OscilloSorta Tutorial

A Low cost wireless Oscilloscope and Function Generator
(V0.4) January 2021

The OscilloSorta is an ESP32 based tool that acts like poor version of an oscilloscope and function generator. It only requires probe wires and a smartphone or laptop with WiFi to interface wirelessly to the device. This tutorial will walk through using the OscilloSorta. For those who are not familiar with Oscilloscopes text is included highlighted in green as reference.

An oscilloscope is used to display and measure voltage signals as they vary over time. The data is shown as a trace on a display moving in time from the left to the right with higher voltages being displayed higher on the display.

The scope has four main control areas shown in Figure 1: Horizontal (time), Vertical (voltage), Trigger, and Channel select. The top two adjust the time scale, time position, vertical scale, and vertical position on the trace on the screen. The scale adjustments are used to zoom into or out of the display to be large enough to see signals of interest yet small enough that the signals are still on the screen.

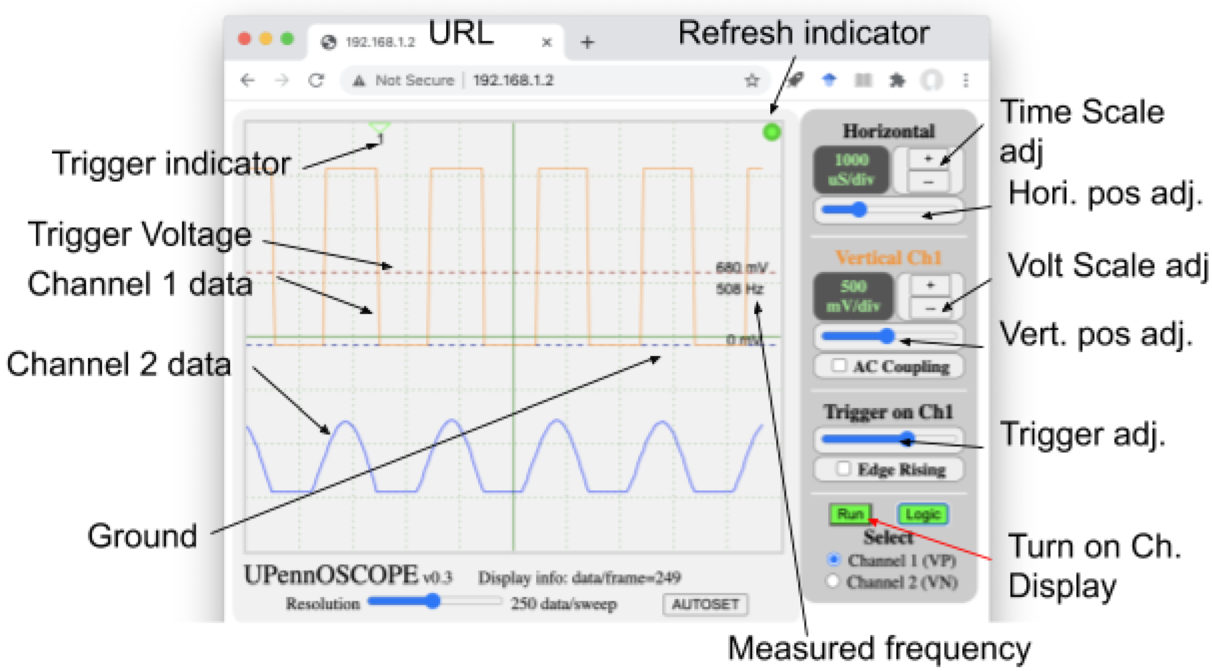


Figure 1: OscilloSorta Scope display highlighting the features.

The bottom of the display (shown in Figure 2) shows a function generator (which is often a separate device from an oscilloscope in the lab).

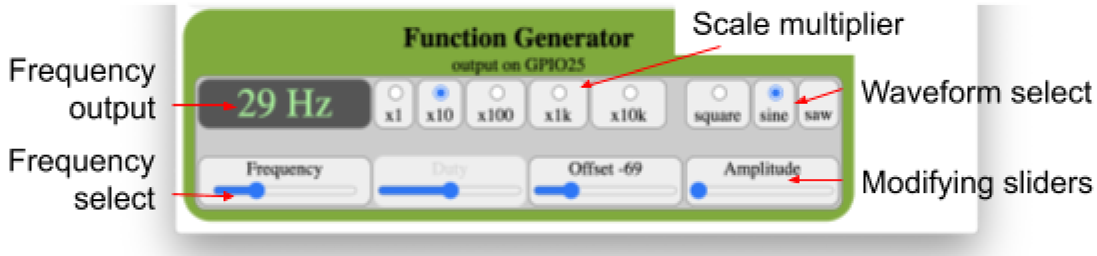


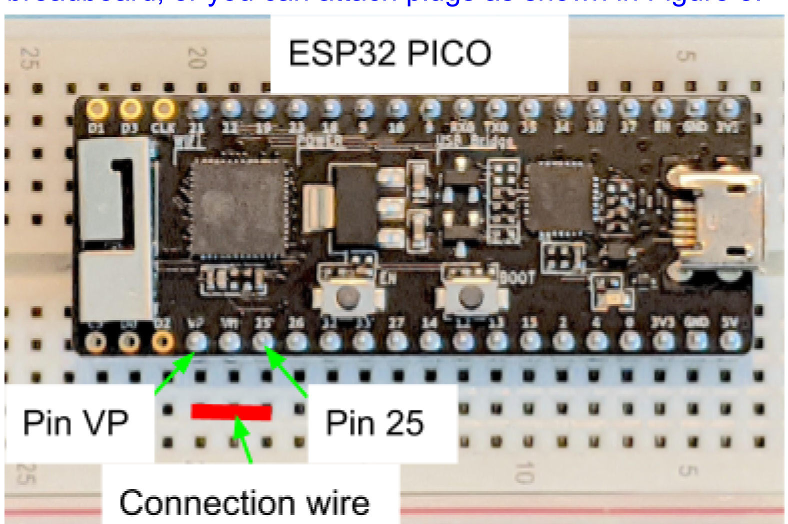
Figure 2: OscilloSorta Function Generator highlighting features.

Using OscilloSorta

Powering the ESP32 with the OscilloSorta programmed will start the program. It can be powered by plugging a microUSB cable into one end and the other end into a laptop or a USB phone charger (battery).

OscilloSorta input uses GPIO 36 (A0) labeled VP on ESP32 and GPIO 39 (A3) labeled VN. The function generator uses GPIO 25 labeled D25 as the output.

1) Hook up the function generator output pin (GPIO25 labeled 25 or sometimes D25) to Channel 1 of the OScope (GPIO36 labeled VP or sometimes 36) so we can visualize both function generator output and oscope display. This may be easiest to do on a solderless breadboard, or you can attach plugs as shown in Figure 3.



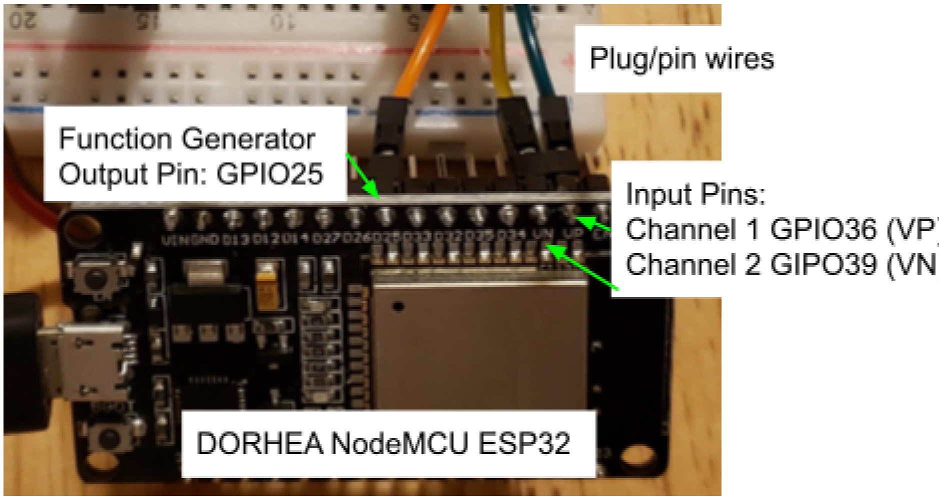


Figure 3: OscilloSorta on ESP32 PICO board with connection wires and DORHEA ESP32 board with plug wires.

Once powered, the device creates a wifi access point labeled "**OscilloSorta**". Switching a smartphone or laptop wifi to that network, then setting a browser (known to work well on Chrome) to **192.168.1.2** will bring up the interface.

2) Turn on your phone or laptop and view the network options as shown in Figure 4. If the ESP32 has the program downloaded, and is on, you should see the red light on. You should see the OscilloSorta as an unlocked option. Select it. If you are sure the OscillosSorta SSID is not appearing anywhere, contact the teaching staff.

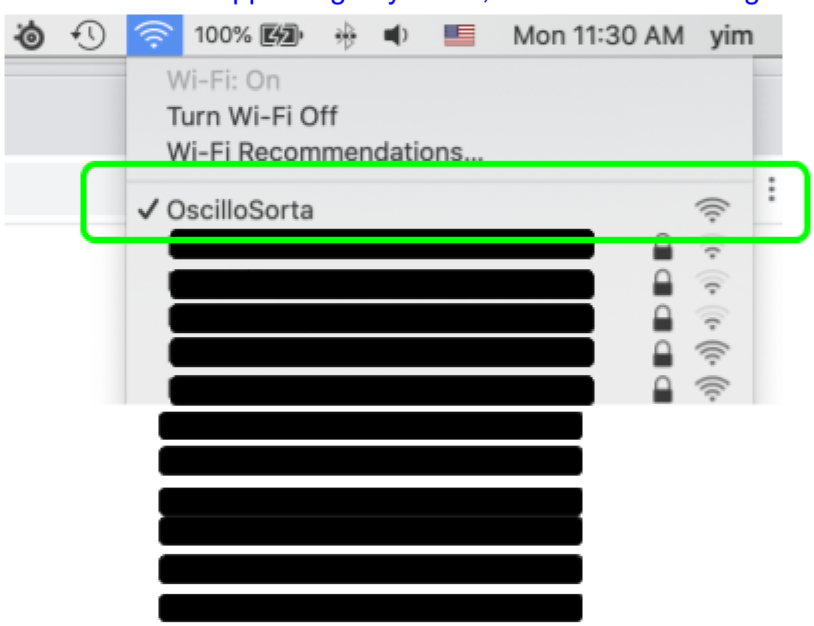


Figure 4: Network menu items on a Mac OSX.

Click on one of the function generator buttons (e.g., x10) to turn on a signal. The default is the square wave, but you can also click on the [Square] button to be sure. The radio button should show the option is selected.

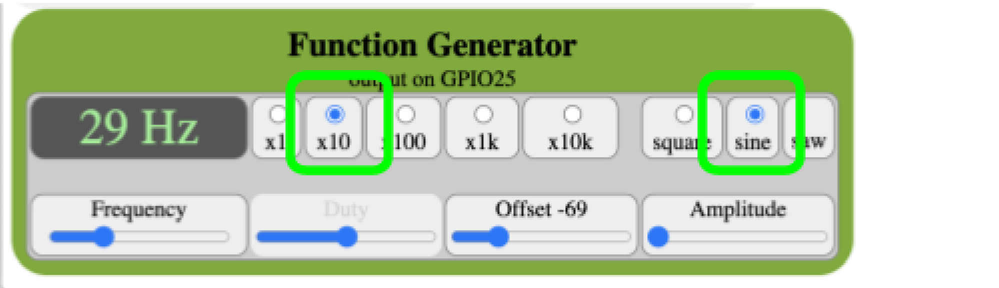


Figure 5: Select frequency multiplier and wave type.

Clicking on the [Sine] button should create a sine wave that looks as in Figure 6..

Figure 6: Sine wave display on channel 1 of scope.

TRIGGER

You may notice that the sine wave in Figure 6 is constantly moving across the display, which may complicate taking measurements. Adjusting the trigger level (the blue slider under the trigger section) will cause the dotted red line to move up or down on the display. When signal lines cross this trigger level the display will “lock” onto that signal.

There is a trigger indicator (the small triangle at the top of the display in Figure 6). A red triangle indicates the trigger has not found the signal. A green triangle indicates the signal is triggered. The small number below the triangle indicates which channel is being used for the trigger.

3) Adjust the trigger such that the line crosses the sine wave. You should see the sine wave stop moving (mostly). Figure 7 shows what it should look like. As you move the line, you should see the voltage number change next to the trigger. This indicates the voltage above the ground line.

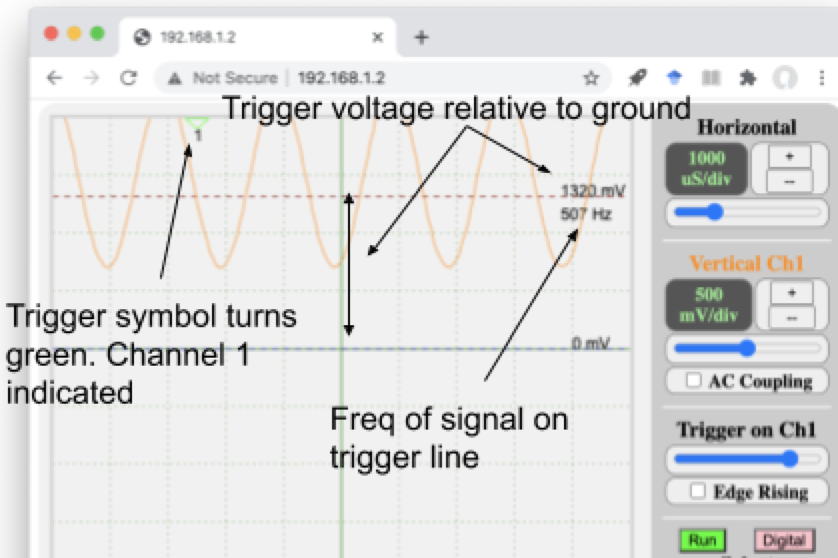


Figure 7: Sine wave triggered. Measurements from trigger line include the measured frequency and the voltage level of the trigger line.

MAKING MEASUREMENTS AND POSITIONING THE SIGNAL

Frequency and voltage measurements can be taken by counting the number of divisions and multiplying by the time scale or voltage scale. The red dashed trigger line can also be used to aid measurements. It indicates the frequency of the signal that crosses that trigger line in Hz on the right side of the line. It also indicates the relative voltage above ground in mV. This ground level can be changed by adjusting the slider in the Vertical section of the panel. Changing the ground level effectively moves the signal up or down on the screen.

The horizontal position of the signal can also be changed by moving the slider in the Horizontal section of the panel. Note that the trigger triangle at the top of the screen shifts to the left and right.

The AC coupling button shifts the vertical positioning of the signal (removing and DC offset) so the signal is averaged around ground. Placing the ground and trigger together then hitting AC coupling is one way to ensure being triggered. The Edge Rising button changes the polarity of the trigger signal (looking for a rising edge or a falling edge).

4) With a sine wave on the screen, click on the AC coupling button (adjust the trigger to be close to ground). Observe how the signal slides down. While triggered, click on the Edge Rising button to see how the signal shifts horizontally aligning with the opposite edge.

FUNCTION GENERATOR SIGNAL MODIFICATION

Most function generators will allow the changing of amplitude, offset and for square waves the duty cycle. Most will also have at least three waveforms, square, sine and triangle (or sawtooth or ramp).

On the OscilloSorta, you can adjust the sine wave frequency, amplitude and offset by the appropriate sliders. The square wave frequency can be changed but the amplitude and offset are fixed (3.3V logic level). However the duty cycle (PWM) of the square wave can be modified. A triangle wave may be implemented in the future.

5) Start with the sine wave, and amplitude at ½, adjust the offset and observe the wave form moving up or down the screen. You may also observe the waveform getting truncated at ground or 3.3V, especially at the larger amplitudes. Shift to a square wave and adjust the duty cycle. See if the duty cycle can reach 0 or 100%.

TIME SCALE AND VOLTAGE SCALE

As frequencies are increased, visibility of the waveforms on the oscope can be improved by adjusting the horizontal time scale. Clicking on the [+] or [-] buttons will increase the time per division (listed in microseconds) from 2uS/div to 100,000uS/div. Clicking on the [+] or [-] buttons in the “Vertical” panel will change the voltage resolution from 10mV/div to 5000mV/div. Larger volts per division will make larger signals more visible. Note that the OscilloSorta can only receive 0 to 3.3V it may not be useful to have more than 1000mV/div.

6) With the square wave and x10 selected on the function generator, move the frequency slider so the frequency is between 1KHz and 2KHz. Clicking on the horizontal and vertical scale [+] and [-] buttons can adjust the signal. Typically it is desirable to have 2 to 4 full waves on the screen with both top and bottom of the waves easily visible.

2-CHANNEL OPERATION

Oscilloscopes can have more than one signal at the same time. For 2-channel operation on the OscilloSorta, the second channel should be selected (hit the radio button next to “Channel 2”). When Channel 2 is selected, all input on the voltage or trigger panels will apply to Channel 2.

By default Channel 2 is off (the Run button is pink). Turn the display on for Channel 2 by pressing the "Run" button. If Channel 2 is active, the "Run" button will be green. while the Channel 2 radio button is selected.   The Channel 2 waveform is shown as a blue line as can be seen in Figure 1.

7) Turn on Channel 2. WIth nothing plugged into the VN (GPIO 36) pin, you may notice that there is some signal on the line. This may either by cross-talk from the function generator plugged into Channel 1 if the signal looks similar - but at different voltages to the Channel 1 line. Or if the function generator is off, you may see something like a wavy sine wave at 60Hz. If you use your finger to touch a wire plugged into VN or VP (Channel 1 or Channel 2) when there is no other signal driving that line, this 60Hz signal may appear. This your body acting as an antenna picking up the 60Hz AC signal from the building you are in. Switching between the Channel 1 and Channel 2 user interfaces can be confusing unless you remember that when a channel is selected the Vertical and Trigger Panels interface apply to that channel.

LOGIC MODE

The OscilloSorta has a "Logic Mode" which is not a common oscilloscope feature. Most oscilloscopes are fast enough that a logic mode isn't needed. Or fancy Logic Analyzers (for measuring large numbers of very fast logic level (binary, square wave) signals.

In Logic mode, the signal is assumed to be a logic level square wave so the signal is displayed with only two possible levels, 0mV and 3300mV. The Logic mode on the OscilloSorta can run much faster than analog mode so it allows the viewing of faster signals up to 100KHz (the standard analog mode is limited to about 3KHz). Note that the signal will disappear if the timescale is below 200uS/div when not in Logic mode.

8) Set the function generator to a square wave faster than 10Khz. Attach the function generator output (GPIO 25) to one of the channels and display it. You may notice that you see waves that look appropriate, but measure much less than the set frequency. The real signal is some integer multiple of the frequency shown at the trigger line. This is aliasing which can be deceptive. So, when using a digital sampling scope it is always useful to know roughly what frequency of signal you are actually expecting.

Caveats

WiFi Lag: The OscilloSorta is not exactly a real oscilloscope. One of the primary limitations comes from using a wireless interface. The WiFi from the ESP32 is not always consistent. There may occasionally be lag times from 10's of ms to one or more seconds depending on other wifi or processor activities. To help distinguish whether the signal is not changing or there is lag in the system, a flashing green “refresh indicator” is included in the upper right corner of the scope display.

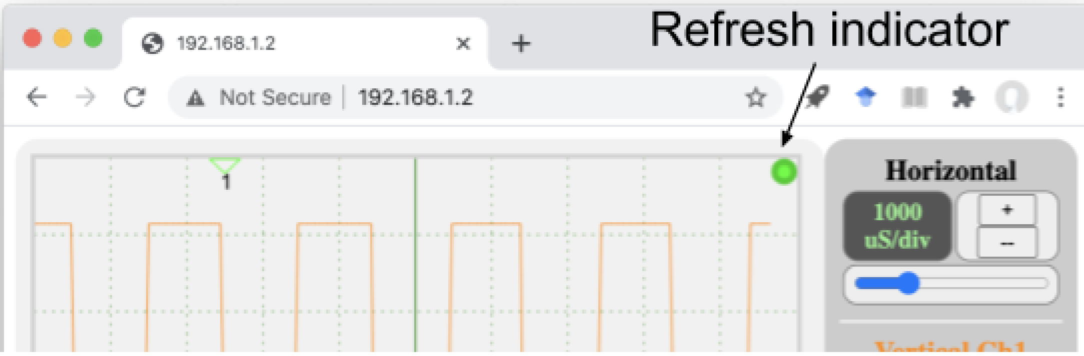


Figure 8: Screenshot showing the refresh indicator.

Bandwidth: Fast signals (>3Khz) are not displayed well in the analog mode. The ADC cannot run fast enough to get faster resolution data. In digital mode (pressing the “Digital” button so it turns green on the display). The speed limitation in digital mode is the WiFi speed.

Displaying two channels at once slows down the data acquisition significantly both due to the longer ADC and the wireless transfer of the data. Signals over 1Khz start to be rough.

Data points per screen: A resolution slider is provided at the bottom of the oscilloscope display which can be used to change the refresh rate by changing the number of data points displayed. At short time scales (fast signals <2000 us/div) the resolution can be reduced, increasing the refresh rate without losing display resolutions. If the number next to data/frame is less than the data/sweep number, this indicates this situation where the resolution can be adjusted and refresh rate increased.

Sine Wave Accuracy: The function generator sine wave has a trade-off between finding accurate frequencies and smooth curves (higher resolution). At integer multiples of about 15 or 16Hz the signal is at highest resolution. The amplitude has only 4 levels (100%, 50%, 25% and 12.5% of full (3.3V)). The square wave PWM at 100% has some glitches.

AC coupling puts a digital high pass filter on the signal. So, for slow signals (e.g. <10Hz signal) may show drooping lines (e.g., square waves should have horizontal lines but they may be sloped instead.) This type of effect is on all oscilloscopes to differing levels.

Browser compatibility: The program relies heavily on javascript and html5. Modern browsers (only tested on Chrome so far) and capable processors (e.g., old smart phones may not work) on the display device are required.

User Interface desync: The wireless interface responsiveness is not perfect. Sometimes button presses will be missed. If buttons are pressed to quickly, the system may become desync'ed. Especially the channel select buttons.