The Oscilloscope

The oscilloscope is such an important tool for scientists that learning how to use one is a major goal of this laboratory. Oscilloscopes provide information about the time varying voltages in a circuit. The oscilloscope works very much like a TV picture tube, where the image you see on its screen is generated by an electromagetically deflected beam of electrons fired from an electron gun located at the back of the tube. The internal circuitry of the oscilloscope itself is quite complex, but the basic operation can be understood by considering several controls. The **gain** (volts/div) knob increases or decreases vertical size of the trace on the screen. The number of cycles viewable on the screen (along the horizontal axis) at one time is called the **sweep rate** and is controlled by the **sweep** (sec/div) knob.

The **Trigger** system lets you select just the right time to begin a trace on the screen, and ensures that every successive pass by the electron beam is redrawn from exactly the same spot on the waveform so that you see a stable pattern. It is helpful to think of the function generator as a switch that opens and closes very rapidly, many times per second. Each time the switch is closed, the oscilloscope "triggers" on the left side of its display so that what you see is the response of the circuit to the closing of the switch. This is repeated many times per second so that what you see on the screen seems to be a fixed image. This is closely related to the way televisions work.

The **Coupling** switch (marked **AC-GND-DC**, beneath the Volts/Div knob) should match the type of signal being measured. Many electrical signals have both AC and DC components. Often you are interested in only the AC part of a signal - setting the coupling for AC will feed the incoming signal through a capacitor, which filters out the DC component and passes the AC component undisturbed. Setting the coupling to DC will pass all of a signal, and GND will ground the signal so that you should see only a straight line, corresponding to zero volts.

EXERCISES: LEARNING TO USE THE TEKTRONIX 2225 AND 2213 OSCILLOSCOPE

1: Obtaining a baseline trace

- Before turning on the scope, you should set all of the front-panel controls as follows:
- Set all horizontal switches to the left. (Don't confuse switches with knobs)
- Set all vertical switches up.
- Set CAL knobs to detect position (all the way clockwise, they should click into place).
- Set all other knobs midrange, except the Trigger VAR HOLDOFF knob, which should be set all the way counterclockwise, to the Norm position.
- Set Channel 1 (CH 1) Volts/Div to 2.0 V (sometimes called the 'gain')
- Set Sec/Div to 0.2 ms/div (this is called the 'sweep rate')
- Set CH1 coupling (AC-GND-DC) to AC

- Turn on power
- After a few seconds a trace should appear on the screen. Adjust intensity and focus as needed, and center the line using the horizontal and vertical POSITION knobs.

2: Making Measurements

- Set the signal generator to produce a sine wave with frequency of approximately 1 kHz: turn the Function knob to its center position, the Frequency Multiplier knob to 1 K and the Frequency knob to about 1, and set Attenuation to 0.
- Connect the signal generator to the CH1 input of the scope, turn it on and increase the power until the wave fills about half of the screen.
- Turn the CH1 vertical position knob to align the bottom of the wave to one of the bottom horizontal graticule lines (a graticule is any of the solid lines on the oscilloscope screen).
- Turn the horizontal position knob(s) until a wave peak crosses the center vertical graticule line.
- To measure the voltage amplitude of the sine wave, count the number of major and minor vertical divisions between the bottom and top of the wave. Multiply the number of divisions by the VOLTS/DIV readout. The result is twice the voltage amplitude. For example, if there are 3 major divisions (graticule lines) and 3 minor divisions (each tick marks a fifth of a division), then twice the amplitude is 2 volts/div times 3.6 divisions, or 7.2 volts. So amplitude equals 3.6 volts.
- To measure the period of the sine wave, we will take measurements from the waveform on the oscilloscope display, instead of using the frequency from the signal generator dial. Turn the horizontal position knob to line up the peak of the wave with one of the vertical graticule lines. Count the number of horizontal divisions in one wave cycle. You can adjust vertical position to make counting easier, if you like.
- To find the period of the wave, multiply the SEC/DIV setting by the number of divisions in one wave cycle. You can calculate the frequency from this period measurement.
- Now without adjusting the signal generator in any way, change the oscilloscope settings: set the volts/div to 5 volts/div, and the sweep rate to 0.5 ms/div. Again measure the potential difference and frequency of the wave.
- Your measurements should be the same as before: by changing oscilloscope settings you are not altering the signal you are observing, just changing the way you see it.
- Now try adjusting the volts/div and sweep rate by several clicks in either direction, just to see what happens.

3: Defining Zero Volts

- This procedure must be done for the *RC* circuit lab. Note: trigger mode must be AUTO for this procedure, and not NORM.

- Set the CH1 coupling switch to GND (this is the switch below the volts/div knob). Then adjust the position of the line on the screen using the vertical CH1 position knob: move it to a horizontal graticule. This horizontal graticule will now represent zero volts. Switch the coupling back to AC.

4: What to Do When a Signal is Unstable or Non-Existent

- Adjust the Trigger LEVEL knob.
- Adjust the VOLTS/DIV knob and/or the sweep rate - the trace may simply be off scale.
- Adjust the focus and intensity.
- See if you can get a baseline trace as in step 3. If you can get a trace then whatever is providing the signal may be faulty.

