ELEC 3509 "Advanced" Tektronix Oscilloscope Tutorial

This tutorial assumes that the reader has a basic understanding of Tektronix oscilloscopes. For introductory tutorials, see the links on the ELEC 3509 laboratory website or refer to your course material from second year.

Introduction

Figure 1 shows an example of a standard 2-channel oscilloscope that you will be using in ELEC 3509. The two channels (CH 1 - yellow and CH 2 - blue) are used to measure AC signals (voltages). Having two channels allows you to measure the signals at two locations on a circuit simultaneously.

To turn on any channel, simply press the corresponding coloured button. To turn off any channel, press that channel's coloured button and then "OFF" under the "Vertical" panel. Recall that each channel's vertical scale can be independently controlled with the vertical "Scale" dial. The horizontal scale is common for both signals and can be adjusted with its corresponding dial.
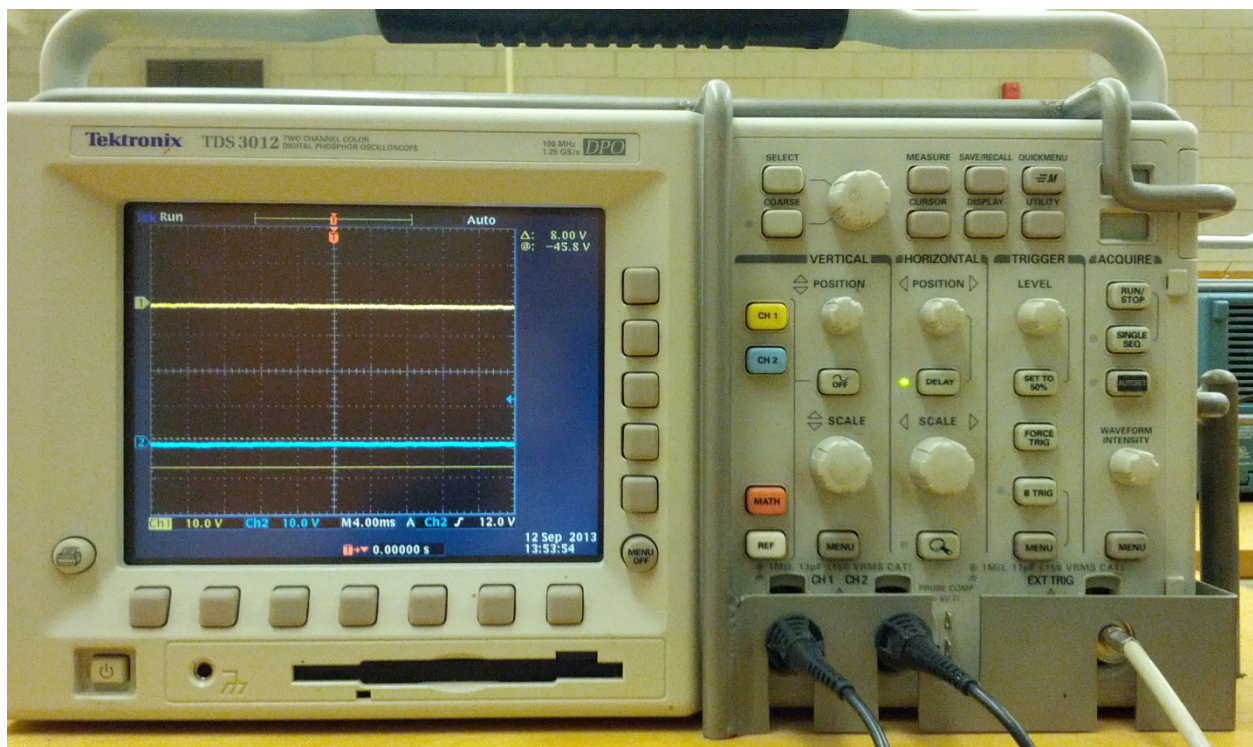

Figure 1: Front view of 2-channel oscilloscope

Signal Acquisition

A common problem that most students have is that they overuse the **Autoset** function (black button under the "Acquire" menu). **Autoset** should only be used if you cannot see your signal after connecting your probes. **Autoset** does not necessarily provide you with a perfect signal; it simply tries to find the appropriate scale for you. It **will alter all of your current settings,** so be wary of this.

In this course, we typically deal with sinusoidal waveforms. When you connect your probes to the desired circuit location and hit **Autoset**, you will likely see something similar to that shown on Figure 2. The signals will probably be noisy (fuzzy) and un-triggered (moving back and forth or with multiple traces as seen in the yellow waveform below).
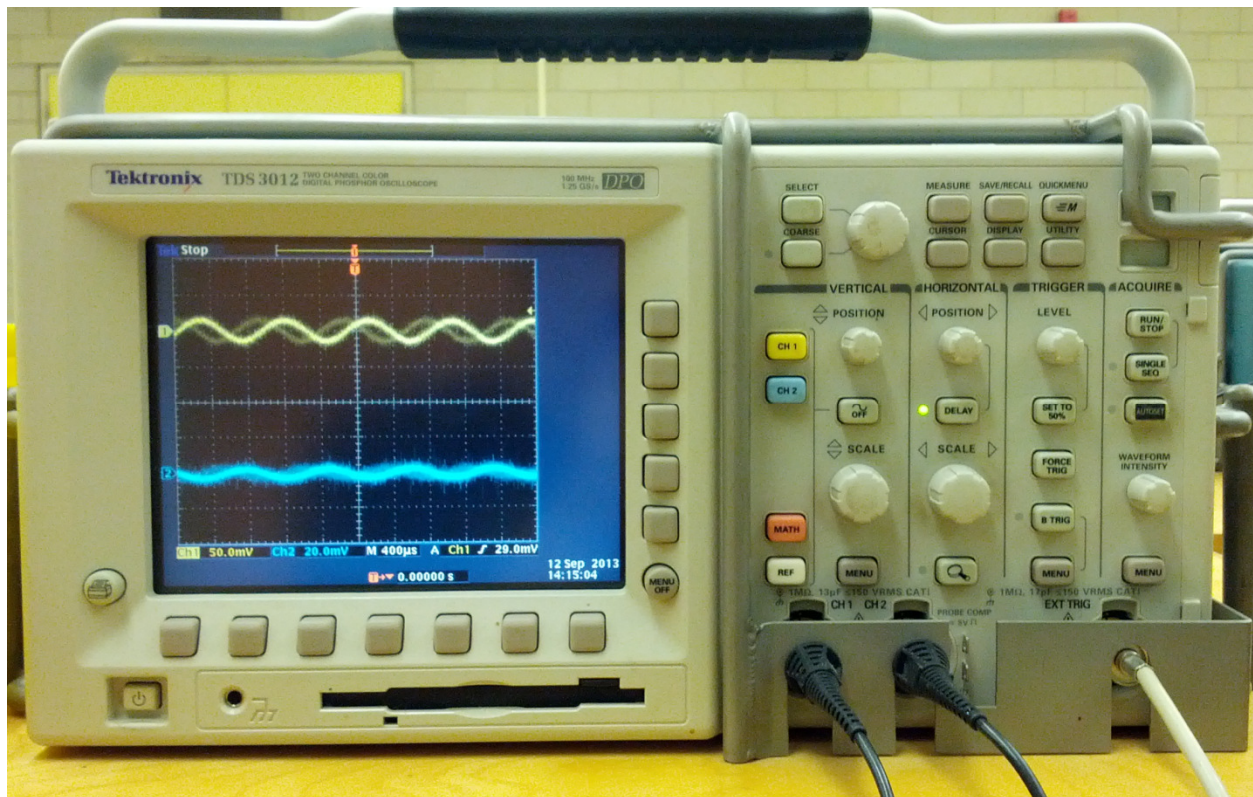

Figure 2: Un-triggered, noisy waveform.

A common mistake is to hit "Run/Stop" or "Single Seq" under the "Acquire" menu and try to measure the paused waveform. At this point any measurement will be unreliable. You will need to clean up your signal before taking any measurements.

Occasionally, when you have a low amplitude signal with a lot of noise, **Autoset** will think the noise is the signal and adjust the scale towards that resulting in a display similar to the example shown in Figure 3.
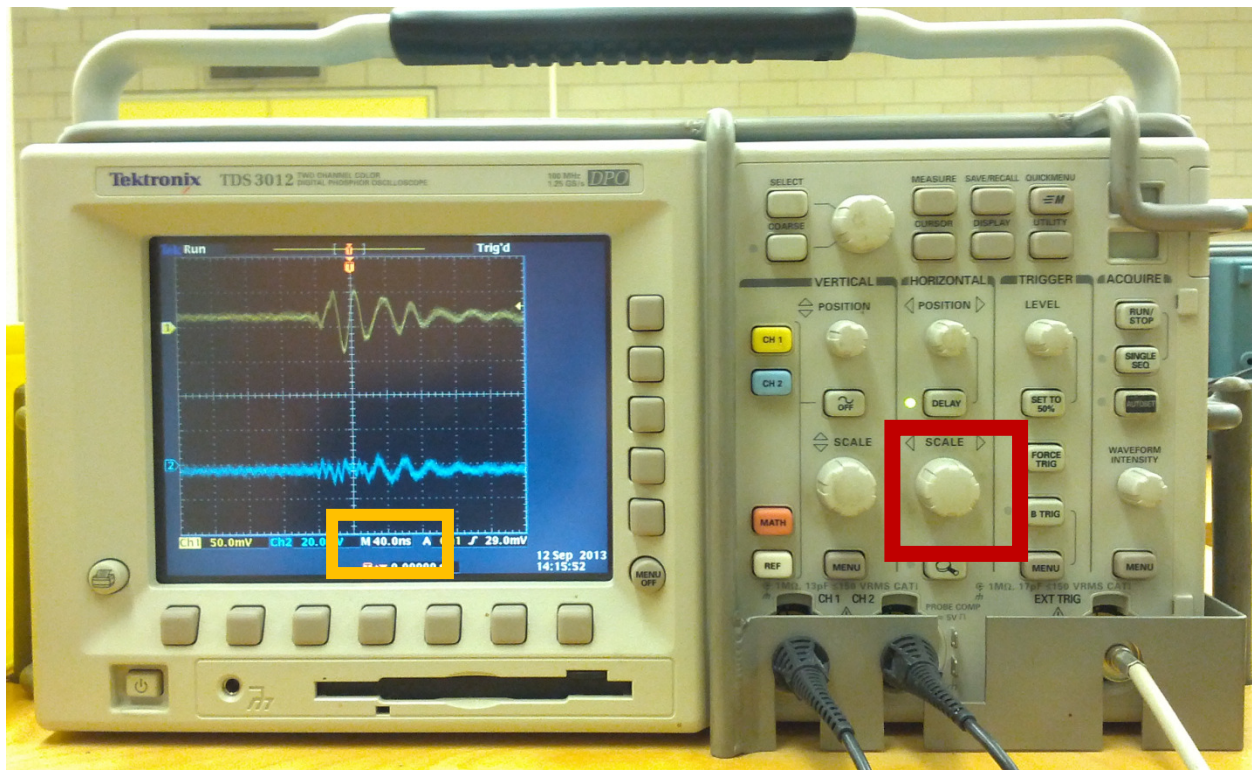
Figure 3: Example of when Autoset goes wrong

It is important to keep an eye on your time scale (indicated by the yellow box in the figure). In this example we see that the timescale is extremely small for our expected signal frequency and it is clear that the time axis is stretched. Therefore you should use your **Horizontal Scale dial** (red box) to compress the view.

Triggering

Triggering is a feature that allows you to synchronize the time axis (horizontal) of the scope with a known reference signal to produce a stationary, steady wave. In our lab, the signal generators are connected to the **"EXT TRIG"** port on the oscilloscope via the white cable as indicated in Figure 4.

To set the trigger, press **Menu** under the **Trigger** panel **(1),** press the source selection soft button directly under the display **(2)** and select "**Ext**" **(3).** In the event that an external trigger is not available, you can trigger to one of your channels by selecting it in the menu. You may also manually adjust the triggering by using the "Level" dial on the "Trigger' panel.
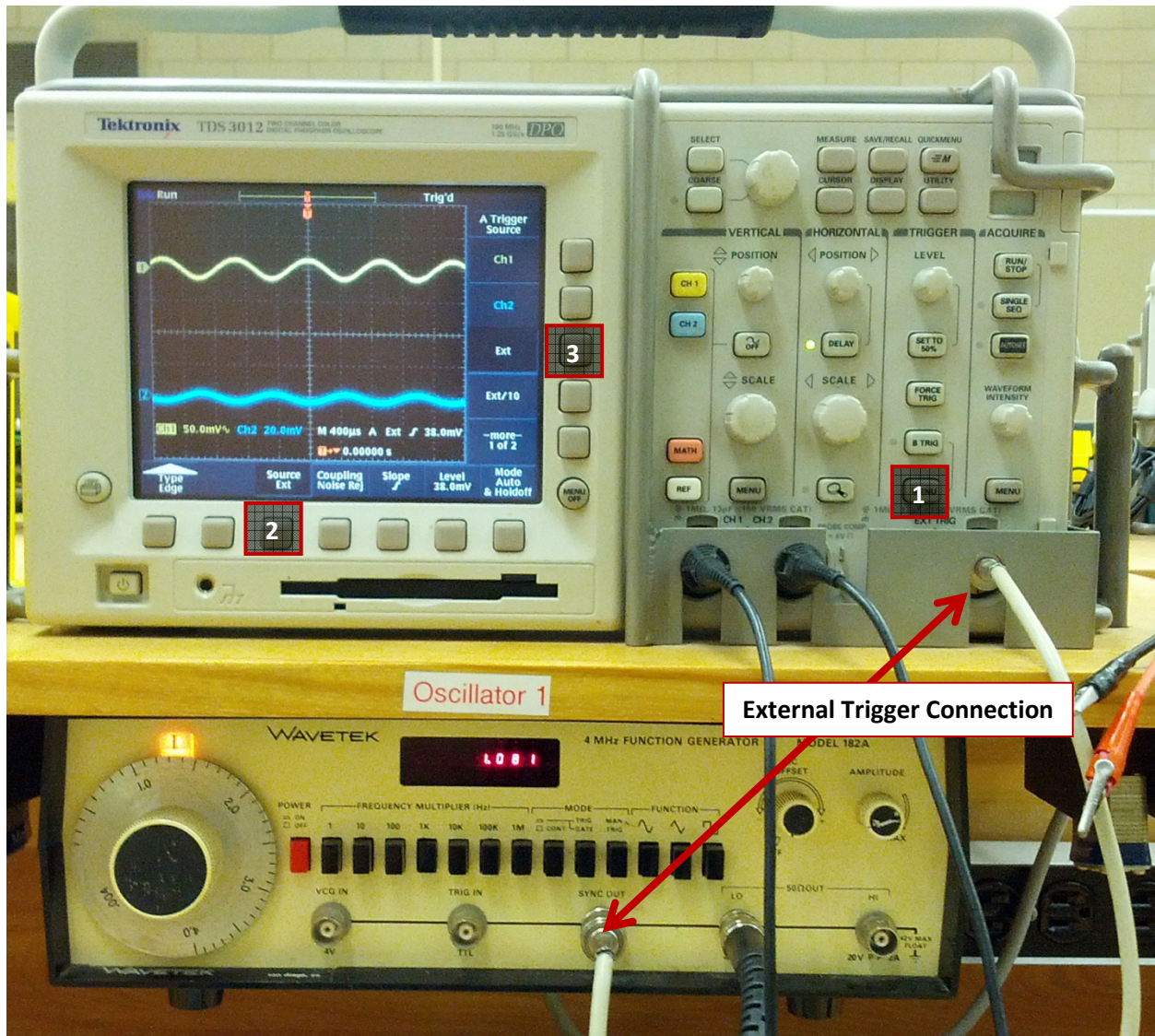
Figure 4: Oscilloscope triggering

At this point you should have a stationary signal displayed. If this is not the case, then your signal is not stable. Check your circuit for loose or improper connections, capacitor polarity or any other misconnection.

DC/AC Coupling

Most of the time you will be taking measurements through a coupling capacitor to isolate your probe from the rest of the circuit. However, you may need to occasionally take measurements where DC voltages are non-zero; in this case you will want to adjust your coupling to AC. This is shown in Figure 5.
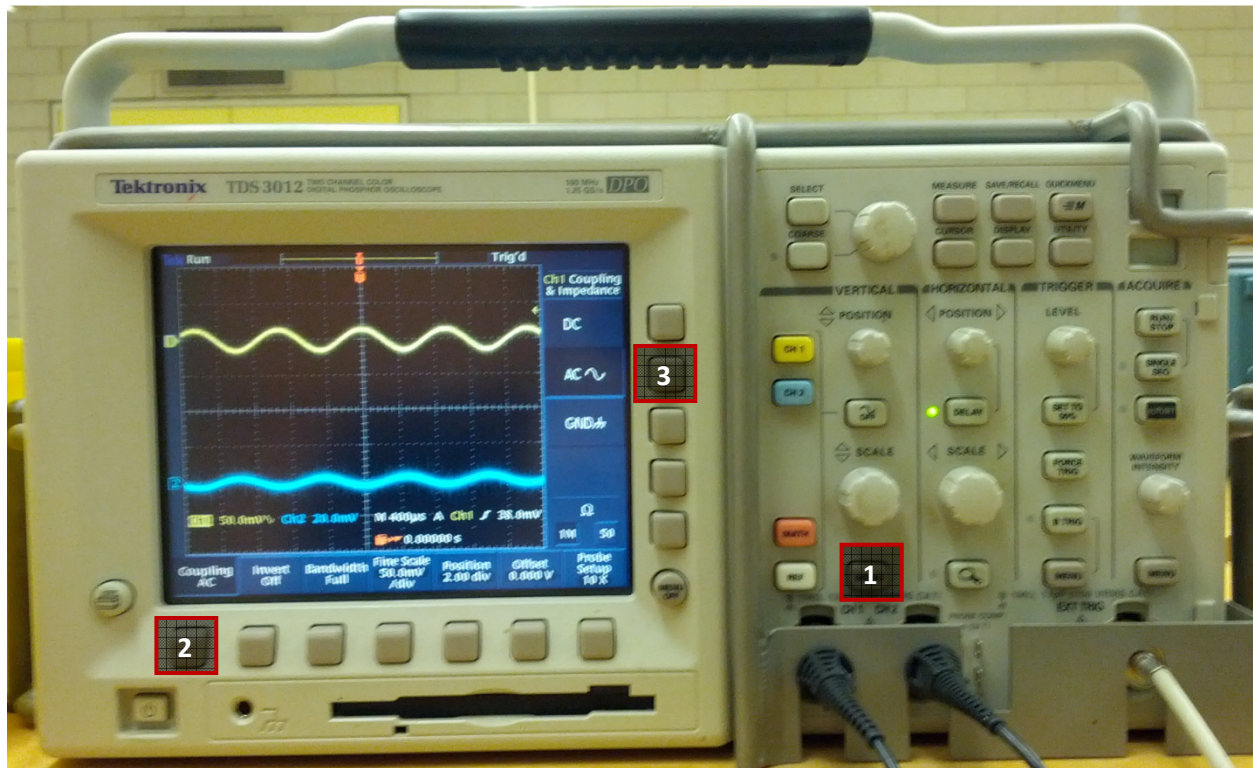
"DC coupling" means the DC voltage value is added onto the AC value. In most cases, the DC voltages are significantly larger than AC amplitudes such that your DC coupled signal will appear very high on your display and will likely flatten out the vertical scale.

For this course you will most likely always want to be using AC coupling (DC voltage ignored). To enable this, press "**Menu**" under the **"Vertical"** panel **(1)**. Select "Coupling" with the soft key **(2)** and select "**AC**" **(3)**.

Note: The **Autoset** function can change this setting so make sure to check it.

Cleaning Up a Noisy Signal

The signals displayed in Figure 1 are examples of noisy signals. Noise can occur for a multitude of reasons; some are within your control while others are not.

You will often times be using the multimeter/voltmeter (DVM) to measure the DC biasing of your circuit, but doing this will add significant noise to your AC signals. **Remember to disconnect the DVM from your circuit** before measuring a signal with your oscilloscope.
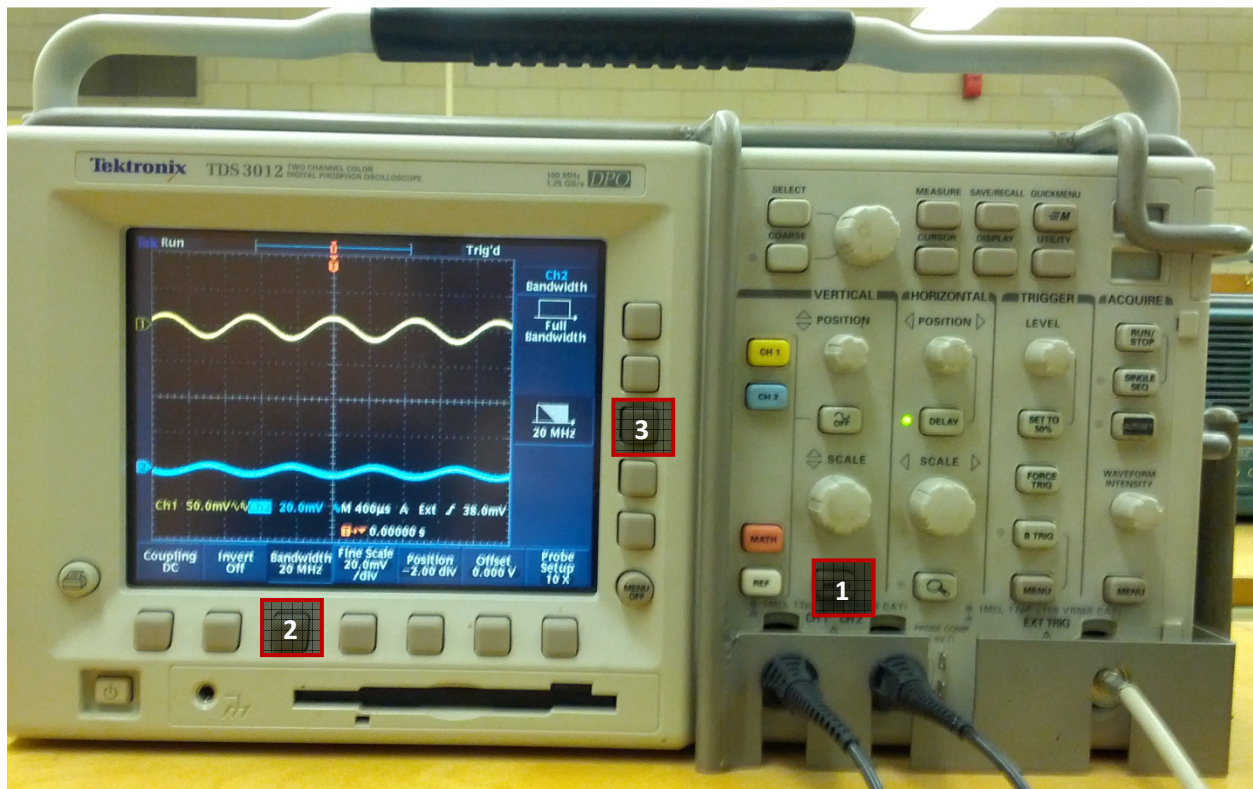
Noise Filter

Figure 6: Adding a 20MHz noise filter

In this course we will typically be working with frequencies no higher than ~4MHz. Therefore we can filter out a lot of noise using the built-in 20 MHz low pass filter (LPF). This can be done by pressing "**Menu**" under the "**Vertical**" panel **(1)**, selecting **"Bandwidth"** with the screen soft keys **(2)** and then enabling the 20 MHz LPF **(3)**.

High frequency noise is very typical in these types of circuits and is produced from many environmental sources (room lights, radio signals, cell phones, etc).
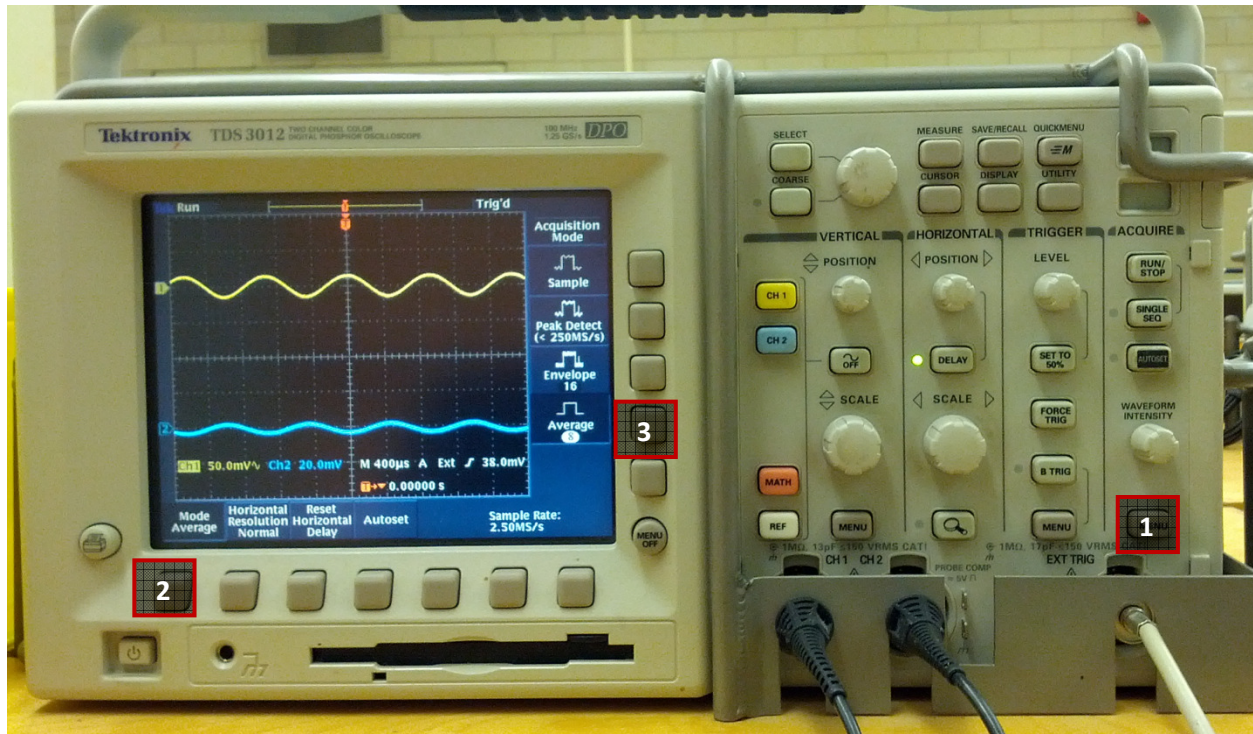
Averaging

One method of improving the visual stability of a signal is to use the oscilloscope's time-averaging. First, make sure that your signal is properly triggered. Then press "**Menu**" under the "**Acquire**" panel **(1)**, select "**Mode**" with the soft keys **(2)** and then select "**Average**" **(3)**

WARNING ABOUT USING AVERAGING

Averaging can be useful if you want to average out a small amount of noise. However, you should **understand that it is not actually getting rid of the noise**. It is simply hiding it from you. Before using averaging, try to actually eliminate the noise in your circuit (apply the LPF, trim your resistor wires short, look for loose ground wires, etc). If you have an excessively noisy signal, it could look accurate through averaging but may not actually be accurate.

In this course, most of the signals should be reasonably clean without needing to average out the noise. If you have excessive noise, that is a symptom of another problem and you should probably not be using averaging yet.
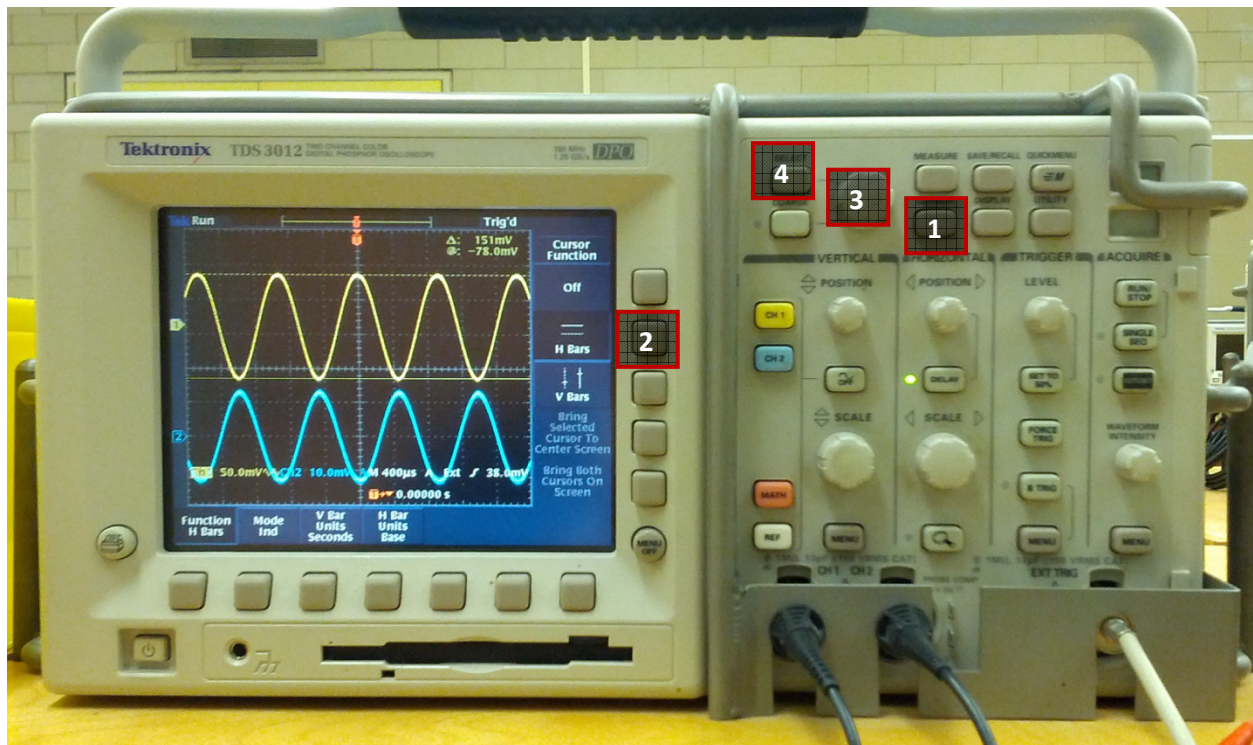
Measuring Values with Cursors

Figure 8: Horizontal Bars should be used for measuring voltages (peak to peak)

In most cases, you will be interested in measuring the peak-to-peak voltages of your signals. These values can later be converted to amplitude or RMS, however that is generally unnecessary. The only acceptable method for accurately measuring your voltages is to use the **horizontal cursor bars.**

First, obtain as clean of a signal as possible. Then press "**Cursor**" on the front panel **(1)** and "**H Bars**" on the vertical soft menu keys **(2)**. Press the coloured channel button of the waveform you want to measure. Using the cursor dial **(3),** line up your horizontal bar with one of the peaks of your waveform. Press the "**Select**" button **(4)** to enable your second cursor which you should place on the other peak. Read the measured voltage indicated by the **Δ** on the display.
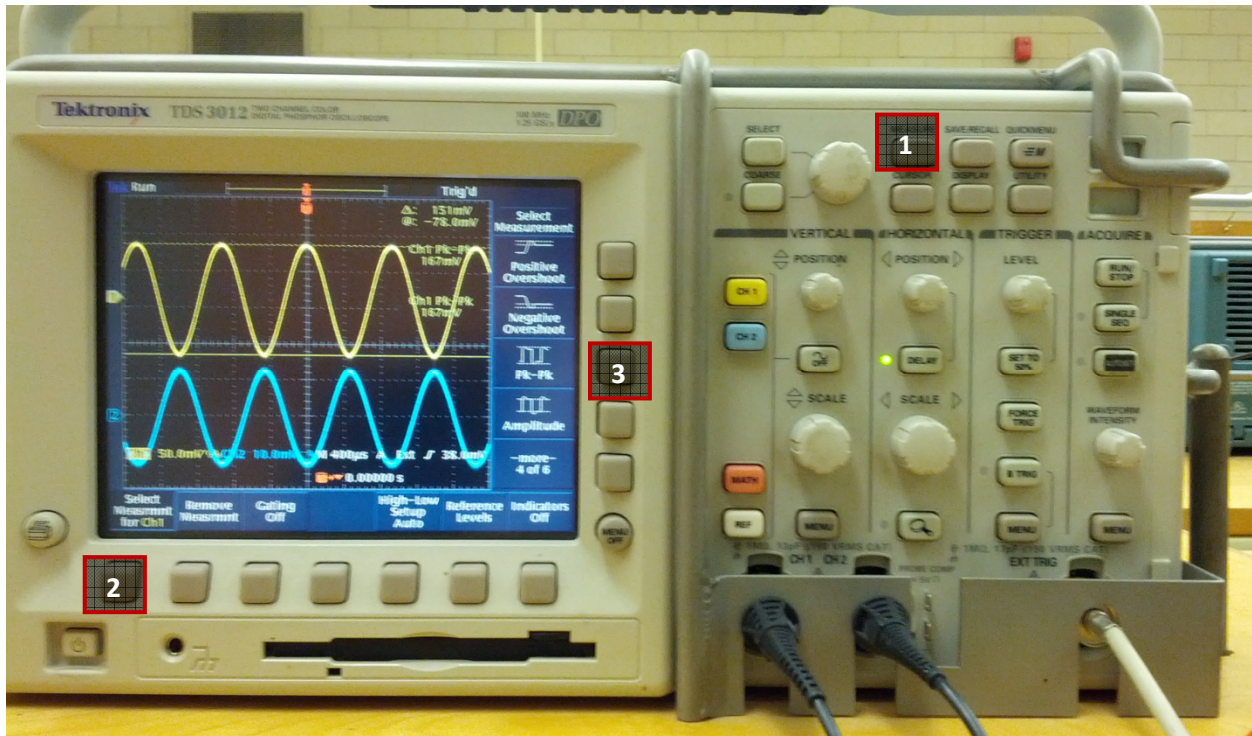
Digital Measure Function

Figure 9: The digital measure function should only be used for rough estimates. Use horizontal bars and cursors for proper values.

Digital oscilloscopes are capable of measuring many values directly from your signal. Many students will prefer this method as it is much simpler and quicker (but potentially less accurate) than using cursors.

First, trigger your waveform and eliminate as much noise from your signal display as possible. Use the horizontal scale dials to ensure at least two periods of the waveforms are clearly visible. Use the vertical scale dial to ensure that the amplitude of the wave is clearly visible.

To enable the digital measurement function, press "**Measure**" on the front panel **(1).** Press "**Select Measurement**" **(2)** and press the coloured channel button of the desired measurement. Then use the vertical soft keys to cycle through and find the value you would like to measure, which will most often be peak-to-peak voltage **(3)**.

WARNING ABOUT DIGITAL MEAUSREMENT FUNCTION

Note that this measurement function derives its values from what is currently being displayed on the screen. Therefore, if you have a noisy display, then this value will be noisy, if you have a clean display, then it will likely be fairly accurate. However, it will never be more accurate or consistent

than using the horizontal bars. Therefore you may use these measurements for obtaining quick values but should **always use cursor bars for accurate measurements**.

For any of the labs that require demonstrations to a TA, they will always measure your values using the cursor bars, so you should also be using them as much as you can.