MEASUREMENTS OF VARYING VOLTAGES

Measurements of varying voltages are commonly done with an oscilloscope. The oscilloscope displays a plot (graph) of voltage versus times. This is done in one of two ways. First is by deflecting a stream of electrons (which has been accelerated from the back of the instrument to the front) both horizontally and vertically before it strikes a fluorescent screen. The amount of vertical deflection is determined by the voltage under study; the horizontal deflection is proportional to the time elapsed since the sweep began. The second is by simply graphing the voltage vs time. Oscilloscopes always respond to voltage, but these voltages are often characteristic of other phenomena. For example, a microphone changes the variations in air pressure associated with the sound to changes in voltage that can then be observed with the oscilloscope.

At the front of the classroom is an oscilloscope of the first variety. For the bulk of your measurements you will be collecting voltage data using data studio and the scope display to show the voltage graph as a function of time. Both devices can show the graph of one or two voltages (traces) simultaneously. The graph can be triggered, which means that the beam/trace starts from the left side of the graph only when “told to” or “triggered.” There are several ways to trigger the beam. For many, but not all, of our uses, the beam will be triggered by the input voltage. If the triggering adjustment is not set correctly, the pattern will drift across the screen and will not be "locked in." (You will probably find this adjustment a bit of a mystery. Don't worry--ask your instructor if adjustments are needed.)

1. Spend some time studying the front panel of the scope. There is a myriad of switches and knobs. Locate the following important ones:

   a) Vertical Gain, in volts/div (one for each channel)
   b) Horizontal Sweep rate, in time/div
   c) The trigger

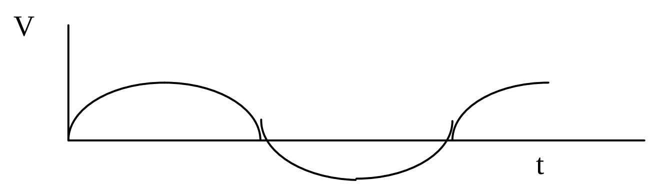
   Be sure you understand the marking on the vertical and horizontal controls.

2. Connect the voltage probes to analog channels A&B physically and in data studio, then drag the ChA voltage from the data window to the scope display.

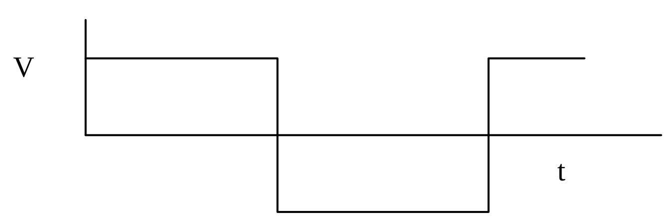
3. Set the vertical gain to .5V/Div. Read the voltage of a 1.5 volt battery on the oscilloscope. Try it with the opposite polarity of the battery by reversing the leads. What would happen if the gain were changed to 1V/Div? Try it and find out if what you expect indeed happens.

4. A signal generator produces a voltage which varies with time. The type of variation is characterized by a plot of the voltage versus times.

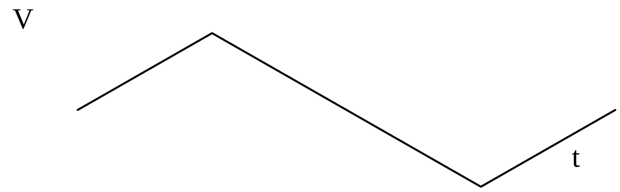
   The plot may look like a sine wave



   a square wave

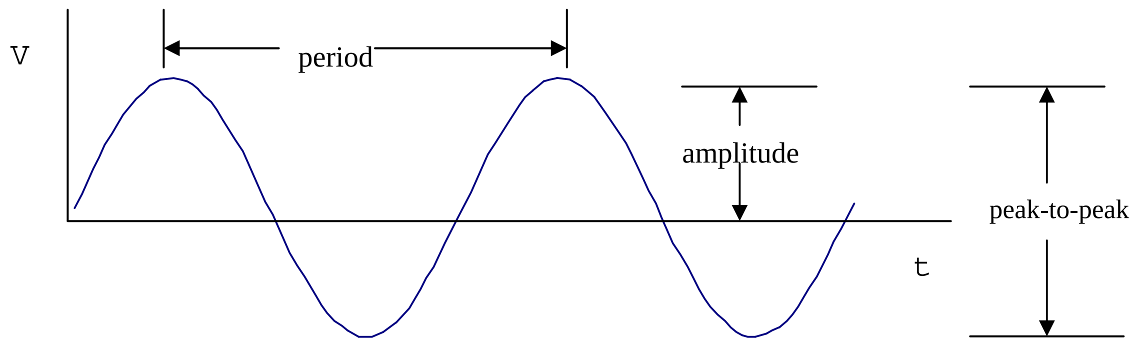


   a triangular wave



or some other form.

The frequency of the signal is the repetition rate of the regular pattern (frequency is the inverse of the period, which is the time between adjacent peaks). The amplitude of the signal is the maximum voltage of the signal (half the peak-to-peak value). (See the figure below).



a) Turn on the signal generator. Make sure it is set for sine output. Set the scope input to A.C. Connect the oscilloscope cable to the output of the generator. You may have to vary the sweep speed (**horizontal on the scope**) to spread the pattern enough to make a frequency measurement and you may need to vary the **vertical gain on the scope** to make it fit nicely vertically on the screen. If you have trouble getting a stable pattern, see your instructor. As you are making these changes in gain and sweep speed, the pattern will change; are the characteristics of the input signal changing? Based on your measurements **with the scope**, what are the period, frequency, amplitude and p-p voltage of the signal you have?

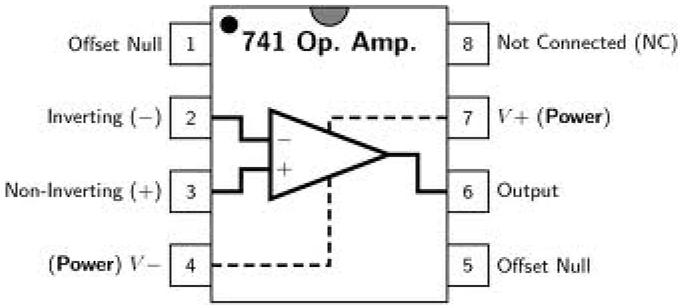
b) Now connect a small speaker to the output of the signal generator and leave the scope also connected to the output. Now the same signal that the oscilloscope looks at is driving the speaker, converting it to sound waves of the same frequency. Do you hear the tone? (If you don't, don't panic yet).

c) Find the controls **on the signal generator** which would change the frequency of the signal. You should be able to observe on the oscilloscope when you have found the right control. Now find the control **on the signal generator** which would vary the amplitude of the signal. Again, you should be able to observe on the scope when you have the right control. Adjust these until you can hear a tone; large enough amplitude (loud enough) and a frequency you are sensitive to. Change the signal frequency and notice the effect it has on the display and the pitch of the tone. Make sure you understand how the display changes as you go from low to high frequency and vice versa. In going over the range of audible frequencies, you may have to change the sweep rate of the oscilloscope. When you do, make sure you understand that the display looks different because of a <u>scale</u> change and not necessarily a change in frequency of the signal. Find the highest and lowest frequencies you can hear.

d) Now try to use your speaker as a microphone. In (b) and (c) you supplied a varying voltage to the speaker and that caused the speaker to vibrate. Suppose you cause the speaker to vibrate (by tapping it or "hitting" it with sound waves). Would it <u>output</u> a voltage? <u>**Disconnect**</u> the speaker from the signal generator so that <u>**only**</u> the speaker is now connected to the input of the oscilloscope. See if you can detect any voltage output from the speaker as you tap it or talk into it. (You may need to increase the sensitive by changing the vertical gain of the scope.) In practice the measurement rate of data studio is not really up to the job for much beyond whistling so please take your speaker with you to the oscilloscope a the front of the room.

5. There will be one or two demonstrations set up for you to observe of sound and light measurements using an oscilloscope.

6. Use your oscilloscope to measure the "gain" of a simple amplifier. The amplifier uses an integrated circuit called an operational amplifier, or "op amp". A couple of resistors are connected to it which determine its amplification. The circuit is already set up. A schematic is shown in the attached figures. **Before connecting the signal generator to the circuit**, hook up one set of leads from the oscilloscope directly to the signal generator output. **Set the generator for a 1 volt signal peak to peak and a frequency of about 1 kHz**. Now hook up the signal generator as your input to the amplifier. Connect the leads for the other channel of the oscilloscope to look at the output of the amplifier. You will now be able to use the dual trace feature of the oscilloscope to simultaneously look at the input to the amplifier (which is the output of the generator) and the output of the amplifier. <u>**Have your set up checked before turning on the power supply that powers your circuit**</u>. After the power supply is turned on, adjust the amplitude control of the signal generator as necessary to keep the input amplitude to the circuit at the 1 volt p-p level. Compare the input and output carefully and completely. One example of a comparison is how much larger is the output than the input. Now interchange the two resistors and again carefully compare the input with the output.



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