# Oscilloscope Introduction—Lab 3

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

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EEGR 2051 OSCILLOSCOPE INTRODUCTION

Objectives:

1. Learn the basics of oscilloscopes and waveform generators.
2. Perform amplitude and time measurements with the oscilloscope.
3. Measure RMS voltages and currents.

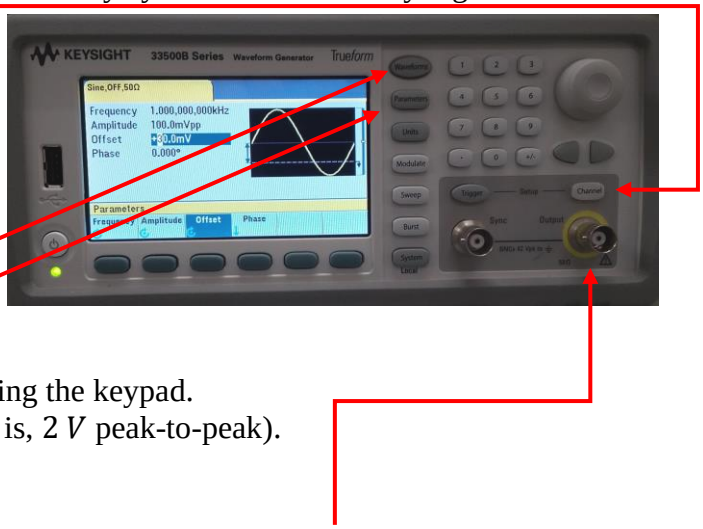
Equipment:

1. One Oscilloscope.
2. One Waveform Generator
3. One DC Power Supply
4. Digital Multimeters (DMMs)
5. Miscellaneous components from the student kit.

Reference: Student Reference Manual, Chapters 6 and 12.

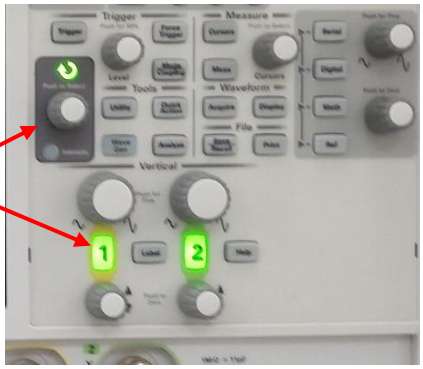
Procedure:

1. Turn on the waveform generator.
2. Wait until initialization completes.
3. In the following steps you will program the waveform generator to output a square wave of 2 $V_{pp}$ amplitude, 500 mV offset, 500 Hz frequency, and 50% duty cycle on a load of very high resistance.
    a. Press the *Channel* button, select *Output Load*, and then *Set to High Z* to specify a load of high resistance. Since output voltage is load dependent, this step is necessary to ensure that the amplitude will be right when the generator is connected to a load of high resistance.
    b. Press the *Waveform* button and select a *Square wave*.
    c. Press the *Parameters* button.
        i. Select *Frequency* and type 500 Hz using the keypad.
        ii. Select *Amplitude* and type 2 $V_{pp}$ (that is, 2 $V$ peak-to-peak).
        iii. Select *Offset* and type 500 $mV$.
        iv. Select *Duty* and type 50%.
    d. Press the *Channel* button and then *Output*. This will turn ON the *Output* BNC connector. The specified waveform appears now on this BNC connector.




4. Turn on the oscilloscope.
5. Wait until initialization completes.
6. Locate the *Back* button in the lower left corner of the oscilloscope.
7. Locate the *Default Setup* button close to the upper right corner.
8. Press *Default Setup*; select *Factory Default*, then *OK*.
9. In the following steps you will transmit the signal of the generator to the oscilloscope without change. However, by default the oscilloscope assumes a signal divided by a factor of 10. Therefore, the probe setting of the oscilloscope will have to be adjusted.

10. Adjust the probe setting as follows.
    a. Press the 1 button of the oscilloscope to select the channel 1 menu.
    b. Select *Probe*.
    c. Select *Probe* again.
    d. Locate the control marked by a lit green curved arrow.
    e. Turn the control until the probe setting is changed to 1.00:1.

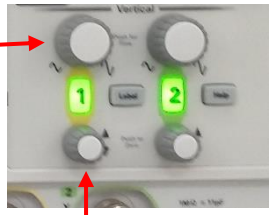


11. After this step, the oscilloscope should display a 1.00:1 ratio for channel 1 and a 10.0:1 ratio for channel 2.

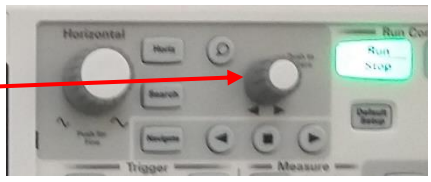
12. To connect the waveform generator and the oscilloscope.
    a. Find a BNC to BNC cable.
    b. Push gently the BNC connector of the cable into the jack of the *Output* terminal of the waveform generator. Rotate gently the metal shell of the plug until the connection is secured.
    c. Connect the other end of the cable to the channel 1 (X) input of the oscilloscope.

13. Locate the Horizontal control at the top of the front panel.
14. As you turn it, look at the top of the screen and note that the number indicating the time per division changes.

*15.* Time per division can be adjusted finely in small steps or coarsely in large steps. It is possible to switch between the fine/coarse modes by pressing the horizontal control. *The coarse mode is normally used because it allows changing quickly time per division.*
16. Press the horizontal control once; verify that time per division is modified in larger/smaller steps.
17. Using the coarse mode of the horizontal control, **select 500 $\mu s$ per division**.
18. Locate the vertical sensitivity control above the 1 button.
19. As you turn it, look at the top of the screen and note that the number indicating the volts per division changes.

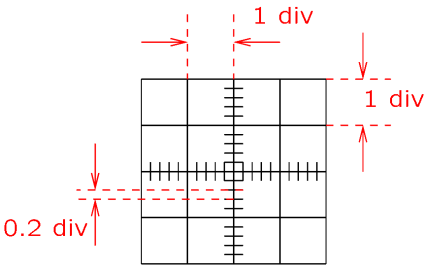


20. Volts per division can be adjusted finely in small steps or coarsely in large steps. It is possible to switch between the fine/coarse modes by pressing the vertical sensitivity control.
21. Using the coarse mode of the vertical sensitivity control, **select 500 mV per division.**
22. Locate the vertical position control under the 1 button.
23. As you turn the vertical position control, look on the left-hand side of the screen and notice the ground symbol ⏚ moving together with the waveform. It indicates the position of the zero level of the waveform.
24. To re-center the waveform, press once the vertical position control.
25. Locate the horizontal position control at the top of the front panel, to the left of the Run/Stop button.

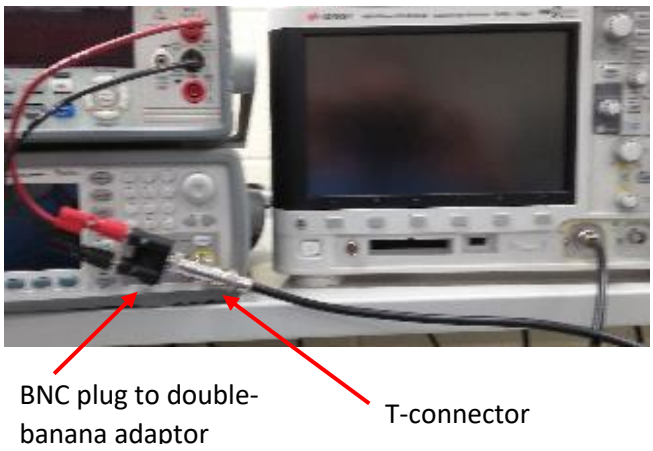


26. Turn the control and note its effect.
27. To re-center the waveform, press once the horizontal position control.

28. Measure with the oscilloscope the parameters of the signal in divisions, and then convert the result to volts or seconds:
    a. The peak (maximum) value has _____div and _____V.
    b. The peak-to-peak amplitude has _____div and _____V.
    c. The average of the signal has _____div and _____V.
    d. The period of the signal has _____div and _____ms.
    e. Calculate frequency as 1/Period: _____Hz.




29. Change the vertical sensitivity to 1V/div.
30. Change the horizontal sensitivity to 1ms/div.
31. Measure with the oscilloscope the parameters of the signal first in divisions, and then convert the result to volts or seconds:
    a. The peak (maximum) value has _____div and _____V.
    b. The peak-to-peak amplitude has _____div and _____V.
    c. The average of the signal has _____div and _____V.
    d. The period of the signal has _____div and _____ms.
    e. Calculate frequency as 1/Period: _____Hz.
32. Verify the average value of the voltage with a DMM.
    a. Obtain a T connector and a BNC plug to double-banana adaptor.
    b. Connect the generator signal to both the oscilloscope and the DMM. A possible way to do this is shown in the picture.
    c. The average value displayed by the DMM is _____V.
33. Press and hold the ON/OFF button of the waveform generator to turn it OFF.
34. **Disconnect the waveform generator** from the circuit.
35. Disconnect the DMM from the circuit.




36. Turn ON the DC power supply.
37. Adjust the power supply to 1.5 V and a current limit of 50 mA. To do this, press first Display Limit and then, as needed, press Voltage/Current to select the voltage or the current limit. Turn the Adjust knob to select the correct voltage or current value.
38. On the oscilloscope press the 1 button and make sure that Coupling is on DC (direct coupling).
39. Adjust the vertical sensitivity to 1V/div.
40. Adjust the vertical position control so that the trace is centered one line up from the bottom of the screen. (That is, the zero reference should be one line up from the bottom of the screen.)
41. Connect the DC power supply to the oscilloscope. Use a coaxial cable and a BNC to double-banana adapter to connect the cable to the power supply,

42. Connect also a DMM to the DC power supply.

43. Make sure the DMM is connected for voltage measurements and set to DC volts.
44. Turn ON the output of the DC source. The trace on the screen should have moved up 1.5 divisions.
45. Readjust the source voltage for the other values listed below. Adjust the vertical sensitivity control of the oscilloscope as shown below.

| DMM Value | VOLTS/DIV | Divisions | VOLTS |
|---|---|---|---|
| 1.5 V | 1 | 1.5 | 1.5 . |
| 5.0 V | 1 | | . |
| 8.0 V | 2 | | . |
| 13.0 V | 2 | | . |

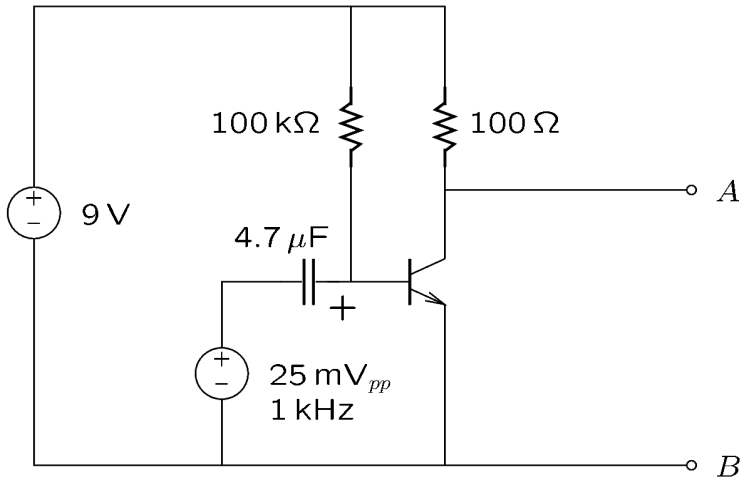
46. Turn OFF the DC power supply.
47. **Disconnect the power supply** from the circuit.
48. Turn ON the waveform generator.
49. Press *Channel* and set *Output Load* to *High Z*.
50. Press *Waveform* and *Parameters* and select a zero-mean sine wave of 60 Hz and 1V rms.
51. Press *Channel* and turn ON the channel of the waveform generator.
52. Connect the waveform generator to the oscilloscope and a DMM. Use a T-connector to connect both the oscilloscope and the DMM to the waveform generator.
53. In what mode will the DMM display the rms value of the signal: (a) DC; (b) AC; (c) AC+DC.
54. Measure the rms value of the signal with the DMM: _____.
55. Press the *Channel* button of the waveform generator. Change the value of the *Output Load* and notice that the amplitude displayed by the waveform generator changes, though the signal displayed by the oscilloscope does not change.
56. For which *Output Load* setting does the waveform generator display the same rms value as the DMM? (a) High Z; (b) 50 Ω; (c) other.
57. Set the output frequency and voltage of the waveform generator to the values listed below. Verify all rms voltages with the DMM. Measure and record the peak-to-peak voltage and the period with the oscilloscope. (It may be necessary to readjust the vertical position and sensitivity controls.)

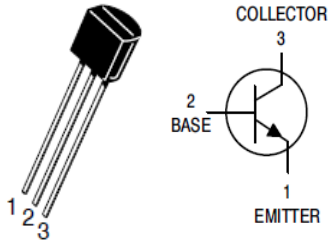
| Frequency (Hertz) | DMM (RMS volts) | Scope volts ($V_{pk\text{-}pk}$) | Period (milli-seconds) |
|---|---|---|---|
| 60 | 1.0 | | |
| 500 | 2.5 | | |
| 1000 | 3.0 | | |
| 2000 | 3.0 | | |
| 4000 | 1.5 | | |

58. The rms voltage measured on the DMM should be approximately 0.353 of the peak-to-peak voltage measured on the oscilloscope. Explain why below. (Hint: See the lecture handout or page 14 of the textbook).

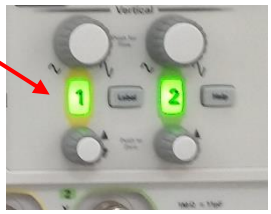
59. Disconnect the DMM from the oscilloscope.

60. Connect the following transistor amplifier; follow the instructions below.




a. Use the 2N3904 transistor from the kit.
b. Connect the polarized capacitor with the long (+) terminal in the position marked with +.
c. Note that the 9 $V$ source is the battery.
d. The 25 $mV$ source is the waveform generator; you may connect it to your circuit with adaptors and alligator clips.
e. Set the waveform generator to a 25 mV peak-to-peak sine of 1kHz.
f. Connect the oscilloscope between the points A and B (with GND at B).
g. Set the oscilloscope channel in AC mode by pressing the channel number and then by selecting AC *coupling*.




61. If the oscilloscope shows a distorted sine, reduce the amplitude of the waveform generator until the sine is undistorted.
62. Verify that by replacing the 100 Ω resistor with a somewhat higher value, the output signal (the signal on the oscilloscope) gets higher.
63. The largest resistor value for which the output is undistorted is _____.
64. Measure the DC component of the signal between the points A and B: _____.
65. Measure the AC component (RMS value) between the points A and B: _____.
66. Theoretically, the overall RMS value (AC+DC) should be _____.
67. The overall RMS value measured with a DMM is _____. To measure this rms value, press the AC+DC button (if the DMM has one), or else press ACV and DCV at the same time.