The Oscilloscope

We continue to familiarize ourselves with means of generating and measuring ***voltages***, which can be either AC (changing) or DC (constant). The most direct way to learn about oscilloscopes is by considering versions that are a straightforward application of cathode ray tubes (CRTs---the electron deflection tubes you've begun to use). Below, we will often refer to an oscilloscope simply as a *scope*. Use only the controls that you *need* to use for the exercise below. By the end of the lab you will be familiar with the most important scope controls. A good reference, as you work, is the Wikipedia article on oscilloscopes at http://en.wikipedia.org/wiki/Oscilloscope

Part 1

- Your scopes can display two voltages simultaneously. Locate the two inputs for the display voltages. They will be labeled "Ch 1" and "Ch 2" or something similar. Next, locate the two knobs that set the volts/division for these two channels. Each of these volts/division controls has an inner knob. It must be turned all the way clockwise until you hear a click (the inner knob is probably already in that position if you cannot turn it clockwise). The advertised volts/division on the outer knob is true only when the inner knob is in this calibrated position.
- Now, find the switch that allows you to put the scope on "X-Y mode" and put it to "X-Y mode." Then put both channels on the 5V/div scale with nothing connected to the inputs. You should see a single dot on the screen, which is the position of the un-deflected CRT electron beam. Adjust the intensity (not too bright—bad for the screen) and focus of the dot using the appropriate controls.
- Apply DC voltages to one of the channels/axes using a power supply and to the other channel/axis using one of the "fixed" voltages (+/-15 V or +5V). Measure the resulting deflection of the fluorescent spot (in "divisions," and use the 5V/div setting to convert this to Volts). Then, measure the applied voltages with a hand-held DMM (Digital Multi-meter) and confirm that the scope calibration is correct.

Part 2

- Use a function generator to apply a "linear ramp" (a.k.a. "sawtooth") voltage function to the "X" input at a frequency of ~1 Hz. See what happens as you change, by hand, the DC voltage that you (independently) apply to the "Y" input using the power supply. Change the volts/div on both axes so that the screen is "filled" as much as possible. Now, increase the frequency of the wave going into the "X" input. Make sense of what you see.
- Now, take the scope out of "X-Y mode" and put it on the time-base mode. Find the seconds/division control and make sure that its inner knob is also in the calibrated position. Then display and examine, separately, your two input channels at several seconds/division settings. Notice that you do not see a single dot moving across the screen but a line or a curve traced out by the electron beam on the screen, especially at smaller second/div settings.
- Note that, when used in "time-base" mode, what is happening inside the stand-alone oscilloscope is the same as what you previously did manually (i.e., a sawtooth/ramp voltage waveform is internally applied to the "X" input). This is how scopes are usually used. How does the second/div setting alter the voltage waveform applied to the "X" channel?

Part 3

- Staying on time-base mode, measure two DC voltages produced by the power supply, first with a DMM and then with the scope using its two channels and displaying both simultaneously. You may have to move the "DC/AC/Ground" setting for both channels to "DC," for this to work. Note the level of agreement between the DMM and the scope.
- Connect a waveform from a function generator to one of the scope channels. Apply DC offset (~1 V) to the waveform coming out of the function generator. Now, play with that

input's DC/AC/Ground "couplings" and see what happens. Write a sentence or two describing the effect of these settings on an oscilloscope input.

Part 4

- Your next objective is to obtain a ***stable*** picture of a function generator waveform, such as a 1 kHz sine wave on the scope display. A stable picture is one that doesn't move around on the screen. For a stable picture to occur, the electron beam needs to re-trace the same path over and over again. To make this happen, you will need to lean about the "trigger" controls on your oscilloscope. If you already have a stable display, play with the trigger controls to understand what is happening. The Wikipedia page listed above will be helpful here. Once you have some appreciation of the trigger functions, talk with your instructor or TA to make sure you are on the right track.

Part 5

- *PLAY* with function generator and scope ....
- Measure the ***period*** of several waveforms.
- How can you check for accuracy?
- Is it better to measure an individual period or measure "*N* of them" and then divide by N to find the individual period? Discuss your reasoning.

Part 6

- Apply a sine wave input to the scope. Measure the ***amplitude*** then, independently, measure "Vac" with your DMM. How are the numbers you measure related? (i.e., by what multiplicative factor do they differ?)

Part 7

- Now turn scope to "X-Y" mode again
- Apply one signal from each of the two function generators (one to the "X" the and one to the "Y" input)
- Try to make a "stable" pattern (called a Lissajous pattern) on the screen, or at least make it as "nearly" stable as possible. The frequency knobs will be useful here.
- For any stable patterns you produce, note the relationships between the frequencies of the signals applied to the two inputs and make a clear sketch of the pattern.
- Ideally, what conditions do you think should be needed to see a stable pattern in XY mode?