Oscilloscope Introduction, Part 2—Lab 4

M.V. Iordache, *EEGR2051 Circuits and Measurements Lab*, Fall 2020, LeTourneau University

See https://mviordache.name/EEGR2051 for more information.

Name: ____ **Date:** ___________ **Section:** ___

EEGR-2051 OSCILLOSCOPE INTRODUCTION – PART 2

Equipment:

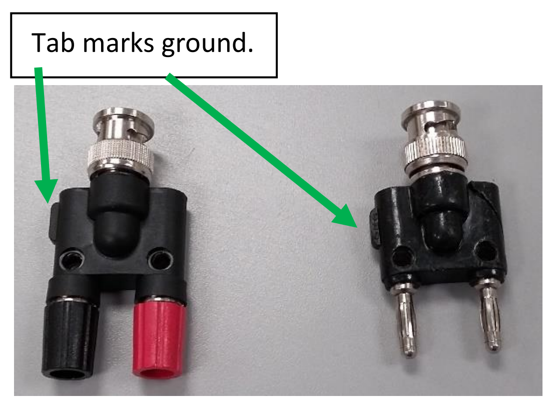
1. One oscilloscope
2. One waveform generator and one DC power supply.
3. One digital multimeter (DMM).
4. One 3.3 $k\Omega$ resistor (or nearest available value).
5. One resistor within the range 10 ... 20 Ω.
6. One 0.33 μF capacitor.

Reference: Student Reference Manual, Chapters 3 and 6.

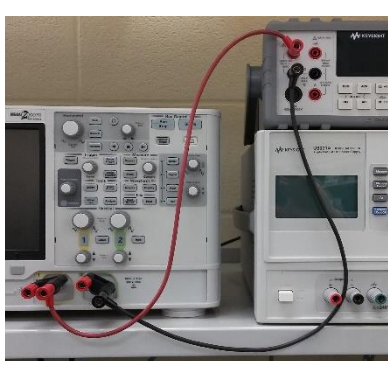
Procedure:

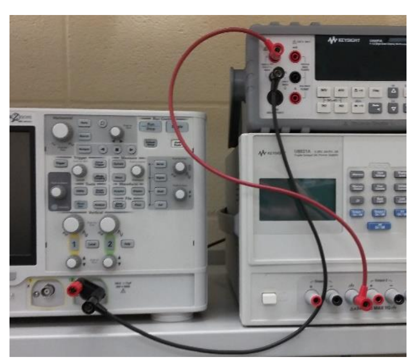
1. **Grounding:** Most lab instruments have terminals connected to the ground terminal of the wall outlet. We say that a terminal is connected to ground or is a ground terminal if it is connected to the ground terminal of the wall outlet.
2. Typically, the BNC jacks on the front panel of an instrument are connected to ground. Specifically, the shield of the BNC jack (that is, the outer metal part of the jack) is the ground terminal.

3. A ground terminal may appear also in the form of a green or black banana jack. A ground terminal is marked with the abbreviation GND or with the symbol ⏚.
4. Obtain two adaptors allowing to connect banana plugs to a BNC jack. You may use any of the adaptors shown in the picture. Note the position of the GND terminals.



5. The following steps will verify that the GND terminals of the oscilloscope and DC power supply are connected to earth GND.
6. To this end, it is not necessary to turn ON the oscilloscope or the DC power supply. As long as an instrument is plugged into the wall outlet, it is connected to earth GND, regardless whether it is ON or OFF.
7. Connect one adaptor to channel 1 (CH1) of the oscilloscope and the other to CH2.
8. Use a DMM to measure the resistance between the GND terminal of CH1 and the GND terminal of CH2. $R =$ ____________________
9. Measure also the resistance between the GND terminal of the DC power supply (the green terminal) and the GND terminal of CH1 of the oscilloscope. $R =$ ____________________

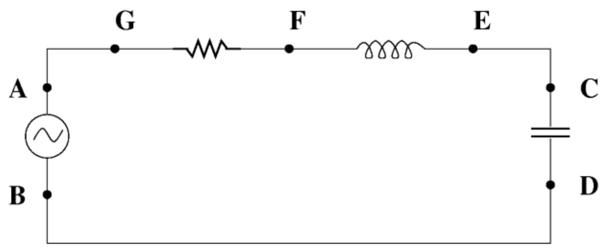




10. What is the expected value of the resistance if the DC power supply is disconnected from the wall outlet? $R =$ ____________________
11. Not all instruments are grounded. Verify that the common (black) terminal of a multimeter is not connected to earth ground by measuring the resistance between the common terminal and a ground terminal of the oscilloscope. $R =$ ____________________
12. Ground connections cannot be ignored. *Grounding errors result in wrong measurements and may damage equipment.*

    Any two points of a circuit that are not supposed be connected directly, may not be both connected to ground.

13. Consider the following circuit. Fill in the blanks.



If B is the GND terminal of the source, connecting a GND terminal of the oscilloscope to A is wrong, because A and B are not connected directly in the circuit.

If B is the GND terminal of the source, connecting a GND terminal of the oscilloscope to D is correct, since B and D are already connected.

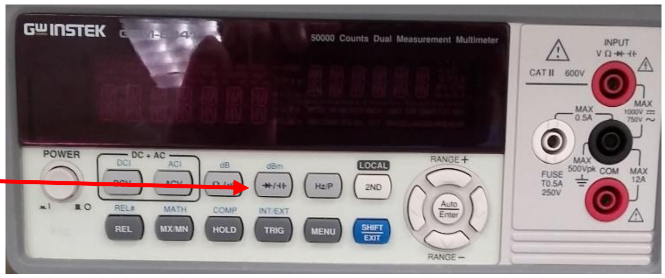
If A is the GND terminal of the source, connecting a GND terminal of the oscilloscope to D is wrong, since A and D are not connected directly in the circuit.

If A is the GND terminal of the source, connecting a GND terminal of the oscilloscope to F is ____.

If A is the GND terminal of the source, connecting a GND terminal of the oscilloscope to G is ____.

If B is the GND terminal of the source, connecting a GND terminal of the oscilloscope to F is ____.

14. Measure the 3.3 $k\Omega$ resistor to find its exact value. $R =$ ___________
15. Locate a GW INSTEK multimeter and find the exact value of the 0.33 μF capacitor.
    a. Connect the capacitor between the common (black) terminal of the DMM and the terminal marked with the capacitor symbol (the top red terminal).
    b. Press once the button for diode/capacitor measurements.
    c. Press one more time the button to select capacitor measurements.

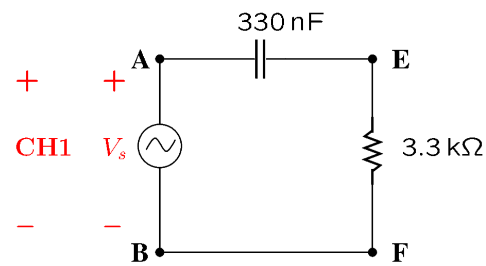


d. Read the capacitor value: $C =$ ________

16. Connect a T-connector to the *Output* BNC connector of the waveform generator. This will allow connecting both the oscilloscope and the waveform generator to the following circuit.

17. Note the position of the ground terminal of BNC adapters.

18. Connect the circuit shown in the figure.



   a. It is good practice to use coaxial cables when possible. This will reduce electric "noise".
   b. Both channel 1 (CH1) of the oscilloscope and the waveform generator should be connected.
   c. Note that + represents the signal terminal and – the GND terminal.
   d. Set the waveform generator to a zero-mean sinewave of 250 Hz and 6V peak-to-peak.
      i. Press *Channel*, select *Load*, and then *HiZ*. (In this way, the instrument will assume a high resistance load.)
      ii. Press *Parameters*, and then set the frequency and the amplitude.
      iii. To turn on the output, press *Channel*, and then set *Output* to ON.

19. Set the horizontal sensitivity control of the oscilloscope to 0.5 ms/div.

20. Measure with the oscilloscope the time from one positive peak of the sinewave to the next positive peak. $T =$ _________.
    Theoretically, for a 250 Hz sinewave, what should this time be? ___________

21. Measure the peak-to-peak voltage of the source with the oscilloscope. $V_s =$ ____________

22. Indicate what a DMM measures in DC mode: (a) average; (b) rms; (c) peak amplitude; (d) peak-to-peak amplitude.

23. Indicate what a DMM measures in AC mode: (a) average; (b) rms; (c) peak amplitude; (d) peak-to-peak amplitude.

24. Without disconnecting the circuit, measure the voltage of the source with a DMM.
    In AC mode, the DMM indicates a voltage of ____________.
    In DC mode, the DMM indicates a voltage of ____________.

25. Explain why the DMM measurements are consistent with the oscilloscope measurement.
    ____
    ____

26. Connect CH2 of the oscilloscope to the resistor. The circuit should have:
   a. CH1 connected to the source.
   b. CH2 connected to the resistor.

27. Where should the GND terminal of CH2 be connected, to point E or to point F?
    ____

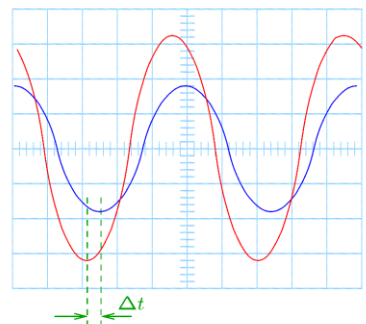
28. Display both the source voltage and the resistor voltage on the oscilloscope. The resistor waveform should be smaller and with a significant phase difference. If this is not the case:
   a. Check the values of the resistor and capacitor.
   b. Check the frequency of the waveform generator.

29. Determine the peak-to-peak value of the resistor voltage. $V_R =$ ____________
30. Is the resistor voltage leading or lagging the source voltage, and how can you tell it?
____
____
____

31. Disconnect the oscilloscope from the circuit and measure the resistor voltage with the DMM. $V_R =$ ____________. Is this measurement consistent with the oscilloscope measurement?
____

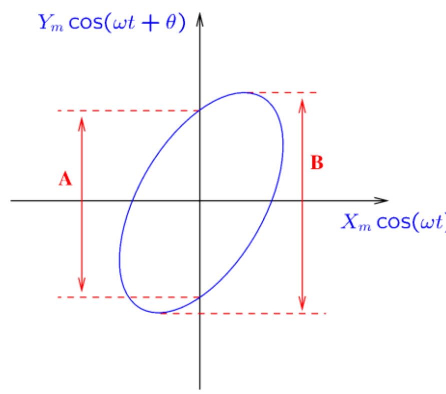
If the measurements are inconsistent, check grounding connections and redo the measurements.

32. Reconnect the oscilloscope to the circuit.
33. Measure the phase angle of the resistor voltage using the formula $\theta = 360\frac{\Delta t}{T}$ where Δt is the horizontal shift between the two waveforms and T is the period.
    a. To obtain accurate measurements of Δt and T, press *Cursors*.
    b. Set *Mode* to *Manual*.
    c. There are two vertical cursors $X1$ and $X2$ that can be positioned in order to determine time accurately. The oscilloscope displays $\Delta X = X2 - X1$ to the right.
    d. Use the middle soft key to set *Cursors* to $X1$ or $X2$.
    e. Position $X1$ and $X2$ to the desired location, and then record ΔX.



$\Delta t =$ _____ $T =$ ______ $\theta =$ ___________ degrees

34. Measure the phase angle with the Lissajous pattern method.
    a. To enter the XY mode, press *Horiz* to select the horizontal menu, and then set *Time Mode* to *XY*.
    b. Calculate the angle with the formula $\theta = \pm \sin^{-1}\left(\frac{A}{B}\right)$.



A = _______ B = _______

$\theta =$__________ degrees

35. To leave the XY mode, select the horizontal menu, and then set *Time Mode* to *Normal*.
36. Assume that the capacitor voltage and the source voltage should be compared on the oscilloscope. To visualize the two voltages at the same time, the positions of the capacitor and resistor should be interchanged. Why? ____
37. Interchange the positions of the capacitor and resistor.
38. Measure the peak-to-peak voltage of the capacitor. $V_c =$ _______
39. Disconnect the oscilloscope and measure the capacitor voltage with the multimeter. $V_c =$ _______. Are the results consistent? ______________________________________

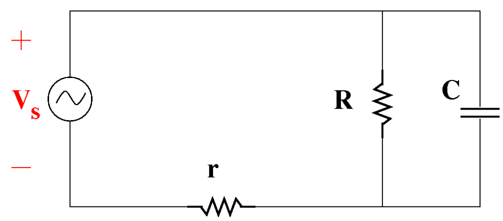
40. Reconnect the oscilloscope. Is the capacitor voltage leading or lagging the source voltage, and how can you tell it?
____
____

41. Measure the phase angle of the capacitor voltage. Angle = __________.

42. While the oscilloscope displays voltage waveforms, current waveforms can also be displayed by converting current to voltage. The simplest way to do this is with a resistor. A resistor of value r will convert a current i to a voltage $v = i \cdot r$ that is proportional to the current and has exactly the same phase as the current. To display the waveform of an unknown current i_x, the resistor will be placed on the current path, and then its voltage will be displayed. To ensure that the resistor will not change considerably the current that is measured, the value of the resistor must be small. A resistor used to sense current is called *sensing resistor*.

43. Obtain a resistor with a value within the range 10 ... 20 Ω. Measure its value: r = _______

44. Connect the 3.3 $k\Omega$ resistor and the capacitor in parallel to the source of voltage. To obtain the waveform of the source current, connect the sensing resistor on its current path (see below).



45. In the figure above, mark the position of the + and – terminals of CH1 and CH2 for which CH1 displays the source voltage and CH2 the sensing resistor voltage.
46. Connect CH1 and CH2 to measure the source voltage and the sensing resistor voltage.
47. Reduce the Volts/div setting of CH2 to the lowest value for which the waveform fits on the screen.
48. Determine the phase angle of the current. Phase angle _________.
    Which is leading, the source voltage or the current? ______________________
49. Assume that the 3.3 $k\Omega$ resistor and the capacitor are in parallel to the source of voltage. Where would you place the sensing resistor to measure the capacitor current? Sketch the schematics, indicating also the position of the + and – terminals of CH1 and CH2.

50. Determine the phase angle of the capacitor current. Phase angle _________.
    Which is leading, the source voltage or the capacitor current? ______________________