ELECTRONIC MEASUREMENTS

In this experiment you will become more familiar with the oscilloscope and the digital multimeter, two of the most versatile electronic instruments.

DUAL TRACE OSCILLOSCOPE

The heart of the oscilloscope is the cathode ray tube (CRT). In the more common uses of the CRT, a beam of electrons is deflected by the electric field between two parallel plates in such a way that the beam moves horizontally across the face of the CRT from left to right many times each second. The points at which it hits the face (screen) are made visible by a phosphor that glows when hit by high-speed electrons. Each position on the horizontal line thus formed corresponds to a particular potential difference between the parallel plates. The left end corresponds to the lowest voltage and the right end the highest. To obtain *linear* sweep, a “saw-tooth” voltage is used:

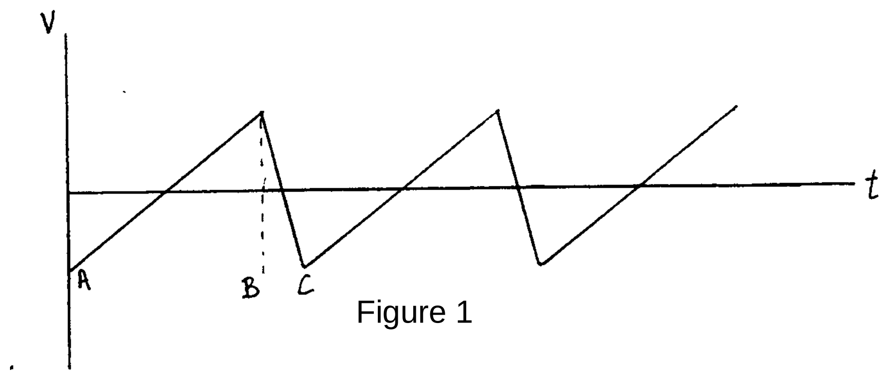


Figure 1

This is a plot of voltage versus time; the lowest voltage (point A in the figure) corresponds to the beam at the left side of the face of the CRT, and the highest voltage (point B) corresponds to the right side. The voltage at the midpoint is half the maximum. The voltage decreases rapidly from B to C to repeat the trace. The sweep rate is adjustable.

A second voltage, usually the signal to be studied, can be applied to a second set of parallel plates that are oriented perpendicular to those causing the horizontal sweep. This is the “vertical” input. The resulting pattern on the CRT is a plot of this input voltage versus time.

The kind of dual trace oscilloscope that we will use has several convenient features including:

1. The time base (sweep rate) is calibrated in sec/cm.
2. Two signals, y_1 and y_2, can be displayed at the same time.
3. Each y scale is calibrated in volts/cm.
4. The input signal may be AC or DC.
5. The start of the horizontal trace may be triggered from y_1, y_2, external input or line voltage.

This oscilloscope has only one electron gun and one set of vertical defection plates, but both y_1 and y_2 can be displayed at the same time on a “time sharing” basis. There are two modes of time-sharing, chopped and alternate. In the chopped mode, one trace is allotted a brief time (e.g. a microsecond) and then the other an equal time. This gives a good display at low sweep rates. (Note: Sweep rate is inversely related to time/cm.) In the alternate mode one trace is made and then the other. This gives a good display at high frequencies but produces a flicker at low frequencies. A rule of thumb for selecting the mode is use ALT when the sweep speed is 200 s/cm or greater and use CHOP at slower sweep speeds.

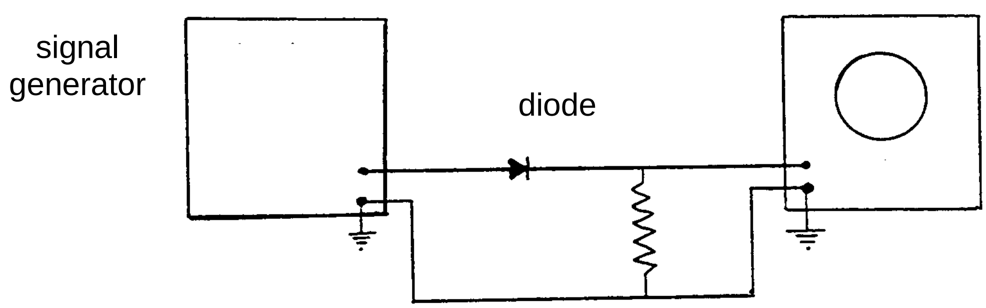
CAUTION: The black terminals of both the oscilloscope inputs and the signal generator are grounded through the power cords. To avoid unexpected short-circuiting of a device always be sure they are connected to the same point.

To illustrate the ideas above connect y_1 to the sine output and y_2 to the square wave output of a signal generator. Set the signal generator to 1000 Hz and the scope sweep rate to 200s/cm. With the display set to y_1, only the sine wave is displayed. Trigger on y_1 and set the trigger level for a stable display. Note the effect of changing the sweep rate and the sensitivity (volts/cm). Select a convenient sensitivity. When the mode is set to y_2, only the square wave is displayed. When it is on CHOP or ALT both signals are visible. Set on ALT and note that if frequency and sweep rate are decreased by a factor of 10, the pattern is the same but a flicker results. Now set on CHOP with the 1000 Hz frequency and 200s/cm. Adjust the trigger level until you are able to see the small gaps in the trace. Notice the display is acceptable but gapped. Decrease both frequency and sweep rate by a factor of 10 and a good display should result. Increase both by a factor of 10 and gaps become very noticeable. Increase both by an additional factor of 10 and the display becomes so gapped as to be nearly useless.

Return to y_1 (the sine wave). Measure the period of the signal. Compute the frequency. How does this value compare to the signal generator dial setting? Measure the peak-to-peak voltage. The amplitude of the signal is the zero-to-peak voltage, i.e. half the peak-to-peak voltage.

Half-Wave Rectifier

Make a simple circuit with a 10 kΩ resistor in series with a diode and signal generator as shown in the figure below. (Note the caution above; it still applies.). Connect to y_1, set the signal generator to give you a 1000Hz signal with a peak voltage of 10V. Explain what you see. What does a diode do?



DIGITAL MULTIMETER

A. Ohmmeter. Set the meter to ohms (Ω). Be sure not to overlook the prefix k for kilo-ohms or M for mega-ohms. Measure the resistance of the following:

1. Wire-wound rheostat. Connect to one end and the upper bar terminal. Note the effect of moving the sliding contact. Are your readings consistent with the values printed on the rheostat?
2. Oscilloscope input. With the oscilloscope unplugged and set for DC signals, measure the resistance of input y_1. Do the same for y_2. Measure from the red lead of y_1 to the red lead of y_2. Is this what you expected?
3. Your body. Gently hold the metal part of one ohmmeter lead in each hand. Read the meter. What happens when you squeeze more tightly? What change occurs when you wet your fingers and squeeze tightly? What implication does this have in regard to shock hazards? From the resistances you observe compute the current you would have experienced if the wires you were holding had been those to a 120 volt household appliance.

B. AC Voltmeter. In previous experiments you have used the DC volts setting of this meter; now set it for AC volts (v~). Use both this meter and the oscilloscope to measure a 500 Hz sine wave. Adjust the signal generator amplitude for one or two volts peak-to-peak. An AC voltmeter should read root-mean-square (rms) voltage. It should be 0.707 times the zero-to-peak voltage. Is this what your readings indicate?

Investigate the frequency response of the meter as follows: at all frequencies use the oscilloscope and the signal generator amplitude control to keep the peak-to-peak voltage constant. Start low and increase frequency. Read the voltmeter. If it is responding properly, it should read the same at all frequencies. Based on your observations, what is the highest frequency at which you have confidence in this meter?