

# Introduction to the Oscilloscope

## 1. Purpose

Understand, read, and use the controls and features of an oscilloscope.

## 2. Theory

The oscilloscope is used as a tool for testing electrical components and circuits. By setting the oscilloscope in parallel with various components in a circuit, voltage across the component can be accurately read and analyzed. Both DC and AC can be evaluated using the oscilloscope. For a DC voltage, the screen will display a straight line, for AC, the screen will show a sinusoidal wave. This lab will introduce you to the general operation of the oscilloscope as well as show you some of the features available.

## 3. Equipment

Speaker  
Oscilloscope  
Function Generator  
Power cord  
2 Patch Cords  
AC Transformer  
Microphone  
Tuning Fork (440 Hz & others)/ Striking Block  
2 or 3 Batteries

### 4C Students only

Open Plastic Pipe  
Reed Pipe, Synthesizer, Guitar

## 4. General Setup

Provide power to the Oscilloscope and the Function Generator. Turn both pieces of equipment on. Attach the patch cords to the Function Generator only.

### A Note on the Oscilloscope

The controls for the oscilloscope are separated into four different vertical sections. The first section contains the controls that affect the oscilloscope itself. Intensity controls the brightness of the beam. Focus controls the “sharpness” of the beam. Power is used to turn the scope on and off.

The second section (VERTICAL) contains the controls that affect the vertical displacement or height of the display.

The third section (HORIZONTAL) contains the controls that affect the horizontal movement and time delineation of the scale on the screen.

The fourth section (TRIGGER) contains the controls that help feed the correct information from the inputs into the scope.

## 5. Experiments

### A. Time and Frequency Measurements

1. Turn all of the calibration knobs (knobs in center of each of the three large knobs) clockwise until they click/stop so that the knobs are calibrated.
2. Set the MODE switch under TRIGGER to P-P AUTO/TV LINE, the left switch under SOURCE to CH 1, and turn the inner knob of the SEC/DIV control, under HORIZONTAL, fully clockwise until it clicks.
3. On the function generator, there should be a two-socket plug in the output port marked 50/600  $\Omega$ . Connect both patch cords into the plug, one cord for each socket. On the oscilloscope, there should be at least one of the same kind of two-socket plug in the port marked CH1 in the VERTICAL section. If not, find and/or move the plug to CH1. Connect the other ends of the patch cords to this plug. Immediately above the CH1, there is a toggle switch marked AC GND DC. Place the switch over AC.
4. Turn on the function generator and set the frequency to 90 Hz - 100 Hz, with the sinusoidal waveform. Adjust the function generator amplitude, with the knob marked amplitude, or use the CH1 VOLTS/DIV knob under the VERTICAL section so that the sine wave pattern is almost full scale on the screen. Verify that the switch in MAG section under HORIZONTAL is set to X1.
5. Adjust the SEC/DIV knob (one large division on screen equals number on dial) under HORIZONTAL so that a wave pattern with two peaks is visible on your screen. Read the number of divisions for one full sine wave cycle and record.
6. Compute the period (T) of one cycle of the sine wave using the selected SEC/DIV setting under HORIZONTAL. Note that the large scale on the screen denotes the number of seconds per division. The smaller tick marks divide that particular setting by 5.
7. Compute the sine wave frequency  $f = \frac{1}{T}$ , and compare with the function generator setting by computing the percent difference.
8. Repeat 4, 5, and 6 with the function generator set at 300 Hz.
9. With the generator output at 300 Hz, under the HORIZONTAL section, slowly and incrementally adjust the SEC/DIV knob and note the relationship between the number of cycles displayed and the SEC/DIV knob setting. Provide a short explanation for this relationship.
10. Set the generator to 60 Hz and measure the number of divisions for one complete cycle of the wave pattern. You may have to adjust the SEC/DIV knob again in order to see the wave pattern. Record this measurement.
11. Replace the function generator with the small transformer. The transformer will give you 60 Hz of AC electricity. Measure the number of divisions for one complete cycle and compare this to the measurement obtained when the function generator was attached to the oscilloscope. What is the percentage difference?

12. Remove the two-prong plug from the CH1 port and attach a microphone to the CH1 port under the VERTICAL section. Strike a tuning fork on the rubber block and hold the fork up to the microphone. The oscilloscope should display the waveform of the resulting sound on the screen. The SEC/DIV knob under HORIZONTAL may have to be adjusted to show the waveform more distinctly. Measure the period,  $T$ , of the waveform and determine the frequency. Compare this frequency with the one printed on the tuning fork. What is the percentage difference?

## B. Voltage Measurement

1. Disconnect the microphone, signal generator, transformer, etc. Re-attach the two-prong plug to the CH1 port in the VERTICAL section and plug two wires into the two-prong plug. Immediately above the CH1 port, there is a toggle switch with the settings AC GND DC. Place the switch over DC.
2. You should see the trace, a horizontal green line, on the screen. If you don't, then use the POSITION knob in the VERTICAL section to bring the trace into view on the screen. Make sure the trace is centered on your screen.
3. Using the wires, check the voltage on three different batteries. If you cannot see the trace move, or if it moves to far, then use the CH1 VOLTS/DIV knob under the VERTICAL section to decrease the amount that the trace jumps when voltage is applied to the circuit. Make sure that the trace does not drift up or down from its initial level between readings. Why is the no waveform displayed for a battery?
4. Reconnect the transformer to the CH1 port and place the switch back over AC. Set and record the CH1 VOLTS/DIV setting.
5. Read the number of vertical divisions corresponding to the full height of the wave.
6. Compute the rms voltage of the wave.  $V_{RMS} = \frac{\text{wave height}}{\sqrt{2}}$ .

## C. Lissajous Figures

1. Connect the AC transformer to CH1 and connect the function generator to CH2 under the VERTICAL section. The function generator should be set to generate a smooth curve. Set the function generator to 30 Hz. Turn the TIME/DIV knob to  $\boxed{xy}$ . On the oscilloscope, there should be a rapidly changing display on the screen. If there is nothing on the screen, adjust the CH2 VOLTS/DIV knob until something is seen on the screen.
2. As the function generator gets close to 30 Hz, the display on the screen will "slow down". Adjust the frequency until the display stops and you can record the shape that is on the screen. Draw the pattern and label it with the frequency of the function generator. Increase the frequency until you find another stable figure and record it in your lab notebook.
3. Examine the number of patterns found at settings which are simple fractions of 60 Hz and integer multiples of 60 Hz.

The following experiments are designed for the 4C students only:

## D. Fundamental Frequency of an Open Pipe

1. Connect a small speaker to the output of the function generator. Place the speaker at one end of the open plastic pipe.

2. Calculate the fundamental frequency for this pipe. Use

$$v_{\text{sound}} = 345 \frac{m}{s}, l = \frac{1}{2} \lambda, v = f \lambda, f_2 = \frac{v}{\lambda} = 2f_1$$

3. Set the signal generator to this frequency. Modulate the frequency higher and lower. See if you can detect resonance with the microphone connected to the oscilloscope.

Observe how much the wave height changes when resonance is achieved.

4. See if you can find higher harmonics.

### E. Harmonics

1. Play the note "A" (440 Hz) on a tuning fork into the oscilloscope. Now play "A" on the reed pipe, guitar, or the Casio synthesizer.

2. Explain what is meant by musical quality. Explain how different instruments playing the same fundamental note can be distinguished from each other, and sketch the different waveforms of each instrument played.

3. See if you can sing "A" and examine your voice waveform.

### F. Interference

1. Connect a signal generator to each input, CH1 and CH2.

2. Under the VERTICAL section, use the slide switches to select the following: BOTH, NORM, and ADD.

3. By adjusting the frequencies of each signal generator, it is possible to show both constructive and destructive interference.

4. By sliding the switch marked ADD to ALT, it is possible to see the waveforms that made up the previous combined pattern.