# EXPERIMENT 2

# Oscilloscope and Function Generator

## Introduction

This experiment introduces two of the most important tools used to test electronic equipment and circuits. The oscilloscope allows one to see and measure time-varying electrical signals on a display screen. The function generator allows one to generate test signals with known frequency, amplitude, and waveshape.

**Experiment Objectives:**

- Learn how to use an oscilloscope to see and measure both DC and AC voltages.
- Learn how to generate DC, sine, triangle, and square wave signals using a function generator.

**Bring to Lab:**

Your completed Pre-Lab. Turn this in when you get to lab.
Several sheets of Engineering Paper. You can purchase this at the bookstore.

## Theory: How the Oscilloscope Works

Most of the oscilloscope screens are similar to a television screen. The inside is coated with phosphor which glows when struck by an electron beam. But, the scope we use in the lab is digital and uses an LCD instead. A signal to be viewed is fed into an amplifier which deflects (moves) the beam position vertically (up and down). The deflection can be time-varying (AC signal) or constant (DC signal). [The detailed manual for the scope can be found at the Tektronix website : www.tektronix.com. Go to support section and look for the manual for TDS1000/TDS2000 series. You might have to register yourself to view this manual.]

Signals displayed on the screen can be measured numerically by counting grid divisions printed on the screen, and multiplying by the amplifier settings on the control knobs.

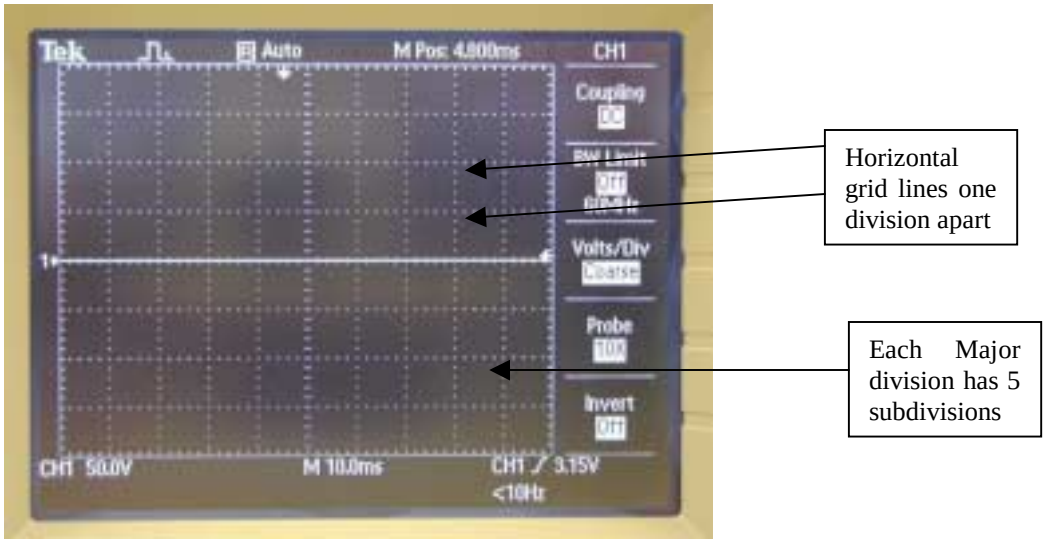


Figure 1. Oscilloscope display. There are 10 horizontal divisions and 8 vertical divisions.

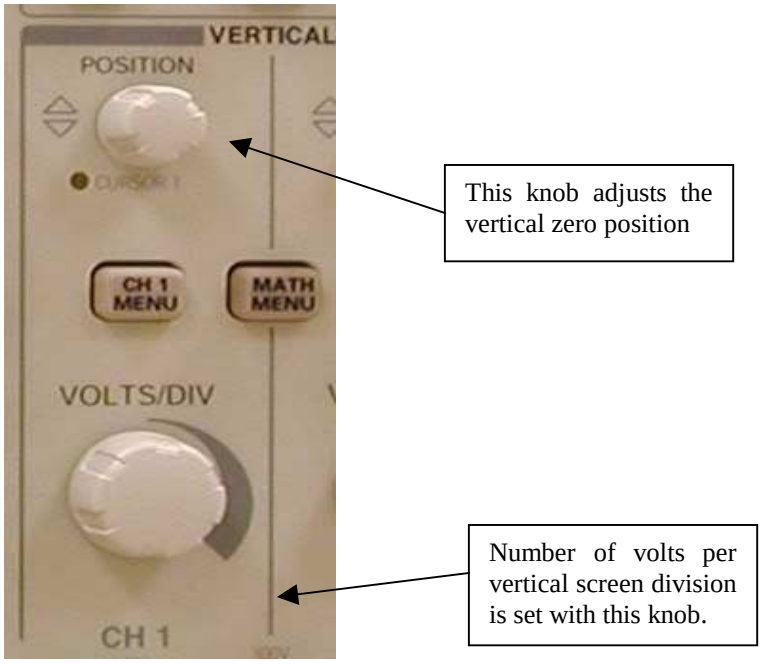


Figure 2. Main Controls for the vertical amplifier. The number of volts per division and the zero reference are set here.

In order to display a signal as a function of time, an internal time-base generator (also called a sweep generator) is used to sweep the beam horizontally at a rate selected on the front panel. This makes the horizontal axis of the display a "time axis."

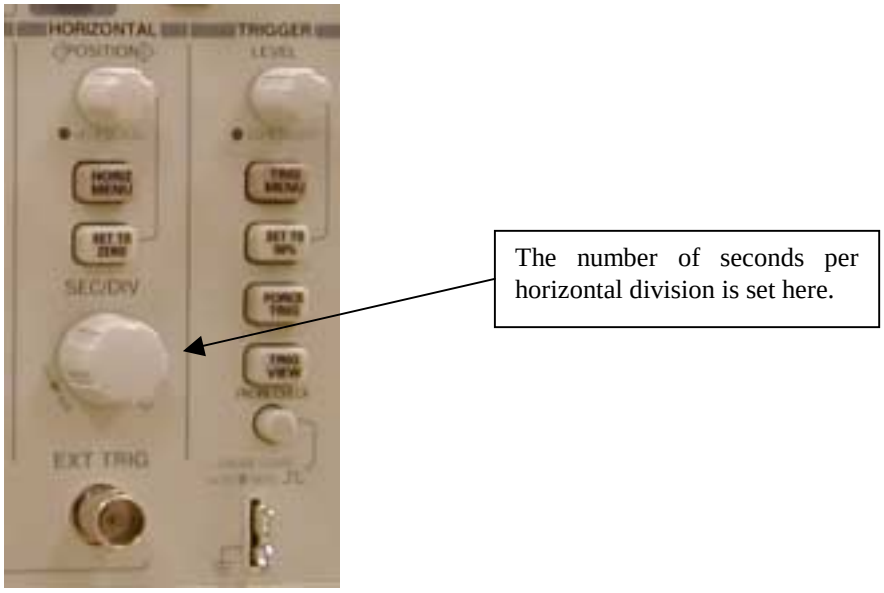


Figure 3. Time-base generator controls

**Triggering the Oscilloscope – "Freezing" the Picture**

If the external signal is periodic (like a sine wave), it is useful to synchronize the sweep generator to the signal. By doing this, the signal will appear "frozen" on the screen, and you can then make careful measurements and observe fine details. The time-base has several controls that let you trigger (start) the horizontal sweep every time the external signal crosses a certain level moving up or down (threshold and slope controls). For example, if you want to "freeze" a sine wave, you could adjust the trigger settings so the sweep always starts when the signal crosses zero, with positive slope. Then the sine wave will appear on the screen as you are used to seeing it plotted on paper.

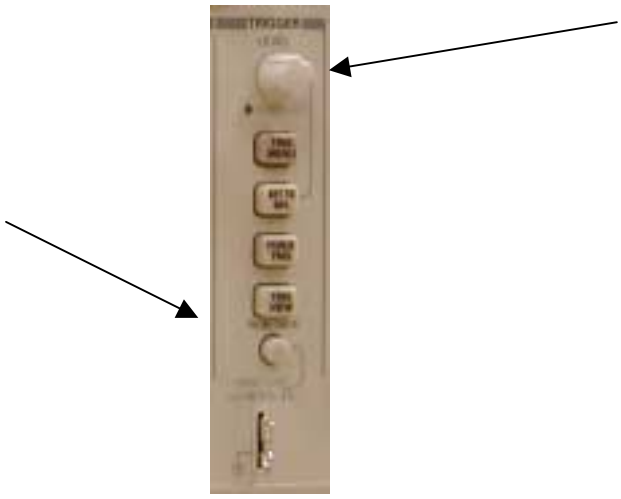

Figure 4. Arrows indicate the location of the trigger control

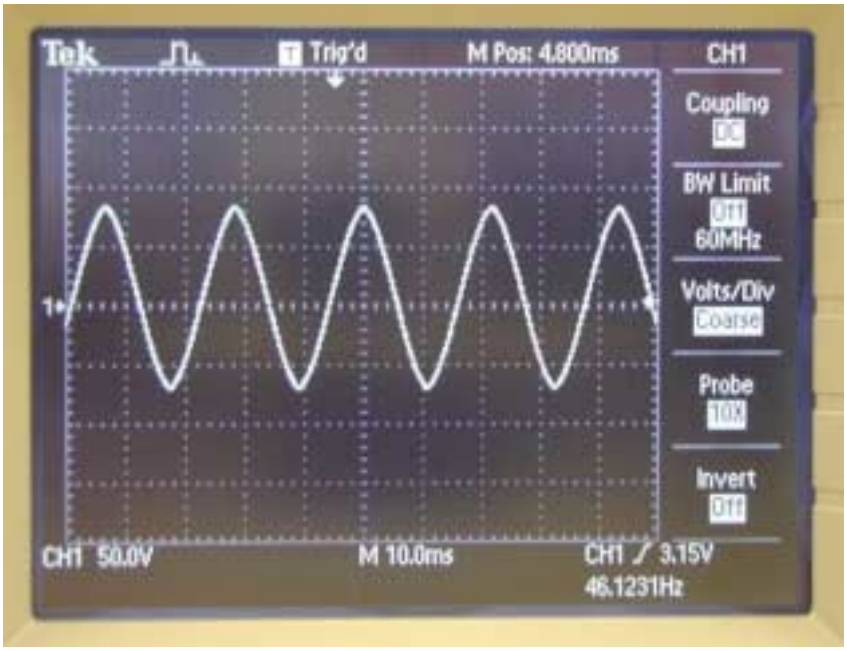


Figure 5. A sine wave appears frozen on the display because the time-base generator triggers at the same point each sweep.

# Theory: How the Function Generator Works

The heart of the function generator (also called a signal generator) is a sine-wave oscillator. The sine wave is produced internally at maximum amplitude. The output amplitude can be adjusted by external controls. Also, the frequency of the sine wave can be adjusted. For other waveshapes, including "square" and "triangle" waves, the sine wave is modified internally by circuitry containing diodes and capacitors. The function generator provides the option to add a DC offset to any waveform. For example, the output sine wave can be centered vertically around 5 V (or any other voltage in the allowed range) instead of around zero.

A photograph of our function generator is shown in Figure 6, with the major controls indicated.

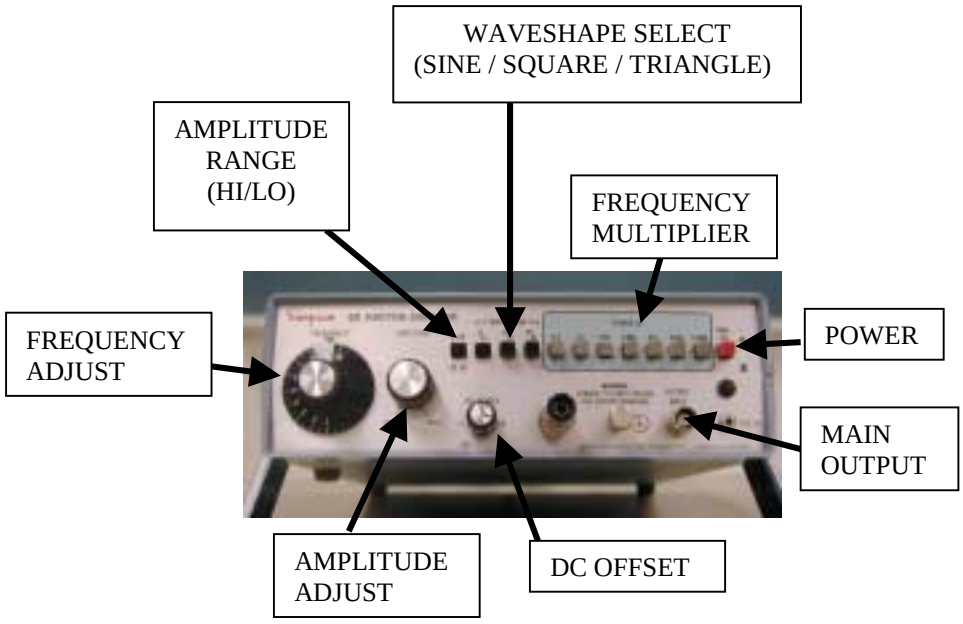


Figure 6. Function generator used to produce sine, square, and triangle waves with variable frequency and amplitude.

Your Name_____

# Prelab Questions (10 points)

Answer these questions before coming to lab and turn them in when you arrive. You may do your work on separate paper (for example you might want to do your work on a computer), but please attach your work to this sheet for submission.

(1) If the vertical VOLTS/DIV knob (see Fig. 2) is set to 10, what is the largest amplitude sine wave that can be displayed on the oscilloscope screen? (Remember that a sine wave with amplitude A extends from –A volts to +A volts.)

(2) Suppose the vertical VOLTS/DIV knob is set to 5. What is the amplitude of the sine wave in Figure 5?

(3) Suppose the SECONDS/DIV knob is set to 1 m. What length of time is represented by the entire horizontal axis? Give your answer in milliseconds (ms) and also write it in seconds (s). (Hints: Look at Figure 1 and count the number of horizontal divisions on the screen. Then multiply by the given setting. The prefix "m" stands for milli, which is .001)

(4) If the SECONDS/DIV knob is set to 0.5 m, what is the period of the sine wave in Figure 5? (Hint: the peaks are separated by two divisions.)

(5) What is the frequency of the sine wave in Question 4? Give your answer in Hz and also in kHz. (Hints: $f = 1/T$, and the prefix "k" stand for kilo, which is 1000.

(6) Briefly explain why we synchronize or "trigger" the oscilloscope to the signal we are measuring.

(7) Find two web sites with information on how to use oscilloscopes and list them here. Very briefly explain the types of information available at each site (theory, detailed theory, experimental procedure, photographs, etc.)

(8) Define the following terms: (a) Amplitude, (b) Peak-to-peak, (c) Max, (d) Min, (e) Frequency, (f) RMS, (g) Time-period, (h) Wavelength.