Introduction
to the
Oscilloscope

Equipment Needed

Cable, BNC/BNC (2)

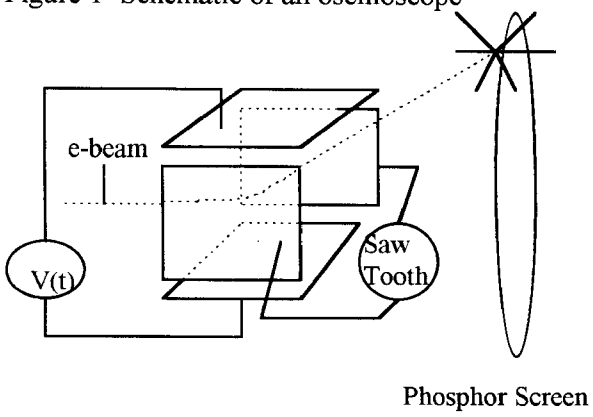
Function Generator w/ Cord (2)

Oscilloscope w/ Cord

Introduction

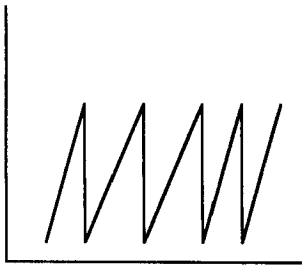
In this lab exercise we will familiarize ourselves with one of the most important of all measurement tools, the oscilloscope. The oscilloscope is essentially a voltmeter that can measure AC waveforms. A schematic of an oscilloscope is shown in Figure 1. The oscilloscope steers an electron beam with two perpendicular sets of parallel plates. The voltage that is measured by the oscilloscope is applied between one set of plates and this is used to steer the beam up and down. The measured voltage is first amplified, and the amount that the voltage is amplified is one of the controls of the oscilloscope. If this were all that an oscilloscope did, then all you would see is a line going up and down on the CRT. In order to see the waveforms, the oscilloscope spreads out the beam by applying a ramp voltage to the other set of plates. The rate at which the voltage is ramped is a second, important control adjusted by the user.

Figure 1 Schematic of an oscilloscope



In this lab, we will use a function generator to generate various waveforms, and we will make measurements on these waveforms. Following this we will make use of the X-Y features of the oscilloscope and create what are known as Lissajous figures.

Figure 2 Ramp Voltage



Procedure

Begin by turning on the oscilloscope and the function generator. The power switch for the oscilloscope is located underneath the CRT on the right. Connect the function generator to Channel 1 of the oscilloscope with the length of BNC cable. To connect the BNC cable, place it over the connector, press down, and turn clockwise until it catches. There are three sets of controls you need to use to manage normal data acquisition with the oscilloscope. These include the vertical sensitivity, the time base, and the trigger. Verify that the sine wave output of the function generator is selected, and then press the 1 kHz button, and adjust the gross and fine buttons so that the display on the function generator reads about 1500 Hz.

Triggering

The oscilloscope doesn't do anything until it knows that a signal is there for it to measure. The trigger controls are how the oscilloscope knows a signal is there. These are on the right side of the oscilloscope. The choices are many. Begin by pressing the small button marked auto. This tells the oscilloscope to handle the triggering and we can forget about it. We will be looking at AC waveforms, so we'd like to set the zero of our coordinate system to be at the center of the scale on the oscilloscope. To accomplish this press the GND button on the channel 1 controls, beneath the vertical sensitivity control. This makes channel 1 display an output of zero. Turn the position knob for channel 1 until the trace on the oscilloscope is centered on the middle axis on the coordinate system for the oscilloscope. Once you've done this, press the GND button again so that the trace again shows the input.

Depending on how the oscilloscope was left the last time it was used, you may or may not actually see anything on the screen at this point. You need to now adjust the horizontal and vertical sensitivities so that the signal will show well on the CRT. At the bottom of the CRT display are two numbers, one marked with units of volts and one with units of seconds. These two numbers are the vertical and horizontal sensitivities. The number given in volts represents the vertical scale. If for instance the sensitivity is 1 V, then this means that one vertical division on the coordinate system on the oscilloscope display corresponds to a signal size of 1 V. The other number represents the size of the horizontal divisions in seconds. Adjust the vertical sensitivity so that the output of the function generator shows completely on the display. A setting of either 2 V or 5 V will probably necessary. Next, adjust the horizontal sensitivity so that several cycles of the sine wave output of the function generator are shown on the display.

Amplitude

Now we will make a few measurements. First determine the peak-to-peak amplitude of the sine wave. This value is the number of divisions between the positive and negative peaks of the sine wave multiplied by the vertical sensitivity. You should be able to determine the number of divisions to at least a tenth of a division. Feel free to use the vertical position knob to move the sine wave to a position where it is easier to make

the measurement. What is the amplitude of the sine wave? Assume that the oscilloscope can measure the amplitude with 5% accuracy. Record your value for the amplitude with your uncertainty.

Period and Frequency

Now we will measure the period of the sine wave. It is probably easiest to measure the period by determining the distance between successive peaks. Use the horizontal and vertical position knobs to align the peaks so that their location is easy to determine. Count the number of divisions between the peaks and multiply by the horizontal sensitivity to obtain the period. You should be able to determine the number of divisions to at least a tenth of a division. What is the frequency of the sine wave shown on your display? How does this compare to the frequency given by the digital readout on the signal generator? If the frequency given by the function generator is accurate to 5%, do the two values for the frequency agree within the uncertainties? Calculate the percent difference between the frequency you determined from the oscilloscope and the frequency displayed by the function generator.

Measurement Cursors

Now, we will use another feature of the oscilloscope, namely its measurement cursors. If the measurement cursors are not already on, press the measurement cursor on/off button. This button is located at the top of the oscilloscope above channel 1. Press the $\Delta V - 1/\Delta t$ toggle until the two vertical lines are shown. Press the toggle on the right until a single circle is highlighted above the cursor on the left. Use the position button to move this cursor to a peak of the sine wave. Press the toggle so that a single circle is highlighted above the other cursor. Move it to the next peak of the sine wave. The oscilloscope display should show something approximately like $1/\Delta t = 1.500 kHz$. This will be the oscilloscope's measurement of the frequency of the sine wave. The number given by the oscilloscope is the reciprocal of the time difference between the position of the two cursors. What is the period of the sine wave?

Pres the $\Delta V - {}^{1}\!/_{\Delta t}$ toggle so that two horizontal cursors appear. Position the cursors in a similar manner so that one is at the positive peak and one is at the negative peak. The oscilloscope will display the potential difference between the two cursors as, for example $\Delta V = 2.3V$.

Lissajous Figures

Last, we will investigate one more feature of the oscilloscope, namely its ability to generate y vs. x graphs. Find the button marked X-Y and press it. Take the output of a second function generator and run it into channel 2 of the oscilloscope. Adjust the frequency of the second function generator so that it is as close to the frequency of the first function generator as possible. Adjust the vertical sensitivity and use the horizontal and vertical position controls until the figure you're creating is centered on the display. If both function generators are at the same frequency, then an oval shaped figure should be displayed. If not then make fine adjustments on one of the function generators until you can get an oval shaped figure on the display.

This figure is known as a Lissajous figure. In X-Y mode, the oscilloscope uses the X input channel to sweep the trace horizontally as opposed to its internal ramp voltage. The function generators are thus sweeping the trace horizontally back forth as well as up and down. If the frequencies at which the traces are being swept are equal, then the combination creates a closed figure. This is more generally true as long as the ratio of the frequencies on the two function generators is a rational number. Adjust one function generator so that it is at double the frequency of the other. Use the 'fine adjust' until a figure with two humps on one side locks in. **Note: Because of the limited resolution of the function generators, you may not be able to get the figures to freeze exactly. Get them as close as you can.** Repeat this with the frequency of one of the generators being three times the frequency of the other. How many humps are there this time? Lastly, adjust the frequencies so that they are in the ration 3/2. Once you've locked in the figure by adjusting the fine adjust knob count the number of humps in each direction. How does the ratio of the number of humps compare to the ratio of the frequencies? Use the oscilloscope camera to record a picture of this Lissajous figure.

Report Format

You should turn in for this lab a one page report which includes all of your measured values, all of your calculations and your answer to all of the questions posed in the lab. You should arrange this material neatly and comprehensibly.