Oscilloscope Introduction, Part 3—Lab 8

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Name: ____ Date: ___________ Section: ___

EEGR-2051 OSCILLOSCOPE INTRODUCTION – PART 3

<u>Equipment</u>:

1. One digital oscilloscope.
2. One waveform generator and one DC power supply.
3. One digital multimeter (DMM).
4. One 270 Ω resistor (or closest available value) and one $0.33\ \mu F$ or $0.1\ \mu F$ capacitor.
5. One inductor substitution box and one resistor substitution box.
6. One transformer #29590.

<u>Reference</u>: Student Reference Manual, Chapters 3 and 6.

<u>Procedure</u>:

Channel Coupling—DC Signals.

1. Oscilloscope channels can be operated in DC or AC mode.
   a) In DC mode, the signal is displayed as it is.
   b) In AC mode, only the AC component of the signal is displayed.
2. Therefore, if you would measure the average value of a signal in AC mode, what value would you obtain? (a) zero; (b) infinity; (c) the same value as in DC mode.
3. Adjust the DC source to 4V and connect it to Channel 1 (CH1) of the oscilloscope.
4. Press the 1 button to display the CH1 menu.

5. Select DC coupling
6. Measure the voltage on CH1.
   a) Vertical sensitivity ____ V/div
   b) Voltage in divisions _____ div
   c) Voltage in volts ____ V
7. Press the 1 button to display the CH1 menu.
8. Select AC coupling.
9. Measure the voltage on CH1. .
   a) Vertical sensitivity ____ V/div
   b) Voltage in divisions _____ div
   c) Voltage in volts ____ V
10. Can DC voltages be measured with the channel in AC mode? Explain.
    ____
11. Disconnect the oscilloscope from the DC source.

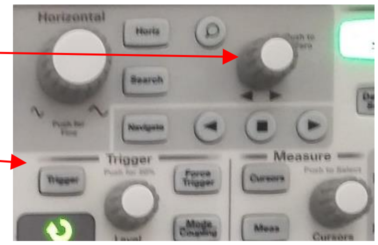
External Trigger.

12. Press $Trigger$ and set Source to 1. This will select CH1 as the trigger *source*.
13. Locate the *Trigger Level* control of the oscilloscope.

14. Note that the trigger level is the voltage displayed in the right upper corner of the screen. As you adjust the trigger level, this voltage should change.
15. Adjust the trigger level to $1.5\ V$.

16. Program the waveform generator for a 1 kHz sinewave. The amplitude will be specified later.
17. The waveform generator provides a square wave signal that is synchronous to the waveform it generates. This “sync” signal, when connected to the external trigger input of the oscilloscope, helps the oscilloscope obtain stable images.
18. We will first measure the sync signal.
19. Connect CH1 to the SYNC output of the waveform generator.

20. Make sure that CH1 is in DC mode.
21. Measure the low level (baseline) of the sync signal: ____________
22. Measure the high level (peak value) of the signal: ____________
23. The sync signal should be of about 3 ... 5 V peak-to-peak. If you obtain different numbers, go back and check your work.
24. Press once the horizontal position control. This will ensure that the waveform is centered.



25. Press the *Trigger* button of the oscilloscope and select rising edges (positive slope).
26. Reduce time per division until the rising edge spreads over several horizontal divisions.
27. Measure the rise time. _________________
28. Press the *Trigger* button of the oscilloscope and select falling edges (negative slope).
29. Measure the fall time. _________________
30. Disconnect Sync from CH1.
31. Set the time per division to 1 ms/div.

Channel Coupling—AC Signals.

32. Locate the EXT TRIG IN jack on the rear panel of the oscilloscope.
33. Connect this EXT jack to the Sync jack of the waveform generator.
34. Select the Trigger Menu and then set Source to Ext.
35. Connect CH1 to the Output jack of the waveform generator.
36. Adjust the waveform generator so that it generates a sinewave of 4V peak-to-peak on a high resistance load (HiZ load).
    a) Adjust the output load setting of the waveform generator.
    b) Adjust the voltage of the generator.
37. Adjust the trigger level of the oscilloscope until the trigger level is between the baseline and the peak values measured at steps 21 and 22.
    a) Note that the trigger level is the voltage displayed close to the upper right corner of the oscilloscope screen.
    b) As you adjust the trigger level, you should see this voltage change.
    c) When the trigger level is within the right range, the oscilloscope image should be stable.
38. Press the 1 button to display the CH1 menu.
39. Set CH1 coupling first on DC and then on AC. Is there any difference?

    ____

40. Can AC voltage be measured with the DC coupling? ____________________
41. Measure the voltage displayed on CH1 with a DMM. With the DMM on the AC setting the measured voltage is _______
42. Is the measured voltage consistent with the 4V peak-to-peak value? Explain.

    ____

43. Measure the voltage on CH1 with the DMM in the DC setting. The measured voltage is

    ____

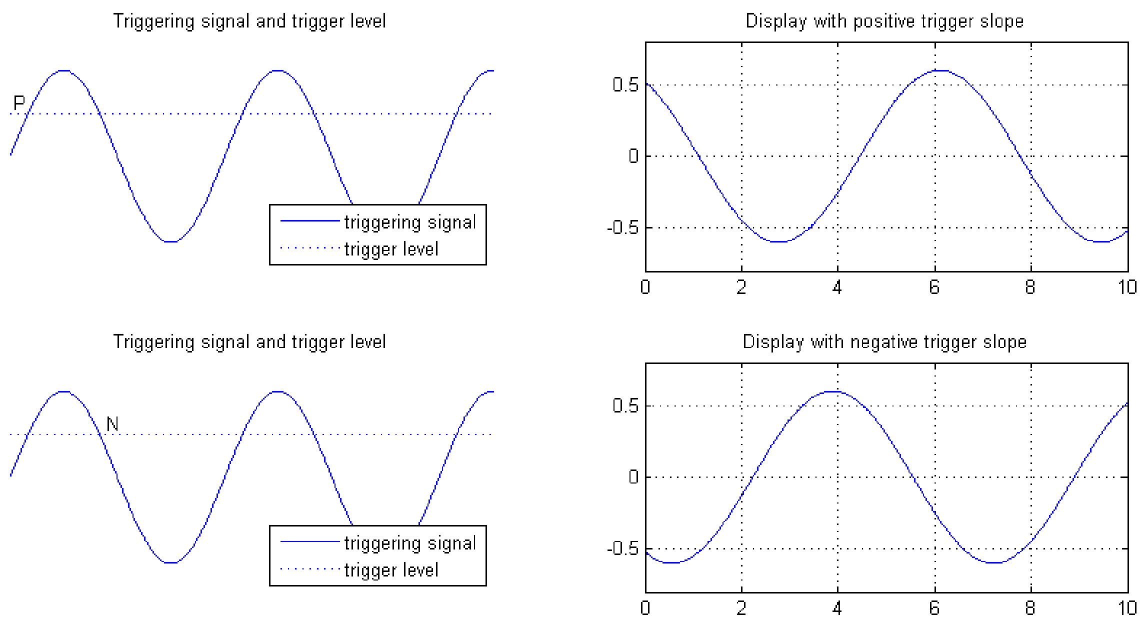
44. Is the measured voltage consistent with your expectations? Explain.

    ____

45. Without changing the amplitude of the waveform generator and with the DMM in the DC setting, adjust the DC offset of the waveform generator until the DMM indicates 2V.
46. Indicate the nature of the 2V value: (a) rms value; (b) peak value; (c) peak-to-peak value; (d) average value; (e) other: _________.
47. Display the output of the waveform generator on CH1.
48. Can you measure the average value of the signal with DC coupling? ________ Can you measure it with AC coupling? _______ According to the oscilloscope, what is the average voltage? ______________
49. In conclusion, what is the difference between the AC and DC coupling of the oscilloscope?
____
____
____
50. How does the DC offset setting of the waveform generator affect the average of the signal?
____
51. Turn off the DC offset of the waveform generator.
52. Disconnect the EXT jack of the oscilloscope.
53. Select the Trigger Menu and then set Source to 1.
54. Press the trigger LEVEL knob to stabilize the image, if unstable.

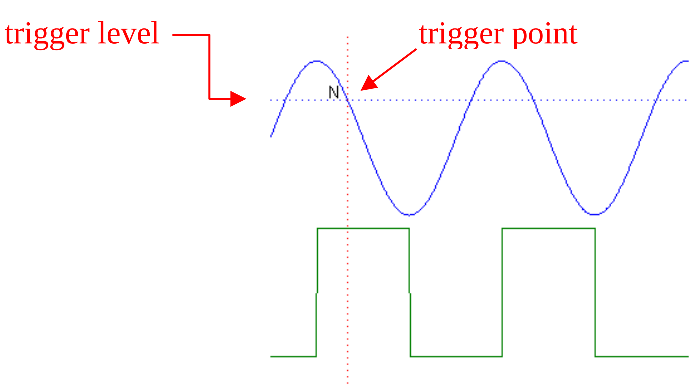
Triggering

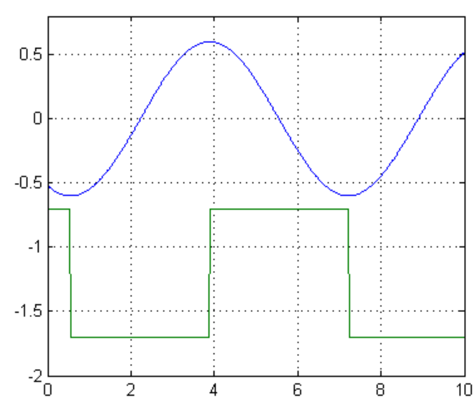
55. Triggering is used to obtain stable images on the oscilloscope.
56. Trigger signals are used to generate trigger events. Displayed images are by default centered about trigger events, so that the data point in the middle of the screen corresponds to the data point acquired when a trigger event has occurred.
57. There are several triggering methods. In *edge triggering*, a trigger event occurs when the triggering signal crosses a certain voltage level called ***trigger level***.
58. Assume that the signal to be displayed and the triggering signal are the same. The next figure illustrates how the signal is displayed. The left-hand side shows the trigger level as a horizontal dotted line. The line intersects the curve at the points P and N.



a) If the SLOPE setting of the oscilloscope is , selecting a POSITIVE slope, the signal is displayed with the trigger point P in the center, as shown on the right-hand side.
b) If the SLOPE setting of the oscilloscope is , selecting a NEGATIVE slope, the signal is displayed with the trigger point N in the center.

59. Estimate the value of the trigger level in the previous figure. Trigger level __________
60. If the trigger level does not intersect the triggering signal, there are two possibilities:
    a) In AUTO trigger mode, the signal will be displayed even if there is no trigger event. The image, however, will be unstable.
    b) In NORMAL trigger mode, the image will not be displayed/refreshed until a trigger event occurs.
61. Use the following oscilloscope settings.
    a) Select CH1 as the triggering signal by setting SOURCE to 1 in the Trigger Menu.
    b) Set Mode to AUTO in the Trigger Mode and Coupling Menu.
    c) Use the LEVEL knob to adjust the trigger level to the center position.
62. Connect the output of the waveform generator to CH1.
63. Set the waveform generator to a 1.2 V peak-to-peak sinewave of 150 kHz.
64. Set CH1 on 200 mV/div.
65. Push the horizontal position knob to zero (center) the horizontal position.
66. The trigger point will now be at the center of the screen.
67. Use the LEVEL knob to vary the trigger level. Indicate how the trigger point changes when:
    a) The trigger level is increased: ____
    b) The trigger level is decreased: ____
    c) SLOPE in Trigger Menu is changed between (POSITIVE) and (NEGATIVE) ____
68. Adjust the trigger level so that it exceeds the maximum value of the signal and wait for a few seconds. Is the image stable? _________
69. What is the maximum value of the trigger level for which the image on the screen is stable? (Read the trigger level from the upper right corner of the screen.) Max value _____ Volts.
70. What is the minimum value of the trigger level for a stable image? Min value ____ Volts.
71. Adjust the trigger level so that the image is stable.
72. Set Mode to NORMAL in the Trigger Mode and Coupling Menu.
73. Verify that if the signal does not reach the trigger level, the image is not refreshed.
    a) Increase the trigger level above the maximum level determined above.
    b) Disconnect the cable from the CH1 input. Is the image refreshed? _________
    c) Reconnect the signal to CH1 and reduce the trigger level until the image is refreshed.
    d) How is the NORMAL mode different from the AUTO mode? ____
74. The triggering signal does not have to be the same as the signal that is displayed. Another signal with the same frequency can be used instead as the triggering signal. In the following figure, the sine wave is the triggering signal.





75. Set the waveform generator to a 6 V peak-to-peak 150 kHz sine wave.
76. Set the oscilloscope as follows.

a) Connect CH1 to the Output terminal of the waveform generator.
b) Select CH1 as the triggering signal (SOURCE set to 1 in the Trigger Menu).
c) Set Mode to AUTO in the Trigger Mode and Coupling Menu.
d) Adjust the trigger level to 1V.
e) Set the horizontal sensitivity to 1μs/div.

77. Connect CH2 to the SYNC terminal of the waveform generator.
78. Display both CH1 and CH2.
79. Turn the trigger LEVEL control. Are both waveforms affected by it? __________________
80. In the trigger menu set the source to CH2. Turn the trigger level control. How are the waveforms affected and why?

    ____

81. Disconnect CH2 from the waveform generator and connect it instead to a DC voltage of 3.5V. Is it possible to stabilize CH1 with the TRIG LEVEL knob? Why or why not?

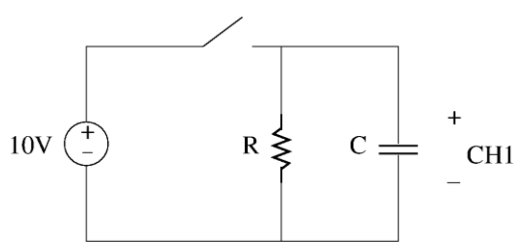
    ____

    ____

82. Press the RUN/STOP button. Is the image stable now? ________________________________
83. A trigger signal is useful in order to obtain a stable image on the oscilloscope. As illustrated above, another way to obtain a stable image is to stop refreshing the screen by pressing the RUN/STOP button.
84. Disconnect the waveform generator from the oscilloscope.

Transient signals.

85. A trigger signal is also useful for displaying aperiodic signals. In the following, you will obtain the transient response of an RC circuit.
86. Disconnect the oscilloscope from the waveform generator and the DC power supply.
87. Locate the R = 270Ω resistor and measure its actual value: R = ______.
88. Turn ON the DC power supply.
    a) Adjust the current limit to $0.2\ A$.
    b) Set the voltage limit to $10\ V$.
89. Connect the following RC circuit.
    a) Use R = 270Ω and C = 0.33μF.
    b) Use a cable for the switch. (Disconnect/connect one end of a cable to turn off/on the switch.)
    c) Set the DC source to 10V.
    d) Connect CH1 across the capacitor.



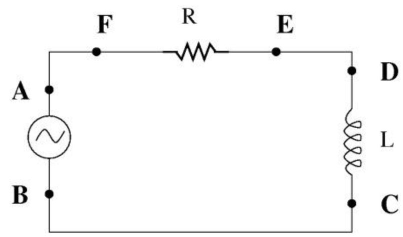
90. Make sure the DC supply is ON and the switch of the circuit is open.
91. Set the oscilloscope as follows.
    a) Adjust the trigger level to 5V.
    b) Set SLOPE to (POSITIVE) in the Trigger Menu.
    c) Set SOURCE to 1 in the Trigger Menu
    d) Set the horizontal sensitivity to 10 μs/div.

e) Press the horizontal position control in order to zero (center) the horizontal position and place the trigger point in the middle.
f) Set Coupling to DC in the CH1 menu.
g) Adjust CH1 to 5 V/div.

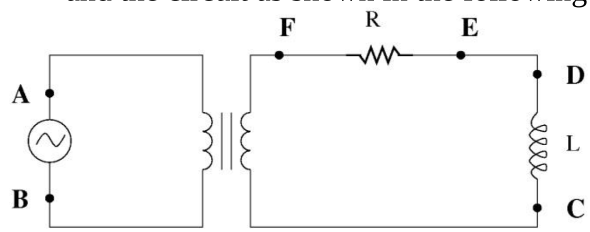
92. Press SINGLE.
93. Close the switch quickly and firmly. If you do not get an appropriate curve, go back to the previous step. Note that unless the switch is closed or opened firmly and quickly, several charging/discharging curves will be obtained, due to contact bounce.
94. A capacitor connected to an ideal source of voltage will charge instantly. However, a nonzero charging time is obtained with a real power supply. According to the image shown on the oscilloscope, approximately how much time is needed to charge the capacitor? ______.
95. Set the horizontal sensitivity to 100 μs/div.
96. To obtain the discharge curve of the capacitor, SLOPE in the trigger menu should be set to _______. Set the SLOPE accordingly.
97. Press SINGLE.
98. Without disconnecting the oscilloscope from the capacitor and without turning off the power supply, disconnect *the + terminal* of the DC power supply from the circuit.
99. The oscilloscope should now display the discharge curve. If not, reconnect the power supply to the circuit and go back to the previous step.
100. The time constant equals the time required for the capacitor to lose 63% of its charge (that is, to lose ΔV = 63% of its voltage). Measure the time constant: τ = _____.
101. If the time constant is different from the product R·C, go back to the previous step.
102. Connect the DC source again to the circuit.
103. Swap the connections to the terminals of the DC supply so as to apply negative voltage.
104. The measured voltage will now be negative and the curve “upside-down”. To visualize the discharge curve, what trigger level and what SLOPE setting would you use?
Trigger level: ______, SLOPE: _________
105. Obtain the discharge curve on the oscilloscope and sketch it below. Show the zero level and the trigger level.

Isolation Transformers and Grounding

106. Set Mode to AUTO in the Trigger Mode and Coupling Menu.
107. In the following circuit assume a grounded waveform generator. Assume that point B is connected to the GND terminal of the waveform generator. Note that because of ground connections it is not possible to have CH1 connected to C and D and CH2 to E and F. Explain why.
____
____
____



108. To avoid grounding issues, an isolating transformer can be connected between the source and the circuit as shown in the following figure.



109. Explain how you would connect CH1 to C and D and CH2 to E and F. Indicate the position of the ground terminals.

____

____

____

110. Using a resistance substitution box, set R = 100 Ω.
111. Using an inductor substitution box, set L to 7 mH.
112. Measure the resistance r of the inductor: r = __________
113. Connect the circuit shown above. Use the *Output* jack of the waveform generator.
114. Set the generator to a sine wave of 2 kHz and 2 V peak-to-peak.
115. If the image on the oscilloscope is unstable:
    a) Check that the trigger level intersects the trigger source signal; for example, you could set the trigger level to zero.
    b) To eliminate instability due to noise on the trigger signal, press the trigger *Mode Coupling* button and select the options *Noise Reject* and *HF Reject*.
116. Without disconnecting anything, verify that ground connections are correct by connecting point B to the GND of the oscilloscope. If connecting B to GND changes the waveforms on the oscilloscope, something is wrong. Otherwise, disconnect B from GND and proceed to the next step.
117. Adjust the frequency of the waveform generator until V_L and V_R have the same peak-to-peak value. Record data in the table.
118. Repeat the previous step for the remaining values of R in the table.
119. Fill in the inductance fields of the table using the formula $L = \frac{\sqrt{R^2 - r^2}}{2\pi f}$, where r is the resistance of the inductor and f is the frequency. Calculate L to the nearest 0.1 mH.

Resistance [Ω]	Measured Resistance [Ω]	Approximate Frequency [Hz]	Actual Frequency [Hz]	$V_{L\ p\text{-}p}$ [Volts]	$V_{R\ p\text{-}p}$ [Volts]	Calculated Inductance [mH]
100		2000				
120		2400				
150		3000				