

Using the Oscilloscope

The oscilloscope is one of the most important tools you will use in these labs, and your career as an electrical engineer. Oscilloscopes allow you to inspect circuit voltages as they vary over time, and measure just about everything you wanted to know about them, from their average value to their frequency. Almost all oscilloscopes have two input channels, allowing you plot two signals together so that you can compare them. The oscilloscope display is broken up into a number of horizontal and vertical *divisions*, marked by the dotted lines on the display.

The Rigol DS1052E

Whilst the information in this section applies to all oscilloscopes, the images and instructions are specific to the Rigol DS1000X series of oscilloscopes that are used primarily in the labs. The interface of the Rigol DS1052E is shown in figure 1, with the display on the left, and various controls on the right.

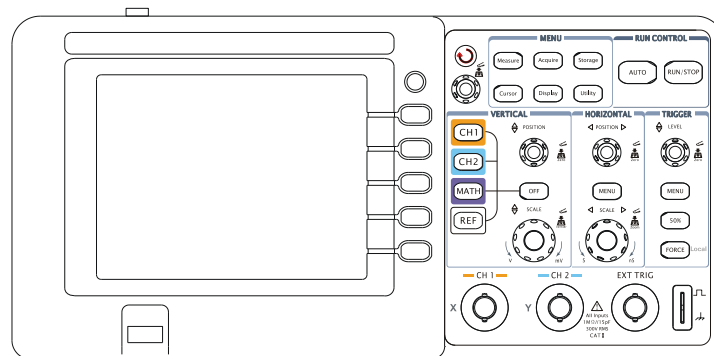


Figure 1: The interface of the Rigol DS1052E.

Channel one on the oscilloscope is yellow, and will be referred to as 'channel one **CH1**', likewise the second channel is 'channel two **CH2**'.

Vertical and Horizontal Scales

The vertical scale on the oscilloscope is measured in volts per division, if your signal is too 'zoomed in' and is cut off at the top or bottom of the screen, adjust the scale higher. Likewise, the horizontal scale is measured in seconds per division. Increasing the number of seconds per division allows you to see more of the signal, however the display will update more slowly as a result.

To modify the scale of one of the channels, press the desired channel select button (coloured borders on the panel). Now any adjustments you make will be applied to the channel you have selected. The larger knobs labelled 'scale' in figure 2 are used to adjust the horizontal and vertical scales. Clicking the vertical scale knob inwards will allow you to more finely adjust the number of volts per division.

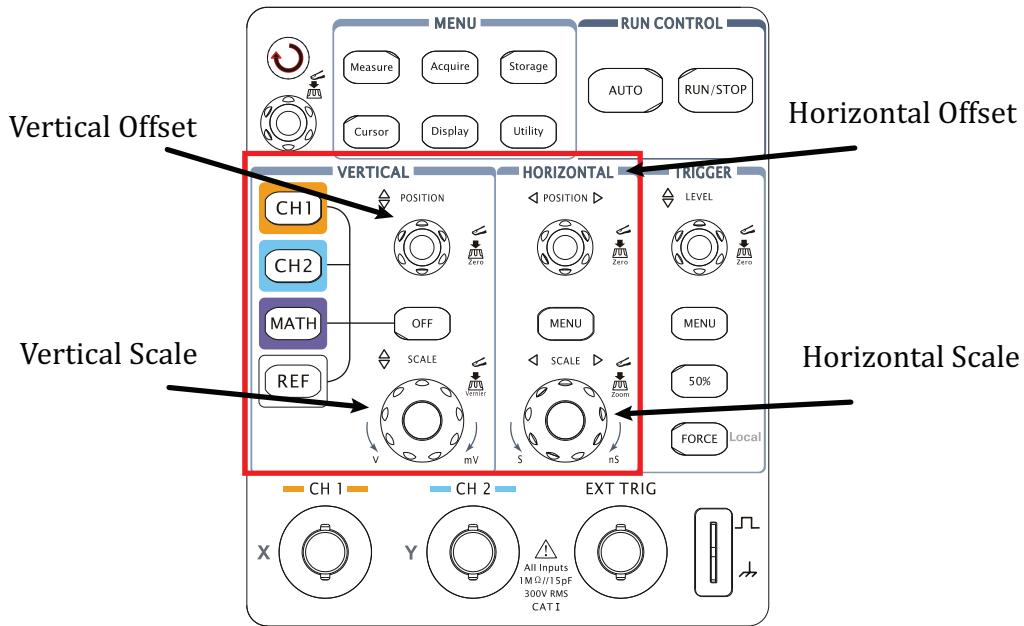


Figure 2: The vertical and horizontal scale adjustment panels.

The smaller knobs labelled 'Position' control the adjustable offsets for the selected channel. Figure 3 shows how two signals can be positioned above one another using the vertical offset control. Clicking either offset knob inwards sets the offsets back to zero.

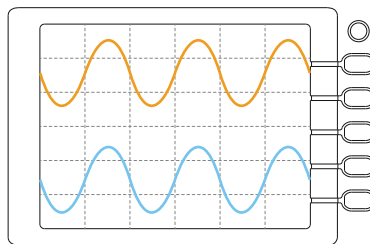


Figure 3: Two AC coupled signals displayed above one another using vertical offsets.

Triggering

Oscilloscopes can be set up easily to display periodic signals, and snapshot single one-shot events using the oscilloscopes' *trigger*. The trigger makes periodic waveforms look still on the screen by displaying the same portion of the input signal in the same position every time the screen is updated. Figure 4 shows the trigger line intersecting the signal, and then not intersecting the signal. In order to determine a starting point from which to draw the signal, the oscilloscope waits for a *trigger event* or *trigger condition* to be met. This condition is usually the input signal crossing the adjustable *trigger level*, shown as a dotted horizontal line in Figure 4. The trigger condition can also be configured to accept either rising or falling edge crossings.

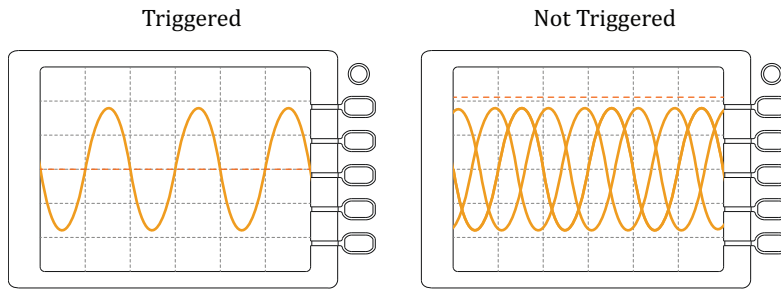


Figure 4: A correctly triggered sine wave, and an untriggered sine wave.

There are three different modes (sweep modes) the trigger can operate in, each mode changes what the oscilloscope does once a trigger condition occurs.

Normal Mode Once a trigger condition is met, the oscilloscope graphs a single time period and leaves this on the display until another trigger condition is met. Once the new trigger event occurs, the oscilloscope graphs the signal again. Periodic waveforms will appear stationary, because they will cross the trigger level at routine intervals.

Auto Mode Operates the same way as normal mode, however the oscilloscope will automatically trigger if no triggers events have occurred recently. This is useful in situations where the input waveform has stopped crossing the trigger level for whatever reason.

Single Mode Waits for a trigger event, graphs one time period and freezes until you hit the RUN/STOP button. This is useful for catching infrequent or non-periodic events.

Figure 5 shows the trigger controls on the Rigol oscilloscope.

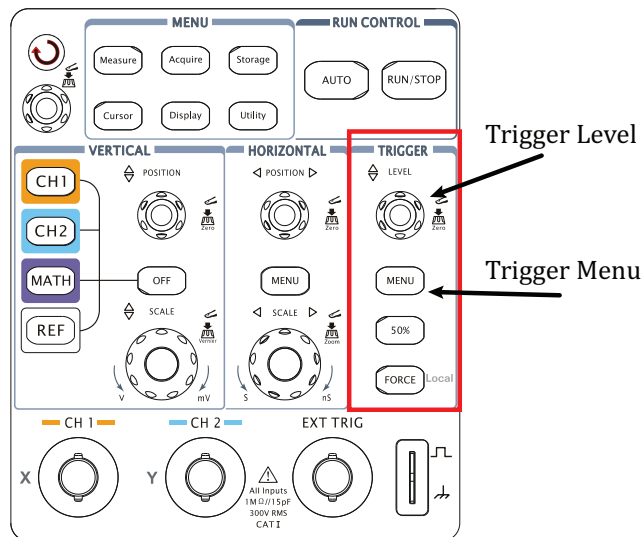


Figure 5: The trigger control panel.

On the Rigol oscilloscopes, the trigger level is simply adjusted with the trigger level knob indicated in figure 5. Opening the trigger menu allows you to:

- Select which channel to trigger from, either channel one **CH1** or channel two **CH2**.
- Change the trigger to look for rising, falling edges, or both.
- Under 'Sweep', you can change the mode the oscilloscope triggers in, described above.

AC and DC Coupling

The channels on the oscilloscope can either be *DC coupled*, *AC coupled*. When the channel is DC coupled, the voltages you see include any DC component present in the signal. However when the channel is AC coupled, only AC signals are graphed and any DC present in the signal is blocked completely. Also, signals slower than 10Hz are attenuated. Figure 6 shows a signal with a DC offset viewed with DC and AC coupling respectively.

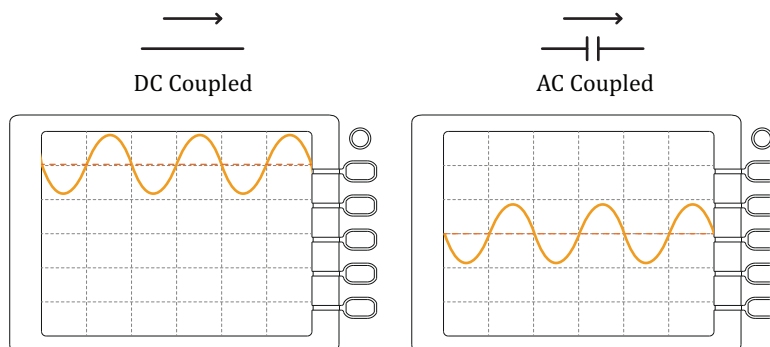


Figure 6: The same signal viewed with DC and AC coupling respectively.

AC coupling is sometimes called capacitive coupling, because a capacitor is added in series with the measurement to achieve the DC blocking required. AC coupling is useful when you need to study a small AC signal superimposed on a large DC voltage.

Autoscale

Digital oscilloscopes have the ability to automatically perform scaling and triggering for you. However, the autoscale feature will not always give you the part of the waveform you are interested in, so knowing how to manually scale and trigger the oscilloscope is a necessary skill. Refrain from using the autoscale feature, you will become much better at using the oscilloscope as a result.

Measurements

Once your waveforms are scaled and triggered appropriately, you can configure the oscilloscope to perform measurements using the 'measure' button. You can change the source you are measuring by pressing the 'Source' option when the measure menu opens. Selecting 'Voltage' allows you to display peak voltages, RMS and average values, percentage overshoot and more. Selecting 'Time' allows you to measure the frequency, duty cycle and many other time-related properties of the waveform. Once an option is selected, it remains on the screen until you clear it away by pressing 'Clear' on the measure menu.

It is important to realise that **the measurements and their accuracy depend on the degree to which the signal is present on the screen**. If you wanted to measure the amplitude of a sine wave accurately, you should scale the waveform so that it fills the display, without clipping at the top.

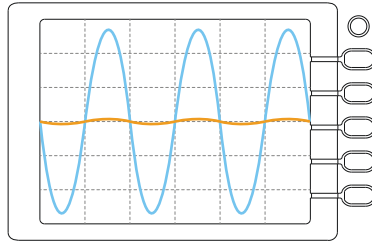


Figure 7: The same sine wave measured on both channels of the oscilloscope.

Figure 7 shows the same sine wave viewed on both channels of the oscilloscope, with different vertical scales. If the amplitude of channel one **CH1** were measured, the result would be far less accurate than the measurement from channel two **CH2**. The same goes for measuring time related quantities like frequency, all of the readouts on the oscilloscope are based on what is displayed on the screen.

Cursors

Whilst the automatic measurements are useful, they can't possibly account for all the things you might want to measure with the oscilloscope. The oscilloscope *cursors* are lines placed either horizontally or vertically, marking either points on the waveform, or measuring the distance between them. There are two important modes the cursors can operate in, *track* mode and *manual* mode.

In track mode, the cursors are orientated vertically, and the oscilloscope will read out the magnitude of the waveform where it intersects the cursor, as illustrated in Figure 8. If you are using two cursors, the oscilloscope will also read out the distance between them in both the horizontal and vertical directions, denoted by Δx and Δy respectively. The cursors are moved with the multi-function knob indicated in Figure 10. While in track mode, the readouts are:

- How many seconds away from the trigger point both cursors are.
- Voltages at the points where the cursors intersect the waveform.
- The Δx and Δy measurements, as well as $1/\Delta x$ for measuring frequency.

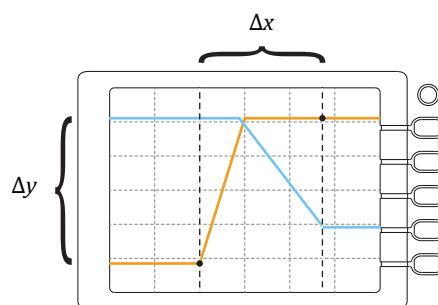


Figure 8: Two cursors tracking channel one, with Δx and Δy indicated.

In manual mode, the cursors can either be horizontally or vertically orientated, and remain where they are until they are moved. The readouts in manual mode are:

- Absolute voltages for both cursors, when horizontal (Type Y).
- How many seconds away from the trigger point both cursors are, when vertical (Type X).
- The distance between the two cursors, either Δx or Δy .

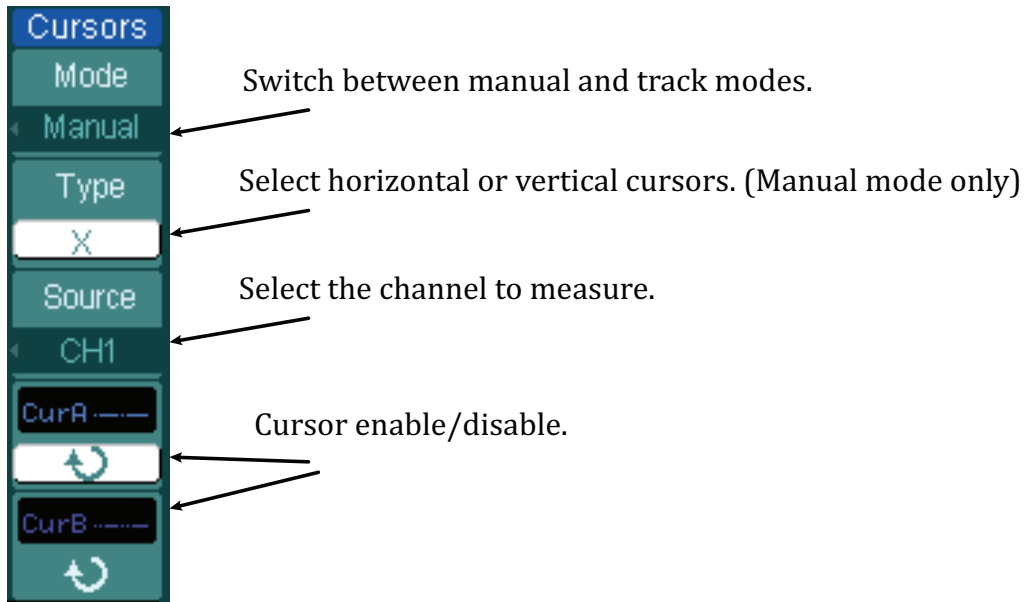


Figure 9: The cursor menu. Currently, only cursor A is adjustable with the multi-function knob.

To use the cursors, press the 'Cursor' button on the oscilloscope to show them. From there you can configure the cursors with the modes just discussed using the options labelled in figure 9. The two options at the bottom toggle either cursor between 'enabled' and 'disabled'. When a cursor is enabled, turning the *multi-purpose knob* identified in Figure 10 will move it. To move just one of the cursors, make it is enabled, and that the other cursor is disabled.

Multi-Function Knob

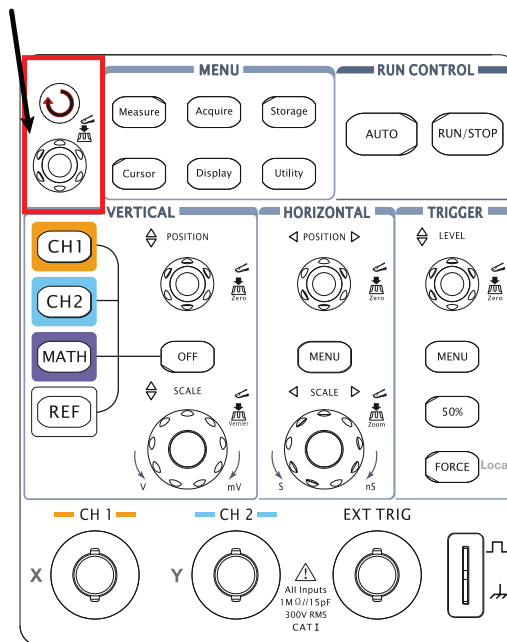


Figure 10: The location of the multi-function knob.