Oscilloscopes
Spring 2024

Introduction

The purpose of this lab is to become familiar with the oscilloscope as a measurement device. You should experiment freely with different combinations of control settings; so long as you do not force any of the knobs, or drop the oscilloscope on the floor, you can do it no harm. *In your journal, use words and sketches to describe what you have observed at each step. Be sure to calculate % difference when comparing values*. Exercise your curiosity!

An oscilloscope is used to graph signals and can display two signals at once on channel 1 (CH1) and channel 2 (CH2). There are knobs to adjust the scale on the graph, one for each voltage (number 12 in *Figure 1*), and one for the time (18). There is also a section on the right side of the oscilloscope labeled *trigger* which tells the scope which signal starts the display. There are two graphing modes that we will use:

- Voltage on channel 2 as a function of voltage on channel 1 ("x-y mode"): the signal going into channel 2 is displayed on the y-axis, and the signal going into channel 1 is displayed on the x-axis.
- Voltage as a function of time: the screen displays voltage on the y-axis and time on the x-axis.

The control panel of an oscilloscope is divided into four major functions:

- CH1 - Left vertical channel (gives horizontal deflection in x-y mode)
- CH2 - Right vertical channel
- Time Base (labeled as Horizontal)
- Trigger options

In addition, there is a section containing **intensity** (1) and **focus** (3) knobs, and a useful button labeled **Beam Find** (2). Press and hold this button to locate the spot if it has been moved off screen.
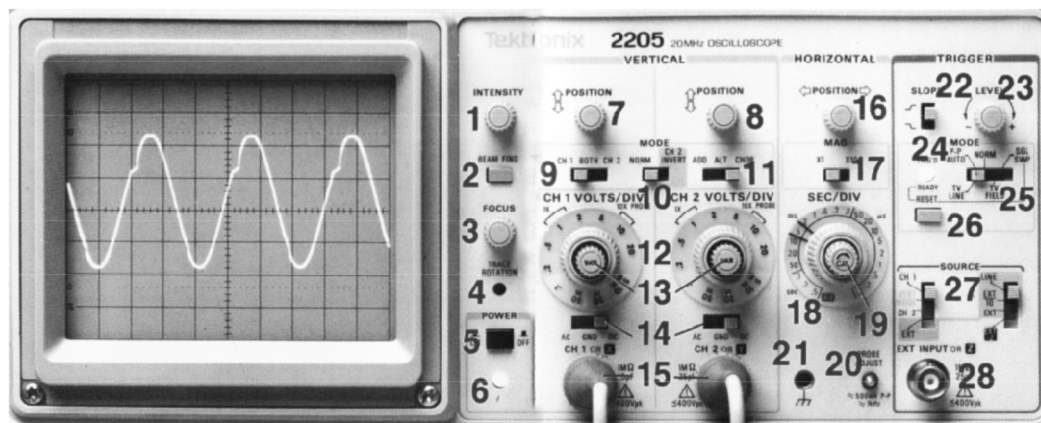

Figure 1 – The oscilloscope face

Oscilloscope Controls, Connectors and Indicators *(numbers in boldface are used in this exercise)*

1. Intensity	**8**. CH2 Vertical Position	**15**. CH1/CH2 Input	22. Slope
2. Beam Find	**9**. Channel Select	**16**. Horizontal Position	23. Level
3. Focus	10. CH2 Norm/Invert	**17**. Magnification	24. Trigger Ready Light
4. Trace Rotation	11. Add/Alt/Chop	**18**. Time Base (Sweep)	25. Trigger Mode
5. Power On/Off	**12**. Volts/Div Knob	**19**. Calibration Knob	26. Reset
6. Power Indicator Light	**13**. Calibration Knob	20. Probe Adjust	**27**. Trigger Source
7. CH1 Vertical Position	**14**. AC/DC Select	21. Chassis Ground	28. External Input

Experiment

I.   *X-Y Voltage Measurements*: In this experiment you will use the x-y mode to measure DC voltages.

1.   Turn the oscilloscope on by pressing the **POWER** button (5).

2.   *Setting X-Y Mode:* Turn the *time base* (also referred to as *sweep*) knob (18) fully counterclockwise to **x-y** and turn both **VOLTS/DIV** knobs (12) to **1** volt/div ("1" on the dial should be aligned with "1x" as shown circled in Figure 2 below).

     Note that *DIV* stands for *division*, the grid lines that appear on the oscilloscope face (Figure 3). This way, a voltage across the CH1 (15 – left) leads displaces the spot horizontally one centimeter for a one-volt potential difference. Voltage across the CH2 (15 – right) leads displaces the spot vertically.
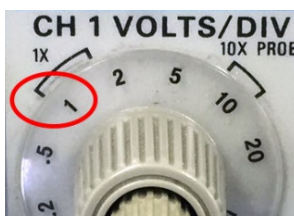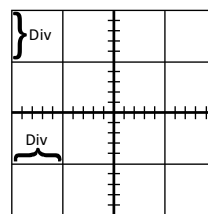

Figure 2

Figure 3

3.   Check that the **AC/DC SELECT** switch (14) under each VOLTS/DIV knob is set to **DC**, and the MAG switch (17) is set to ×**1**.

4.   *Center the Spot:* Each **CH1/CH2 INPUT** (15) has a *BNC-to-banana* adapter so that you can easily attach standard banana-plug wires to use as *input leads*. Connect four wires to the oscilloscope, two wires *each* into CH1 and CH2.

     > **BNC** stands for "Bayonet Neill–Concelman", a type of connector used with coaxial cable and named for its inventors, Paul Neill, and Carl Concelman.
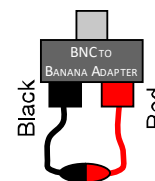

Figure 4

5.   Connect the CH1 input leads directly together (Figure 4, right); do the same on CH2, and **FOCUS** (3) the spot so that it is a small dot. Adjust the spot **INTENSITY** (1) so that it is not too bright, which will burn an image on the screen.

6.   Move the spot horizontally with the **HORIZONTAL POSITION** knob (16), and vertically with the CH2 **VERTICAL POSITION** knob (8) so that the spot is centered at the origin. When the spot is centered, disconnect the input leads from each other on both CH1 and CH2.

7.   *Measuring Voltages:* Make sure that both **CAL** knobs (13) are turned fully clockwise. Hold the CH1 leads across the terminals of a 9-volt battery and observe the movement of the spot (note that the red connector on CH1 is the positive terminal, and black is the negative terminal). At the current sensitivity setting (1 VOLTS/DIV) the spot probably has moved off the screen. *Why do you think this happened?*

8.   With the leads still connected to the battery, change the sensitivity with the CH1 vertical sensitivity knob (12) to see how it works. When an appropriate scale is set, measure the battery voltage by interpreting each centimeter mark as a number of volts equal to the "volts/div" setting on the sensitivity knob.

9.   Use a voltmeter to measure the voltage across the battery, and compare this voltage to that measured with the oscilloscope.

10. Reverse the battery and connect the CH1 leads to see how it affects the spot.

11. Repeat your voltage measurement with the CH2 leads.

II. *Voltage as a function of time*: In this experiment we are going to use the voltage-time mode to measure the amplitude and period of two waveforms – a sine wave (Figures 5a) and a triangle wave (Figures 5b). A function generator on the front bench creates these waveforms, which are supplied to each set up through the lab bench power panels (Figure 6).
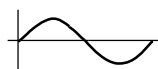
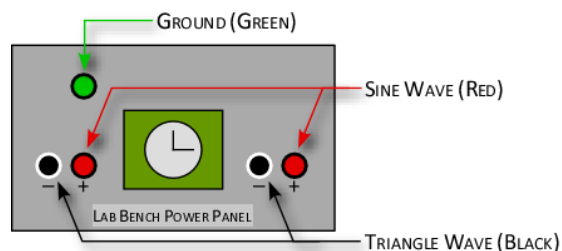**Figure 5a – Sine Wave**   **Figure 5b – Triangle Wave**   **Figure 6 – Lab Bench Power Panel**

1. The red lab bench connector provides a low frequency *sine wave* (Figure 6). Connect the *red* CH2 lead to the *red* connector in the lab bench power panel; likewise, connect the *black* CH2 lead to the *green* (ground) connector on the lab bench (***do not** use the **black** connector; use the **green** ground connector!*).

2. Adjust the CH2 VOLTS/DIV knob (12) to **5** *volts/div*. In the TRIGGER SOURCE menu (27), select **CH2** for the source; also set the MODE switch (9) to **CH2**. The spot will move up and down rapidly as the voltage oscillates (the oscillating spot will appear as a vertical line!) You can see the sine shape if you 'drag' the spot horizontally by turning the HORIZONTAL POSITION knob (16) back and forth rapidly.

3. Adjust the time base knob (18) until you can see this sine wave on the oscilloscope display. Sketch the wave with appropriate scale labeling for each axis.

4. Make sure the CAL knob (19) is turned fully clockwise. Measure the period of the sine wave by counting the number of horizontal divisions and multiplying by the time scale. Calculate the frequency of the wave (in *Hertz*) from the period, recalling that $f = \frac{1}{T}$.

5. Ask your instructor for the function generator frequency so you can compare it with your measured value.

6. Disconnect the CH2 leads from the lab bench connectors. Connect the CH1 leads to the *black* and *green* connectors (Figure 6); this will provide a *triangle wave*. In the TRIGGER SOURCE menu (27), select **CH1** for the source and set the MODE switch (9) to **CH1**.

7. Adjust the time base (18) until you can see this triangle wave. You may need to use the CH1 VOLTS/DIV knob (12) to adjust the scale as well. Sketch the wave with appropriate scale labeling for each axis and record the time and voltage scales that you used.

8. Put the scope back in **x-y** mode (18) and connect the CH2 leads to the audio generator sitting on your bench (the CH1 leads are still connected to the black and green connectors). Turn on the generator and observe the patterns you create when you adjust the various settings on the generator: try turning the frequency and amplitude knobs, and the frequency range buttons. Also try pressing the "Wave Form" button: you get a square wave when it's pressed in, and a sine wave when it's out.

III. *Examining Sound Waves*:

1. Turn off and disconnect audio generator and remove the *BNC-to-banana adapter* from CH1. Connect a microphone and amplifier to CH1. Sing the various vowel sounds into the microphone and observe what their pressure waves look like. Try singing the vowels at different pitches or whistling. Briefly describe your observations.

2. Set the time base (18) to 2 *ms*. Strike a tuning fork *gently* with the rubber hammer and capture the sound with a microphone so that you can see it on the oscilloscope. Measure the period of the sound wave and calculate the corresponding frequency. Calculate the % difference between your calculated value and the frequency stamped on the tuning fork.

Discussion:

- This was an exploratory lab, so no discussion is required this week.

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