL COUPLING set to DC. Connect the circuit of Figure 1-5.

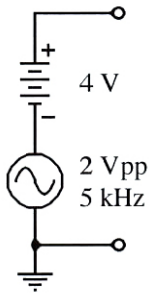


Figure 1-5. Combined DC and AC

12. Connect the scope input to the circuit of Figure 1-5 and draw the observed waveform on the graticule provided in step 3 of the Data Sheet.

13. Switch the COUPLING from DC to the AC position and draw the observed waveform on the graticule provided in step 4 of the Data Sheet.

Other Oscilloscope Measurements

14. If your oscilloscope is not equipped with two vertical inputs, omit this portion of the procedure.

15. Set your signal generator to 6 Vpp at a frequency of 10 kHz.

16. Set both scope vertical sensitivities to 2 V/DIV, and set the POSITION controls so that channel 1 is 2 divisions above the centre of the graticule and channel 2 is 2 divisions below the centre.

17. Connect both scope inputs to the generator. Set the VERT MODE switch to the BOTH function, and observe the positions and sizes of the waveforms.

18. Try changing the VOLTS/DIV and position controls for each channel to observe that they are independent of each other, then return the settings to that described in step 15.

19. Switch the VERT MODE to the ADD function, with the POLARITY on the NORM position, and measure the resulting waveform to assure yourself that it is 12 Vpp, the sum of the two signals.

20. Switch the POLARITY to the INV position, and observe the resulting waveform. It should be 0 Vpp, the difference between the two signals.

21. Switch back to the BOTH function. Set the VOLTS/DIV on CH 1 to 20 V/DIV and the channel 1 magnifier to its x 10 position. The observed channel 1 waveform should still be the same as the channel 2 waveform.

Oscilloscope Probes

22. Refer to the Operator's Manual for your particular scope to learn the operation of whatever probes you have available at your lab station.

23. Study the front panel controls of your vertical sections of your scope and determine how you can tell which VOLTS/DIV setting you are supposed to read when a x 10 probe is connected, or when a x 1 probe is connected.

24. If a square wave signal is available, your instructor may wish to have you learn how to compensate your z 10 probe at this time.

1 Prep Sheet Name

1. Complete the data required for Table 1-1 below.

VOLTS/DIV MAGNIFIER	0.2 V/DIV x 1	5 V/DIV x 10	10 mV/DIV x 1	20 V/DIV x 10
Desired Measurement	Peak to Peak Voltage	RMS Voltage	Peak Voltage	Peak to Peak Voltage
Measurement				

2. Complete the data required for Table 1-2 below.

MODE VOLTS/DIV MAGNIFIER	CH 1 0.1 V/DIV x 1	CH 2 20 mV/DIV x 10	CH 1 10 V/DIV x 10	CH 2 0.5 V/DIV x 1
Desired Measurement	Peak Voltage	Peak to Peak Voltage	RMS Voltage	Peak to Peak Voltage
Measurement				

1 Data Sheet Name

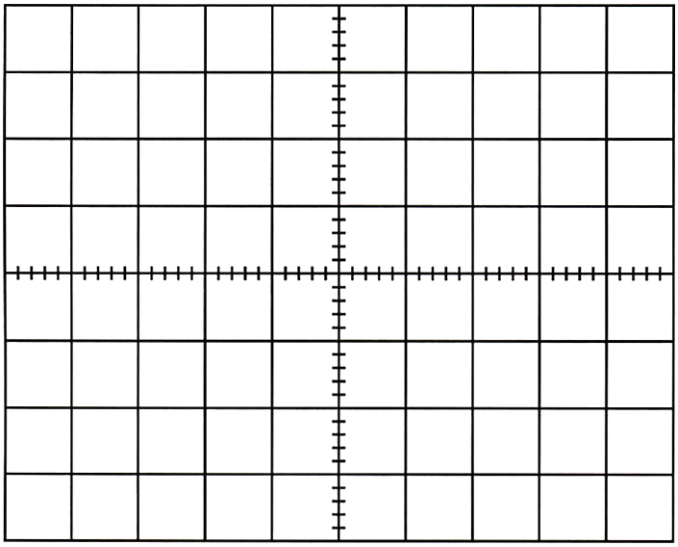
1. Complete the data required for Table 1-3 below.

CH 1 Measured	CH 2 Measured	CH 1 Calculated	CH 2 Calculated

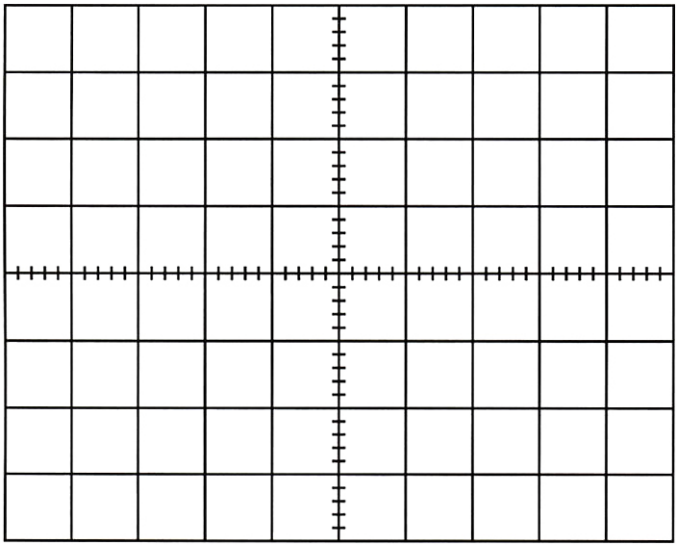
2. Complete the data required for Table 1-4 below.

Resistors	Scope voltages with resistors fixed	Scope voltages moving resistors
R1		
R2		
R3		

3. Draw the waveform observed in step 12 of the procedure on the graticule provided below.



4. Draw the waveform observed in step 13 of the procedure on the graticule provided below.



Questions

1. For your particular scope, describe how you determine which VOLTS/DIV setting to read when you are using a x 10 probe.

2. Describe the effect that the various positions of the vertical COUPLING control will have on a combined dc and ac signal.