MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

6.007 – Electromagnetic Energy: From Motors to Lasers
Spring 2011

Tutorial: Oscilloscopes
Due: Read before the start of Lab 1 (7:00PM on Tuesday, Feb 8 / Wednesday, Feb 9, 2011)

Introduction

An oscilloscope is an instrument that allows signal voltages to be displayed, usually as a 2D graph of one or more voltage signals plotted as a function of time or of some other voltage signal. In most cases, an oscilloscope shows repeating events (although there can can be a slowly varying envelope).

Figure 1: The Tektronix oscilloscope we will use in the lab.

We will use oscilloscopes when we need to observe the exact shape of a voltage signal. In addition to the amplitude of the signal, an oscilloscope can show us the pulse width and rise time of the signal. It can also depict the relative timing of two signals on different channels. Finally, oscilloscopes can tell us the frequency of signal events.

1 Getting Started

We are going to measure the reference output of the oscilloscope. This is a 1 kHz 0V to 5V signal that the oscilloscope outputs.
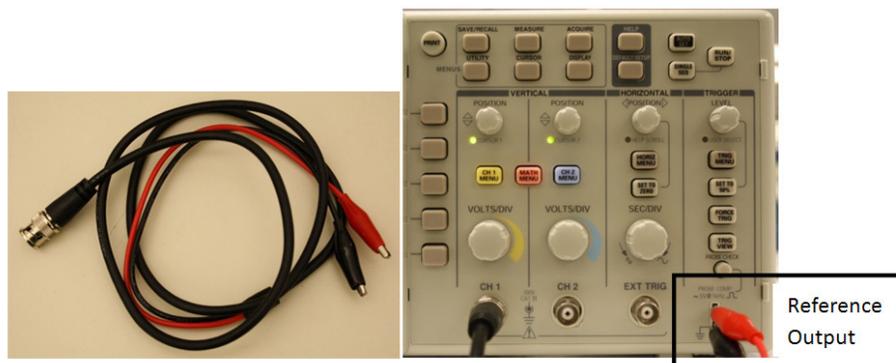

Figure 2: Connect Channel 1 to the reference signal.

Connect Channel 1 ("CH 1") to the reference signal as shown above. Make sure the red wire is connected to the +5V out and the black wire is connected to ground. The oscilloscope is hard wired to have the black

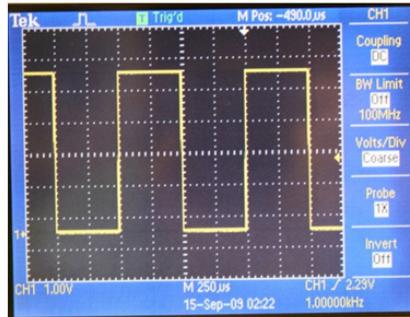wire always at ground. If you attach the wires in reverse, you will see an output of 0V.

Figure 3: The reference signal on the screen of the oscilloscope.

1. Press the yellow "CH 1 MENU" button until the menu appears and a yellow waveform appears on screen.

2. Press the button to the right of "Probe" (on the right menu bar of the screen) until it reads Probe 1X. Notice how the signal displayed at the output scales in proportion to the probe multiplier as you toggle through probe selections.

3. Make sure the Coupling is set to DC. This allows for DC signals to be measured by the oscilloscope. Try changing the coupling to AC. You will notice that the square wave shifts from a mean of +2.5V to a mean of 0V. Since DC is no longer being measured, the average value of the signal will be 0V.

2   Configuring the Waveform

Now we want to make sure the square wave is visible on screen, stationary, and scaled properly for us to measure its parameters. Let's start by scaling our waveform properly.

2.1   Scaling the Y-axis (Voltage)

Figure 4: The "VOLTS/DIV" knob that scales the Y-axis.

You will notice some text that says "CH1 # V" on the bottom left of the display. This specifies the current volts per division, where a division is 1 square of the white grid on the display. Since we expect to be measuring a 5 V peak to peak square wave, we should set this to 1 V per division.

1. Locate the "VOLTS/DIV" knob in the Channel 1 section of the oscilloscope. (You might notice a duplicate knob to the right. This is the same control for Channel 2.)

2. Turn the knob either left or right until the display on the bottom right reads "CH1 1.00V".

2.2 Voltage Offset

You might notice that your waveform is being clipped either at the top or the bottom of the screen. This is because the voltage offset is not set properly. Since our waveform has a minimum of 0V and a maximum of 5V, getting it to the middle of the display would require us to set the voltage offset to 2.5V.
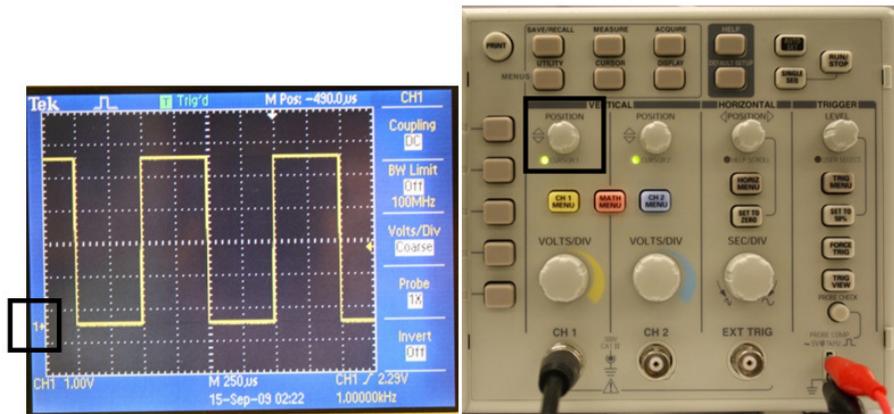

Figure 5: The arrow labeled "1" tells you where 0V is with respect to the display. The "POSITION" knob sets the voltage offset.

1. Locate the smaller knob above the "VOLTS/DIV" knob labeled "POSITION". Associated with this knob is a right pointing arrow at the left side of the display. This arrow tells us where 0V is with respect to the display.

2. Turn the knob until the level is set to 2.5V and the right pointing arrow is at -2.5V relative to the center of the screen as shown above.

2.3   Scaling the X-axis (Time)

The waveform is centered, but maybe you have too few or too many periods to see anything! Let's adjust the timescale to a more reasonable value.
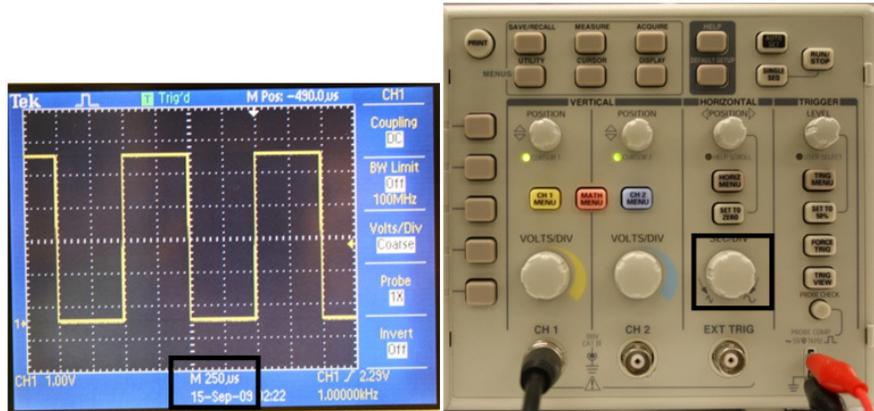

Figure 6: The seconds per division is shown on the bottom of the screen. The "SEC/DIV" knob scales the X-axis.

1. Locate the knob labeled "SEC/DIV". Associated with this knob is a display parameter showing us what the "SEC/DIV" is currently set to.

2. A 1 KHz square wave should have 1 period every 1 ms. Let's set our time scale to 250 us so we can see 2.5 periods of our square wave on screen, as in Figure 6.

3   Triggering

Now that our waveform is centered, we need to make sure the oscilloscope can lock to the signal.

Figure 7: The "LEVEL" knob sets the trigger level.

1. Locate the small knob labeled "LEVEL" at the top right of the oscilloscope panel.

2. This knob tells the oscilloscope where your signal is and where it should look for rising and falling edges. Associated with this knob is a left pointing arrow on the right side of the screen. This arrow tells you where the level is set currently.

3. If your signal is hopping around and unstable, try adjusting the level knob until the arrow is at the center of the waveform. You will notice that the oscilloscope now displays a stationary signal.
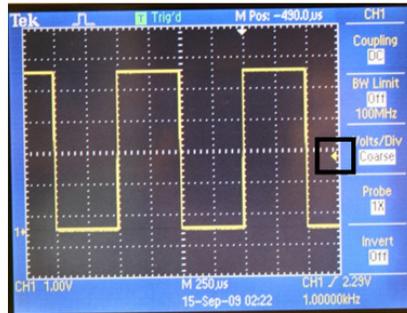

Figure 8: The arrow on the right of the screen tells you the trigger level.

4 Cursors and Measurements

Now that our waveform is stable and centered, let's try measuring some parameters of the square wave using the oscilloscope.

Figure 9: The "CURSOR" button toggles the Cursor Mode. When the LEDs are lit, that means you are in Cursor Mode, and the "POSITION" knob now controls the cursor.

1. Locate the button labeled "CURSOR" on the panel. The menu on the display should change to cursor mode. Set the type to Voltage and the green LED's should light up. The knob next to the left LED is now controlling cursor 1 and the knob next to the right LED is now controlling cursor 2.

2. Change the "Source" to "CH1" (located on the bar at the right of the screen) and play with the knobs until you can measure the peak-to-peak voltage of the square wave. Delta should read 5V as shown in Figure 10.

3. To measure the frequency, change the "Type" to "Time" and move the cursors as shown below. Delta should now read 1.000 ms and 1.000 kHz, as shown in Figure 11.

Fortunately, there is an easier way to accomplish measurements.

1. Locate the button labeled "MEASURE." The display menu should change to the "MEASURE" menu.

2. Press the uppermost menu button. Then change the "Source" to "CH1" and the "Type" to "Freq." As shown in Figure 12, we have configured 3 of the menu items to automatically measure frequency, mean voltage, and peak to peak voltage.
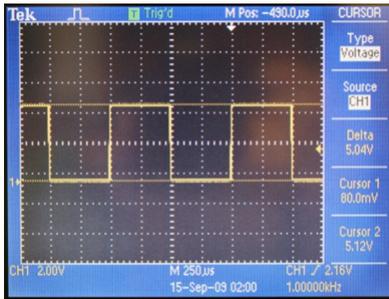
Figure 10: Measuring the peak-to-peak voltage with cursors.
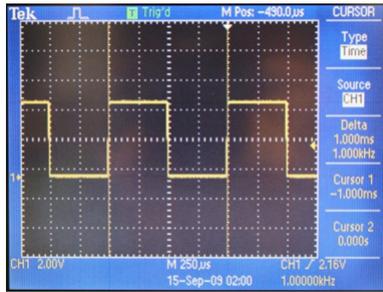

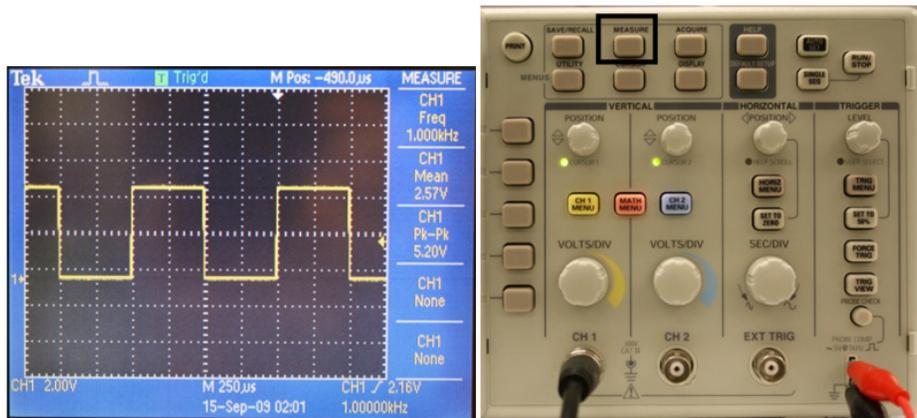Figure 11: Measuring the period / frequency with cursors.

Figure 12: Configure the menu items to automatically measure frequency, mean voltage, and peak-to-peak voltage.

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