Oscilloscopes
Spring 2009

Introduction

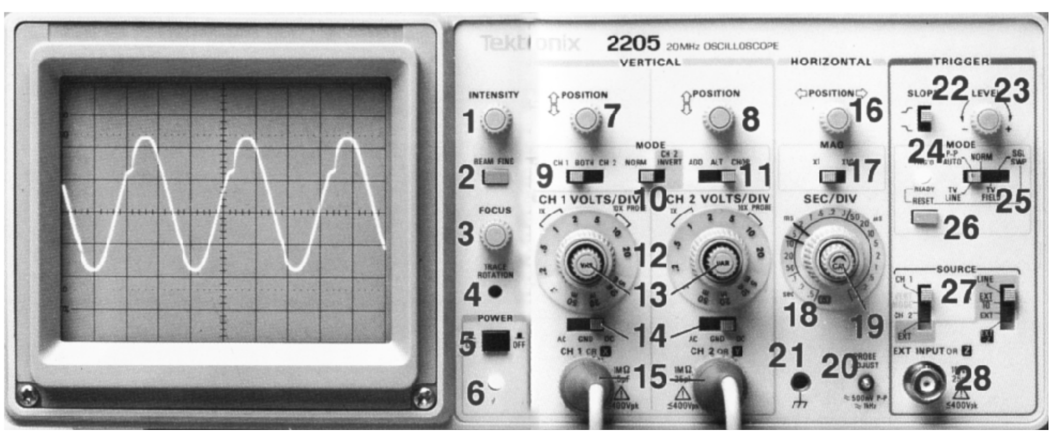
The purpose of this lab is to become familiar with the oscilloscope as a measurement device. You should experiment freely with different combinations of control settings; so long as you do not force any of the knobs, or drop the oscilloscope on the floor, you can do it no harm. *In your report, use words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

An oscilloscope is used to graph signals, and can display two signals at once on channel 1 and channel 2 (CH1 and CH2). There are two graphing modes: voltage as a function of time, and voltage on channel 2 as a function of voltage on channel 1. In the former case, the screen displays voltage on the y-axis and time on the x-axis. In the latter case, 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. This is called the x-y mode and can be activated by adjusting the time scale knob (18 in the picture below) to “x-y”. There are knobs to adjust the scale on the graph, one for each voltage (12), and one for the time (18). There is also a section called trigger which tells the scope which signal starts the display.

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.



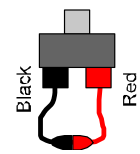
<u>Oscilloscope Controls, Connectors and Indicators</u> <u>*(numbers in boldface are used in this exercise)*</u>

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

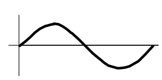
I. *X-Y Voltage Measurements ("Etch-a-Sketch mode")*: In this experiment you will use the x-y mode to measure DC voltages.

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 *volt/div* knobs (12) to **1** volt/div ("1" on the dial should be aligned with "1x" on the faceplate; *div* stands for *division*, the grid lines that appear on the oscilloscope face). 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.
3. Check that the switches (14) under each volt/div knob are set to **DC**.
4. *Center the Spot:* Plug in two wires *each* to CH1 and CH2. Short out the input leads on CH1 (i.e. connect them directly together, as shown at right); do the same on CH2, and focus the spot (3). Adjust the intensity (1) so the spot will not burn the screen. Now 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, remove the shorts from CH1 and CH2.

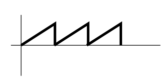


5. *Measuring Voltages:* Hold the CH1 leads across the terminals of a 9-volt battery and observe the movement of the spot (note that the red connector on CH1 is the positive terminal, and black is the negative terminal). At the current sensitivity setting (1 volt/div) the spot probably has moved off of the screen (Why?). With the leads still connected to the battery, change the sensitivity with the CH1 vertical sensitivity knob (12) to see how it works. Make sure that the **cal** knob (13) is turned fully clockwise, then measure the battery voltage by interpreting each centimeter mark as a number of volts equal to the "volts/div" setting on the sensitivity knob. Use a voltmeter to measure the terminal potential of the battery, and see if the scope agrees with the voltmeter. Reverse the battery and repeat your measurements
6. Now repeat with the CH2 leads, and verify the calibration for vertical displacements.

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 and a sawtooth wave.



Sine Wave



Sawtooth Wave

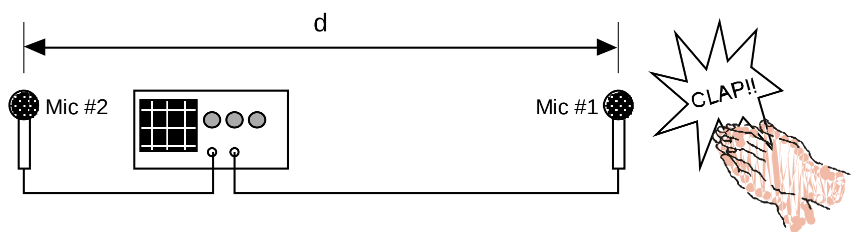
1. Connect the *red* CH2 lead to the *red* connector on the lab bench; likewise, connect the *black* CH2 lead to the *green* (ground) connector on the lab bench (***do not** use the **black** connector; use the **green** ground connector!*). The red connector provides a low frequency *sine wave*. Adjust the voltage (12) sensitivity to 5 *volts/div*. In the trigger menu, select CH2 for the source (27); also set the mode switch (9) to CH2. The spot should go up and down rapidly as the voltage oscillates (the oscillating spot will appear as a vertical line!). You can see its sine shape if you 'drag' the spot horizontally by turning the horizontal position knob (16) back and forth rapidly. Adjust the time scale (18) until you can see this sine wave. Sketch the wave with appropriate scale labeling for each axis.
2. Measure the peak to peak amplitude of the sine wave by counting the number of vertical divisions and multiplying by the voltage scale. 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 from the period. Record these measurements, and ask your instructor for the accepted values so you can calculate the percent difference.

3. Disconnect the CH2 leads from the lab bench connectors. Connect the CH1 leads to the *black* and *green* connectors; this will provide a low frequency *sawtooth wave*. In the trigger menu, select CH1 for the source (27) and set the channel select switch (9) to CH1. Adjust the time scale (18) until you can see this sawtooth wave. You may need to adjust the voltage (12) sensitivity as well. Sketch the wave with appropriate scale labeling for each axis.
4. Put the scope back in x-y mode and reconnect the CH2 inputs to the red and green lab bench connectors; leave the CH1 leads connected as well. Describe what you see and provide a brief explanation.

III. *Examining Sound Waves*:

1. Connect either channel to an audio oscillator set for 1000 Hz (set the amplitude on the oscillator to anything other than zero) and measure the period (there are three connectors on the audio oscillator – one black, and two red. Use the black connector and the red connector on the right). The period *should* be T = 1/1000 sec (1.00 ms); many of the oscillators are old and may not provide the correct period. Record your measured period, and calculate the actual frequency at this setting.
2. Disconnect the audio oscillator and the BNC-to-banana adapter, and connect a microphone to either channel. 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.
3. Strike a tuning fork *gently* on the sole of your shoe 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, where $f = 1/T$. Compare your measured value to the frequency stamped on the tuning fork.

IV. *Measuring the speed of sound*: This experiment allows you to measure the speed of sound. You will measure the distance between two microphones, and the time it takes for the sound of your hands clapping to get from one microphone to the other. A special oscilloscope, called a “storage scope” for its ability to store a graph on its display, will be used to measure the time.



1. Measure the distance between the two microphones. The time scale on the scope will have been set by your instructor to an appropriate scale; record the time scale setting.
2. There are two signals on the oscilloscope, one from each microphone. Make sure you know which signal is created by each microphone.
3. The scope is triggering on the channel that contains the microphone where one of you will be clapping. Now one person should clap, and the other person should push the *save* button in the storage section. You may need to repeat this several times, but you will see the two waves with peaks separated by time.
4. When you have an acceptable trace, you can print the screen by simultaneously pressing and releasing the *Recall* and *Hold* buttons (one printout per group is fine). Calculate the scale of the graph on the printout by measuring the entire width of the grid, which covers 200 *ms* of time.
5. Measure the time delay on the graph and calculate the speed of sound using $v = d/t$.
6. Calculate the percent difference between your velocity calculation and the speed of sound (344 *m/s* at 20° C). How precisely can you measure the time – to the nearest microsecond? 1 millisecond? 10 milliseconds? Be as specific as you can. What range of values does this give you for the speed of sound?