UNIVERSITY OF CALIFORNIA AT BERKELEY
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE105 Lab Experiments

Agilent DSO5014A Oscilloscope Tutorial

Contents

1 Introduction

The Agilent DSO5014A is an oscilloscope, and it is used to measure voltages that vary with time. There are four independent input channels available on the DSO5014A; thus, it can be used to simultaneously measure and compare four different waveforms (e.g. input and output waveforms of an amplifier).

The default mode of the oscilloscope plots time on the horizontal axis and voltage on the vertical. The scaling of the axes can then be adjusted for each input signal. Scaling can either be done manually or with the "Auto Scale" button. There are other modes of operation for the oscilloscope as well, such as the XY mode that plots one channel against the other in a Voltage-Voltage plot. However, in these labs, you will primarily use the default mode.

This tutorial starts with quick notes on the most vital information. So, if you feel somewhat comfortable using the oscilloscopes, you can check over the quick notes and figure out the details on your own. Otherwise, please also read the later sections, which include more detailed descriptions of the Agilent DSO5014A interface as well as examples of common measurement procedures.

2 Quick Notes (to get started fast)

- After connecting the probes, try the "Auto Scale" button. It will generally provide a good axis scaling if the waveform is not too irregular, small, or at a high-frequency.

- Each channel has an independent control knob to allow the manual setting of the vertical scale. Each channel only has one scale reading, which is displayed to the left of the corresponding channel number at the top of the screen. To adjust the scale, simply turn the knob in the ANALOG section. These knobs are located above the numbered buttons; there is one vertical scaling knob for each input channel.
- To conduct measurements (e.g. measuring V_{pp}), press the "Quick Measure" button in the MEASURE section of the panel. Notice the softkeys that appear on the bottom of the screen. Select the desired source and measurement using the first two menu buttons below the screen (e.g. Source 1, Pk-Pk). Then initiate the measurement by pressing the third menu button (i.e. Measure).
- Cursors can be activated by pressing the "Cursor" button. Use the menu buttons below the screen to adjust the settings, and use the entry knob next to the "Cursor" button to move the cursors.
- AC coupling will remove any DC bias (offset) from the measured signal. This feature can be selected using the menu button below the screen; note that this can only be done in the channel menu. Press the corresponding numbered button (e.g. 2) in the ANALOG section to have the channel menu appear on the bottom of the screen.
- The oscilloscope's ground is **earth-grounded**, so the black alligator wires on the probes are connected together. Since the function generator is also earth-grounded, the oscilloscope probe grounds are connected to the function generator ground. To avoid shorts to ground, you should **always connect the oscilloscope ground clips to the same node**. Do not try to use the probes to measure floating signals (as you can with the DMM).

3 Trigger

The Agilent DSO5014A has a TRIGGER section on its interface panel. Triggers are used to synchronize the oscilloscope with an external signal so that measurements can be taken at the right moment. For example, to capture a single voltage pulse, one might use a trigger input to signal the oscilloscope to take measurements at the pulse arrival. Triggers can also be used with periodic inputs. However, you will generally not need to use oscilloscope triggering in these labs.

4 Interface Details

The power button is in the lower-left corner of the front panel. Press it to turn on the oscilloscope.

The oscilloscope screen should now display a coordinate system. At the top of the screen, vertical and horizontal scaling units are displayed. The default mode will display vertical scaling for each input in volts/div and horizontal scaling in seconds/div. Note that these units correspond to the respective lines that make up the square grid.

The buttons below the screen are referred to as "menu buttons" or "context buttons" in this tutorial. Their functionality changes with the selection of other buttons (e.g. by pushing the "Quick Measure" button). Each button's current function is labeled on the screen by the text immediately above the button. These menu buttons are essential to taking measurements and performing more complex functions on the oscilloscope.

The following sections cover the front interface panel in the general order you would consider them when making waveform measurements. At the end of the tutorial, there are examples of common measurement procedures.

Please refer to a photo of the Agilent DSO5014A in Figure 1; this might help in locating the mentioned controls/buttons.

4.1 Auto Scale Button

The "Auto Scale" button has the oscilloscope "guess" a good axis scaling based on the input waveform. This button is always a good first pass for scaling, and often, it will be the only scaling that you will need. You

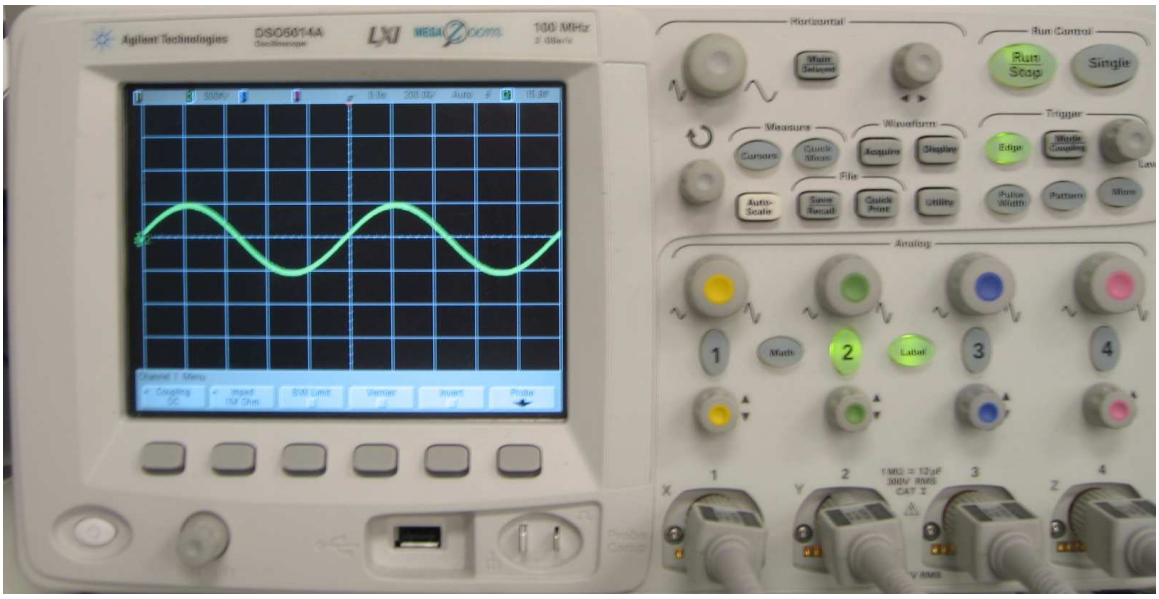

Figure 1: Agilent DSO5014A Front Panel

can also tune the scaling manually with the ANALOG and HORIZONTAL controls, which are described below.

4.2 Analog Section

The controls of the ANALOG section adjust the vertical scaling and position of each independent channel signal. Note that the controls for each channel are aligned vertically with respect to the input port.

- The knobs above the numbered buttons set the vertical scaling (vertical zoom) on the display.
- The "1", "2", "3", and "4" (numbered buttons) toggle showing their respective inputs.
- The position knob is located below the numbered buttons and have up and down arrow markings next to them. These knobs control the voltage offset against the display axes. The horizontal axis does not represent 0 volts, but instead, the 0 volt position for each input is designated by a numbered ground symbol on the left side of the screen. When you adjust the offset with the position knob, you will see the corresponding channel's ground symbol move vertically.
- The "Math" button can combine inputs with one of the following arithmetic operators: subtraction and multiplication. The operation can be selected with the menu buttons below the screen after pushing the "Math" button.

When using the ANALOG section (e.g. after pushing "1" or "2"), the menu buttons below the screen correspond to various options related to the probe inputs. The list below assumes that the "1" button has been pressed.

Menu 1

- 1: ON/OFF - Toggles the display of input 1.
- Imped: 50 Ω/1 MΩ - Toggles the input impedance of the channel input. Should usually be set at 1 MΩ.
- Coupling: DC/AC - Sets the coupling for the channel input: DC will show both DC and AC values. AC will only give time-varying voltage values and remove any offset.

- BW Lim: Off/On - Leave this at default.
- Vernier: Off/On - Leave this at default.
- Invert: Off/On - Leave this at default. This option can be used to invert the input signal (e.g. in combination with the math subtraction operator to result in input addition).
- Probe: Displays channel probe menu.

Probe Menu

- AutoProbe - Leave this at default.
- Skew - Leave this at default.
- Units - Leave this at default.
- ↑ - Go to Menu 1

4.3 Horizontal Section

The horizontal axis is the same for all input channels.

- The knob with waveforms on both sides (in the HORIZONTAL section) sets the horizontal scaling (horizontal zoom) on the display for all input channels.
- Control the horizontal position using the knob marked with left/right arrows next to it.

4.4 Display Button

By pressing the "Display" button, the menu buttons below the screen become the following:

- ∞ Persist: Off/On - Leave this setting Off.
- Clear Display - Clears/refreshes the screen.
- Grid - Leave this setting at default.
- Vectors: Off/On - Leave this setting On.

4.5 Measure Section

The MEASURE section has buttons for "Quick Measure" and "Cursors". Cursors are discussed in the next subsection.

To make a voltage measurement on an input signal, press the "Quick Measure" button. It will change the menu buttons below the screen so that you can select which voltage parameters to measure. Values will be displayed at the bottom of the screen, and automatic cursors will be placed around the selected measurement on the display. Additional measurements will line up at the bottom of the screen.

After pressing the "Quick Measure" button, the menu buttons below the screen become the following:

- Source: 1 / 2 / 3 / 4 - Selects the source on which to perform the measurement.
- Select: *Peak-Peak* / *Average* / *RMS* / *Maximum* / *Minimum* / etc. - Press this button until the intended value to measure is selected or turn the entry knob (the one with a green ↻ above it) after pressing the button.
- Measure - Press this button to initiate the measurement selected.
- Clear Meas - Clear measurements on the bottom of the screen.
- Thresholds - Leave these settings on default.

Similarly, to make a time measurement on an input signal, press the "Quick Measure" button in the MEASURE section. It will change the menu buttons below the screen so that you can select which time parameters to measure via the Select button (e.g. $Frequency/Period/DutyCycle/RiseTime/FallTime/$etc.). As mentioned above, remember to press the Measure button to initiate the measurement. Values will be displayed at the bottom of the screen, and automatic cursors will be placed around the selected measurement on the display. Additional measurements will line up at the bottom of the screen.

An important note about the $Phase/Delay$ measurement:

- Settings - this option becomes availabe when $Phase$ or $Delay$ is selected. Use this option to select the input sources that are to be compared as well as whether the measurements should be made on the rising or falling edges of the input waveforms.

4.6 Cursors

Cursors are markers that you can place to manually to measure quantities on the display axes. For example, you can measure a specific voltage point on the vertical axis with a cursor or measure the voltage difference between two cursors placed on the vertical axis.

After pressing the "Cursor" button, use the menu buttons below the screen to activate a particular cursor. You can use the entry knob (the one with a green ⟳ above it) to adjust the position of the cursor manually. Cursor measurements are displayed at the bottom of the screen.

The following is a list of the buttons in the Cursor menu:

- Mode - leave on "Normal" to measure voltage and time.
- Source: 1 / 2 / 3 / 4 - Select the source on which to place the cursor(s).
- X Y: Select either the X (time) or Y (voltage) cursors. Note that in order to measure time, the X cursors are perpendicular to the x-axis, and similarly, the Y cursors are perpendicular to the y-axis.

  The following options appear if X is selected:

- X1: Select this to adjust the first X cursor. The value indicated by the cursor is displayed on the bottom of the screen below "X1".
- X2: Select this to adjust the second X cursor. The value indicated by the cursor is display below "X2".
- X1 X2: Select this to simultaneously move the X1 and X2 cursors.

Note that the measurements $\triangle X = X2 - X1$, $\frac{1}{\triangle X}$, and etc. are displayed immediately above the cursor menu options. Also, if Y is selected instead of X, the screen displays the Y counterparts of the options and cursors mentioned above.

5 Examples

These examples assume you already have the oscilloscope turned on and that the signal of interest is on Channel 1.

5.1 Measuring the Peak-to-Peak Voltage (V_{pp}) of a Waveform

1. Press the "AutoScale" button and adjust the horizontal and vertical scaling so that the wave is visible.
2. Press the "Quick Measure" button in the MEASURE section.
3. Verify that the correct source is selected (1) on the leftmost menu button.
4. Press the second menu button that corresponds to Select and use the entry knob to choose Peak-Peak.
5. Press the third menu button that corresponds to Measure.

6. The V_{pp} value will be displayed at the bottom of the screen, and the measured peak-to-peak distance will be displayed via two horizontal cursors around the waveform.

5.2 Measuring Frequency of a Waveform

1. Press the "AutoScale" button and adjust the horizontal and vertical scaling so that the wave is visible.
2. Press the "Quick Measure" button in the MEASURE section.
3. Verify that the correct source (1) is selected on the leftmost menu button.
4. Press the second menu button that corresponds to Select and use the entry knob to choose Frequency.
5. Press the third menu button that corresponds to Measure.
6. The frequency value will be displayed at the bottom of the screen, and the measured period will be displayed with two vertical cursors on the waveform.

5.3 Measuring Voltage with Cursors

1. Press the "AutoScale" button and adjust the horizontal and vertical scaling so that the wave is visible.
2. Press the "Cursors" button in the MEASURE section.
3. Verify that the correct source (1) is selected using the second menu button.
4. Press the third menu button until Y is selected.
5. Press the fourth menu button that corresponds to Y1.
6. Turn the entry knob until the voltage cursor is moved to the desired vertical position.
7. The voltage value will be displayed at the bottom of the screen under "Y1".

5.4 Using Averaging

1. Press the "Acquire" button in the WAVEFORM section.
2. Press the "Acq Mode" menu button until Averaging is selected.
3. Use the "# Args" menu button to select the number of samples to average over.
4. The signal noise should be reduced proportional to the number of samples that are averaged. A greater number of samples will take longer to be computed.

5.5 Measuring a Transfer Characteristic

1. Input the intended v_{in} and v_{out} each on its own channel. The following steps will assume that Channel 1 has v_{in} and Channel 2 has v_{out}.
2. Press the "Quick Measure" button in the MEASURE section, select Channel 1 as the source and $Peak - Peak$ as the measurement. Then, press the third menu button that corresponds to Measure.
3. Repeat the previous step for Channel 2.
4. At the bottom of the screen, each peak-to-peak voltage will be displayed. Calculate $\frac{Pk-Pk(2)}{Pk-Pk(1)}$ as the frequency response at the given frequency. The measurement is only a true scalar frequency response if the input signal is a sinusoid and the system is linear.