University of California, Riverside

Electrical Engineering

EE120A

LOGIC DESIGN

Laboratory Manual

Lab Instruments and Devices Manual

Edited by Roman Chomko, Winter 2009

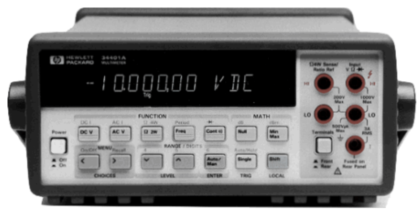
1. Multimeter: HP 34401A
2. Function generator: HP 33120A
3. DC Power supply: Tektronix CPS250 or HP E3630A
4. Oscilloscope: Tektronix TDS 340 or HP 54600B
5. Potentiometers
6. Color Codes of Resistors
7. ee001a - Oscilloscope Orientation

College of Engineering
University of California, Riverside

Lab Instrument/Device Introduction

College of Engineering
University of California, Riverside

1. Multimeter: HP 34401A



The multimeter on most lab benches is the HP 34401A. This instrument is used to measure voltages currents, and resistances.

To turn on the instrument, push the DC V button (left side of panel) to turn instrument on.

To measure a DC voltage, (1) Push the DC V button. The ranges are 100 mV to 1000 V, with maximum resolution of 100 nV in the 100mV range. The instrument automatically selects the range. (2) Connect the two Input V (HI and LO) terminals on the upper right corner of the panel to the two points whose voltage difference is to be measured. A positive value means the node connected to the HI input is positive with respect to the other node.

To measure the resistance, (1) Push the Ohm button (2-wired measurement). The ranges are 100 ohm to 100M ohm. The instrument automatically selects the range. (2) Connect the two Input V (HI and LO) terminals on the upper right corner of the panel to the two points whose resistance is to be measured.

To measure the DC current: (1) Push the shift button for DC current measurement mode (blue DC I marking above the DC V button). The ranges are 10 mA to 3 A. (2) Connect the LO and I input terminals (on the lower right corner of the panel) to the two points of a circuit branch whose current is to be measured. Note that the instrument must be connected on series with the branch. A positive value means the branch current flows from the I input to the LO input through the branch.

2. Function generator: HP 33120A 15 MHz Function / Arbitrary Waveform Generator or Wavetek Signal Generator

This instrument can provide one signal output to the circuit under test (OUTPUT connector at the lower right corner of the front panel) and a synchronizing output to the oscilloscope (SYNC output immediately above the OUTPUT connector). The basic signal output may be a sine wave, a square wave, and a ramp signal.

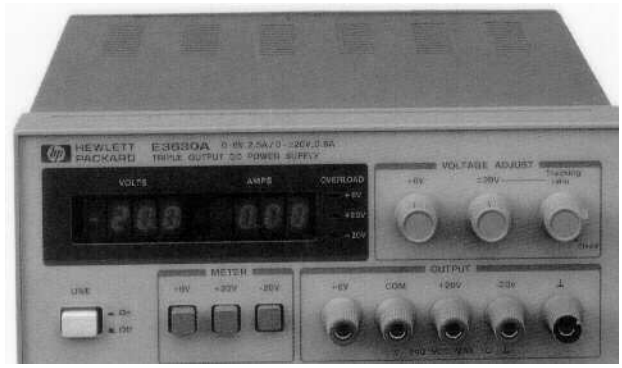
To turn on the instrument, Push POWER button (lower left of the panel) to ON. At power-on, the instrument automatically sets the signal type to sine wave, frequency to 1KHz, amplitude to 100 mV peak-to-peak, and offset to 0V.

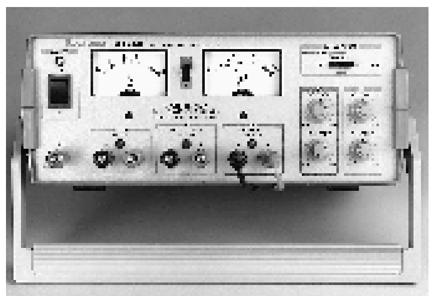
You may push/tune the relative button to set signal type, set signal frequency, set signal amplitude, set a DC offset or set a duty cycle for square waves.

For High Impedance Measurements:

> **The HP Function Generator's output termination setting must be set from 50 ohm to High Z (High Impedance) to display the proper p-p voltage. To do this, press the front panel buttons in this order: Shift, Enter, >, >, > (displays "sys menu"), v (displays "out term"), v (displays "50 Ω"), > (displays "high Z"), press Enter.**

3. DC Power supply: Tektronix CPS250 or HP E3630A





This instrument can provide various DC power supply voltages up to +6V, +20V, and –20V.

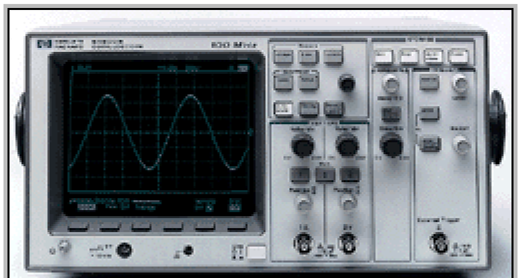
To turn the instrument, push ON/OFF switch on the front panel.

Connecting GROUND: the Ground connection of the instrument is usually connected to the COM connection and is used as the ground for all the instruments and circuits under test. Connect this Ground to your circuit Ground.

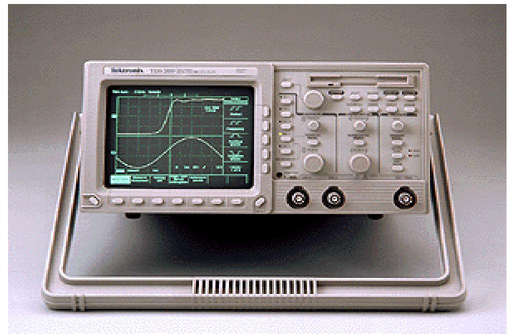
Connecting DC power supply and setting value: push relative buttons according to relative ranges such as +6V, +20V or dual power supplies.

If a DC input signal is needed and DC power supply still has unused outputs, the simplest way is to use one output of DC power supply to provide a DC signal to the circuit under test.

4. Oscilloscope: Tektronix TDS 340 or HP 54600B



HP 54600B 2 Channel 100 MHz Oscilloscope



The oscilloscope is a complex instrument and is commonly used both in teaching labs and in the electrical engineer's career. The first lab will introduce you to the basics of its operation.

A simple description of an oscilloscope is that a beam of electrons travels between two pairs of conducting plates and collides with a coated screen. The screen illuminates at the point of impact. One pair of plates is located vertically to the left and right of the electron beam. The other is located horizontally above and below the electron beam. By changing the voltage on the two vertical plates, the electron beam can be forced to scan horizontally across the display. By changing the voltage on the two horizontal plates the electron beam can be made to scan vertically across the display. By changing both voltages in a coordinated fashion, various waveforms can be traced.

For more detail, contact Mr. Dan Giles (dgiles@ee.ucr.edu) or go to the following site: http://pender.ee.upenn.edu/rca/instruments/HPscope/54600B.html

Before proceeding, please take note of the following warnings:

(1) Never connect any alligator clip or similar device directly to the oscilloscope probe.

(2) The spring loaded clip on the oscilloscope probe may be removed to expose a needle-like probe useful for contacting small conductors such is the op-amp pins. Never insert this probe into the breadboard. Always, replace the clip to the probe end.

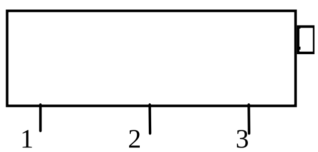
Violation of these warnings may bend or break the oscilloscope probe.

5. Potentiometers

Figure 2a shows the potentiometer that will be used in the labs. The small rectangle on the right end represents a small screw that can be turned to adjust the resistance between either terminals 1 and 2, or terminals 2 and 3. The corresponding circuit diagram is shown in Figure 2b. The potentiometer will have a fixed resistance, R, between terminals 1 and 3. The screw adjusts the point of contact of terminal 2, so that the resistance between terminals 1 and 2, R_{12}, can be varied between zero and R ohms. Since the point of contact is always between terminals 1 and 3, the resistance between terminals 2 and 3, R_{23} must satisfy

$$R_{23} = R - R_{12} \text{ or } R = R_{12} + R_{23}.$$

To use a potentiometer as a variable resistor, connect to terminals 1 and 2 (2 and 3 may be used instead). Connect an ohmmeter, and turn the screw to adjust the potentiometer to the desired resistance.



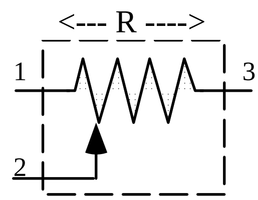


Figure 2A. Side View of Potentiometer Figure 2b. Potentiometer Circuit

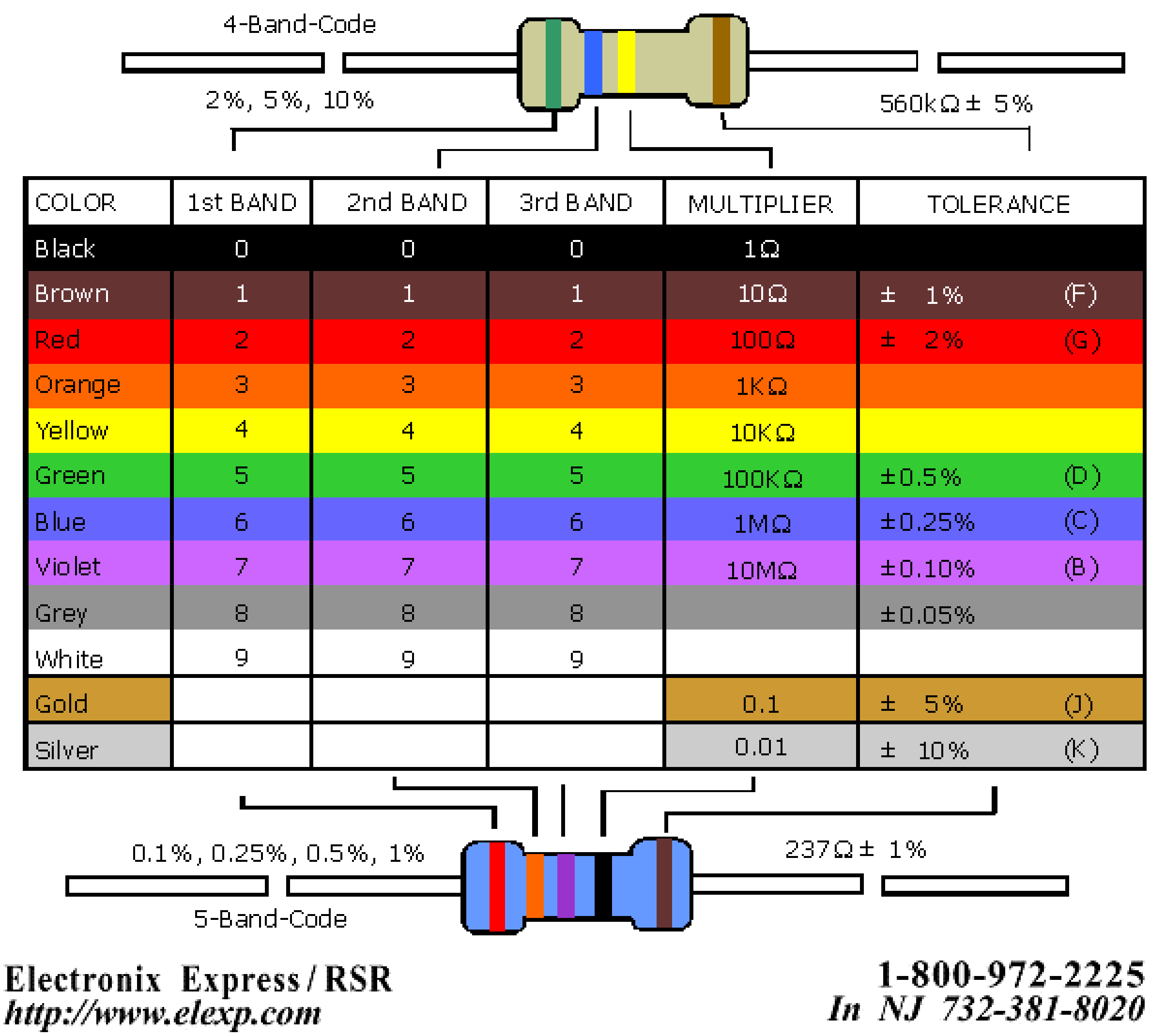
6. Color code of the resistors

Color	Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Gray	White
Number	0	1	2	3	4	5	6	7	8	9

The resistance R of a resistor is given by a color code. The color bands specify the resistance according to the following rule:

R = (1st color#) (2nd color#) X 10 (raised to the 3rd color#)

The first digit of the resistance is given by the color band <u>closest</u> to the end of the resistor. The 4th band gives the tolerance of the resistor: **gold** means $\pm$5% tolerance, **silver** means $\pm$10% tolerance, and <u>no</u> 4th colored band means $\pm$20% tolerance. For example a resistor with a color code **Red Black Red Gold**, a 2 kΩ - 5% resistor, will have a resistance somewhere between 1.9 kΩ and 2.1 kΩ.
http://www.elexp.com/t_resist.htm



COLOR	1st BAND	2nd BAND	3rd BAND	MULTIPLIER	TOLERANCE	
Black	0	0	0	1Ω		
Brown	1	1	1	10Ω	± 1%	(F)
Red	2	2	2	100Ω	± 2%	(G)
Orange	3	3	3	1KΩ		
Yellow	4	4	4	10KΩ		
Green	5	5	5	100KΩ	±0.5%	(D)
Blue	6	6	6	1MΩ	±0.25%	(C)
Violet	7	7	7	10MΩ	±0.10%	(B)
Grey	8	8	8		±0.05%	
White	9	9	9			
Gold				0.1	± 5%	(J)
Silver				0.01	± 10%	(K)

EE1A

Oscilloscope Orientation

College of Engineering
University of California, Riverside

Objective

To introduce the student to the use of Digital Storage Oscilloscopes together with the Signal/Function Generator and the DC Power Supply unit.

Background

The oscilloscope is a complex instrument and is commonly used both in teaching labs and in the electrical engineer's career. This lab will introduce you to the basics of its operation.

A simple description of an oscilloscope is that a beam of electrons travels between two pairs of magnetically-charged plates and collides with a phosphor-coated screen. The screen illuminates at the point of impact. One pair of plates is located vertically to the left and right of the electron beam. The other is located horizontally above and below the electron beam. By changing the voltage on the two vertical plates (timebase), the electron beam can be forced to scan horizontally across the display. By changing the voltage on the two horizontal plates (signal input), the electron beam can be made to scan vertically across the display. By changing both voltages in a coordinated fashion, various waveforms can be traced.

Laboratory Procedure

1. a) Look at the front instrument panel. Notice that the panel is organized into three main areas containing (from right to left) : Trigger Controls, Horizontal Controls, and Vertical Controls. A forth area located above the main controls contain: Acquisition Controls, Cursor Controls, CRT[1] Display Controls, and Set-up Controls.
   b) Locate the power button and turn the oscilloscope on.
   Use the CRT display controls to adjust the focus and intensity to achieve a good image quality. **Warning: high intensity will damage the phosphor display!**
   c) Observe the signal on channel 1. You should see, at least, one horizontal line on the CRT display.
   Adjust the vertical position knob and describe the effect.
   Adjust the horizontal position knob and describe the effect.
   Question: In terms of the above description of the operation of an oscilloscope, what are the horizontal and vertical position knobs changing to move the beam position on the display.
   d) Find the input coupling setup for channel 1 and set to GND. Adjust the vertical

[1]Cathode Ray Tube

and horizontal positions so that the line is centered on the display along a major grid line. Then set the input coupling switch to DC.

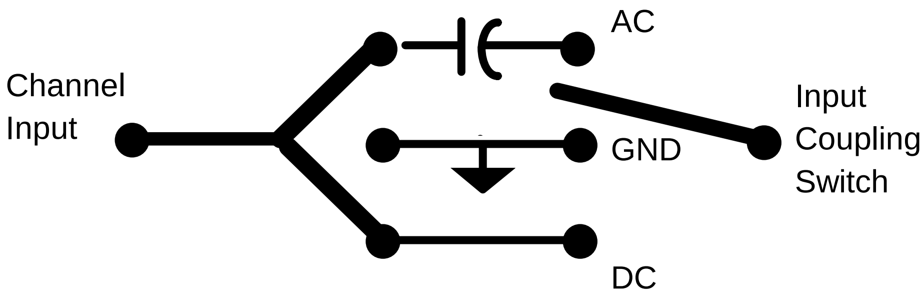


Figure 1. Schematic of Input Coupling Switch.

<u>Explanation:</u> The input-coupling switch allows the user to control the manor in which the input signal is displayed, without changing the input signal (see Figure 1). The DC setting displays the entire signal. The GND setting grounds the input channel without grounding the applied signal. This is useful for establishing a zero voltage reference position on the screen, as you have just done. The AC setting uses a capacitor to block the DC component of the applied signal. This is useful when you are interested in observing a small AC signal that is superimposed on a large DC signal.

2 The Oscilloscope as a DC Meter.

a) Set the Ch 1 volts per division (vertical) scale to read 5V per division.

Connect the output of the DC Power Supply to the input of the Ch. 1 Oscilloscope probe. ***Note: The oscilloscope probes are calibrated for the instrument and should remain connected to the scope. They have built-in attenuation (10x) and will not work properly on different scopes or test equipment.***

Carefully, connect the red (+20V) and black (COM) connections of the DC Power Supply to the Ch. 1 Scope probe (red to spring-clip, black alligator-clip to black alligator-clip).

Set all the power supply voltage adjustment knobs to zero.

Turn the power supply on.

b) Adjust the power supply voltage and describe what happens to the trace on the oscilloscope.

Set the power supply voltage so that the voltmeter on the power supply reads 10 volts.

How many divisions above the zero voltage reference position is the trace on the oscilloscope?

Multiply this number of divisions by the number of volts/per division. How many volts is indicated by the oscilloscope?

Reset the Oscilloscope Ch 1 volts per division scale to read 2V per division. Now how many volts is indicated by the oscilloscope?

c) Set the input coupling switch to GND. What happens to the oscilloscope trace? What happens to the voltage read by the voltmeter on the power supply? Why?

d) Set the input coupling switch on the oscilloscope back to DC.

Reverse the red and black alligator clips on the power supply.

What happens to the oscilloscope trace? Why?

e) Turn the power supply voltage to zero, and turn the power off.

3. The Oscilloscope as an AC Voltmeter.

Note that Ch1 is also labeled X and that Ch2 is also labeled Y.

Connect channel 2 on the oscilloscope and the output of the function generator. Set the oscilloscope as follows: CH1 at 2 V/div, CH2 at 2 V/div, both input coupling to DC, X vs Y mode (keep the intensity low).

Turn the three instruments on.

Select a 1 hertz (cps) sine wave on the signal generator.

On the oscilloscope, you should see a dot moving vertically on the display. This is because channel two (Y) is now controlling the voltage on the two horizontal oscilloscope plates. Since this signal from the signal generator is changing sinusoidally at one hertz, the dot (electron beam) is oscillating vertically. The beam is not moving horizontally, as the signal being applied through the power supply is constant.

Use the horizontal position control knob on the oscilloscope to move the oscillating point to the left edge of the oscilloscope screen.

Using the voltage control knob on the power supply, manually increase the voltage applied to channel one. Try to increase it at a constant rate. Do this several times, and notice the oscilloscope trace. If you increase the voltage at a constant rate, the oscilloscope will display a sinusoidal signal.

Increase the frequency of the signal generator to 100 hz.

Repeat the exercise of trying to display a sinusoid on the oscilloscope. Can you do it?

Turn the instruments off.

Disconnect the power supply.

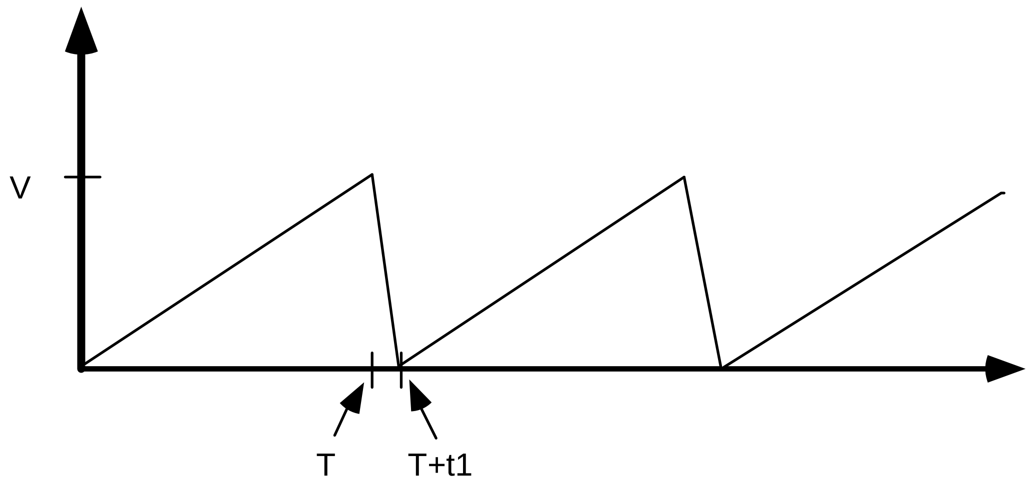


Figure 2. Oscilloscope Automatic Sweep Signal

Explanation. Imagine the difficulty of manually controlling the horizontal scan for higher frequency signals. To simplify the process and allow precise measurement of signal timing, oscilloscopes have internal mechanisms (timebase) to control the horizontal scan. A signal such as that shown in Figure 2 is applied to the vertical plates of the oscilloscope. While the Sweep signal increases from zero to V volts, the signal traverses the screen from left to right. During the reset time t1, the input signal is blocked–to eliminate confusing displays. The time t1 in the figure is greatly exaggerated. In actuality, t1 << T.

b) Turn on the oscilloscope and signal generator.
Set the signal generator frequency to 1000 hz.
Select channel 2 on the scope.
Ground the input coupling for channel 2 to adjust the zero voltage position.
Readjust the horizontal position to center the trace.
Set the time base calibration dial to .1 ms/div. (displayed on the screen)
Set the input coupling to AC. You should observe one cycle of a sinusoid on the display. This is because the period of a 1000 hertz signal is 1.0 millisecond and there are 10 divisions across the display.
c) Set the input coupling to DC. Watch the waveform while changing to DC coupling. If the position of the waveform changes, then there is a DC bias on the AC signal. Can you measure the amount of the DC bias?
Use the DC Offset on the signal generator to add or subtract DC bias.
Note. Both the DC bias on the signal and the vertical position knob on the oscilloscope will affect the location of the waveform on the oscilloscope; however, the DC offset and the vertical position knob have very different effects. The DC offset is changing the waveform itself. The vertical position knob has no effect on

the waveform; it only changes the oscilloscope display. This distinction will be important in later labs.

d) Change the frequency to 200 hz.

Change the horizontal control knob until you get a few cycles of the sinusoid on the display.

Change the frequency to 20000 hz.

Change the horizontal control knob until you get a few cycles of the sinusoid on the display.

Notice how easy it is to display and observe signals of different frequencies on the oscilloscope.

e) You can use the oscilloscope to determine the frequency of a signal.

Change the frequency of the signal generator and do not look at its display.

Change the oscilloscopes horizontal control until you get a few cycles of the sinusoid on the display.

Count the number of horizontal divisions for one period of the signal.

Multiply the number of divisions by the horizontal control factor (msec/div) to determine the signals period.

Take the reciprocal of the period to determine the frequency.

Compare this with the frequency displayed on the signal generator. How close is your measurement? What is the dominant source of error?

4 Dual Trace.

The oscilloscope has two input channels so that two signals can be observed. Since there is only a single beam of electrons, the circuitry in analog scopes that controls the beam location is switched between the two channels. There are different means of accomplishing this switching (alternate & chop), but it can be accomplished fast enough, that to the human eye, both waveforms appear to be displayed simultaneously. In digital storage scopes, the analog signals are sampled, digitized and displayed without switching between channels.

With both channels selected, you should observe a horizontal line and a sinusoidal waveform.

Set the zero voltage reference position for channel 1 two lines above the midpoint on the screen, and the zero voltage reference position for channel 2 two lines below the midpoint on the screen. This way you can distinguish the two traces.

5 Triggering.

To this point, we have not considered how the oscilloscope knows when to trigger a horizontal sweep. You can imagine that it would be convenient for the user to have control of when a horizontal sweep occurs. This is the purpose of the trigger control panel at the right of the front panel.

a) Notice that as you adjust the trigger level knob, you can control the point at which the waveform triggers a horizontal sweep.
Alternate between positive and negative slope and note the slope of the waveform when the horizontal sweep is triggered.

Conclusion: The oscilloscope has many capabilities beyond those you have used in this exercise. Some of them are described in the handout–others will be described as needed by the TA.

You do not need to write a report on this lab, but a good understanding of this exercise will help you in future labs. If you have questions, ask the TA for assistance.