



Moku Oscilloscope User Manual





Table of Contents

Introduction	3
Quick start guide	4
RC circuit characterization	4
Principles of operation	6
Downsampling	7
Triggering	9
Using the instrument	10
Configuring the measurement	10
Configuring inputs	10
Configuring acquisition	14
Configuring timebase	17
Configuring the trigger	19
Measuring signals	25
Cursors and measurements	25
Saving and sharing data	33
Generating waveforms	34
Oscilloscope examples	35
Characterization of a noisy signal	35
Op-amp transfer curve characterization	36
Additional tools	38
Main menu	38
File converter	39
Preferences and settings	40
External reference clock	41
Tips and tricks	43



Introduction

An oscilloscope is a standard tool on most experimental and engineering workbenches, used to display time series voltage across multiple channels. The Moku Oscilloscope allows users to navigate signals using gesture-based controls. It includes cursors and automated measurements to assist with signal analysis, and it can generate outputs using the built-in Waveform Generator. Detailed instrument specifications are available in your Moku device's [specification sheet](#).

Moku Oscilloscope is also embedded within many other instruments such as the Lock-in Amplifier, with "probe points" able to be dropped throughout the signal processing chain for quick and detailed analysis. This user manual applies both to the main Oscilloscope instrument as well as embedded oscilloscopes.

This manual is intended to help users understand the [user interface](#) and [underlying architecture](#) of the instrument. It also includes a general example in the [quick start guide](#) and a small number of [in-depth examples](#) to provide a foundation for new users.

These user manuals are tailored to the graphical interfaces available on macOS, Windows, iPadOS, and visionOS. If you'd prefer to automate your application, you can use Moku API; available for Python, MATLAB, LabVIEW, and more. Refer to the [API Reference](#) to get started.

AI-powered help is available to aid both workflows. AI help is built into the Moku application, and provides fast, intelligent answers to your questions, whether you're configuring instruments or troubleshooting setups. It draws from Moku manuals, the Liquid Instruments [Knowledge Base](#), and more, so you can skip the datasheets and get straight to the solution.

Access AI help from the main menu

For more information on the specifications for each Moku hardware, please refer to our [product documentation](#), where you can find the specifications and the [Oscilloscope datasheets](#).

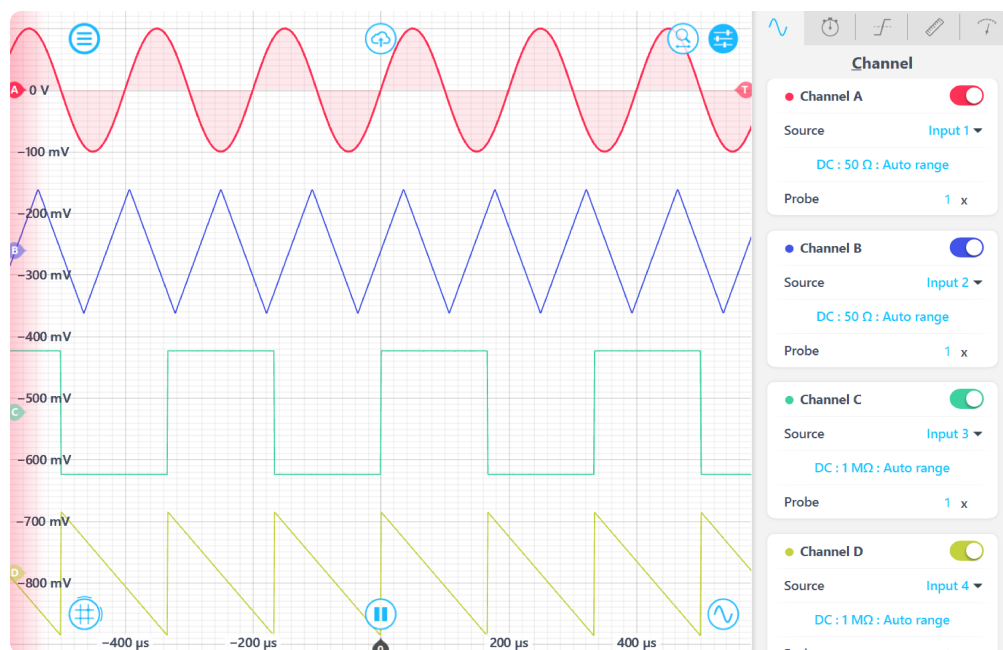


Figure 1. Oscilloscope user interface showing the graph panel (left) and settings panels (right).



Quick start guide

In this example, we'll measure how a simple resistor–capacitor (RC) circuit responds to a short voltage pulse. This will demonstrate how capacitors charge and discharge with an exponential rise and fall, and how you can measure this behavior on an oscilloscope. Further, more detailed, examples may be found in the [examples](#) section.

RC circuit characterization

In this example we measure an RC circuit driven by a 100 μs pulse signal, output from the embedded waveform generator.

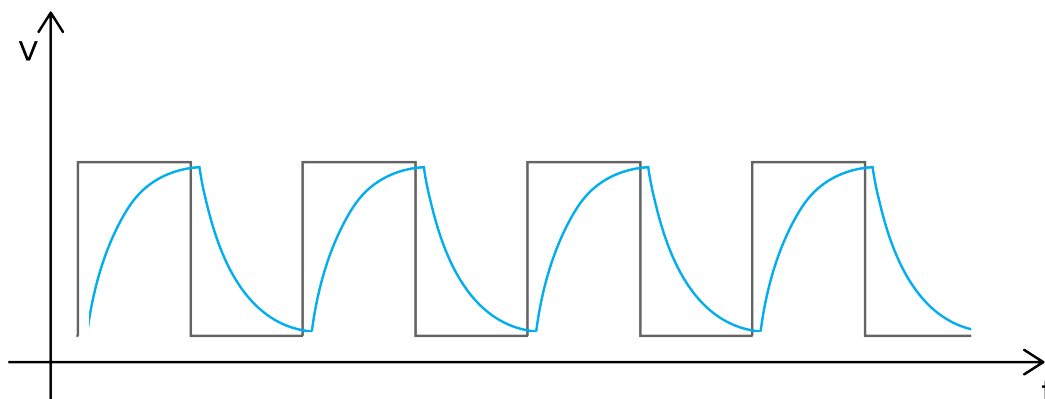


Figure 2. RC circuit pulse (black) and response (blue).

- **Step 1:** Generate signal with [embedded Waveform Generator](#)
 - Generate your output signal in the waveform generator  embedded in the oscilloscope. Here we are going to generate a 1 V, 100 μs pulse wave, from Output 1, to stimulate the circuit.
 - Connect the Output 1 BNC to your circuit and turn the Output ON.
- **Step 2:** Configure [analog front end settings](#)
 - Select the source of the signal to be measured. In this case, the returned signal being measured is connected to BNC Input 1, set Channel A source to be Input 1 and Channel B source to be Output 1 so we can compare the signals.
 - Configure the appropriate analog front end settings; coupling, impedance, range. In this case the coupling is set to AC to remove any offset. Impedance is set to 50 Ω , to match the output impedance. The range is set to "Auto" so that the range adjusts with any changes in the signal.
 - Set the probe attenuation. We are going to use 1x probe attenuation, as no attenuation is needed to match the probe settings.
- **Step 3:** Configure [acquisition](#)
 - Set Precision Acquisition mode. Precision Acquisition will capture the signal in this example, with better signal-to-noise ratio.
 - Ensure interpolation is set to Linear and averaging are OFF. There are enough sample points to capture the signal without interpolation and we expect little noise in this case, so averaging is not needed.
- **Step 4:** Configure [timebase](#)
 - Set a Span of 50 μs , which will be sufficient to view a single period of the response.
 - Set Offset to 0 s, to view the signal around the trigger.
- **Step 5:** Configure [trigger settings](#)



- Set "Auto" trigger mode. The oscilloscope will continue to update the display periodically, even when no events are detected.
- Set trigger channel to Channel B (output pulse signal), as the output signal is more stable.
- Set trigger holdoff to 0.0 s so each trigger event and all following ripples are captured.
- Set "Edge" triggering, to trigger on the rising edge and set the edge level to just above 0 V to trigger effectively.
- **Step 6:** Configure [measurements](#) and [math channel](#)
 - Add a measurement for the signal rise time from the measurements panel . Press "Add" to add a measurement. Select "Rise time" for Channel A.
 - Verify measurement with cursors. Drag out cursors vertically from the cursor menu , aligning them with the start and end of the measured RC response. This is your rise time.
- **Step 7:** [Capture or export data](#)
 - Export the traces, measurements, and screenshot. Press the Share button to open the exporting menu. Toggle on the types of data to be exported, such as the signal "Traces" and "Screenshots". Change the filename, add comments if desired, and export.

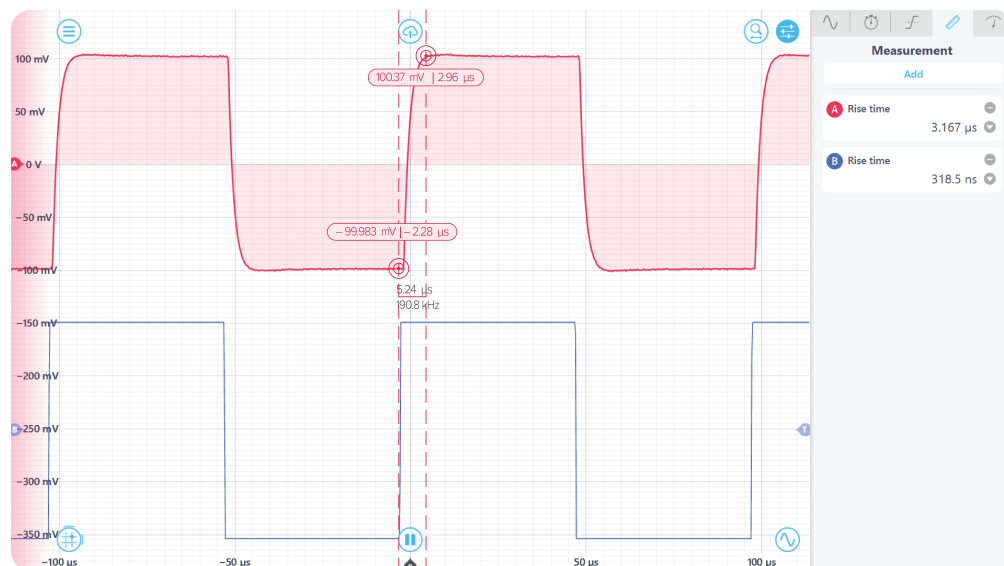


Figure 3. Rise time measurement of the RC circuit response (red) compared to the input signal (blue).



Principles of operation

The principle objectives of an oscilloscope is to capture trigger events and display the voltage as a function of time. The instrument can track a number of live measurements and statistics, track mean voltage in the Voltmeter, and export traces and output analog voltage signals. Understanding the instrument's fundamental architecture will enable you to make more precise and accurate measurements on your Moku.

A modern oscilloscope might sample the voltage many billions of times a second, far too many for a human to see all the samples on a screen, so an oscilloscope must include a trigger system and a method of downsampling. Taken together, these systems ensure that events of interest are displayed in the oscilloscope. Effective use of an oscilloscope comes down to the correct configuration of these systems for your purpose.

The core concepts of the oscilloscope are downsampling and triggering:

Downsampling is how the sampled data is processed and displayed on screen, without losing any important information.

Triggering defines the precise conditions under which waveform acquisition begins. A trigger event is typically defined by the input signal crossing a specified voltage threshold, either on a rising or falling edge, or meeting certain pulse width or pattern criteria. The trigger point serves as the time reference (0 s) on the horizontal axis, ensuring that successive waveforms are aligned consistently for analysis.

This is the overarching process that signals take from input to display, for more information on how downsampling and triggering work see [Acquisition Modes](#) and [Principles of triggering and waveform capture](#).

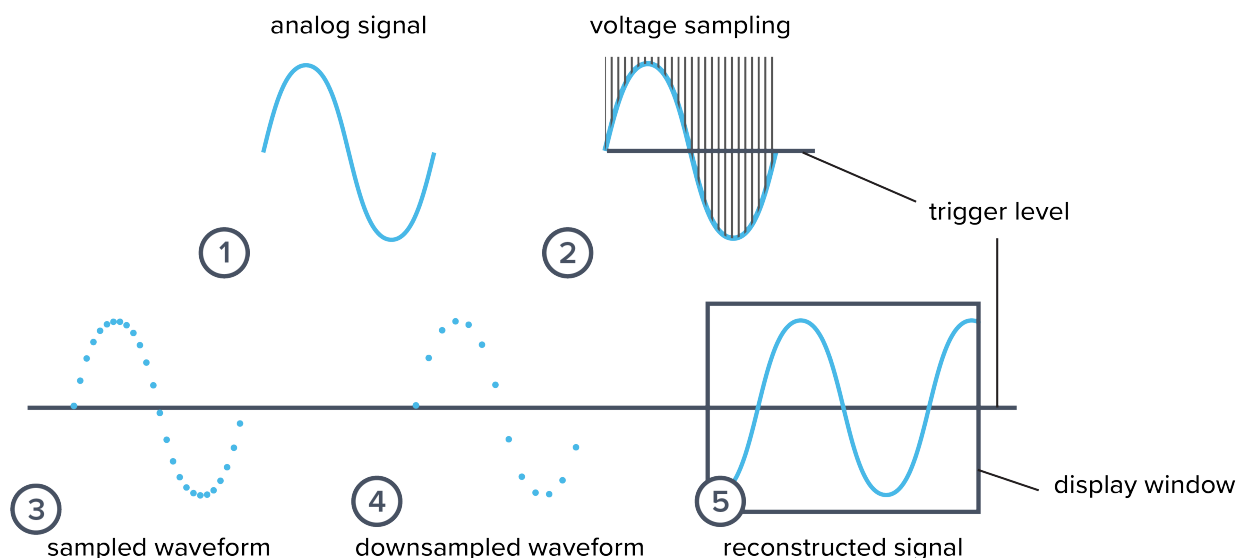


Figure 4. Architecture of the Moku Oscilloscope, showing (1) the analog signal input, (2) the voltage sampling of the signal, (3) the triggered and sampled waveform, (4) down-sampled waveform, and (5) the reconstructed signal, with interpolation.



Downsampling

The Moku Oscilloscope supports the acquisition of data from all analog channels simultaneously. This means that data can be captured and represented in each of the different phases or channels. Deep memory mode is useful in applications where simultaneous multi-channel analysis is critical, such as observing interactions between different signals or in vector signal analysis.

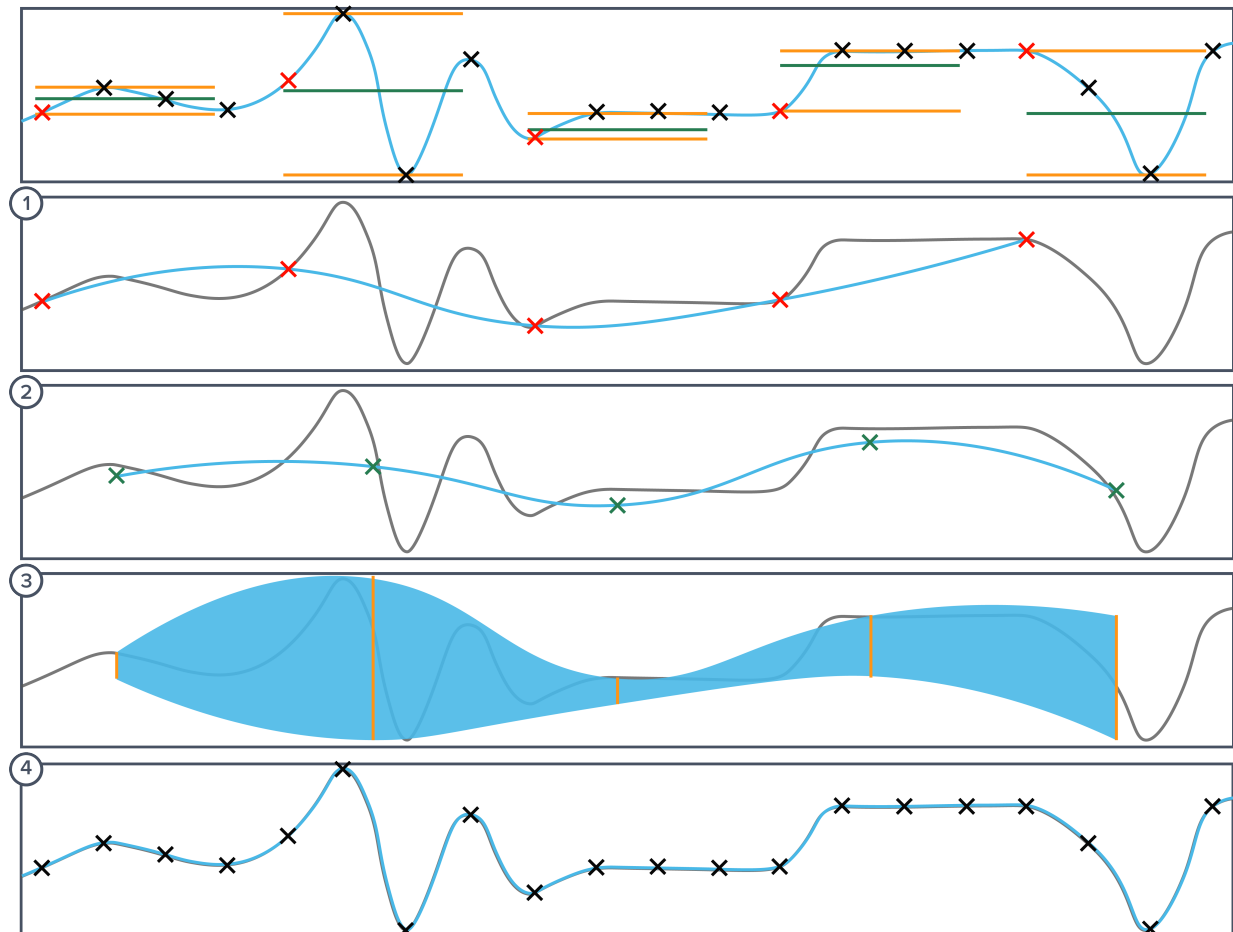


Figure 5. Acquisition modes; (1) normal mode is shown in red, (2) precision mode is shown in green, (3) peak detect is shown in orange, (4) deep memory mode is shown in black.

A common workflow is to use **normal mode** to find the signal and align it as you want, then switch to **precision mode** to improve the signal quality for measurement.

① **Normal mode** Simply removes extra data from memory (direct down-sampled). For example, if the ADC is running at 1.25 GSa/s and the selected time span on the Moku Oscilloscope requires 1 MSa/s, then 1249 out of 1250 points will be ignored. This causes the signal to alias and doesn't increase the precision of the measurement. It does however provide a view-able signal at all timespans and all input frequencies.

② **Precision mode** averages extra data to memory (decimation). For example, if the ADC is running at 1.25 GSa/s and the selected time span on the oscilloscope requires 1 MSa/s, then 1250 consecutive samples will be averaged to produce one data point in the memory. This increases precision and prevents aliasing, however if you have the wrong time span selected for the signal then all points can average to zero (or close to it), making it appear like little or no signal is present. Precision mode works well on small signals or noisy signals.



③ **Peak detect** records the maximum and minimum data points within the downsampling window to memory, drawing a shaded area between the two points. This captures all the noise and glitches in the signal, which improves the visibility of and makes it easier to trigger on these events. Peak detect is best used to find high frequency transients, glitches and noise on a slow signal, but will capture all noise which may make it more difficult to see the signal of interest.

④ **Deep memory** mode retains the maximum number of samples in the acquisition window, up to 134 million points per trigger per channel. The maximum number of samples recorded in deep memory mode will differ on each hardware as shown [here](#). This has the benefits of maintaining the acquisition bandwidth while acquiring over a longer period, and/or maintaining a sampling rate over an increased period of time. This reduces aliasing when measuring high frequency signals but slows the processing and update rate compared to the other down-sampled acquisition modes. This data can be exported using the High-res data option in the data export menu.



Triggering

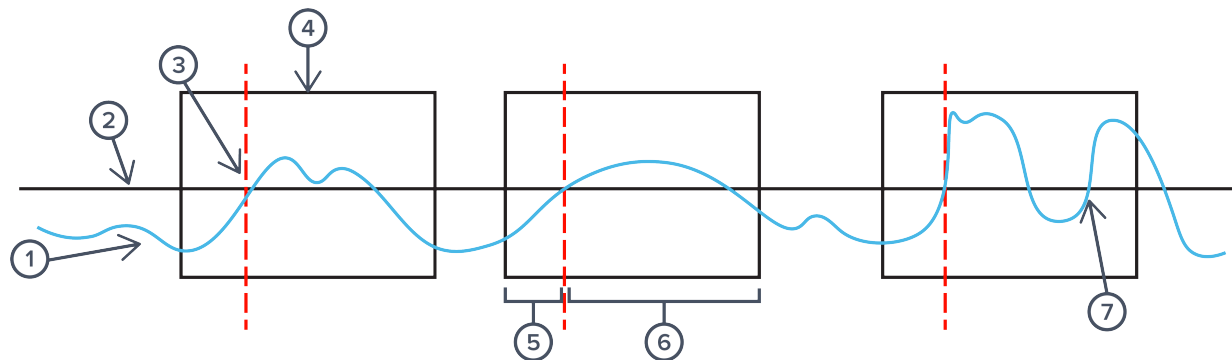


Figure 6. Illustration of oscilloscope triggering. (1) Signal input, (2) trigger voltage level, (3) trigger event, and (4) timebase. The timebase consists of the (5) pre-trigger and (6) post-trigger regions. (7) A new trigger event can only occur if the post-trigger time has elapsed.

① An oscilloscope plots how a **signal** varies over time, with voltage on the vertical axis and time on the horizontal axis.

② For a simple trigger like rising edge, a single **voltage level** is required. Referred to as the trigger level, it is the voltage that needs to be crossed to cause a trigger event, triggering a waveform capture. Other types of triggering will have different parameters; for example, pulse width triggering will require several voltage and time parameters to define the shape of pulses that should constitute a trigger event.

③ The **trigger event** is the "zero second" time reference seen in the graph area. Times before the trigger event on the time axis are negative, and times after are positive.

④ This time window, or **timebase**, around each trigger event defines the captured portion of the waveform. This segment is defined by the pre-trigger and post-trigger settings and is what you see displayed on the screen.

⑤ The amount of time between the start of the waveform and the trigger (i.e. the amount of time you can view leading up to the trigger event), is called the **pre-trigger time**.

⑥ The time in the waveform after the trigger event is the **post-trigger time**. The combination of pre-trigger and post-trigger values is called the time base. Each successive waveform has the same time base, and therefore guarantees that the trigger event is shown in the same location on the screen every time.

The Moku Oscilloscope digital architecture allows you to view data from before and after the trigger event, even with negative pre-trigger or post-trigger times. This makes it possible to examine events that occur well before the trigger condition is met or long after it, in a single capture.

⑦ A trigger event can only occur if the oscilloscope is not already capturing a waveform. That is, the post-trigger time has to have elapsed, and the waveform capture completed, before the oscilloscope starts **watching for another trigger**.



Using the instrument

This section is divided into ways to configure the Moku Oscilloscope instrument ([timebase](#), [acquisition](#), [inputs](#), [triggering](#)), capturing and measuring the input signal ([measurements](#), [statistics](#), [voltmeter](#), [cursors](#)) and additional functions ([embedded waveform generator](#), [sharing](#), etc.).

Configuring the measurement

Configuring inputs

You can change the view and measurement of the input by changing the range or impedance, attenuating with a probe multiplier, or coupling.

The channel panel allows you to toggle channels ON/OFF and change the analog frontend settings for each ADC channel and configure the Math channel. The Math Channel allows you to perform simple operations on your input channel signals and view the result.

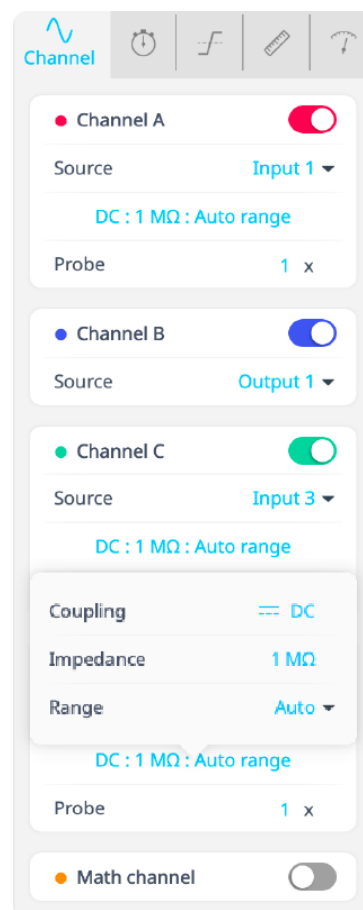


Figure 7. Acquisition settings panel.

Source The source can be set to any Moku input or output (single instrument mode only).

Coupling Use AC coupling to eliminate any DC offset in your signal, and DC coupling to capture all DC and AC components.



Impedance Toggle between 1 M Ω and 50 Ω impedance, depending on your circuit and device hardware.

Range Choose to "Auto" set or manually set the input range.

Probe Specify the probe attenuation, if an attenuating probe is connected.

Analog front end settings

Coupling

- **DC coupling** shows all of the input signal, including any alternating waveforms as well as any DC offsets present in the measured signal.
- **AC coupling** will remove any DC offset present in the signal with a highpass filter, showing only the signal's AC component. This can attenuate low frequency signals in the process, such as low frequency signals.

For most applications, DC coupling is the preferred option; this does not filter or modify the signal in any way. AC coupling is best used when your signal is relatively small compared to its DC offset, such as a small ripple along a DC power supply, so you can utilize the full range and resolution of the ADC.

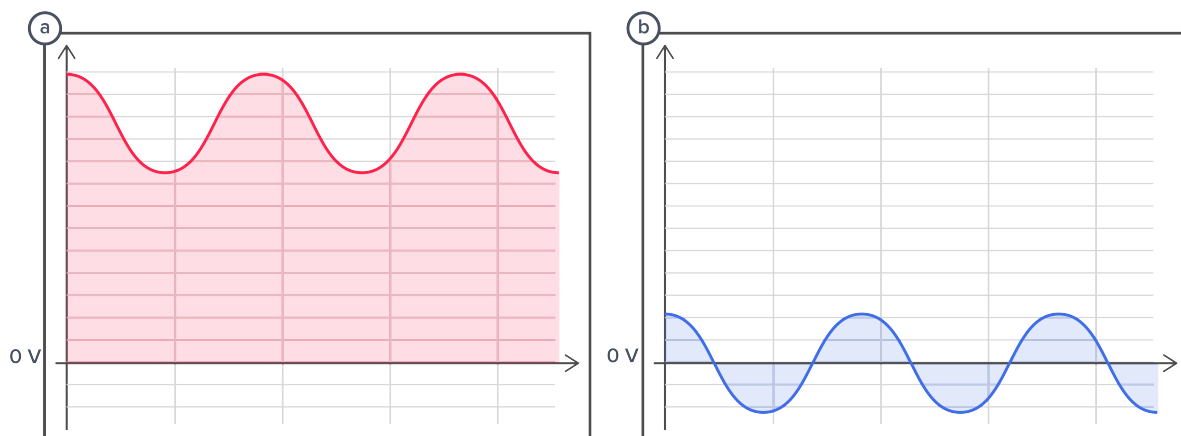


Figure 8. DC (a) and AC (b) coupled signals

Input impedance

Input Impedance is effectively the resistance from the signal line to ground. For high-frequency measurements, it is important that the impedance on your Moku matches that of the device under test. This matching maximizes power transfer and minimizes signal reflections. If the impedances are mismatched, part of the signal will reflect back toward the source, which can distort the measurement and, in some high-power or sensitive systems, potentially damage the source equipment.

High-impedance mode (1 M Ω) is used where Moku is observing a signal that is already terminated elsewhere (e.g. between two high-speed devices), or where absolute voltage measurement accuracy is required, and the signal is low enough frequency that reflections from the measurement equipment do not significantly interfere with the original signal.

The input impedance also forms a voltage divider with the signal's source impedance, which can reduce or increase the apparent voltage if the impedances do not match.



Range

The range settings are used to ensure the ADC utilizes all its bits of resolution, giving you the most accurate signal reconstruction at all times. The oscilloscope applies attenuation or gain (hardware dependent) to the incoming signal so that it is always scaled appropriately for the ADC, irrespective of the input signal amplitude. The best approach is to use the smallest input range that can fully represent your signal.

If the input range is set too small, the signal will be clipped at the ADC. If the range is set too large, the ADC will use too few bits of resolution, making the signal appear noisy. The ideal case is when the signal is correctly scaled to match the ADC input range. These scenarios are illustrated in [Figure 9](#).

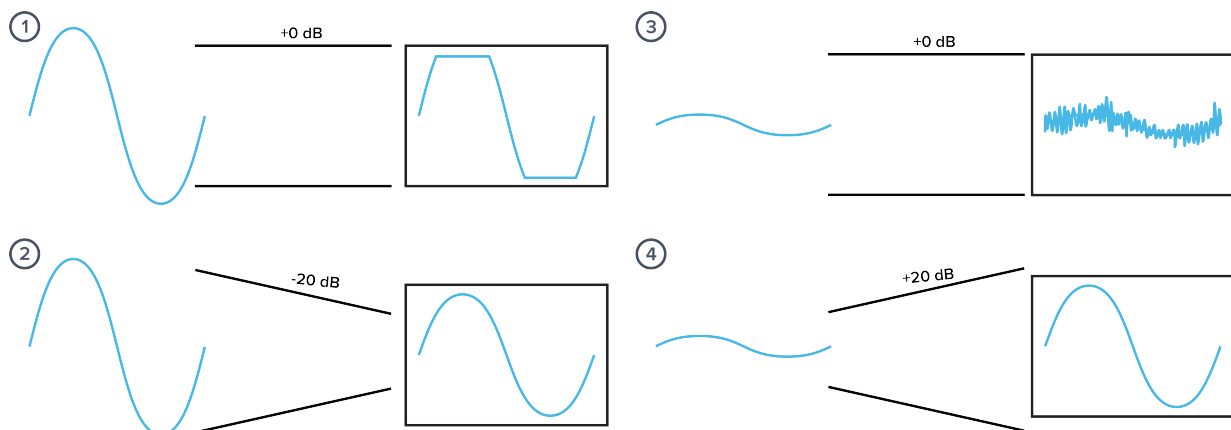


Figure 9. Illustration of oscilloscope range scaling. (1) Input range too small, causing signal clipping at the ADC, (2) the correctly scaled input range, ensuring accurate signal capture, (3) input range too large, reducing ADC resolution and making the signal appear noisy, and (4) the correctly scaled input range.

It is recommended to first use the Moku Oscilloscope automatic range selection, which chooses a range based on the displayed y-axis (voltage) range. You can then manually adjust the range to best match your signal. For example, a 1 Vpp signal measured with an oscilloscope that has a 400 mVpp ADC must first be attenuated to fit within the ADC's range, ensuring the waveform is captured without distortion.

Probe attenuation

Probes often attenuate the signal before it reaches the input of the oscilloscope, both to protect the instrument and to allow measurement of higher voltages. To ensure your readings remain accurate, the Moku Oscilloscope includes a probe attenuation setting that automatically scales the displayed voltage to match the true value at the test point.

For example, a 10x probe divides the input signal amplitude by ten; thus, configuring the input settings to "10x" ensures the displayed signal matches the true voltage. Similarly, for 100x probes, the probe scale factor in the Moku Oscilloscope is set to "100x" to display the signal with the correct scale. This approach helps achieve accurate voltage representation by compensating for probe attenuation.

Compensating probes

Moku Oscilloscope can be used to compensate a probe to ensure both accurate measurements of voltage and frequency and also precise waveform representation.



The Moku Oscilloscope has an embedded waveform generator which you can use to compensate your probes.

To do this, set the waveform generator to output a 1 kHz, 2 Vpp square wave. Use your probe to measure this signal, it may appear under- or over-compensated. Adjust as needed until you are measuring a sharp square wave which measures 1 kHz and 2 Vpp in the measurements tab.

This is achieved with the probe in "10x" setting; the Moku Oscilloscope is also setup to "10x" probe. For further instructions, read our [article on probe compensation](#).

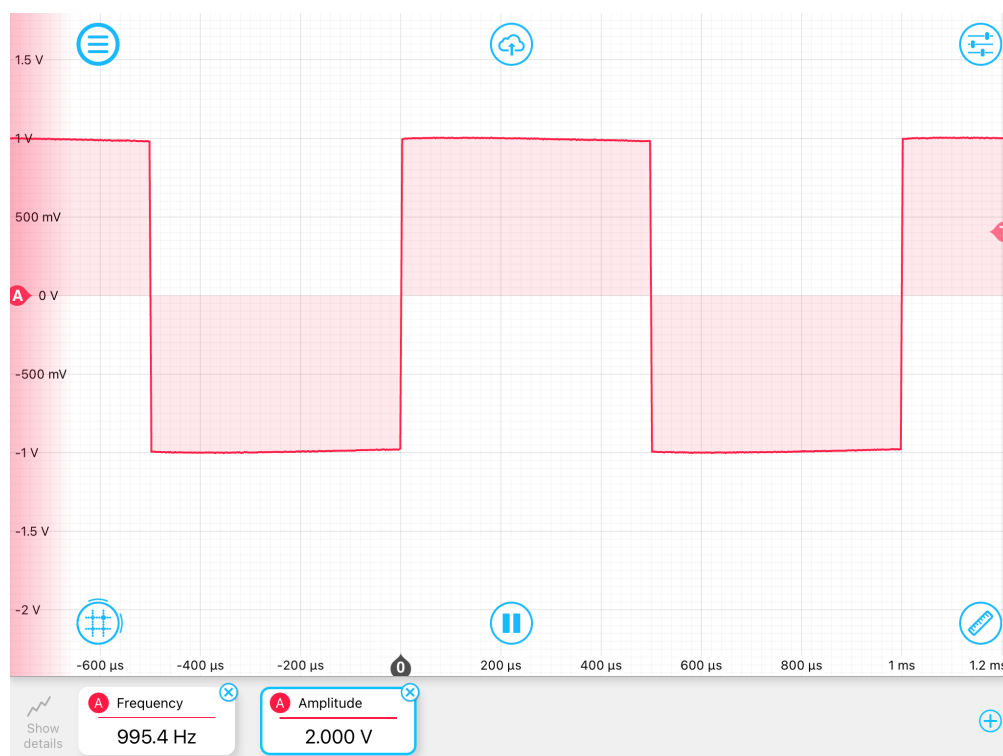


Figure 10. Accurately compensated, sharp square wave with an accurate 2.000 V amplitude measurement.

Overvoltage protection

It is always recommended to operate within the specified input range of your Moku to protect the device and ensure accurate measurements. However, Moku is equipped with built-in overvoltage protection to help safeguard the hardware in case of unexpected signal spikes. Overvoltage protection in the input will automatically switch to 1 MΩ mode to reduce current and power dissipation through the device.

If you're having trouble viewing your signal, ensure the signal is within this range, for example, by using an attenuating probe.



Configuring acquisition

A digital oscilloscope samples signals at very high rates, and since it can't display every captured point, the acquisition mode you choose defines how the oscilloscope selects or computes the points from an analog waveform to the display on-screen.

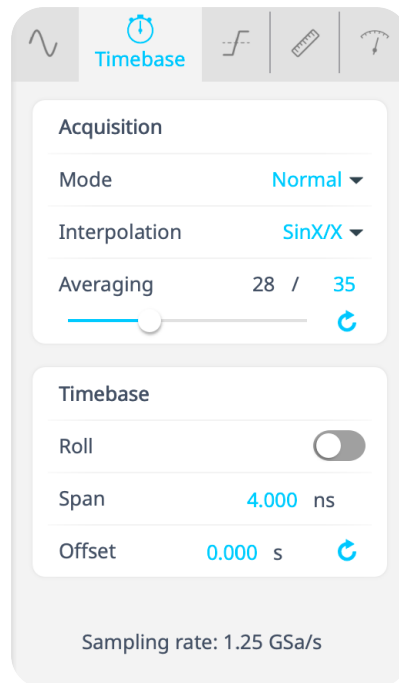


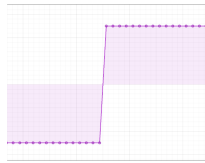
Figure 11. Acquisition and timebase settings panel.

- **Mode** Select the mode of acquisition used to down-sample your measurement.
- **Interpolation** Select the mode of interpolation used to reconstruct the signal.
- **Averaging** Display an averaged trace taken from many consecutive waveforms. This can help to remove noise in periodic waveforms. Press to reset the average count.
- **Persistence** Drag the slider to keep the number of old waveforms on the screen, fading out.
- **Roll mode** Turn ON to view the traces acquired in real-time, or OFF for triggered acquisition. This is more suitable for slow-changing signals.
- **Span** Set the displayed time span.
- **Offset** Select an offset to view before or after the trigger. Press to return to zero offset.
- **Sampling Rate** is the number of samples the oscilloscope takes per second.

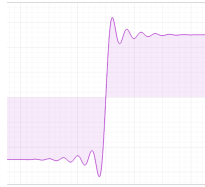
Interpolation modes

Oscilloscopes typically **down-sample** data for display, since the ADC captures more points than the screen can show. At very small time spans near the device's bandwidth limit, interpolation can be applied to smooth the trace. While it does not add new data, interpolation estimates the signal shape between samples for a cleaner, more continuous display.

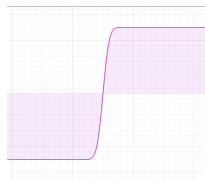
When up-sampling with interpolation, you can choose from three modes: "Linear", "Sin X/X" (sinc), or "Gaussian". Each uses a different method to reconstruct the signal between displayed points.



Linear interpolation does not perform any up-sampling. For display, it marks each point in the original data set and draws a straight line between them. This can make the signal look jagged but does not invent any new data points. This is best used for square-wave-type signals.



Sin X/X Also called “Sinc” interpolation, this mode preserves the frequency characteristics of the signal. In the time domain though, it can appear that there is over- or under-shoot that is not in fact present in the signal. Use Sin X/X if your signal is sine-like; it doesn’t include significant frequency components that have been removed by filtering or decimation.



Gaussian interpolation “smooths” the signal out, preserving the visual characteristics of the signal at the expense of frequency information. Use this mode if your signal is square-like; it contains harmonics or other signal elements that have been removed by filtering or decimation.

Averaging

This averages the data points of multiple signal acquisitions, which can improve the signal-to-noise ratio by removing random noise if the waveform is strictly repetitive, as seen in [Figure 12](#). Averaging works with repeated data frames, so accurate triggering is crucial to ensure all frames are perfectly aligned before averaging. If the waveform is strictly periodic, averaging increases vertical resolution and decreases random noise, however averaging does not improve triggering precision as it occurs after the acquisition and triggering.

Higher average counts remove more noise, as the oscilloscope displays the pointwise average of the selected number of acquisitions.

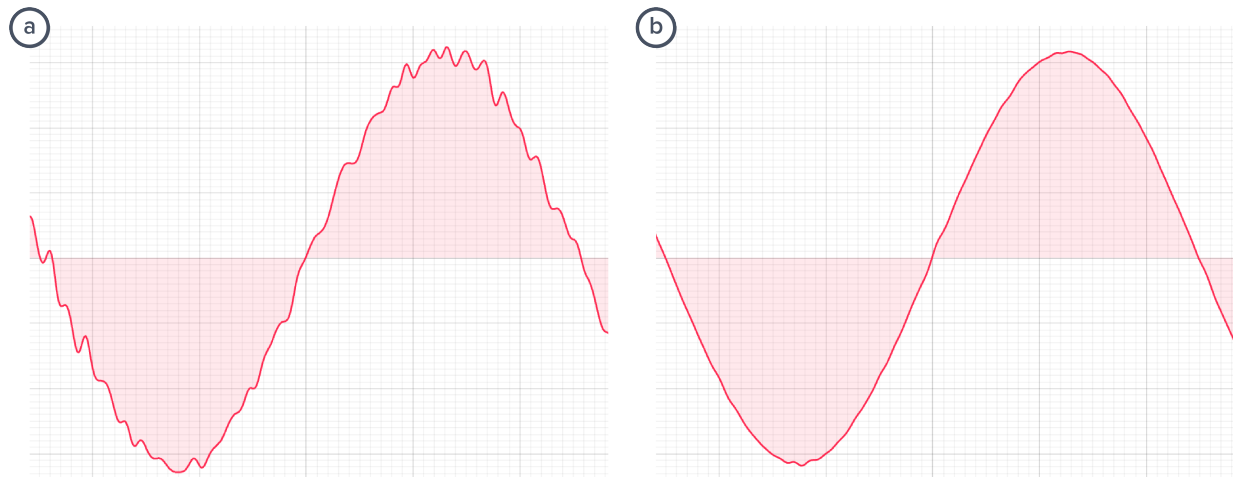


Figure 12. Signal with no averaging (a) and 100 waveform acquisitions averaged (b).

Persistence

Persistence sets how long previously captured waveforms remain visible on the screen before fading. This allows you to compare multiple acquisitions over time instead of only seeing the most recent trace.

Use the persistence slider to set the number of past waveforms to keep. Sliding it all the way to the right enables infinite persistence, where old traces are never cleared until you manually



reset the display. Persistence is especially useful for spotting occasional or intermittent events that might otherwise appear for only a single frame.

Note: Persistence is available in the iPad version of the Moku application only.

Sampling rate

Changing the horizontal zoom or time on the x-axis will adjust the sampling rate of the oscilloscope. Showing more time on the x-axis, or zooming out, will reduce the sampling rate of your signal. This is necessary so the oscilloscope can always show the maximum number of samples on the screen by using the maximum memory depth. Using the maximum memory depth ensures the most accurate reconstruction of the signal. [Equation 1](#) expresses the relationship between the memory depth and the sampling rate. Scaling the display horizontally changes the time span, leaving the sampling rate to vary to achieve maximum memory depth.

$$\text{Memory depth} = \text{sampling rate} \cdot \text{measurement duration (span)} \quad (1)$$

To keep the oscilloscope at its maximum sampling rate, you can zoom in to the minimum time span or select "Deep Memory" acquisition mode.



Configuring timebase

Normally, the oscilloscope will wait for a waveform to be complete before displaying it on the screen. If the time base is very long, this may not be desirable, and the oscilloscope can be changed to roll mode, which can be manually selected from the timebase ⌚ tab .

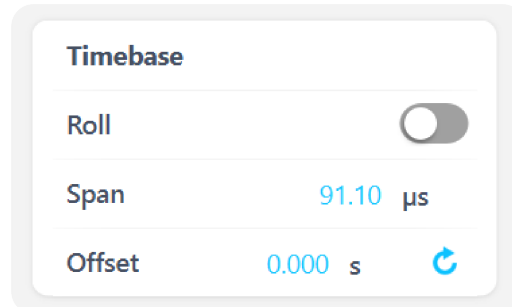


Figure 13. Timebase settings panel.

For both **Sweep** and **Roll** mode, the span and offset can be controlled using pinch and pan actions (on iPad) or click and scroll (on desktop) in the graph area, or by manually entering their values in the settings panel.

Span is the horizontal screen scale, which changes dynamically when pinch zooming the display, scrolling a trace, or can be entered manually. Changing the span in either mode will change the sampling rate, which will affect the accuracy of the signal displayed and signal measurements.

Offset Horizontal trigger point offset. Changes dynamically when horizontally-dragging a trace or can be set manually.

Sweep mode

Sweep mode is the standard operating mode for an oscilloscope and is best suited for viewing fast or periodic signals. When a trigger event occurs, the oscilloscope captures a complete waveform and refreshes the display all at once. For high-speed signals, this happens so quickly that the waveform appears instantly and steadily, you won't see the points "filling in".

With very slow signals or long time spans, all points up to the trigger event will be displayed at once, then the trace will build across the screen from the trigger point as new data arrives. This is the oscilloscope plotting the signal in real time until the full sweep is complete. Because each acquisition is aligned to the trigger point, sweep mode produces a stable, consistent display, making it ideal for detailed analysis of high frequency or periodic signals. When using "Normal" mode, the screen will not update until the next valid trigger is received, so you always see a complete and aligned waveform



Roll mode

Roll mode is designed for slow-changing signals, such as temperature trends, sensor outputs, or low-speed serial data. In this mode, triggering is not used and incoming data is continuously plotted in real time, scrolling from right ($t = 0$ s) to left. The most recent data appears at the right edge of the screen, with older data moving toward the left.

Because roll mode shows the signal as it is being acquired, it allows you to watch slow signals evolve without waiting for a trigger. However, it is not suitable for high-speed signals, as they will blur or appear aliased at the slower update rates, as shown in Figure 14. The minimum roll mode span is longer than sweep mode, see your specifications [here](#).

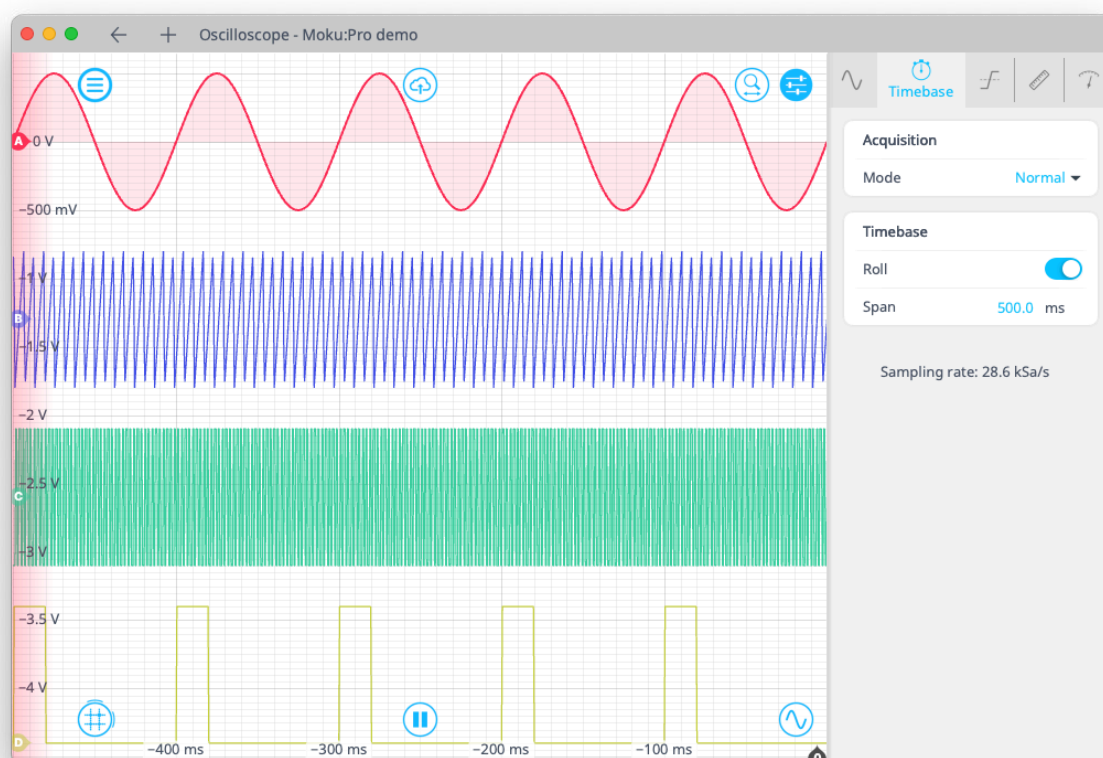


Figure 14. Roll mode in the oscilloscope, showing real-time data streaming. Some signals are clearly visible (red, yellow) in roll mode, whereas high frequency signals are not clear, or appear aliased.



Configuring the trigger

Triggering tells the oscilloscope when to capture and display a waveform so it appears stable and aligned on the screen. Without it, the trace would drift or jump from one sweep to the next, making it hard to interpret the signal. Several different types of triggering are available, but the simplest type is edge triggering, where the oscilloscope shows new data every time the voltage rises or falls past a preset level (rising edge and falling edge respectively).

The Moku Oscilloscope can trigger on either an edge, a pulse, or a runt pulse of the trigger source. The input signal can be triggered on the edge or pulse any of the inputs or outputs, or the external trigger (hardware dependent).

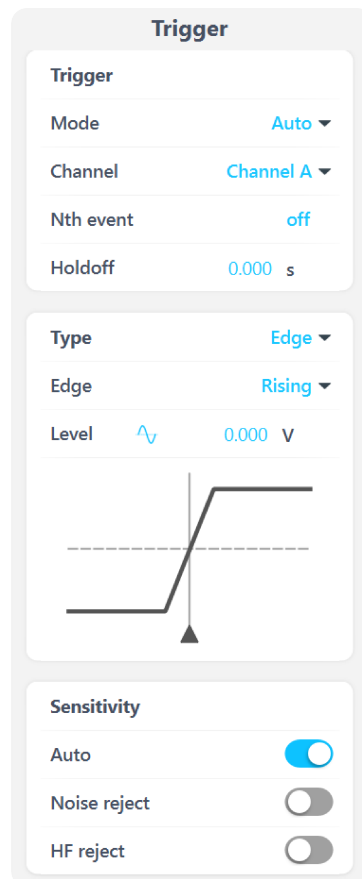


Figure 15. Trigger settings panel.

Mode Switches between auto, normal and single trigger modes.

Trigger Select the channel and modes to determine how and when the oscilloscope detects a trigger event.

Type Select the conditions the oscilloscope will look for to detect a trigger event, either an edge, pulse, or runt. Select between edge, pulse, and runt triggering with selectable levels, edge types and pulse widths.

Sensitivity Configure "Auto" or manual hysteresis for noise rejection. Configure HF reject to enable a lowpass filter on the trigger circuit, giving better noise immunity but with a short delay between the trigger event and detection.



Trigger settings

- “Normal” trigger mode will only trigger, and therefore update the display, when a trigger event is detected. This is very useful if you genuinely only care about the signal around the trigger event, but you cannot view the signal in real-time without a stream of triggers (e.g. for a DC signal or while setting up the trigger in the first place).
- “Auto” trigger mode acts like “Normal”; however if no trigger event has been detected in a short while, it will display the data points available in the memory buffer, this way the trace will still be updated in real-time in the absence of a trigger event.
- “Single” trigger simply captures the first trigger event then stops acquisition until the user starts it again. This is useful when you need time to study your signal in detail or to capture a specific signal event for sharing or saving.

Channel Select the channel used for triggering. This can be one of the oscilloscope channels, inputs, outputs, or external trigger input (if available), independent of what is displayed on the screen.

Nth event Captures every Nth qualifying trigger event instead of every event. This is useful when viewing or recording a subset of repeated events, such as every 10th pulse in a high-rate pulse train.

Hold off Select a time to holdoff oscilloscope trigger, after a trigger event. Holdoff begins when an event is detected, which is useful on packetized signals or noisy asymmetric pulses.

For example, when observing a chirp signal to measure how often it repeats the whole cycle, defining just a rising or falling edge and setting a hold off period that is just below the period of the chirp will ensure the waveform will always get triggered at the start of the chirp, instead of in between, and will avoid unwanted trigger events.

Trigger types

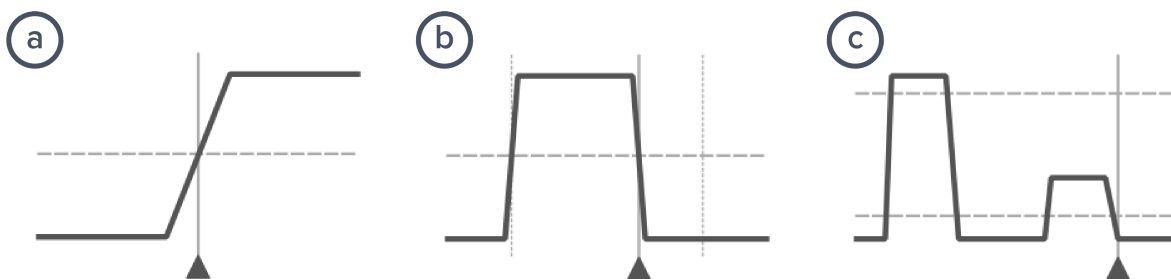


Figure 16. Illustrations of (a) edge triggering, (b) pulse triggering, and (c) runt triggering.

Edge triggering watches for the input signal to cross a threshold in a rising, falling or both rising and falling directions.

Pulse triggering watches for pulse, either positive- or negative-going. The pulse trigger type has a voltage threshold, determining the minimum magnitude of the pulse; and a time threshold, determining the minimum or maximum width of a pulse that will cause a trigger.

Runt triggering watches for pulses that cross one voltage threshold but fail to cross a second.



Edge triggering

Edge triggering watches for the input signal to cross a specified voltage threshold. The crossing can be detected on a rising edge, a falling edge, or both. This type of trigger is most useful for stabilizing repetitive waveforms and for capturing signals that consistently transition through a known threshold.



Figure 17. Edge triggering settings.

Edge The trigger watches for the input signal to cross the level on a rising, falling or both rising and falling directions.

Level The trigger watches for the input signal to cross the level threshold. Press $\bar{V}$ to detect at the signal's instantaneous mean voltage level.



Pulse triggering

Pulse triggering watches for pulses that begin on one edge and end on the opposite edge, with a duration defined by a time threshold. Pulse triggering is useful for detecting narrow glitches, missing pulses, or abnormal duty cycles in digital and mixed-signal systems.

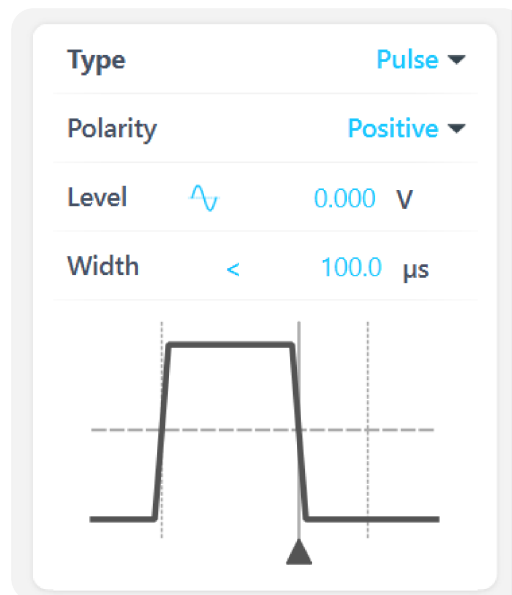


Figure 18. Pulse triggering settings.

Polarity Select the polarity of the pulse the trigger detects, where positive polarity begins on a rising edge and ends on the falling edge, and vice versa.

Level The trigger watches for the input signal to cross the level threshold. Press $\bar{v}$ to detect at the signal's instantaneous mean voltage level.

Width Set the width threshold to be greater or less than an input value. Click the $</>$ arrow to invert its direction.



Runt triggering

Runt triggering watches for pulses that cross one voltage threshold but fail to cross a second. In other words, a runt pulse is a signal that is too short in amplitude to qualify as a valid logic transition. Runt triggering is especially useful for capturing glitches, timing errors, or faulty transitions in digital circuits where a signal rises or falls but doesn't reach its expected full voltage level.

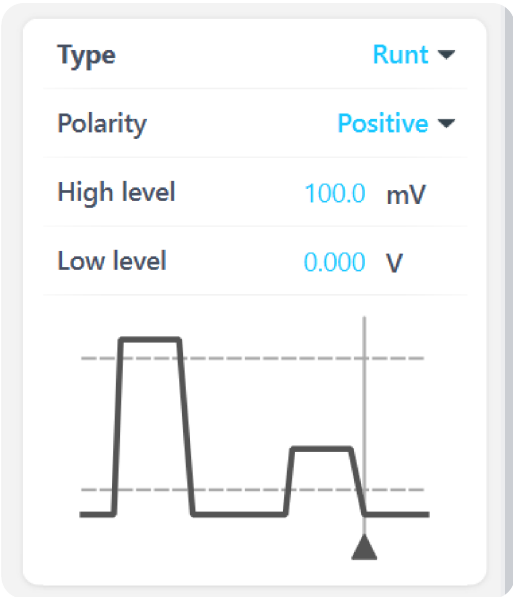


Figure 19. Runt triggering settings.

Polarity Select the polarity of the pulse the trigger detects, where positive polarity begins on a rising edge and ends on the falling edge, and vice versa.

High level Set the larger threshold that the signal should reach for a valid transition.

Low level Set the baseline threshold that the signal must cross first.



Trigger sensitivity

Often a signal will be noisy and setting a simple trigger event such as “rising edge” may cause a trigger event due to noise rather than due to the underlying signal. Moku Oscilloscope has two automatic features to help reliably trigger on noisy data: **Noise reject** and **HF reject**. **Hysteresis** may also be manually configured to prevent false triggers caused by noise.

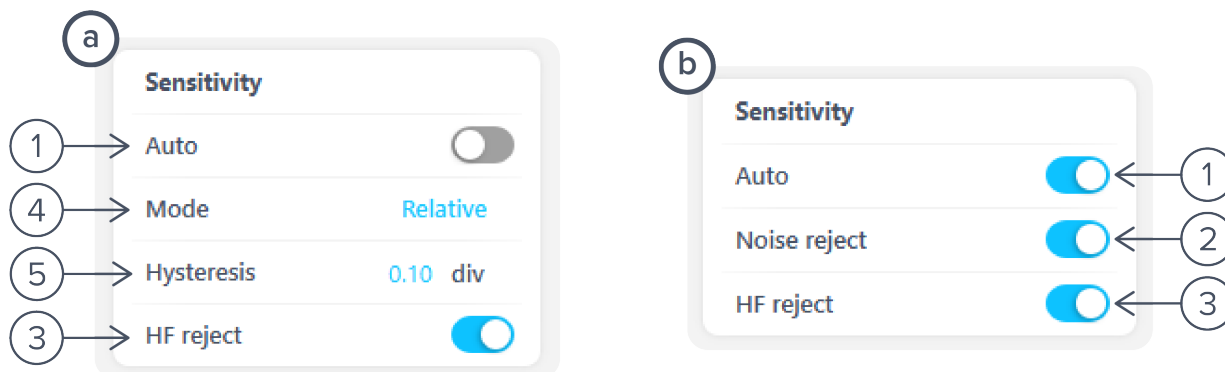


Figure 20. Auto sensitivity settings (a) and manual sensitivity settings (b).

Trigger sensitivity filtering determines when the trigger is "armed" to detect the next event that meets the specified trigger conditions. This can be done automatically or manually to further bound the trigger conditions for more stable and accurate triggering.

- ① **Auto** sensitivity sets the hysteresis to 1/25th of the total vertical voltage range, and is increased by a factor of 5 when noise reject is turned on. Turning "Auto" mode OFF allows you to select the relative or absolute hysteresis to reduce false triggering caused by noise or jitter in the signal.
- ② **Noise reject** automatically adds a small amount of hysteresis to the trigger event. This stops the trigger from firing several times as noise repeatedly crosses the trigger threshold.
- ③ **HF reject** passes the trigger signal through a lowpass filter before looking for the trigger event. This smooths out any noise, allowing the trigger circuit to observe just the underlying signal. The trade off is that this filter introduces some delay in the signal, offsetting the trigger event from the actual data.
- ④ **Mode** Toggle between Relative (div) and Absolute (mV) Hysteresis inputs.
- ⑤ **Hysteresis** in an oscilloscope adds a voltage margin above and below the trigger level to prevent false triggers caused by noise or small fluctuations in the signal. Once the signal crosses the trigger level in the desired direction, it must then move past the hysteresis margin in the opposite direction before the oscilloscope will trigger again. This helps ensure stable triggering on noisy or jittery waveforms.

If hysteresis is too large for the signal, the triggering may look unstable. This may occur when measuring very small signals or signals with large amplitude modulations. In this case, manually set the hysteresis to be less than the smallest signal amplitude and larger than the signal noise to ensure consistent triggering.



Measuring signals

After your oscilloscope is set up and capturing signals, the Moku Oscilloscope provides several tools for measuring and analyzing your waveform. Moku Oscilloscope supports both manual and automatic measurements in the form of [graph cursors](#), [voltmeter](#), [automatic measurements](#) and [statistics](#).

Cursors and measurements

Cursors

Cursors are managed from the cursor icon. Drag up from the button to insert a **voltage** cursor, drag to the right to insert a **tracking cursor** (desktop), or a **time** cursor (iPad). Click the cursor icon to manage cursors, including adding a tracking cursor, or remove all cursors. On desktop, cursors can also be added from the context menu, by right clicking the graph.

Cursors can also be positioned to measure unique events by voltage, time or by channel tracking, as shown in [Figure 21](#). Cursors attached to a channel will track the voltage scale of that channel.

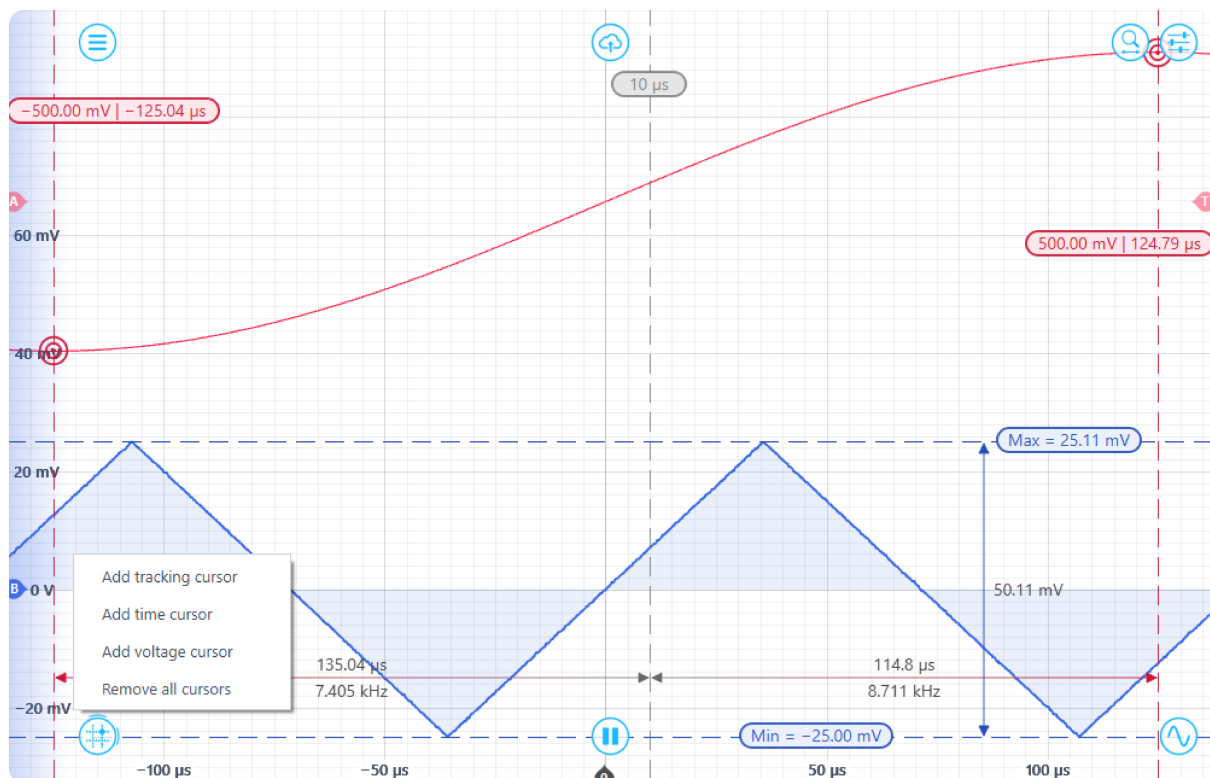
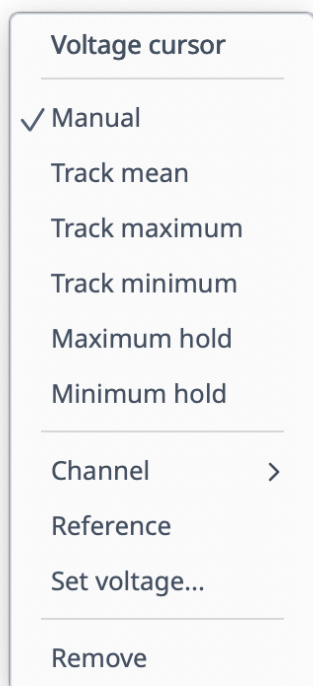


Figure 21. Cursors measuring the rise time (red) with time cursor (gray) and voltage peak-to-peak (blue) with voltage cursors.

Voltage Cursor

Voltage cursors reference and measure the amplitude between other voltage cursors. Right-click (secondary click) on a voltage cursor to reveal the voltage cursor options.

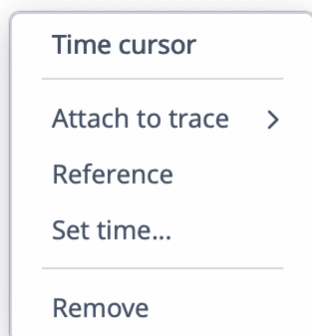


- **Manual** Position the cursor manually by dragging it to a feature of interest.
- **Track Mean** Track the mean voltage.
- **Track Maximum** Track the maximum voltage.
- **Track Minimum** Track the minimum voltage.
- **Maximum hold** Set the cursor to hold the maximum voltage level.
- **Minimum hold** Set the cursor to hold the minimum voltage level.
- **Channel** Assign the voltage cursor to a specific channel.
- **Reference** Set the cursor as the reference cursor.
- **Set Voltage...** Set the voltage of the cursor to a given voltage value.
- **Remove** Remove the voltage cursor.

Figure 22. Voltage cursor context menu.

Time cursor

Time cursors reference and measure the time between other time cursors, without being attached to a specific trace. Right-click (secondary click) on a time cursor to reveal the time cursor options.

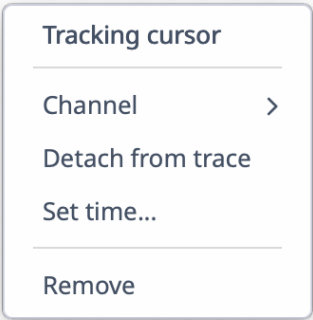


- **Attach to trace** Assign the time cursor to a specific trace, turning it into a tracking cursor.
- **Reference** Set the cursor as the reference cursor.
- **Set time...** Set the time of the cursor to a given time value.
- **Remove** Remove the time cursor.

Figure 23. Time cursor context menu.

Tracking cursor

Tracking cursors automatically follow a selected signal trace as it moves or changes with each captured data frame, maintaining its relative position on that trace. This allows you to dynamically measure parameters such as time or voltage as the waveform changes, without needing to reposition the cursor manually.



- **Channel** Assign the voltage cursor to a specific channel.
- **Detach from trace** Detach the cursor from the trace, turning it into a time cursor.
- **Set time...** Set the time of the cursor to a given value.
- **Remove** Remove the time cursor.

Figure 24. Tracking cursor context menu.

Automatic measurements

There are several automatic measurements that the Moku Oscilloscope specifically can make in real time when acquiring in "Auto" or "Normal" trigger conditions. These are controlled from the **Measurement** tab, found in the right-hand settings drawer on Desktop applications, or opened from the button on the iPad.

Add a new measurement by tapping the plus button or configure an existing measurement by tapping the measurement itself. The available measurements are described below.

Name (unit)	Icon	Description
Frequency (Hz)		Frequency of the signal as determined by the time between rising or falling edges.
Phase (degrees)		Phase of strongest frequency component with respect to a perfect sine wave.
Period (s)		Time between pairs of rising or falling edges.
Duty Cycle (%)		Ratio of the time spent above the median to that spent below it.
Pulse Width (s)		Time the signal spends above the median.
Negative Width (s)		Time the signal spends below the median.
Mean (V)		Average value of the signal



Name (unit)	Icon	Description
RMS (V)		Root-Mean-Square value of the signal
Cycle Mean (V)		Average value of the signal, discounting partial cycles at the beginning and end of the frame.
Cycle RMS (V)		Root-Mean-Square value of the signal, discounting partial cycles at the beginning and edge of the frame.
Standard Deviation (V)		Mathematical description of the spread of the points in the signal
Peak to Peak (V)		Difference between the highest and lowest voltage in the signal.
Amplitude (V)		Difference between the high- and low-level voltage, excluding over- and undershoot.
Maximum (V)		Highest voltage in the signal
Minimum (V)		Lowest voltage in the signal
High Level (V)		Highest voltage in the signal, excluding overshoot.
Low Level (V)		Lowest voltage in the signal, excluding undershoot
Rise Time (s)		Time taken for the signal to transition from 10% to 90% of the way from minimum to maximum.
Fall Time (s)		Time taken for the signal to transition from 90% to 10% from maximum to minimum.
Rise Rate (V/s)		Rate at which the signal transitions from 10% to 90% of the way from minimum to maximum



Name (unit)	Icon	Description
Fall Rate (V/s)		Rate at which the signal transitions from 90% to 10% of the way from minimum to maximum
Overshoot (V)		Distance the signal shoots above the maximum level before settling
Undershoot (V)		Distance the signal shoots below minimum level before settling
Fringe visibility (%)		Measurement of interference

Measurement statistics

Click the drop down on a measurement to open the measurement statistics.

Reset the number of trigger events that have occurred with the button.

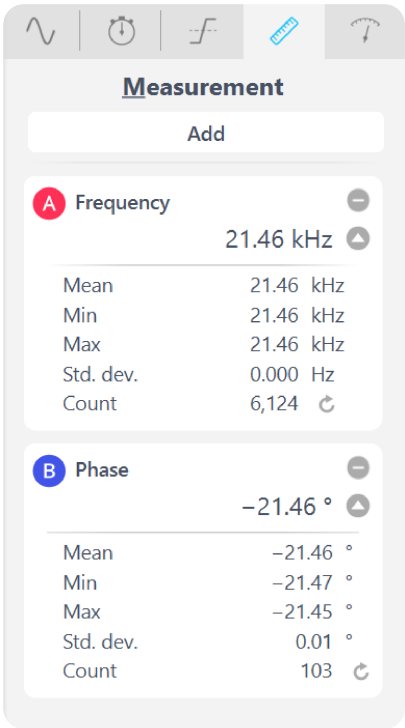


Figure 25. Measurement statistics available, including mean, min, max, standard deviation and the count.



Voltmeter

The voltmeter tiles constantly read the mean voltage level from each channel. They are displayed under the Voltmeter panel of the settings.

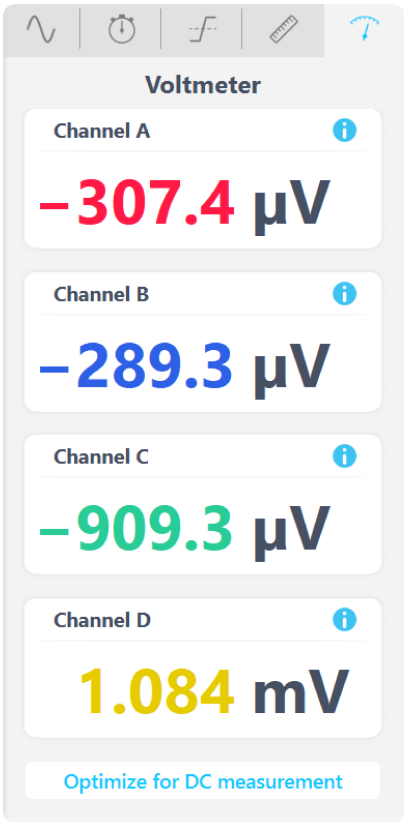


Figure 26. Voltmeter settings

The "Optimize for DC measurement" button auto-scales each channel's voltage (y-) axis such that the entire DC signal is viewable in the signal display area, for better mean calculations.

Using the math channel

Real-time math operations, across two different channels, can be performed using the Math channel. A wide range of math operations are available:

Operation	Symbol	Description
Addition	+	Sum of two channels.
Subtraction	-	Difference of two channels.
Multiplication	x	Product of two channels. The two channels can be the same, giving a squaring of the signal values.
Division	÷	Ratio of two channels.
XY	XY	Plots a trace whose horizontal axis is not time, but the voltage of the selected channel. See an example of using XY mode to characterise a transfer curve .
Integral	∫	Discrete time-integral (running sum) of the trace
Derivative	d / dt	Discrete time-derivative (pointwise difference) of the trace



Operation	Symbol	Description
FFT	FFT	Fast Fourier Transform of a trace, giving the frequency domain representation. See FFT function for more information.
Min Hold	Min hold	Pointwise minimum hold of the all time waveform minimum voltage value.
Max Hold	Max hold	Pointwise maximum hold of the all time waveform maximum voltage value.
User entered function	f()	A user-defined math function, edited in the input box. See user defined function for more information.



Figure 27. The Math channel calculates the product of Channel A and Channel B.

The math channel cannot be routed to an analog port. If you want to perform real-time math operations for signal output, use an instrument with a cross-over matrix, such as the [PID Controller](#), to perform basic math operations; otherwise consider [Moku Cloud Compile](#), see some existing [Moku Cloud Compile examples](#).

User defined function

The math channel can plot a user-entered function of all input channels. The channels are represented by the variables **A**, **B**, etc.

When using this function, the units can be changed from volts to amps, watts or ohms. You can connect other types of probes to the oscilloscope inputs and compute the probed current, power and resistance.



FFT function

The FFT math channel converts the input signal from the time domain into its frequency-domain representation, allowing you to quickly see the different frequency components present in the signal. This is useful for a fast check of frequency-related parameters without switching instruments. For precise and detailed frequency measurements, we recommend using the dedicated Spectrum Analyzer.



Figure 28. FFT measurement of a square wave and cursors to observe the signal harmonics.

There are several limitations and therefore the best option is to view the signal is with the Spectrum Analyzer alongside the Oscilloscope using Multi-Instrument Mode. The limitations of the FFT function of the Moku Oscilloscope include:

- The FFT is subject to aliasing, depending on acquisition mode. Moku Spectrum Analyzer instrument has an advanced DSP anti-aliasing chain, minimizing the effect of unwanted signals.
- The FFT is not windowed. The Moku Spectrum Analyzer provides a range of different windows for minimizing harmonics and spurs and improving amplitude accuracy.
- The FFT has a fixed frequency resolution set by the time span. The Spectrum Analyzer has a fully-configurable Resolution Bandwidth (RBW).
- The frequency span in FFT function is defined by the oscilloscope's time span, and always starts at DC. The Spectrum Analyzer can have any span and offset, providing much more detail around the signal of interest.
- Zooming out in the time domain will give you greater resolution for the FFT measurement in the frequency domain, which can overcome some of these limitations.



Saving and sharing data

The export data options can be accessed by clicking the  icon, allowing you to export data in a number of different formats. Opening this window will automatically pause the oscilloscope display and acquisition. Restart acquisition by pressing the play icon .

Live data

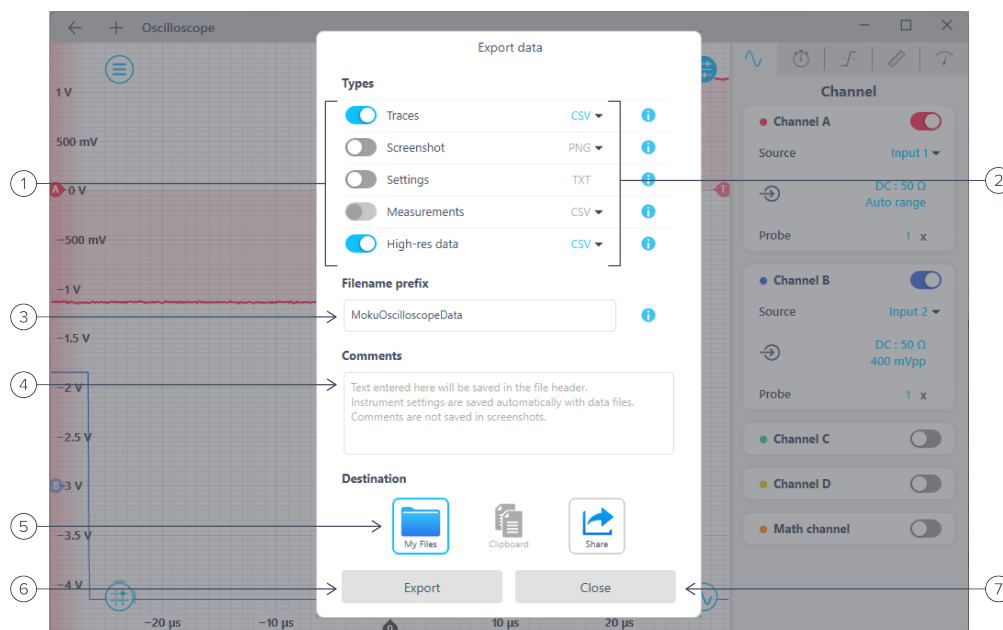


Figure 29. Live data exporting user interface and settings.

① Select the type of data to export:

- **Traces** Saves the trace data for all visible signal traces, in either a CSV or MAT-file format.
- **Screenshots** Saves the app window as an image, in either a PNG or JPG format.
- **Settings** Saves the current instrument settings to a TXT file.
- **Measurements** Saves the active measurement values, in either a CSV or MAT-file format.
- **High-res data** Saves the full memory depth of all visible channels statistic values for all visible channels, in LI, CSV, HDF5, MAT or NPY format.

② Select the **export format**.

③ Select the **Filename Prefix** for your export. This is defaulted to “MokuOscilloscopeData” and can be changed to any filename of alphanumeric characters and underscores. A timestamp and the data format will be appended to the prefix to ensure the filename is unique.

For example: “MokuOscilloscopeData_YYYYMMDD_HHMMSS_Traces.csv”

④ Enter additional **Comments** to be saved in any text-based file header.

⑤ Select the export **Destination** on your local computer. If “My files”  or “Share”  is chosen, the exact location is selected when the Export button is clicked. Multiple export types can be exported simultaneously using My Files and Share, but only one export type can be exported to the clipboard  at a time.

⑥ **Export** the data, or



⑦ **Close** the export data window, without exporting.

Generating waveforms

The Moku Oscilloscope has an embedded Waveform Generator. It has all the same functions as the [Moku Waveform Generator](#), though does not support modulation.

Controls for the embedded waveform generator are found in the **Output** tab of settings on the Moku iPad application, or revealed from the  button, in the bottom right corner of the graph area in the Moku desktop application.



Figure 30. Embedded Waveform Generator (bottom), oscilloscope graph area (top), and settings panels (right) open.



Oscilloscope examples

Characterization of a noisy signal

This example demonstrates how to configure your oscilloscope to measure and visualize distortion in a signal, such as harmonics or waveform irregularities caused by a non-linear circuit element. Using the Moku Oscilloscope, we trigger on a clean reference signal from the embedded waveform generator and use precision acquisition to observe subtle distortion features in detail.

- **Step 1:** Setup your Moku device
 - Connect a BNC to Output 1 and pass it out to your circuit to drive the input.
 - Connect the signal to be measured to Input 1.
 - Open the Moku Oscilloscope in single Instrument mode.
- **Step 2:** Configure the output from the embedded waveform generator.
 - On Output 1, configure a 50 mVpp, 5 kHz sine wave and turn the output ON.
- **Step 3:** Configure analog front end settings
 - Select the channel sources; for Channel A select Output 1 and for Channel B select Input 1.
 - Set coupling to DC as we want to observe the entire signal, including offsets and any low frequency drift.
 - Set the coupling to match the output of your system. This is fixed on some devices and variable on others, view your specifications [here](#).
 - Set the Range to "Auto", which will automatically maximize the ADC range for the measurement.
 - Set the probe to 1x attenuation and ensure this matches your probe setting.
- **Step 4:** Configure acquisition
 - Set acquisition to Precision mode. This will show a more precise signal than Normal mode. You can compare this to Normal mode, which looks more noisy as it has downsampled and removed a large amount of the data and precision.
 - Set interpolation to SinX/X and slide averaging OFF to capture the distortion.
- **Step 5:** Configure the timebase
 - Turn roll mode off and set the offset to 0 s to view the signal around the trigger.
 - Set the span to ~ 1 ms to see multiple consecutive cycles.
- **Step 6:** Configure the trigger
 - Set the trigger to use "Auto" mode so that we can get frequent display updates.
 - Trigger on Channel A, to trigger on a stable waveform rather than the noisy signal that is being input to Channel B. Ensure Nth event is off and holdoff is set to 0 s.
 - Set the trigger to detect on a rising edge at the 0 V level.
 - Turn "Auto" sensitivity off, as it is likely too large for the signal in this example. Set the mode to relative and 1.00 div of hysteresis.
 - Turn HF reject ON to remove as much high frequency noise as possible.
- **Step 7:** Setup measurements and cursors
 - With the waveform stable on the display, enable cursors and automatic measurements to quantify
 - harmonic measurements or calculate Total Harmonic Distortion (THD) using the cursor measurements in post-processing
 - peak-to-peak voltage to confirm clipping behavior or other non-linear effect.

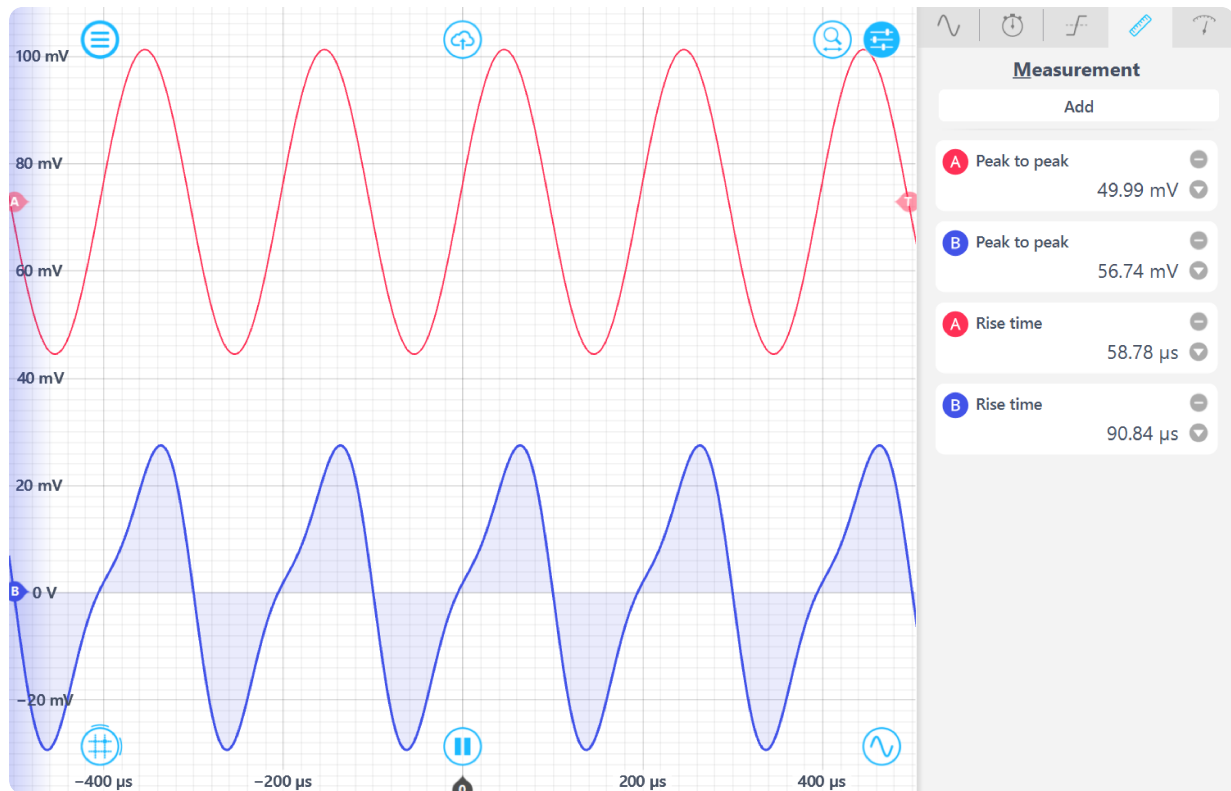


Figure 31. The distorted peaks on Channel B reveal harmonic distortion caused by harmonic coupling in the circuit compared to the input signal on Channel A.

Op-amp transfer curve characterization

This example demonstrates how to use XY mode in the Moku Oscilloscope to visualize an op-amp's input–output relationship. By plotting the input signal on the X-axis and the op-amp's output on the Y-axis, we can see its linear gain region, where the output closely follows the input, and identify saturation points where the output clips against the supply rails.

- **Step 1:** Setup your Moku
 - Connect Inputs 1 and 2 and open the Moku Oscilloscope. Probe the input signal to the op-amp with Input 1 and the op-amp output with Input 2.
- **Step 2:** Configure analog front end settings
 - Set coupling to DC as we want to observe the entire signal, including offsets.
 - Set the impedance to match the output of your system. This is fixed on some devices and variable on others, view your specifications [here](#).
 - Set the range to "Auto", which will automatically maximize the ADC range for the measurement.
 - Set the probe to 1x attenuation, ensuring this matches your probe setting.
- **Step 4:** Configure acquisition
 - Set acquisition to Precision mode to see subtle non-linearities. This will show a more precise signal than Normal mode. You can compare this to Normal mode, which looks more noisy as it has downsampled and removed a large amount of the data and precision.
 - Set interpolation to SinX/X and slide averaging OFF.
- **Step 5:** Configure the timebase
 - Turn roll mode off and set the offset to 0 s to view the signal around the trigger.
 - Set the span to ~ 1 ms to see multiple consecutive cycles.



- **Step 6:** Configure the trigger
 - Set the trigger to use "Auto" mode so that we can get frequent display updates.
 - Trigger on Channel A, to trigger on a stable waveform rather than the noisy signal that is being input to Channel B. Ensure Nth event is off and holdoff is set to 0 s.
 - Set the trigger to detect on a rising edge at the 0 V level.
 - Turn "Auto" sensitivity OFF, as it is likely too large for the signal in this example. Set the mode to relative and 1.00 div of hysteresis.
 - Turn HF reject ON to remove high frequency noise.
- **Step 7:** Enable XY Mode in the math channel
 - X-axis: Input 1 (op-amp input voltage)
 - Y-axis: Input 2 (op-amp output voltage)
 - The display will now show a transfer curve, as shown in Figure 32; A straight line in the op-amp's linear range (slope represents gain). The flat region is where the output saturates at the positive and negative rails. The XY signal passes through the origin, so there is no offset present.
- **Step 7:** Setup measurements and cursors
 - Drag out the cursors from the cursor button , difference measurements will automatically appear. Click and drag up for voltage and to the right for time cursors.
 - Voltage gain (slope in the linear region)
 - Clipping levels (output saturation points)
 - Offset voltage or bias if present



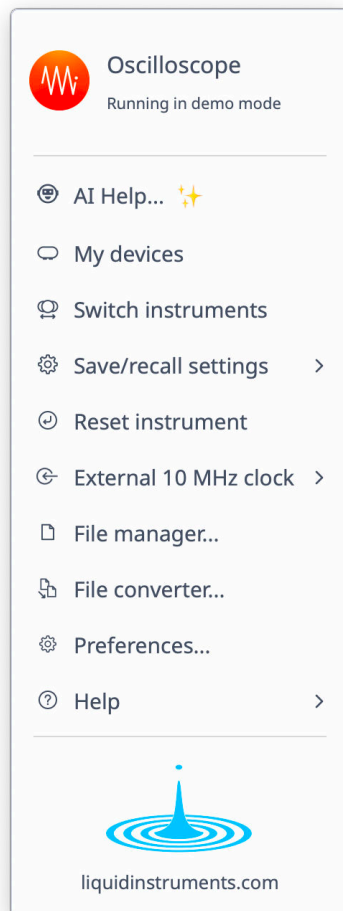
Figure 32. Op-amp input signal (Channel A), output signal (Channel B) and transfer curve (Math channel).



Additional tools

Main menu

The main menu can be accessed by clicking the  icon on the top-left corner.



AI Help... Opens a window to chat to an AI trained to provide Moku-specific help (Ctrl/Cmd+F1)

My Devices returns to device selection screen

Switch instrument to another instrument

Save/recall settings

- Save current instrument state (Ctrl/Cmd+S)
- Load last saved instrument state (Ctrl/Cmd+O)
- Show the current instrument settings, with the option to export the settings

Reset instrument to its default state (Ctrl/Cmd+R)

Sync Instrument slots in Multi-Instrument Mode*

External 10 MHz clock selection determines whether the internal 10 MHz clock is used.

Clock blending configuration opens the clock blending configuration pop-up *

Power Supply access panel*

File Manager access tool

File Converter access tool

Preferences access tool

* If available using the current settings or device.

Figure 33. Main menu options for the Oscilloscope.

Help

- **Liquid Instruments website** opens in default browser
- **Shortcuts list** (Ctrl/Cmd+H)
- **Manual** Open the user manual in your default browser (F1)
- **Report an issue** to the Liquid Instruments team
- **Privacy Policy** opens in default browser
- **Export diagnostics** exports a diagnostics file you can send to the Liquid Instruments team for support
- **About** Show app version, check for updates or licence information



File converter

The File converter can be accessed from the main menu .

The File converter converts a Moku binary (.li) format on the local computer to either .csv, .mat, .hdf5 or .npy format. The converted file is saved in the same folder as the original file.

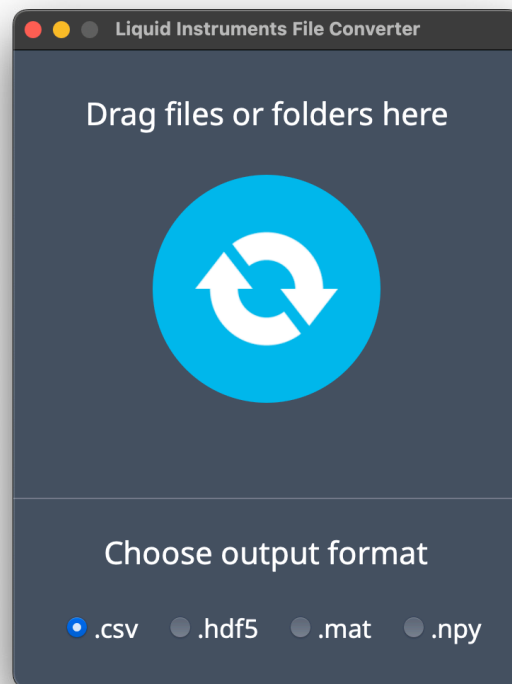


Figure 34. File Converter user interface.

To convert a file:

1. Select a file type.
2. Open a file (Ctrl/Cmd+O) or folder (Ctrl/Cmd+Shift+O) or drag and drop into the File converter to convert the file.



Preferences and settings

The preferences panel can be accessed via the Main Menu . In here, you can reassign the color representations for each channel, switch between light and dark mode, etc. Throughout the manual, the default colors are used to present instrument features.

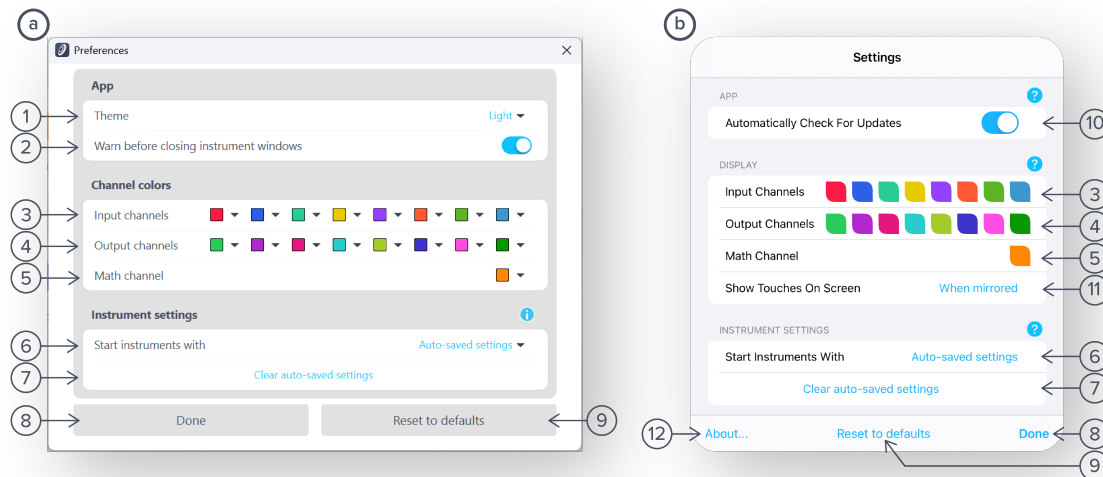


Figure 35. Preferences and settings for the Desktop (a) and for the iPad (b) App.

- ① Change the App theme, between dark and light mode.
- ② Choose if a warning opens before closing any instrument windows.
- ③ Tap to change the color associated with the input channels.
- ④ Tap to change the color associated with the output channels.
- ⑤ Tap to change the color associated with the math channel.
- ⑥ Select if instruments open with the last used settings, or default values each time.
- ⑦ Clear all auto-saved settings and reset them to their defaults.
- ⑧ Save and apply settings.
- ⑨ Reset all application preferences to their default state.
- ⑩ Notify when a new version of the app is available. Your device must be connected to the internet to check for updates.
- ⑪ Indicate touch points on the screen with circles. This can be useful for demonstrations.
- ⑫ Open information about the installed Moku application and license.



External reference clock

Your Moku may support the use of an external reference clock, which allows Moku to synchronize with multiple Moku devices, other lab equipment, lock to a more stable timing reference, or integrate with laboratory standards. The reference clock input and output are on the rear panel of the device. Each external reference option is hardware dependent, review the [available external reference options for your Moku](#).

Reference Input: Accepts a clock signal from an external source, such as another Moku, a laboratory frequency standard, or an atomic reference (for example, a rubidium clock or a GPS-disciplined oscillator).

Reference Output: Supplies the Moku internal reference clock to other equipment that require synchronization.

If your signal is lost, or is out of frequency, your Moku will revert to using its own internal clock until the reference signal returns. If this occurs, check the source is enabled, and that the correct impedance, amplitude, tolerance, frequency, and modulation are attached to the reference. Check the required specifications in the device [specsheets](#).

When the reference returns within range, status changes to "validating" and then "valid" once lock is re-established.

10 MHz external reference

To use the 10 MHz external reference function, ensure "always use internal" is disabled in the Moku application, found in the main menu under "External 10 MHz clock". Then, when an external signal is applied to your Moku reference input and your Moku has locked to it, a pop up will show in the app. On some devices, the external reference information will be shown in the LED status as well, more information can be found in your Moku [Quick Start Guide](#).

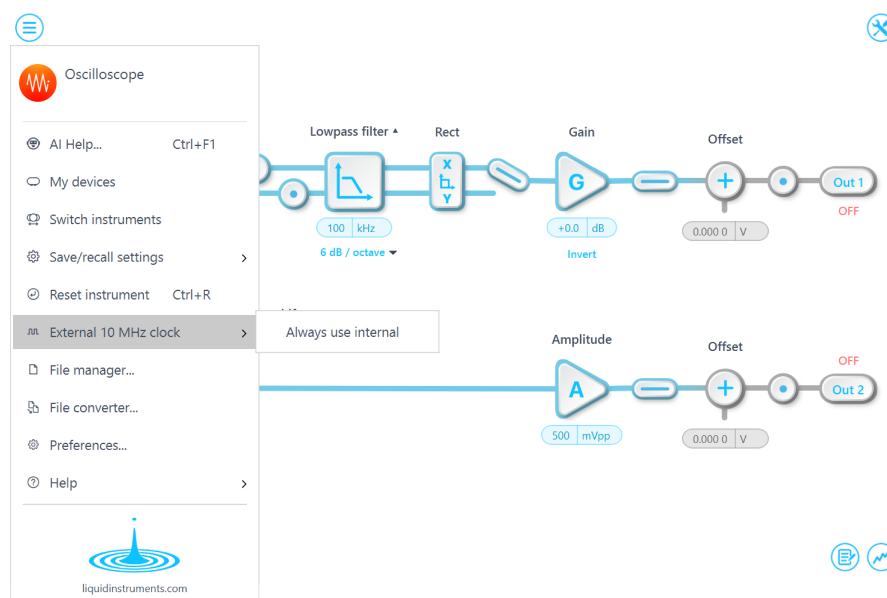


Figure 36. Moku main menu with "Always use internal" reference disabled and using an external reference.



Clock blending configuration

If available, Moku blends up to four clock sources simultaneously for more accurate phase, frequency, and interval measurements across all time scales. A low phase-noise Voltage-Controlled Crystal Oscillator (VCXO) is blended with a 1 ppb Oven-Controlled Crystal Oscillator (OCXO) for optimal wide-band phase noise and stability, which can be blended further with an external frequency reference and GPS disciplining to synchronize Moku with your lab and UTC.

The VCXO and OCXO will always be used for the clock generation signal. The external and 1 pps references are optional and can be enabled or disabled in the “Clock blending configuration...” settings from the main menu . The loop bands are adjusted based on the different possible clock source configurations, shown in [Figure 37](#), where the frequencies of the bands represent where each oscillator's phase noise dominates.

Read [how the clock blending works on Moku:Delta](#) for more details.



Figure 37. Moku clock blending configuration dialog with an external 10 MHz frequency reference and GNSS enabled.

- ① **VCXO jitter reference** is always used for clock generation, handling high frequency jitter with the lowest noise.
- ② **OCXO jitter reference** is always used for clock generation, ensuring moderate term stability.
- ③ **External 10/100 MHz frequency reference** uses a "10 MHz" or "100 MHz" external reference to correct drift in the local oscillator, noting your Moku will have to be restarted after each change between a 10 MHz and 100 MHz source.
- ④ **1 pps synchronization reference** uses an "External" or "GNSS" reference to sync with UTC and correct drift in the local oscillator. The estimated clock stability is a measure of how much the reference performance deviates relative to the local OCXO/VCXO timebase (as currently blended and, if enabled, steered by the external 10 / 100 MHz External reference).



Tips and tricks

These tips and tricks are designed to help you upgrade your workflow to get the most of your Moku.

- Double click on any white space on the graph to auto scale all channels.
- Click and drag the "T" teardrop icon on the right to quickly adjust the trigger level.
- Double click any axis to quickly center the signal, this will move the axis zero tick in the middle of the graph view.
- Adjust your parameters whichever way is preferable; click, drag, scroll, arrows, numeric input to adjust parameters for quick and easy adjustments.
- To use the Oscilloscope in instruments like the PID Controller and Laser Lock Box, select the relevant probe point by clicking on any  point in your system as if you were probing your system in real life, then set the signal parameters and measurements in the same way as in the Oscilloscope.
- A lot of the elements of the Oscilloscope are the same in the embedded Oscilloscope found in instruments like the PID Controller, Lock-in Amplifier, etc. Set the signal parameters and measurements in the same way as you do in the Oscilloscope.
- To get to the maximum sampling rate, zoom all the way in on the signal or use the smallest span available.