

Experiment 7 ~ AC Voltages, Frequency and the Use of the Oscilloscope

Objective:

After completing this experiment, you will be able to use the oscilloscope to measure unknown voltages and frequencies. There is a worksheet available on the lab webpage at:

<http://www.umsl.edu/~physics/lab/electricitylab/12-lab7.html>

Equipment:

Oscilloscope, signal generator, connecting wires

Note:

Buttons or markings on the oscilloscope are in bold.

These instructions are written for the 'blue' oscilloscopes. Differences for the 'gray' oscilloscopes are noted.

Experimental Procedure and Questions:

Part 1

In the first part of this experiment, we'll try a few different things with the oscilloscope to help you become more familiar with it. Turn your oscilloscope on and let it warm up for a few seconds. While it's warming up check the following switches to make sure they're set correctly. Look for the area marked **Trigger**. There is a switch marked **Mode** which should be set to **Auto**. There's also a switch here marked **Source**. This switch should be all the way up, (it will be set on **line**). We will also be using **Channel 1** throughout this lab, unless otherwise directed, so any switches marked **CH1** or **CH2** should be set to **CH1**. For the gray oscilloscope, leave the Source set to **CH1**.

By now your oscilloscope should be warmed up. If you don't see something on the screen, try pushing the **Beam Find** button and use the **Position** knobs to move the trace back to the center of the screen. If you still see nothing, try turning the **Intensity** up a little. If you still can't see anything, ask your TA for help.

You'll notice the screen is divided into squares. Each square is called a division. This is important to know because you'll notice the 3 largest knobs are marked **sec/div** or **volts/div**. So when we see that something has moved say 3 divisions, we'll be able to convert that to Volts or seconds. This is how we'll make our measurements.

Now, look for the knob marked **sec/div**. This knob controls the 'Time base'. Turn this knob to .1 sec/div. For the grey oscilloscope you may need different values for this knob. You can now see the trace move across the screen from left to right. You'll notice it takes about a second to cross the screen. Actually it takes exactly a second to cross the screen. We can calculate this because the time base knob is on .1 sec/div and the grid on the screen is divided into 10 divisions horizontally and 8 divisions vertically. Multiplying gives:

$$.1 \frac{\text{sec}}{\text{div}} \times 10 \text{ div} = 1 \text{ second.}$$

If you now set the time base knob to something smaller like 1ms/div, (Remember, m stands for milli = 10^{-3}), you'll see the trace move so fast that it's hard or impossible to see.

Question 1: How many seconds does it take the trace to go across 1/2 the screen at the 1 ms/div setting?

Remember, the horizontal axis of the screen is where we measure time, so you just have to count the divisions between any two points you're interested in and multiply by the scale on the sec/div knob. So now you can (or will soon be able to) find how long it takes the trace to move between any two points on the screen.

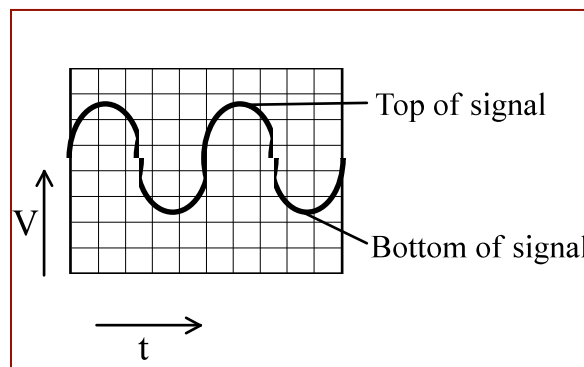


Figure 1: Example of a signal on an oscilloscope.

The vertical axis works the same way, except we use it to measure volts rather than time. Looking at Figure 1 as an example, we can see that there are 4 divisions between the bottom of the wave and the top of the wave. If our volts/div knob is set on 1 volt/div, then we would have:

$$1 \frac{\text{volt}}{\text{div}} \times 4 \text{ div} = 4 \text{ volts}$$

A helpful way to think about these knobs is that changing the setting is like changing which units you can use on a ruler; if you're measuring a piece of paper you can use centimeters or millimeters or whatever. But the object you're measuring doesn't change as you switch between scales. Or you might imagine you're zooming in or out with a variable magnifying glass; changing the knobs just changes the magnification, and the numbers tell you what the magnification scale is.

Part 2

Remember, the vertical scale factor (the number of volts/div) is controlled by the two knobs marked volts/div. There are two inputs on this scope so that two voltages may be viewed simultaneously, but for now we will use only one input, Channel 1. Look for the switch by the volts/div knob marked AC-GND-DC and set this to GND. This grounds the input to the scope; the vertical scale is at zero volts. Now use the vertical position knob to move the trace to the center of the screen. Once the line is centered, set the switch to AC (DC voltages will be eliminated at the input of the scope.) For the gray oscilloscope, push in the GND button and then center the trace. Then return the GND button to its original position. Check that the AC/DC button is out.

Connect a triangular wave of about 1 KHz frequency from the signal generator to CH 1 of the scope.

Since we are measuring a wave whose frequency is in the 1 kHz range, the typical period will be in the ms range. Set the time base knob to 1 ms/div. Make sure the cal knob is all the way clockwise.

Set the volts/div switch to 2 volts/div. Check that the small knob marked cal on the volts/div knob is turned all the way clockwise, i.e. in its calibrated position. If this knob is not in the calibrated position, your measurements will be incorrect.

Adjust the amplitude of the signal generator using the output level knob to give you a +/- 6 volt wave (12 volts peak to peak). Be sure that the DC offset knob on the generator has the white dot pointed up, i.e. zero volts DC offset. You should see a triangular wave which has a positive maximum three divisions above the middle line across the screen and a negative minimum three divisions below.

The sweep (i.e. the movement of the dot across the screen) is "triggered" when the voltage crosses the threshold set with the level control. The point at which this crossing takes place then becomes the "origin" of the graph. The threshold is controlled with the small knob marked level. Use the horizontal position knob to move the whole trace to the right so you can see the beginning. Explore what happens when the level knob is rotated. Note that you can change the location of the origin of your graph.

Now look at the button or switch right by the level control marked slope. This controls the polarity of the voltage for which the triggering takes place. Both positive triggering and negative triggering are possible. Explore what happens when this button is both up and down or in and out for the gray oscilloscope. You may have to adjust the level to get stable triggering after this. Now make an accurate measurement of the frequency of the triangular wave. You will measure the period, T, the time between any two repeating points on the wave. For example, count accurately the divisions between the two maxima, and then use the information about sec/div from the time base knob setting to find T. The frequency is given by:

$$f = 1 / T$$

Question 2: Is the signal generator frequency knob very accurate? Sketch the triangular wave in your notebook. Compare your measured value with the settings on the signal generator.

The scope is capable of looking at two waves simultaneously. Look for the switch marked CH1-both-CH2. Push this switch to both. When you do this, you will activate the capability to look at both inputs. Leaving the triangular wave connected to CH 1, connect the TTL pulse to CH 2. Make sure to set the sec/div switch to same value as you are using on CH 1. Use the two vertical position knobs to adjust the two waveforms for a convenient display. Make a sketch of them in your notebook. Note that the amplitude of the TTL wave is not adjustable on the signal generator. Measure its amplitude in volts and label your sketch accordingly.

