Oscilloscope / Voltmeter

Moku:Go User Manual

Moku:Go's Oscilloscope instrument can be used to observe, analyze, measure, and record signals over time on 2 channels, with an analogue bandwidth of 30 MHz and sampling to 125 MSa/s.

Oscilloscopes are the most essential item of test equipment in any electronics lab. Moku:Go's user interface makes control and setup of the oscilloscope very efficient.

Additionally, there are a wide range of measurements available together with a computed math channel.

LIQUID INSTRUMENTS

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Ensure Moku:Go is fully updated. For the latest information:

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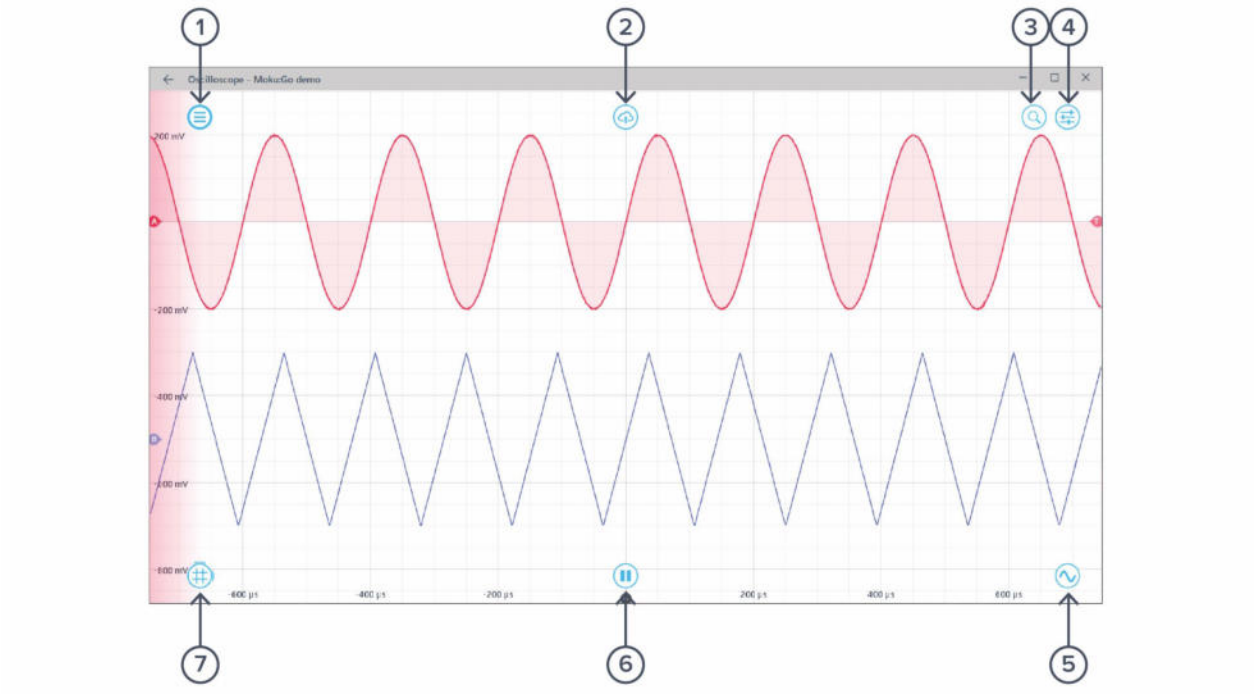
User Interface



ID	Description	ID	Description
1	Main menu	5	Waveform generator
2	Save data	6	Play/Pause
3	Signal display navigation	7	Cursors
4	Settings		

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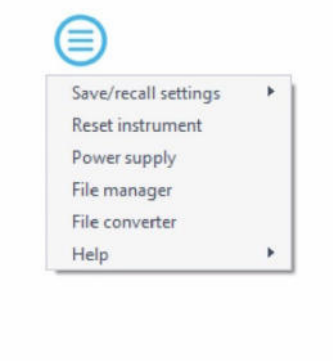
Main Menu

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



This menu provides the following options:

Options	Shortcuts	Description
Save/recall settings:		
• **Save instrument state**	Ctrl+S	Save the current instrument settings.
• **Load instrument state**	Ctrl+O	Load last saved instrument settings.
• **Show current sate**		Show the current instrument settings.
Reset instrument	Ctrl+R	Reset the instrument to its default state.
Power supply		Access power supply control window.*
File manager		Open file manager tool.**
File converter		Open file converter tool.**
Help		
• **Liquid Instruments website**		Access Liquid Instruments website.
• **Shortcuts list**	Ctrl+H	Show Moku:Go app shortcuts list.
• **Manual**	F1	Access instrument manual.
• **Report an issue**		Report bug to Liquid Instruments.
• **About**		Show app version, check update, or license information.

* Power supply is available on Moku:Go M1 and M2 models. Detailed information about the power supply can be found in Moku:Go power supply manual.

**Detailed information about the file manager and file converter can be found at the end of this user manual.

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Signal Display Navigation

Signal display position

The displayed siganl can be moved around the screen by clicking anywhere on the signal display window and dragging to a new position. The cursor will turn into a icon once clicked, drag horizontally to shift along the time axis and drag vertically to shift along the voltage axis.

The signal display can also be moved hotizontally and vertically with arrow keys.

Display scale and zoom

Scrolling the mouse wheel zooms in and out along the primary axis. Access the scroll setting by hovering the cursor over the icon.

Icons	Description
	Assign the horizonal axis as the primary axis.
	Assign the vertical axis as the primary axis.
	Rubber band zoom: hold the primary mouse button to draw a region to zoom-in, release the button to execute.

Additional keyboard combinations are also available.

Actions	Description
Ctrl + Scroll Wheel	Zoom secondary axis.
+/-	Zoom primary axis with keyboard.
Ctrl +/-	Zoom secondary axis with keyboard.
Shift + Scroll Wheel	Zoom primary axis towards the center.
Ctrl + Shift + Scroll Wheel	Zoom secondary axis towards the center.
R	Rubber band zoom.

Auto scale

Double click anywhere on the signal display window to auto scale the traces.

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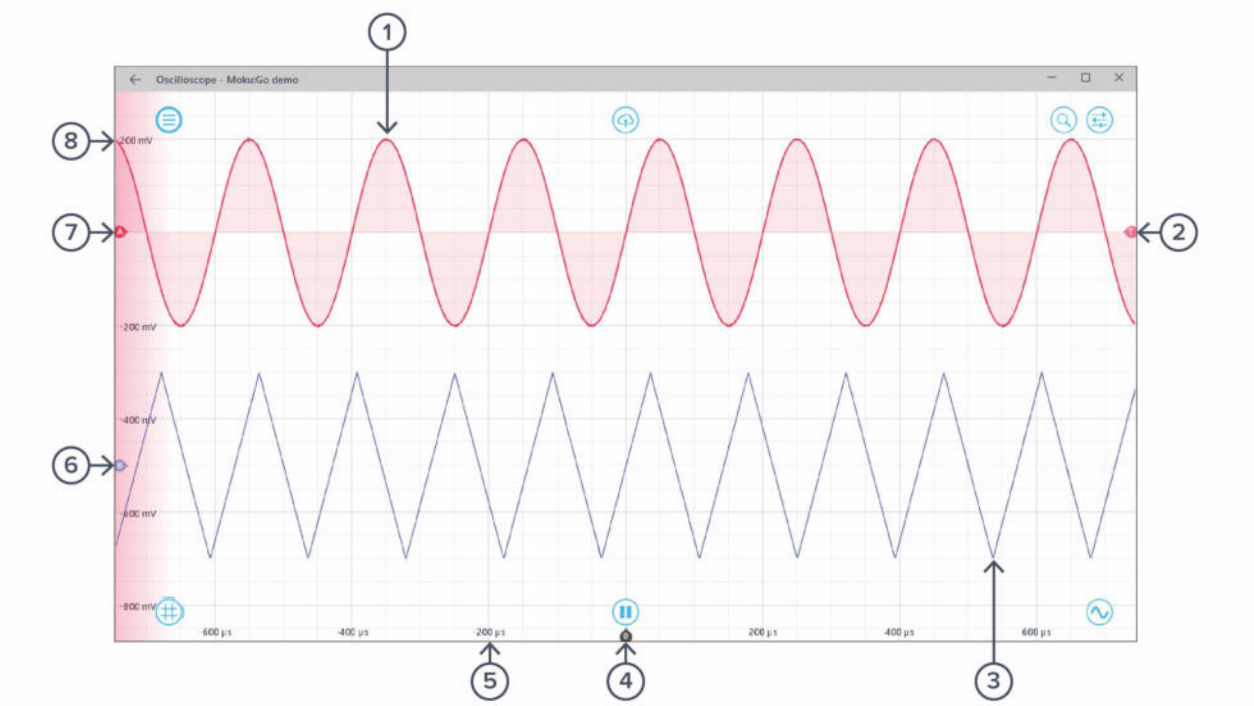
Axes and Traces



ID	Button	Description
1	Channel A Trace	The time/voltage trace for channel A. When channel A is active, the trace will have a light red fill to the zero-volt level (as shown).
2	Trigger Level Mark	Marks the trigger threshold level. Shown against whichever trace is currently set for triggering (if either).
3	Channel B Trace	The time/voltage trace for channel B. When channel B is active, the trace will have a light blue fill to the zero-volt level (not shown above).
4	Time Origin Mark	Marks the “zero second” point on the time scale. This will be the trigger point if the Oscilloscope has triggered, otherwise is undefined.
5	Time Axis	Shows the time scale for both channels (the channels always share the same time scale).
6	Channel B Origin Mark	Marks the “zero volt” level for channel B.
7	Channel A Origin Mark	Marks the “zero volt” level for channel A.
8	Voltage Axis	Shows the voltage scale for the active channel. The active channel is selected by tapping on the waveform and is indicated by the shading of the voltage axis and the trace itself.

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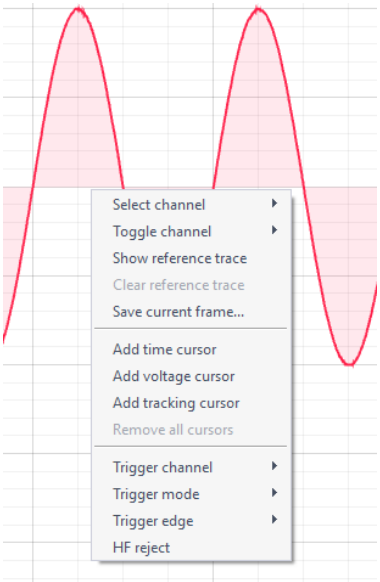
Right-click (secondary click) in the signal display area reveals additional option for the active channel. You can switch active channel, toggle on and off channels, add or remove reference trace, or save the current frame on the display via this menu. Options regarding to cursors and triggers are covered in detail in later sections.



Options	Description
Select channel	Select the active channel.
Toggle channel	Turn a channel on/off.
Show reference trace	Display the current frame as reference trace.
Clear reference trace	Clear the current reference trace.
Save current frame	Open the export data window.

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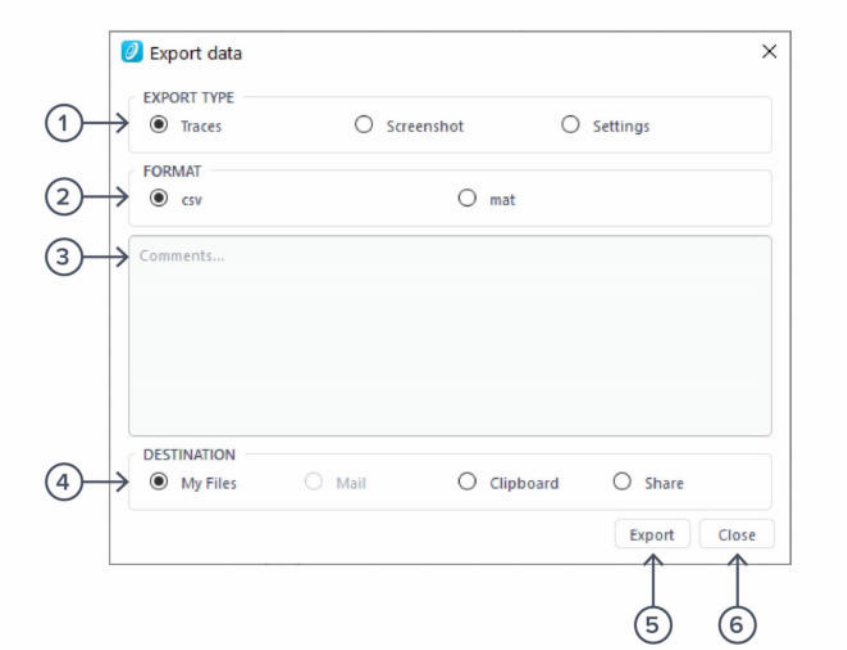
Export data

The **export data** options can be accessed by clicking the icon, allowing you to:



ID	Description
1	Select the type of data to export.
2	Select the exporting format (CSV or MAT).
3	Enter additional comments for the saved file.
4	Select the exporting location on your local computer.
5	Click to execute data export.
6	Click to close the export data window.

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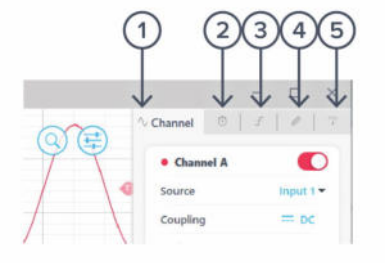
Settings

The **controls** options can be accessed by clicking the icon, allowing you to reveal or hide the control drawer, giving you access to all instrument settings. The controls drawer contains channels, timebase, trigger, measurement, and voltmeter settings.



ID	Description
1	Channel
2	Timebase
3	Trigger
4	Measurement
5	Voltmeter

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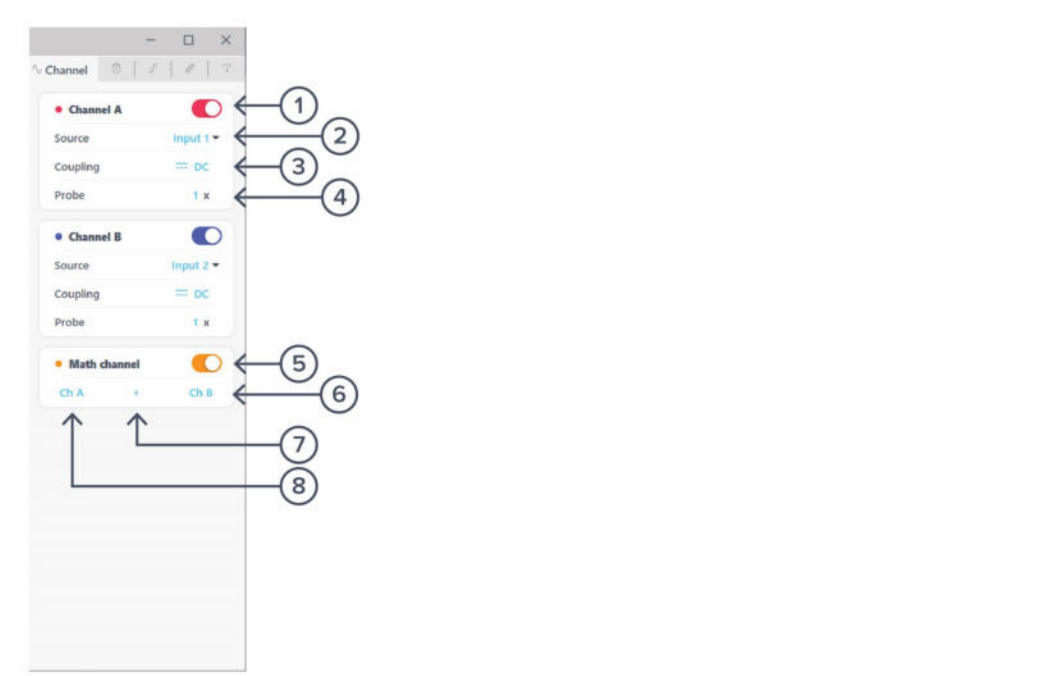
Channels

The **channels** pane allows you to change the input settings for each ADC channel, adjust the input scales and coupling, and enable/disable the math channel.



ID	Button	Description
1	Channel A	Toggles channel A on/off.
2	Channel A source	Changes data source for channel A. The default is to view data from input 1, but channel A may also view input 2, output 1 or output 2.
3	Coupling	Toggles between DC/AC coupling.
4	Probe	Specifies the probe attenuation, if such an attenuating probe is connected.
5	Math	Toggles math channel on/off.
6	Math channel source 2	Second channel in Math channel calculation. It is not available for certain operations, such as FFT.
7	Math operations	Detailed explanation about the math operations can be found in the *Instrument Reference – Math Operation* section.
8	Math channel source 1	First channel in Math channel calculation.

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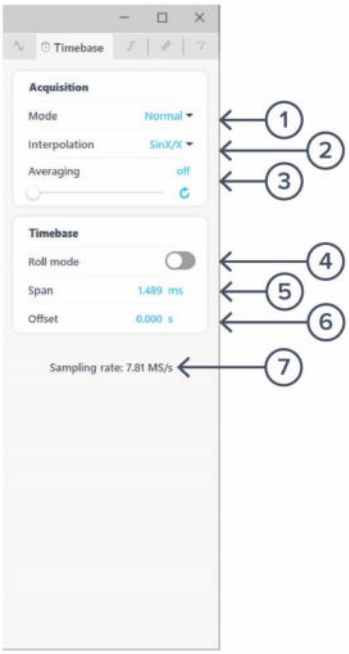
Timebase



ID	Button	Description
1	Acquisition mode	Changes acquisition mode between normal and precision. Detailed information can be found in the *Instrument Reference* - *Acquisition Modes and Sampling* section.
2	Interpolation mode	Change the interpolation mode. Detailed information can be found in the *Instrument Reference* – *Interpolation Mode* section.
3	Averaging	Displays on screen an average trace taken from this many consecutive frames. Click the icon to reset.
4	Roll-mode Toggle	Toggles between roll and sweep modes. See Display Options section.
5	Span	Horizontal screen scale. Changes dynamically when zoom in and out along the horizontal axis.
6	Offset	Horizontal trigger point offset. Changes dynamically when drag along the horizontal axis.
7	Sampling rate	Instant sampling rate at the current timebase setting. Channels dynamically when the span changes.

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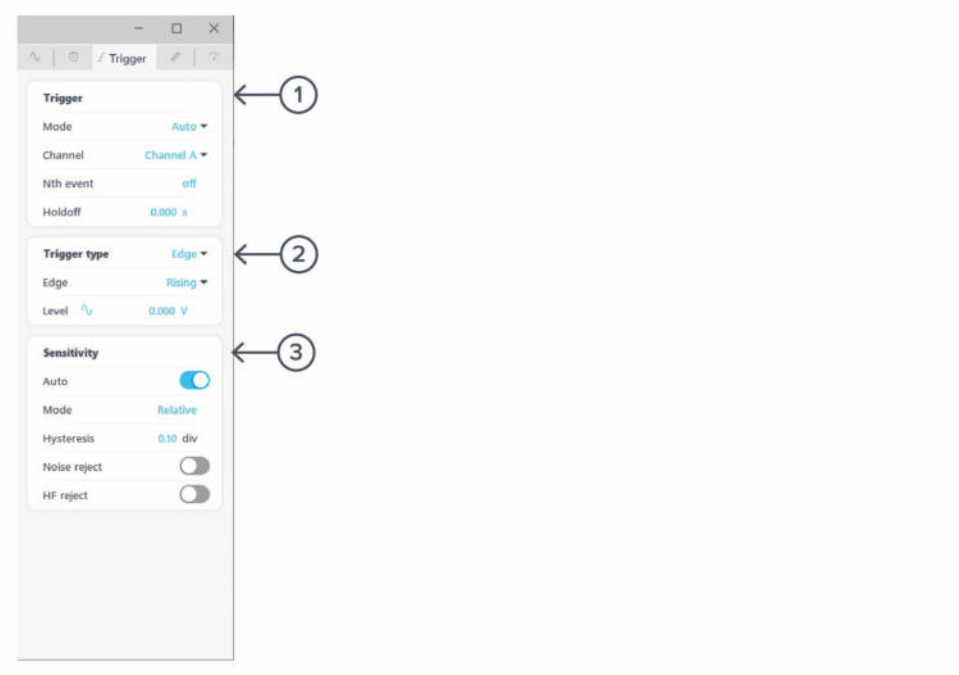
Trigger



ID	Button	Description
1	Trigger Settings Pane	**Mode:** Switches between auto, normal and single trigger modes. See Navigating your Signal section. **Channel:** Select the source for the trigger circuit. This can be one of the Oscilloscope channels, Moku:Go inputs, Moku:Go outputs. **Nth event:** Select up to 65,535 trigger events before actually triggering the Oscilloscope. **Holdoff:** Select a time to holdoff Oscilloscope trigger post trigger event.
2	Tigger type	Select between edge and pulse triggering with selectable levels, edge types and pulse widths. Click ∿ to zero the trigger level.
3	Sensitivity	Configure auto or manual hysteresis for noise rejection. Configure HF reject to enable a low pass filter on the trigger circuit, giving better noise immunity but with a short delay between the trigger event and detection.

Additional information about the trigger type, trigger sensitivity can be found in the Navigating your Signal section.

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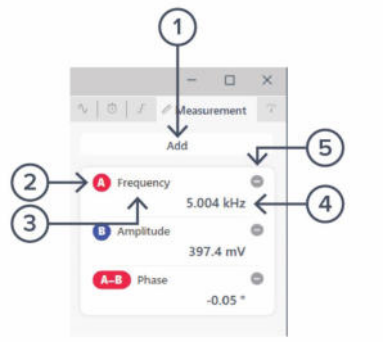
Measurement

The measurement pane allows you to add/remove measurements to measure frequency, amplitude, or other properties of a channel. A measurement can be assigned to a specific input channel, math channel, or difference between any two channels.



ID	Description
1	Click to add additional measurement tile.
2	Measurement source channel. Click to loop through the channels.
3	Measurement type.
4	Measurement value.
5	Click to remove the measurement tile.

Click a measurement tile to open the menu to adjust the measurement. The following options are available:

Options	Description
Type	Select the measurement type. Detailed explanation about the measurements can be found in Making Measurements section.
Channels	Select measurement source.
Difference Channels	Measure the difference between the measurement source to another channel.
Remove	Remove the measurement tile.

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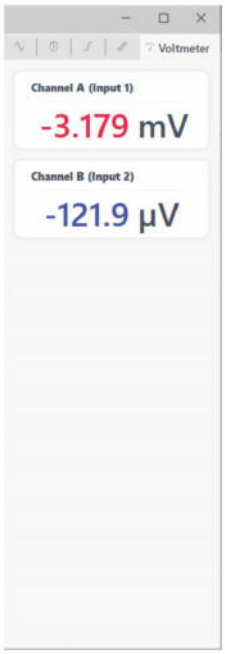
Voltmeter

The voltmeter tiles constantly read the voltage level from input 1 and 2, and display them under this pane.



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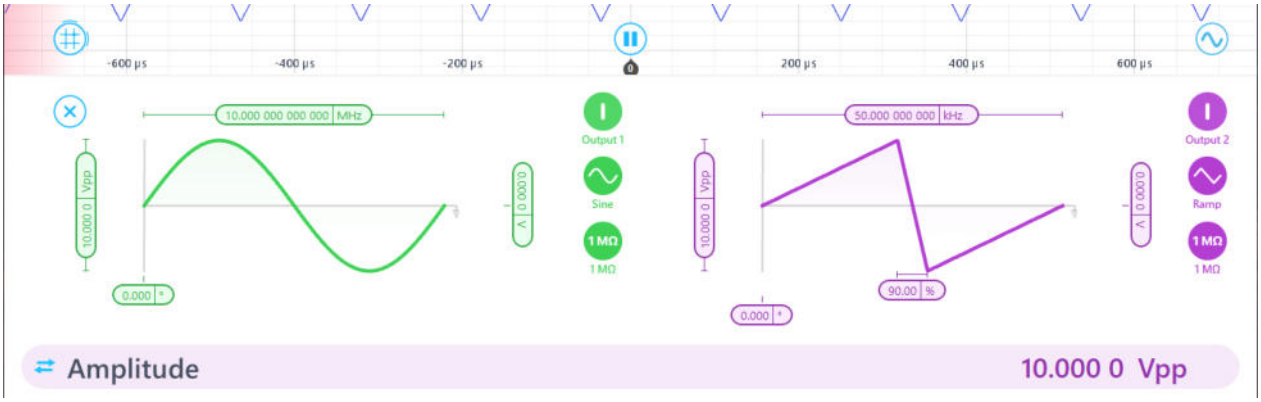
Waveform generator

Moku:Go's Oscilloscope has a built-in waveform generator capable of generating basic waveforms on the two output channels. Detailed instructions for the waveform generator instrument can be found in Moku:Go waveform generator manual.



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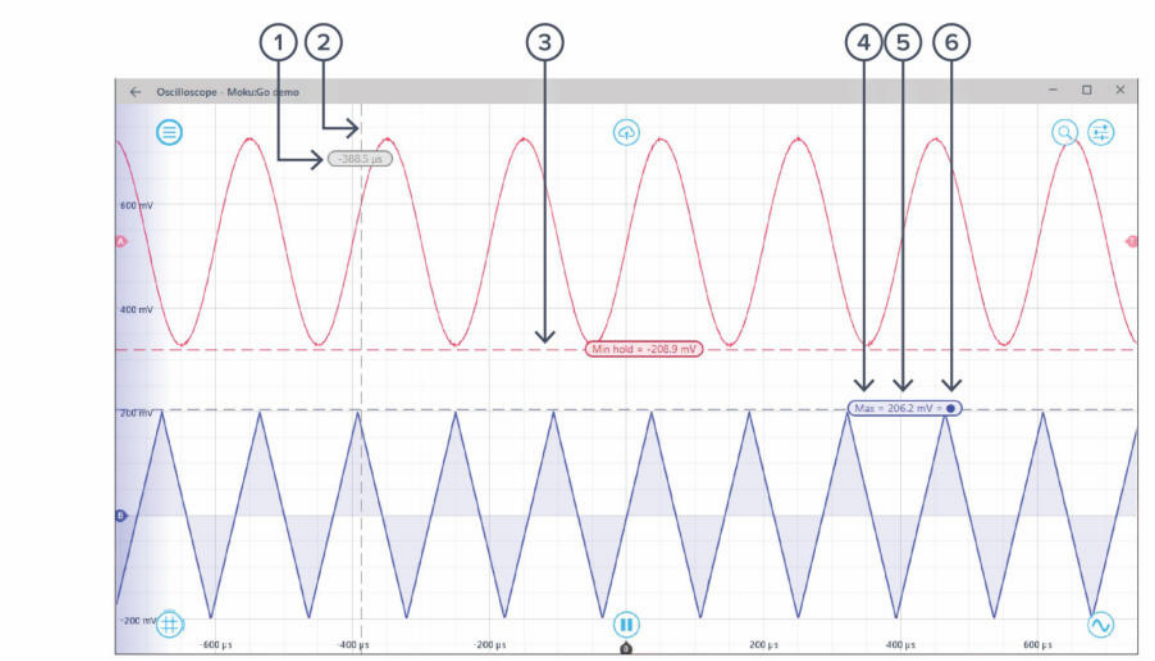
Cursor

The **cursors** can be accessed by clicking the on, allowing you to add voltage or time cursors, or remove all cursors. In addition, you can click and hold the cursors icon, and drag horizontally to add a time cursor, or vertically to add a voltage cursor.

User Interface



ID	Parameter	Description
1	Time reading	Right-click (secondary click) to reveal time cursor options. Drag left or right to set positions.
2	Time cursor	Color represents the channel of the measurement (Gray – Unattached, Red – channel 1, Blue – channel 2).
3	Voltage cursor	Drag up or down to set positions.
4	Cursor function	Indicates the current cursor function (max, min, max hold, etc).
5	Voltage reading	Right-click (secondary click) to reveal voltage cursor options.
6	Reference indicator	Indicates the cursor is set as reference. All other cursors in the same domain and channel measure the offset to the reference cursor.

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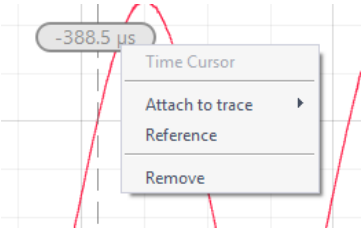
Time Cursor

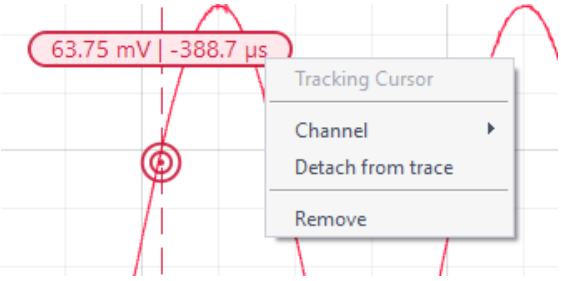
Right-click (secondary click) to reveal time cursor options:



Options	Description
Time Cursor	Cursor type.
Attach to trace	Choose to attach the time cursor to input 1, input 2. Once the cursor is attached to a channel, it becomes to a tracking cursor. The tracking cursor gives continuous voltage reading at the set time position.
Reference	Set the cursor as the reference cursor.
Remove	Remove the time cursor

Tracking Cursor

Right-click (secondary click) to reveal tracking cursor options:



Options	Description
Tracking Cursor	Cursor type.
Channel	Assign the tracking cursor to a specific channel.
Detach from trace	Detach the tracking cursor to a time cursor.
Remove	Remove the time cursor

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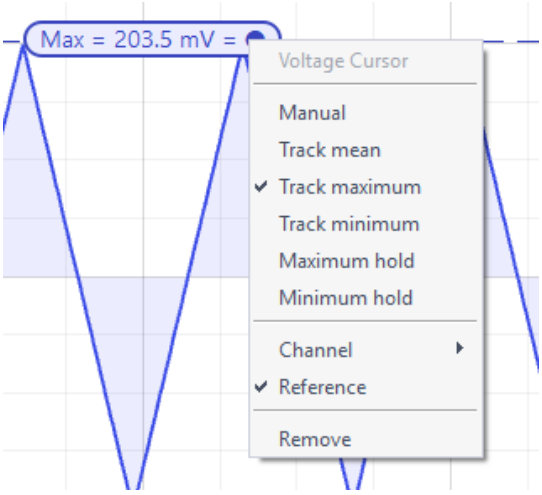
Voltage Cursor

Right-click (secondary click) to reveal voltage cursor options:



Options	Description
Voltage Cursor	Cursor type.
Manual	Manually set the vertical position of the cursor.
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 at the maximum voltage level.
Minimum hold	Set the cursor to hold at minimum voltage level.
Channel	Assign the voltage cursor to a specific channel.
Reference	Set the cursor as the reference cursor.
Remove	Remove the voltage cursor.

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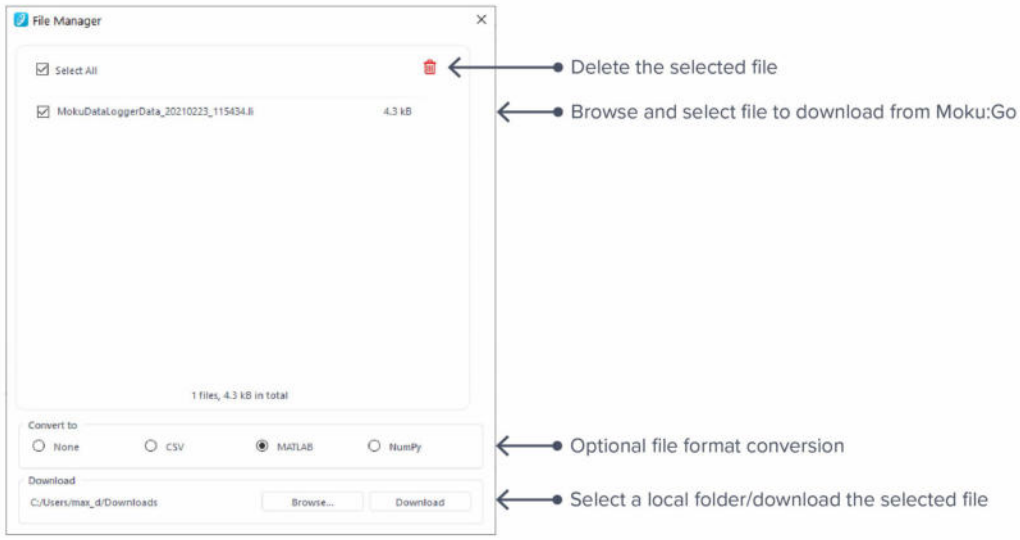
Additional Tools

Moku:Go app has two built-in file management tools: file manager and file converter. The file manager allows user to download the saved data from Moku:Go to local computer, with optional file format conversion. The file converter converts the Moku:Go's binary (.li) format on the local computer to either .csv, .mat, or .npy format.

File Manager



Once a file is transferred to the local computer, a icon shows up next to the file.

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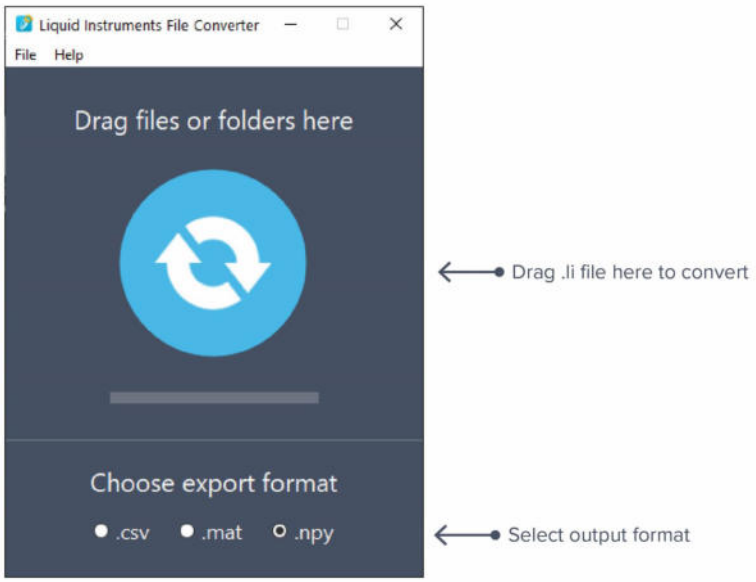
File Converter



The converted file is saved in the same folder as the original file.

Liquid Instruments File Converter has the following menu options:

Options	Shortcut	Description
File		
• **Open file**	Ctrl+O	Select a .li file to convert
• **Open folder**	Ctrl+Shift+O	Select a folder to convert
• **Exit**		Close the file converter window
Help		
• **Liquid Instruments website**		Access Liquid Instruments website
• **Report an issue**		Report bug to Liquid Instruments
• **About**		Show app version, check update, or license information

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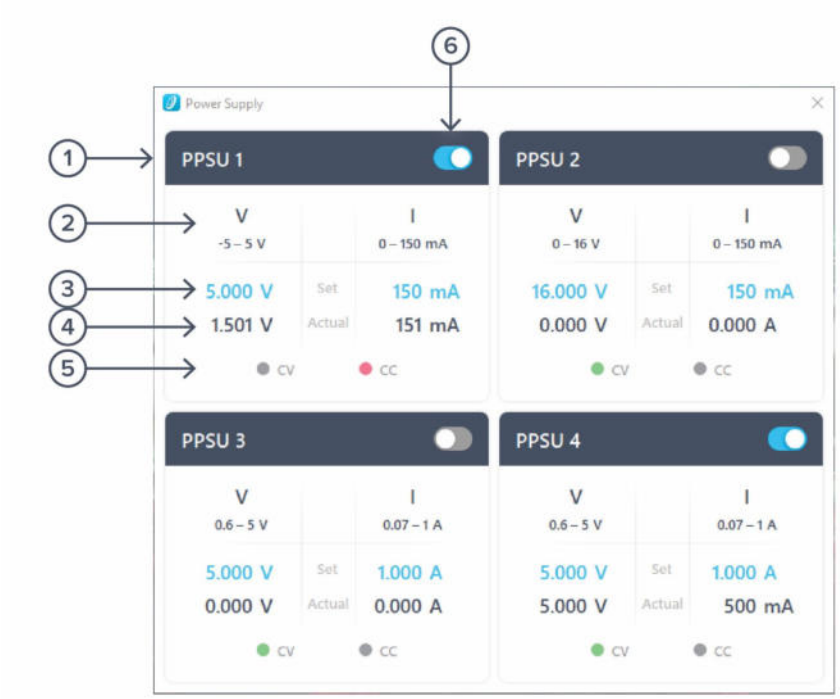
Power Supply

Moku:Go Power supply is available on M1 and M2 models. M1 features a 2-channel power supply, while M2 features a 4-channel power supply. The power supply control window can be accessed in all instruments under the main menu.

The power supply operates in two modes: **constant voltage (CV)** or **constant current (CC)** mode. For each channel, the user can set a current and voltage limit for the output. Once a load is connected, the power supply operates either at the set current or set voltage, whichever comes first. If the power supply is voltage limited, it operates in the CV mode. If the power supply is current limited, it operates in the CC mode.



ID	Function	Description
1	Channel name	Identifies the power supply being controlled.
2	Channel range	Indicates the voltage/current range of the channel.
3	Set value	Click the blue numbers to set the voltage and current limit.
4	Readback numbers	Voltage and current readback from the power supply, the actual voltage and current being supplied to the external load.
5	Mode indicator	Indicates if the power supply is in CV (green) or CC (red) mode.
6	On/Off Toggle	Click to turn the power supply on and off.

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Instrument Reference

Configuring Inputs

Coupling

Moku:Go includes a switchable AC/DC coupling circuit on each input. This is activated from the channels tab.

For most applications, DC-coupled is the preferred option; this does not filter or modify the signal in any way.

AC-coupled acts as a high pass filter, removing the DC component of the incoming signal (and attenuating other components with a frequency below the coupling corner). This is useful when you're looking for a small signal on top of a large DC offset. Doing so can give better precision than simply scrolling the trace up the screen, as it may avoid Moku:Go activating its internal attenuator (see Gain Ranges).

Navigating your Signal

Trace Selection

Moku:Go's Oscilloscope can display up to two signal traces, plus a math trace. Each signal trace may either be the analogue input (default) or a preview of the analogue output if the waveform generator is active.

To turn a trace on and off, click the slider next to the corresponding trace on the channels tab.

To change the source of a channel, click the Source dropdown box of the channel, then select between the input channels and output channels.

Triggering

The triggering circuit of the Oscilloscope allows you to indicate what kind of signal event you're interested in. This event will then be aligned to the "zero second" mark of the time axis. Common events that can be triggered are simply times when the signal rises or falls past a particular voltage, these are "rising edge" and "falling edge" triggers respectively. The particular voltage which the signal must past is called the "trigger level".

Data to be displayed before the trigger point (negative values on the time axis) is called "pre-trigger" data and data after, "post-trigger" data. Moku:Go's Oscilloscope can record and display a maximum of 16,384 points of pre-trigger data but as many as 2^{32} points of post-trigger. In practice, this limits the distance that you may scroll to the left and right.

In the Oscilloscope, the trigger level is set from the trigger tab, or by dragging the trigger marker on the screen. Other trigger parameters such as the event to be triggered upon and the channel to be monitored are also on this tab.

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Trigger Modes

Trigger modes describe how the Oscilloscope responds to several trigger events. The options are “Auto”, “Normal”, and “Single” triggering.

“Normal” trigger mode will only trigger, and therefore update the display, when a trigger event is detected. This is very useful if you 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 generate a fake event, causing the display to update. The delay from a real trigger to a fake one is longer than that between fake events, so the signal can be viewed in real-time without triggers while still giving time to view events around a trigger if one does arrive.

“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.

Trigger Filtering

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:Go’s Oscilloscope has two features to help reliably trigger on noisy data: noise reject and high-frequency (HF) reject.

Noise reject adds a small amount of hysteresis to the trigger event. This stops the trigger firing several times as noise repeatedly crosses the trigger threshold; the rising and falling events happen at different levels.

High-frequency (HF) reject passes the trigger signal through a low pass filter before looking for the trigger event. This smooths out the 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.

Screen Update Modes

As you zoom out, you will come to a point where the displayed time span is longer than the time between screen updates. In this case, the Oscilloscope will enter one of two update modes: sweep or roll.

Sweep Mode

Sweep mode is the default if roll is not active. In sweep mode, the screen will only update once a trigger event is received. At this time, all the currently-captured data (all the data before the trigger point) will be updated on the screen at once. New data will be shown on the screen as it arrives, with the new data progressively “sweeping” across the screen.

This mode is useful when you still require trigger events despite the low data rate.

Roll Mode

If roll mode is active, trigger events are completely ignored. Instead, all new data is displayed on the screen in real time with the most recent data on the right of screen. This causes the trace to roll from right to left continuously.

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Use this mode if you want to view all your data in real time and no longer care about aligning the data by trigger.

Making Measurements

Automatic Measurements

The Oscilloscope can automatically make a number of measurements on your data in real time. Automatic measurements can be accessed in the measurement tab. Add a new measurement by clicking the “Add” button, you can change a measurement by clicking on the measurement tile. The available measurements are described below.

Name (unit)	Description
Frequency (Hz)	Frequency of the signal as determined by the time between rising or falling edges.
Phase	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
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

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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
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

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Acquisition Modes and Sampling

The Oscilloscope processes data in two stages. First, data is acquired from the analogue-to-digital converters (ADCs), down-sampled, and stored in memory. From there, the data is aligned relative to the trigger point and displayed on the screen.

Both of these operations require down- or up-sampling of the data (reducing or increasing the total number of data points) and the method for doing this can provide increased precision and different aliasing behavior.

Acquisition Modes

The acquisition mode refers to the process of capturing the data and storing it in Moku:Go's internal memory. This is always down-sampled.

Normal Mode: Extra data is simply removed from the memory (direct down-sampled). For example, the ADC is running at 125 MSPS and the selected time span on the Moku:Go's Oscilloscope requires 1 MSPS, then 124 out of 125 points will be ignored.

This can cause 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.

Precision Mode: Extra data is averaged to the memory (decimation). For example, if the ADC is running at 125 MSa/s and the selected time span on the Oscilloscope requires 1 MSa/s, then 125 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 no signal is present.

A common workflow would be 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.

Interpolation Modes

Once the data is in the memory, it needs to be displayed on the screen. This may be down-sampling or up-sampling, depending on zoom level. Down-sampling is done by Cubic Spline Interpolation and cannot be configured by the user. Up-sampling mode can be selected and is one of Linear, Sin X/X or Gaussian.

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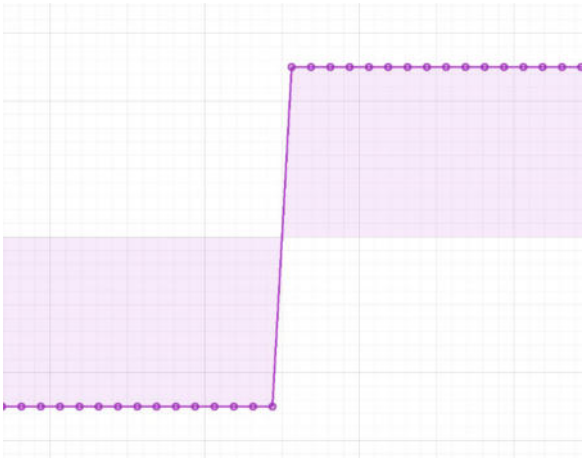
Linear



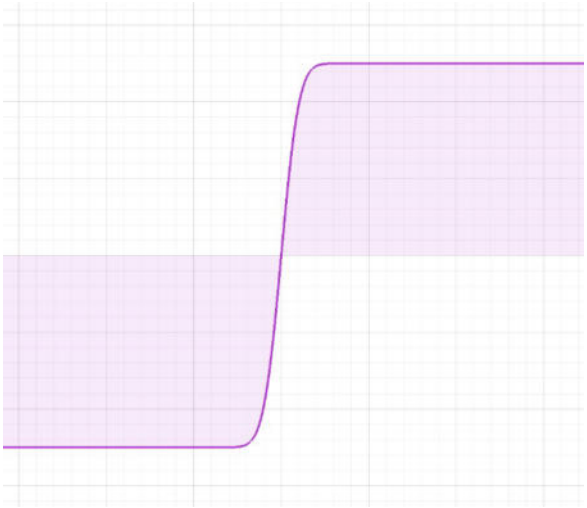
Linear interpolation does not perform any up-sampling. For display, it marks each point in the original data set and draws a straight line between them. This is “ugly” but doesn’t “invent” any new data points.

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 does not include significant frequency components that have been removed by filtering or decimation.

Gaussian



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.

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Display Options

When displaying data on the screen, the Oscilloscope can provide waveform averaging to reduce noise and persistence to catch brief events. Averaging and persistence are not exported for either channel or high-res data, see Saving and Sharing Data.

Averaging

Drag the slider to average the given number of waveforms on the screen. If the signal is strictly repetitive then this can give you improved precision and noise performance. If not, this mode should not be used.

Persistence

Drag the slider to keep the given number of old waveforms on the screen, fading out. Dragging the slider all the way right will set infinite persistence, in which waveforms are never erased from the screen.

Persistence is useful for capturing events that would otherwise only be on the screen for one frame.

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Math Operations

The Oscilloscope can perform real time math operations on the incoming data and display it as a third channel. This math channel is different from the measurements above; measurements can be configured to be performed on the math channel rather than on a physical input channel.

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.
Integral	∫	Discrete time-integral (running sum) of the trace
Derivative	d/dt	Discrete time-derivative (pointwise difference) of the trace
FFT	FFT	Fast Fourier Transform of a trace, giving the frequency domain representation. This mode is complex and described in more detail below.
Min Hold	Min hold	Minimum hold
Max Hold	Max hold	Maximum hold
User entered function	f()	A user-defined math function

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FFT Function

The FFT math channel gives the user the frequency-domain representation of the input data. This can be useful for quickly checking parameters in that domain. In general, the user should switch to Moku:Go's Spectrum Analyzer instead, gaining access to advanced features that drastically improve the quality of the measurement.

Limitations of the FFT function of the Oscilloscope include:

- The FFT is subject to aliasing, depending on acquisition mode. Moku:Go's Spectrum Analyzer instrument has an advanced DSP anti-aliasing chain, minimizing the effect of unwanted signals.
- The FFT is not windowed. The Spectrum Analyzer provides a range of different windows for minimizing harmonics and spurs, improving amplitude accuracy, and so on.
- The FFT has a fixed frequency resolution set by the time span. The Spectrum Analyzer has a fully-configurable Resolution Bandwidth (RBW).
- The FFT has its span completely defined by the time span. The Spectrum Analyzer can have any span, providing much more detail around the signal of interest.

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Waveform Generator

Moku:Go User Manual

Moku:Go's Waveform Generator is designed to generate common signals with high accuracy and configurability across two independent output channels. The outputs are precisely adjustable for frequency, phase and amplitude. Further, the outputs may be modulated with a variety of internally generated or external signals and there are flexible, programmable triggers.

LIQUID INSTRUMENTS

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V21-0323

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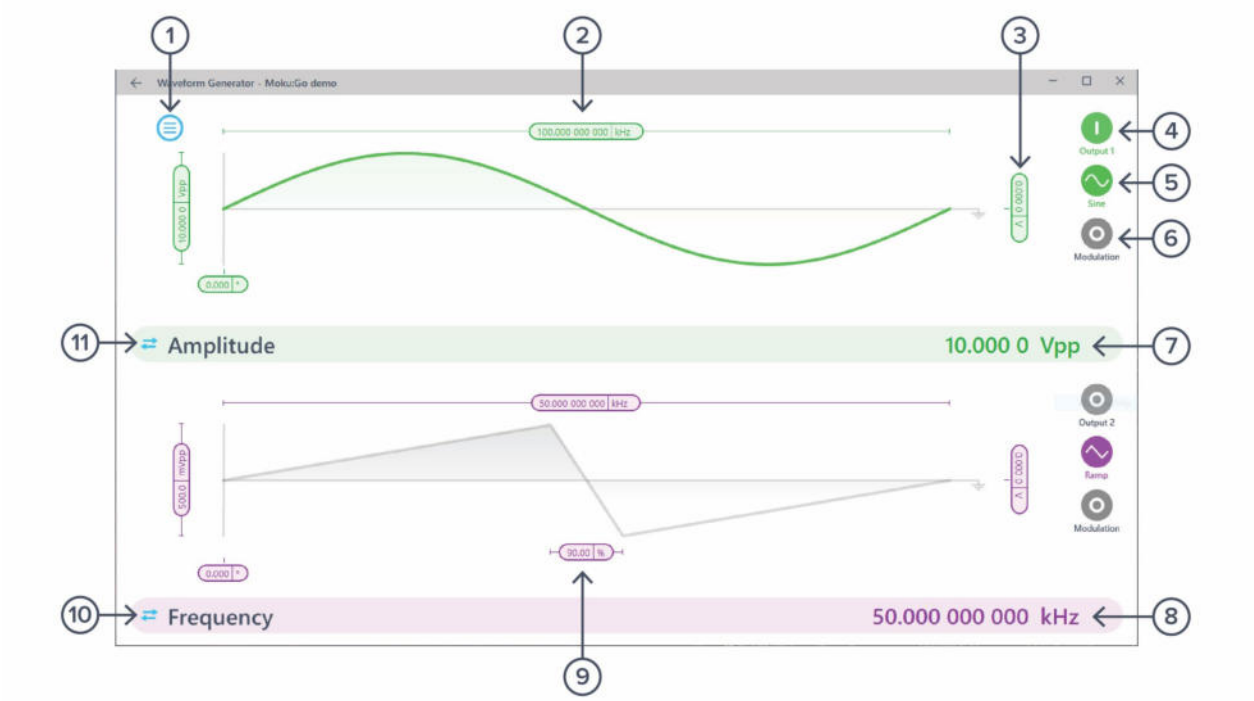
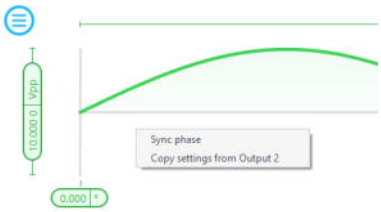
User Interface



ID	Description	ID	Description
1	Main menu	7	Configure displayed parameter (Out 1)
2	Configure frequency / period	8	Configure displayed parameter (Out 2)
3	Configure waveform offset	9	Configure ramp symmetry
4	Enable / disable output	10	Switch between frequency and period
5	Waveform shape	11	Switch between frequency and period
6	Configure modulation		

Sync phase with copy settings between channels can be accessed by right click (secondary click) menu on the main user interface. The settings on one output can be instantly applied to the other output with copy setting. And the phase between two channels can be aligned with sync phase.



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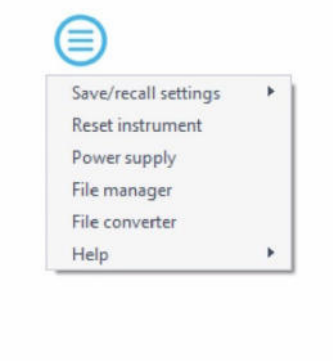
Main Menu

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



This menu provides the following options:

Options	Shortcuts	Description
Save/recall settings:		
• **Save instrument state**	Ctrl+S	Save the current instrument settings.
• **Load instrument state**	Ctrl+O	Load last saved instrument settings.
• **Show current sate**		Show the current instrument settings.
Reset instrument	Ctrl+R	Reset the instrument to itss default state.
Power supply		Access power supply control window.*
File manager		Open file manager tool.
File converter		Open file converter tool.
Help		
• **Liquid Instruments website**		Access Liquid Instruments website.
• **Shortcuts list**	Ctrl+H	Show Moku:Go app shortcuts list.
• **Manual**	F1	Access instrument manual.
• **Report an issue**		Report bug to Liquid Instruments.
• **About**		Show app version, check update, or license information.

* Power supply is available on Moku:Go M1 and M2 models. Detailed information about power supply can be found in Moku:Go power supply manual.

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Output Configuration

Enable / Disable Outputs

shows the output channel is disabled, click to enable

shows the output channel is enabled, click to disable

Note on impedance

Moku:Go's outputs have an impedance of 200 Ω. As such, voltages supplied to a 50 Ω load will be reduced and not recommended.

Waveform types

Each channel can be set to generate one of five predefined waveforms.

Each of Sine, Square and Ramp can be configured for Frequency, Amplitude, Offset and Phase.

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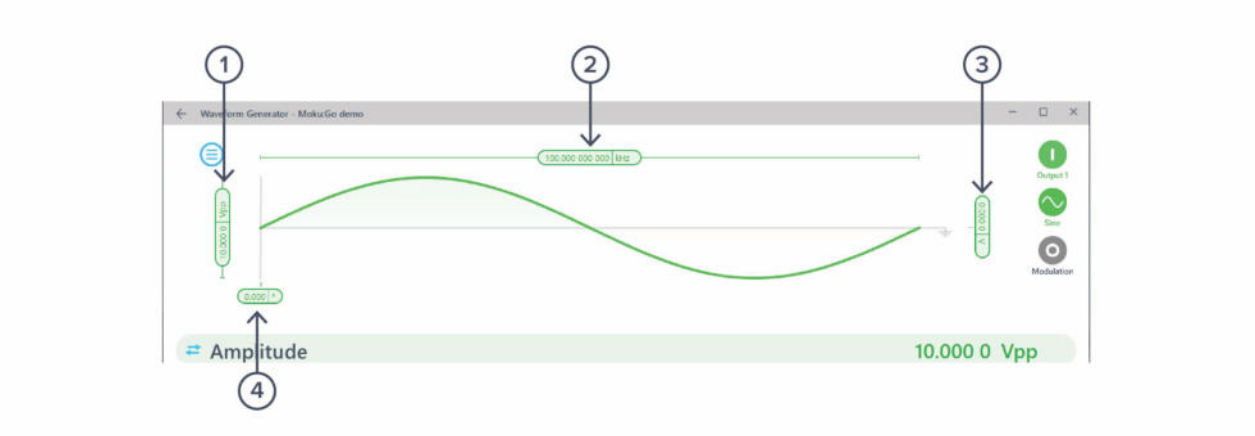
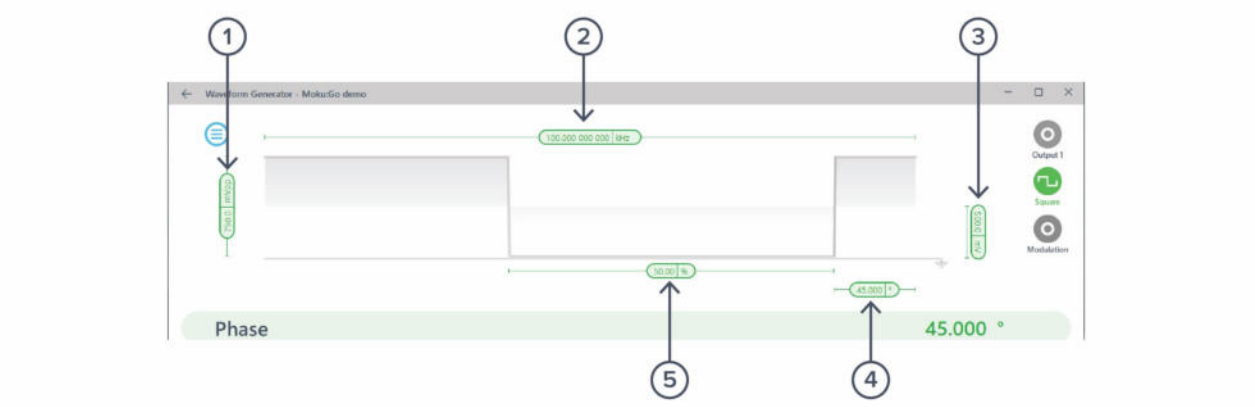
Sine Wave



ID	Description	ID	Description
1	Amplitude (High Level)	3	Offset (Low Level)
2	Signal Frequency (Period)	4	Phase

Click Parameter Settings pill or bar to change. Parameter bar can show different representations of many parameters; these alternative representations are shown in brackets.

Square Wave



ID	Description	ID	Description
1	Amplitude (High Level)	4	Phase
2	Signal Frequency (Period)	5	Duty Cycle*
3	Offset (Low Level)		

Click Parameter Settings pill or bar to change. Parameter bar can show different representations of many parameters; these alternative representations are shown in brackets.

*Above 2.5 MHz, the duty cycle range is limited between 32% to 68%.

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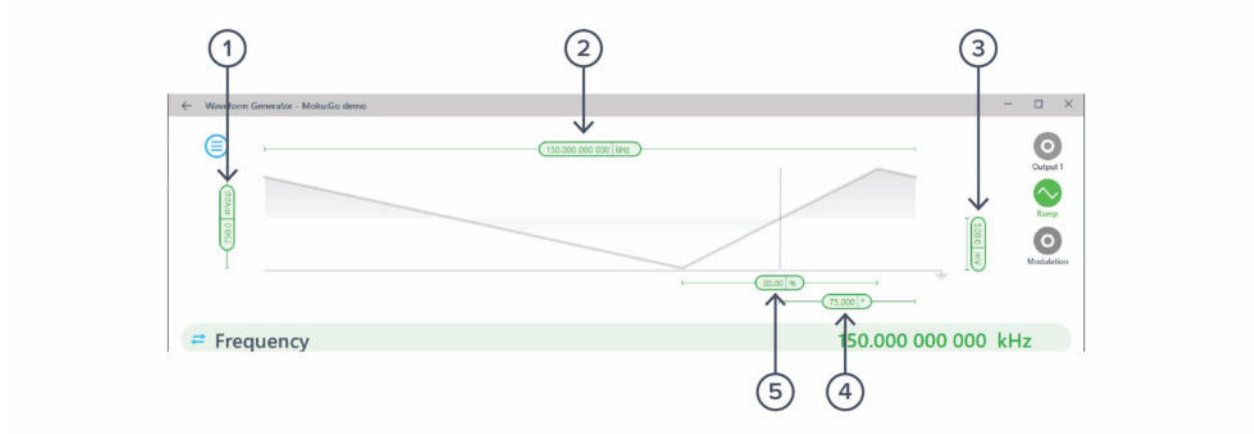
Ramp Wave



ID	Description	ID	Description
1	Amplitude (High Level)	4	Phase
2	Signal Frequency (Period)	5	Symmetry
3	Offset (Low Level)		

Click Parameter Settings pill or bar to change. Parameter bar can show different representations of many parameters; these alternative representations are shown in brackets.

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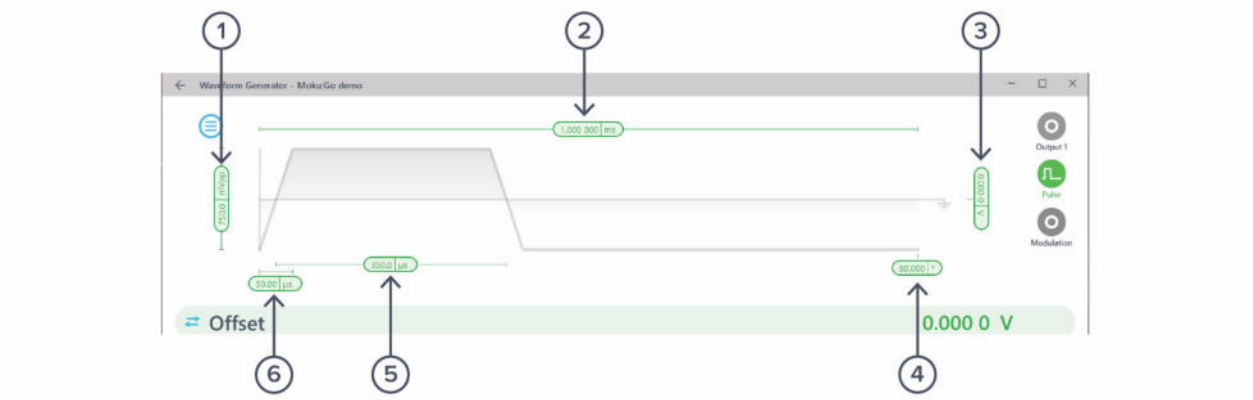
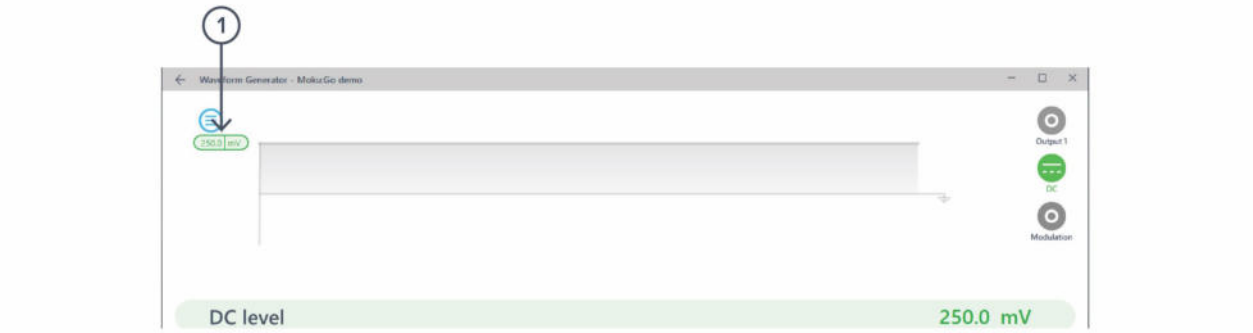
Pulse Wave



ID	Description	ID	Description
1	Amplitude (High Level)	4	Phase
2	Signal Frequency (Period)	5	Pulse Width
3	Offset (Low Level)	6	Edge time

Click Parameter Settings pill or bar to change. Parameter bar can show different representations of many parameters; these alternative representations are shown in brackets.

DC wave



ID	Description
1	DC level

Click Parameter Settings pill or bar to change the DC level.

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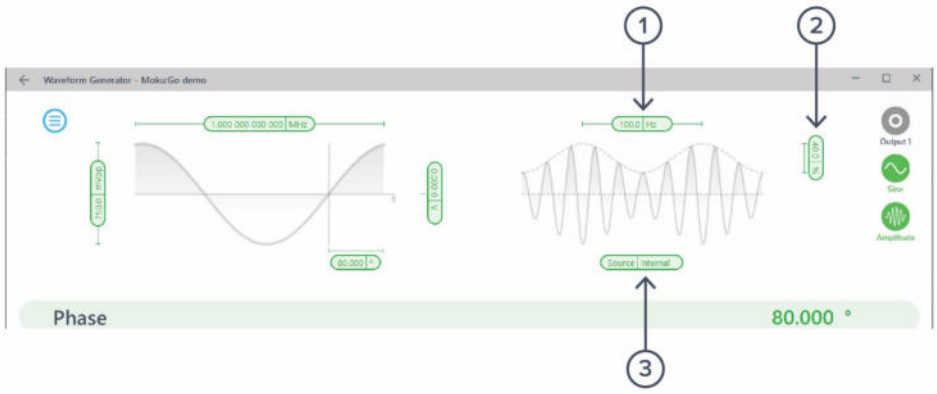
Modulation types

Moku's Waveform Generator supports a variety of modulations. Modulation is available on all waveforms except DC. Ramp waveforms can only be amplitude modulated; but all other waveforms can be Amplitude, Frequency or Phase modulated and can be continuous or triggered in burst or sweep modes.

Amplitude modulation



ID	Parameter	Description
1	Frequency	Only for "Internal" modulation; the frequency of the sine wave being used for modulation.
2	AM Depth	Fractional depth of modulation. 100% depth will reduce the signal amplitude to zero for a full-range negative modulation signal
3	Modulation Source	The modulation source can be a Moku input; the other Moku output or a "internal", an internally-generated sinewave.

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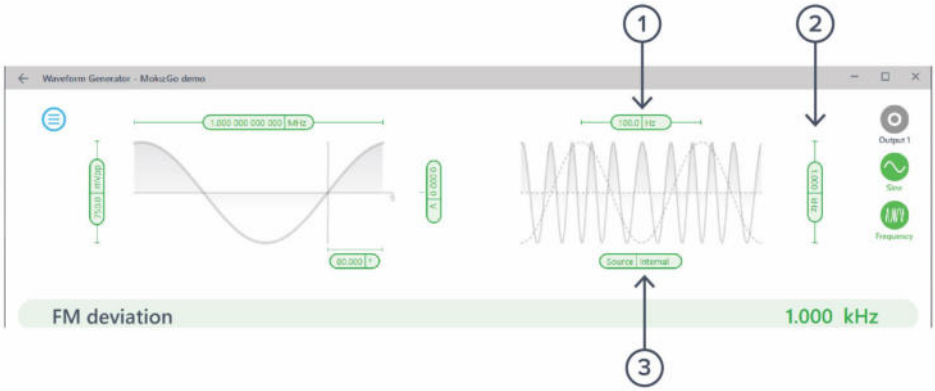
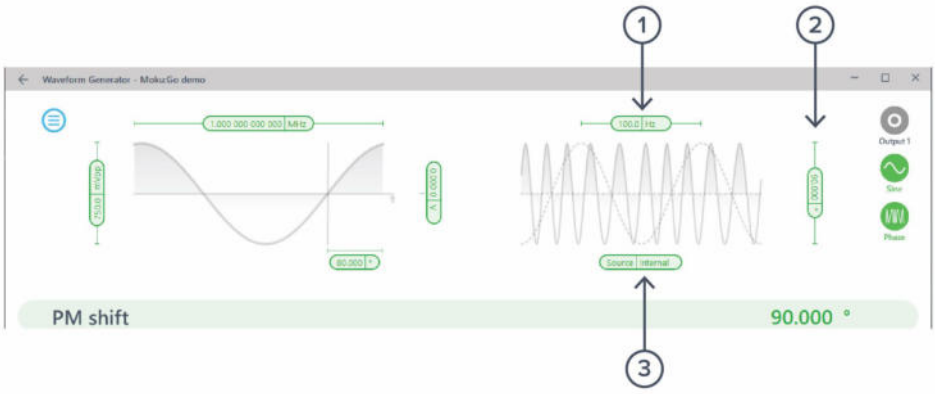
Frequency modulation



ID	Parameter	Description
1	Frequency	Only for “Internal” modulation; the frequency of the sine wave being used for modulation.
2	FM Deviation	Full-range frequency deviation. A full-range input signal will vary the output frequency by this amount.
3	Modulation Source	The modulation source can be a Moku input; the other Moku output or a “internal”, an internally-generated sinewave.

Phase modulation



ID	Parameter	Description
1	Frequency	Only for “Internal” modulation; the frequency of the sine wave being used for modulation.
2	Depth	Full-range phase deviation. A full-range input signal will vary the output phase by this amount.
3	Modulation Source	The modulation source can be a Moku input; the other Moku output or a “internal”, an internally-generated sinewave.

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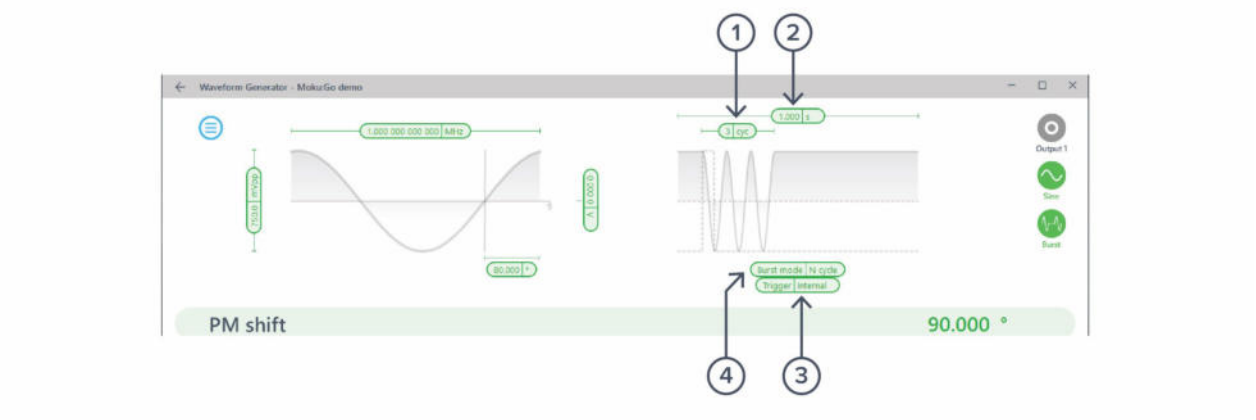
Triggered modulation modes

Sine, Square and Pulse waves can be triggered from an external source. The behaviour upon receipt of the trigger signal varies according to the trigger mode.

Burst



ID	Parameter	Description
1	Cycle count	N - Cycle mode only. The number of cycles to generate before re-arming.
2	Burst period	Total period of time for the burst.
3	Trigger source	One of: Internal: Trigger automatically at the defined rate External: Trigger event on from rear-panel external trigger input Input: Trigger from associated input channel, at given voltage Output: Trigger from opposite output channel, at given voltage
4	Mode	One of: Gated: Continue to generate the output signal while ever the trigger event is asserted (level-triggered) Start: Begin generation of the waveform on trigger, continue indefinitely. N Cycle: Upon receipt of trigger signal, generate this many cycles of the waveform then re-arm.

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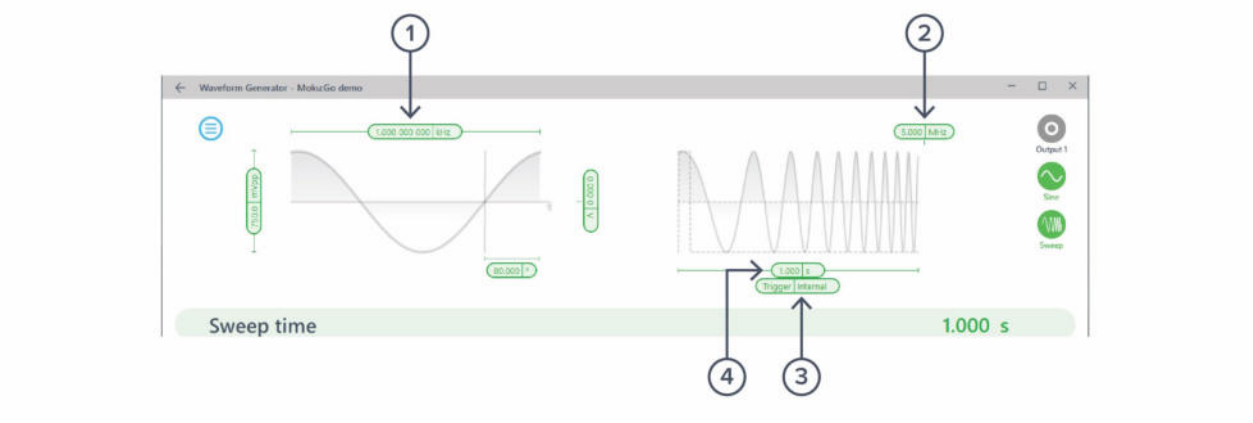
Sweep



Sweep modulation acts like frequency modulation with a sawtooth, where the sawtooth starts on the trigger event.

ID	Parameter	Description
1	Start Frequency	Waveform frequency at the trigger event (sweep start)
2	End Frequency	Waveform frequency at the sweep end
3	Trigger Source	One of: **Internal:** Trigger automatically at the defined rate **External:** Trigger event on from rear-panel external trigger input **Input:** Trigger from associated input channel, at given voltage **Output:** Trigger from opposite output channel, at given voltage
4	Sweep Time	Time between sweep start and end

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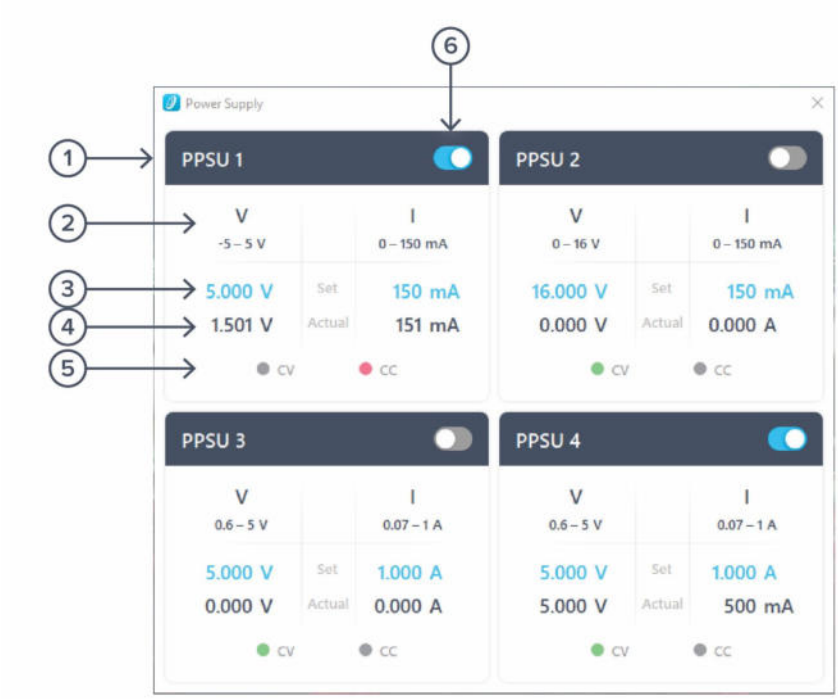
Power Supply

Moku:Go Power supply is available on M1 and M2 models. M1 features a 2-channel power supply, while M2 features a 4-channel power supply. The power supply control window can be accessed in all instruments under the main menu.

The power supply operates in two modes: **constant voltage (CV)** or **constant current (CC)** mode. For each channel, the user can set a current and voltage limit for the output. Once a load is connected, the power supply operates either at the set current or set voltage, whichever comes first. If the power supply is voltage limited, it operates in the CV mode. If the power supply is current limited, it operates in the CC mode.



ID	Function	Description
1	Channel name	Identifies the power supply being controlled.
2	Channel range	Indicates the voltage/current range of the channel.
3	Set value	Click the blue numbers to set the voltage and current limit.
4	Readback numbers	Voltage and current readback from the power supply, the actual voltage and current being supplied to the external load.
5	Mode indicator	Indicates if the power supply is in CV (green) or CC (red) mode.
6	On/Off Toggle	Click to turn the power supply on and off.

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Instrument Reference

Waveform Types

The Moku:Lab's waveform generator is programmed to generate one of five different signals, each with optional modulation.

Sine Wave

The Sine wave is the simplest dynamic signal in the Moku. It features extremely low harmonic distortion; it's very close to a pure single frequency.

The Sine wave can be modulated by all available modulation types. Moreover, it forms the basis of the "Internal" selectable modulation source, providing a modulating waveform regardless of whether either channel of the Moku is currently outputting a Sine wave.

Square Wave

The Square wave is a low-jitter waveform with a variable duty cycle and high slew rates. The high analogue bandwidth of the Moku gives very sharp rise and fall times, highly desirable in many applications. If you require slew-rate limits or variable duty cycle in your application, see Pulse Wave below.

Ramp Wave

The Ramp wave consists of linear ramps from low level to high and back again. The ratio between the time spent rising and the overall period is referred to as the symmetry. If you require configurable dwell times at the high or low levels but common rise and fall times, you may use the Pulse Wave with large edge times.

Pulse Wave

The Pulse wave is like the Square wave but has configurable edge times (rise and fall time). The trade-off is that at high frequency, Pulse has slightly worse edge jitter behaviour compared to the Square wave.

DC

Provides a high precision, fixed reference voltage at the output.

Waveform Parameters

Amplitude

Applicable To: Sine, Square, Ramp, Pulse

Amplitude is specified as a Peak-to-Peak value; that is, the high level minus the low level. If you wish to specify the high and low levels explicitly, tap the Amplitude pill then the Toggle Arrows in the parameter bar; or just tap the Amplitude label in the Settings Drawer to toggle between the two representations.

Frequency

Applicable To: Sine, Square, Ramp, Pulse

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Specified in Hertz. Can also be represented as period in seconds by tapping the Frequency label in the Settings Drawer, or the Toggle Arrows in the parameter bar.

Offset

Applicable To: Sine, Square, Ramp, Pulse

Average value of the Sine wave over time. The alternative representation of this parameter is Low Level, which combined with High Level also specifies Amplitude.

Phase

Applicable To: Sine, Square, Ramp, Pulse

Defines the phase of the waveform with respect to the Moku's internal reference. By tapping the "Sync Phase" button in the Settings Drawer, this phase also becomes relative to the other output channel.

Symmetry

Applicable To: Ramp

Ratio, in percent, between the time spent on the rising edge and the overall period. In the limit of 0% and 100% symmetry, the ramp wave becomes a sawtooth (zero[1] rise and fall times respectively).

Pulse Width

Applicable To: Pulse

Positive width of the pulse. Any specified Edge Time is split equally between the Pulse Width and the rest of the cycle; that is, duty cycle is preserved when altering Edge Time.

Edge Time

Applicable To: Pulse

Time taken to transition from low level to high and vice-versa. This limits the slew rate of the signal which can be advantageous in some applications. Edge Time is split between high and low time equally, preserving duty cycle.

Duty Cycle

Applicable To: Square

The percentage of one period that the signal is active, or non-zero. This is similar to pulse width except that the edge time is not factored into the duty cycle due to the fast rise and fall times.

DC Level

Applicable To: DC

Fixed voltage to output.

---

[1] The minimum rise and fall time of the Moku:Lab is actually 2ns not zero, which means in practice that the output can never achieve exactly 0% or 100% symmetry, even if specified.

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Modulation Types and Trigger Modes

Modulation Sources

Each modulation type can be driven by one of three sources.

Internal

Modulation is driven by an internally-generated sine wave of configurable frequency. The amplitude of this wave is “full range”, in that it will modulate to the depth specified when configuring the modulation type.

Input

Modulation for a given channel is driven by the corresponding analogue input (i.e. Output 1 can only be modulated from Input 1, Output 2 from Input 2). The depth is specified *per volt* on the input.

Output

Modulation for a given channel is driven by the opposite analogue output (i.e. Output 1 is modulated by the waveform on Output 2 and vice-versa). This allows the user to doubly-modulate a signal by modulating a signal on one channel, then using that signal to modulate the opposite channel. This can be useful for example when you wish to generate an “ideal” modulated signal on one channel, but then perturb the phase, frequency or amplitude in order to test a system’s response.

Trigger Sources

Burst and Sweep modes depend on the detection of a trigger event. There are three possible sources for this event.

Internal

The trigger event is generated automatically at a given rate (specified period).

External

A rising edge on the back-panel External Trigger Input is used as the trigger source. For trigger level and precision characteristics, refer to the Moku:Lab Technical Specifications available at www.liquidinstruments.com.

Input

The corresponding Analogue input is monitored for a rising edge past the specified voltage. Output 1 can only be triggered from Input 1; Output 2 from Input 2.

Output

The opposite Analogue output is monitored for a rising edge past the specified voltage. Combined with the fact that that opposite output can in turn be modulated from a variety of sources, this provides extremely flexible control of the trigger period (included for example changing period based on an external voltage).

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Amplitude Modulation

Applicable To: Sine, Square, Ramp, Pulse

Amplitude modulation will change the amplitude of the generated signal proportionally to the modulation input. The actual proportion changed is called the modulation depth, the units of which depend on the modulation source (see discussion of sources above).

Frequency Modulation

Applicable To: Sine, Square, Pulse

Frequency modulation will change the frequency of the generated signal proportionally to the modulation input. The change in frequency caused by a given input is called the modulation depth and has units of Hertz or Hertz per Volt depending on the modulation source used.

Phase Modulation

Applicable To: Sine, Square, Pulse

Phase modulation will change the phase of the generated signal proportionally to the modulation input. The change in frequency caused by a given input is called the modulation depth and has units of Degrees or Degrees per Volt depending on the modulation source used.

Burst Mode

Applicable To: Sine, Square, Pulse

In burst mode, a trigger event causes the given output to begin generating its configured waveform. Burst requires you to specify a sub-mode that defines if or when the generation ends.

N-Cycle: The waveform will stop being generated after the specified number of cycles, at which time is will re-arm and become ready to receive a new trigger.

Gated: The waveform will continue to be generated while-ever the trigger signal is high (level-triggered).

Start: The waveform generation begins on a trigger signal but will continue indefinitely.

Sweep Mode

Applicable To: Sine, Square, Pulse

Sweep mode provides a frequency modulation of the input waveform, where the modulation waveform is a ramp wave that begins generation on the detection of a trigger signal. That is, when a trigger is detected, waveform generation will begin at the Start frequency and sweep (or “chirp”) to the End frequency over a given duration.

Sweep mode has three configurable parameters:

Start Frequency: Initial frequency of the output waveform, immediately on detection of a trigger. Note that in sweep mode, the waveform itself cannot have a frequency set independently; its frequency parameters are completely defined by the sweep.

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End Frequency: Final frequency of the output waveform, *duration* sections after the trigger has been detected.

Duration: The time taken to sweep from Start to End frequency. Upon completion of the sweep, the sweep circuit will re-arm and be ready to receive a new trigger input.

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Logic Analyzer / Pattern Generator

Moku:Go User Manual

Moku:Go's Logic Analyzer / Pattern Generator is equipped with 16 bidirectional digital I/O with sampling rates up to 125 MSa/s. It supports 3.3 V logic levels (5V tolerant) and 8M ×16 input sample depth. Extensive measurements are readily available through the interface. Data, screenshots, and logs can be readily captured to email or cloud-based services for rapid sharing and evaluation. Combined with the analog inputs and outputs, and the intuitive graphical user interface, Moku:Go is your go-to solution for undergraduate curriculum labs and senior design projects.

LIQUID INSTRUMENTS

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V21-0420

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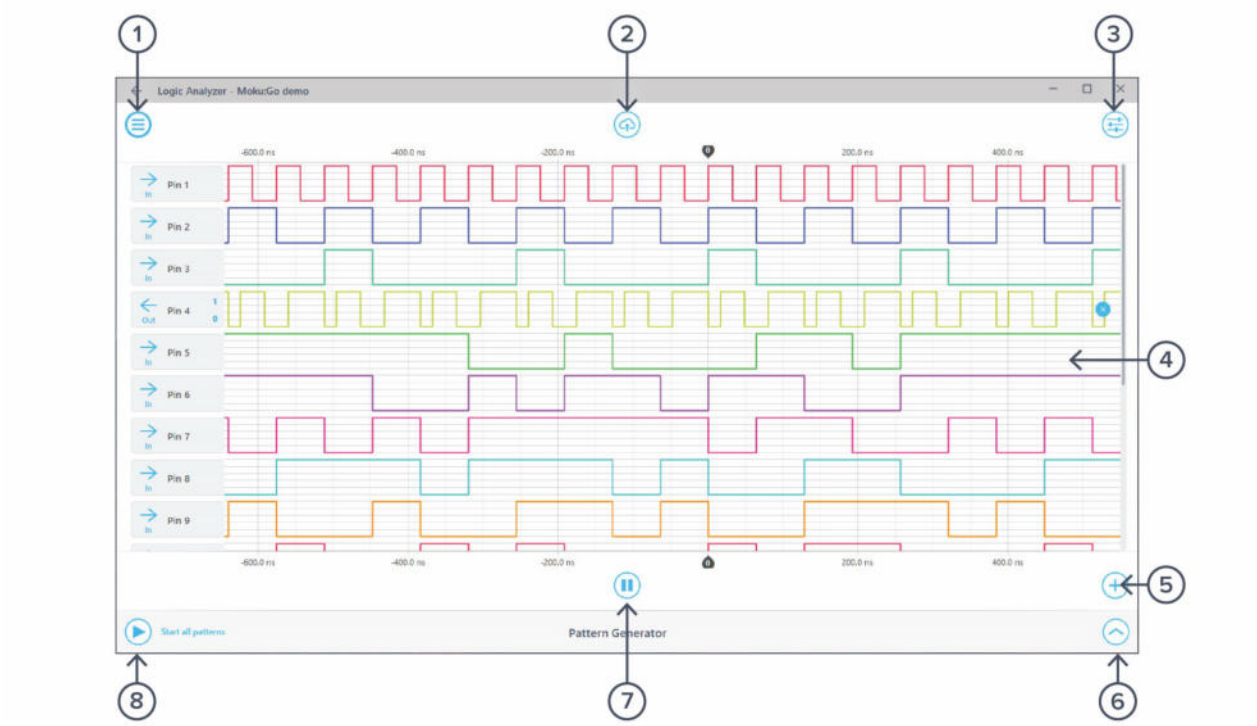
User Interface



ID	Description	ID	Description
1	Main menu	5	Add channel
2	Save data	6	Output pattern editor
3	Settings	7	Input start/pause
4	Signal display area	8	Start pattern generation

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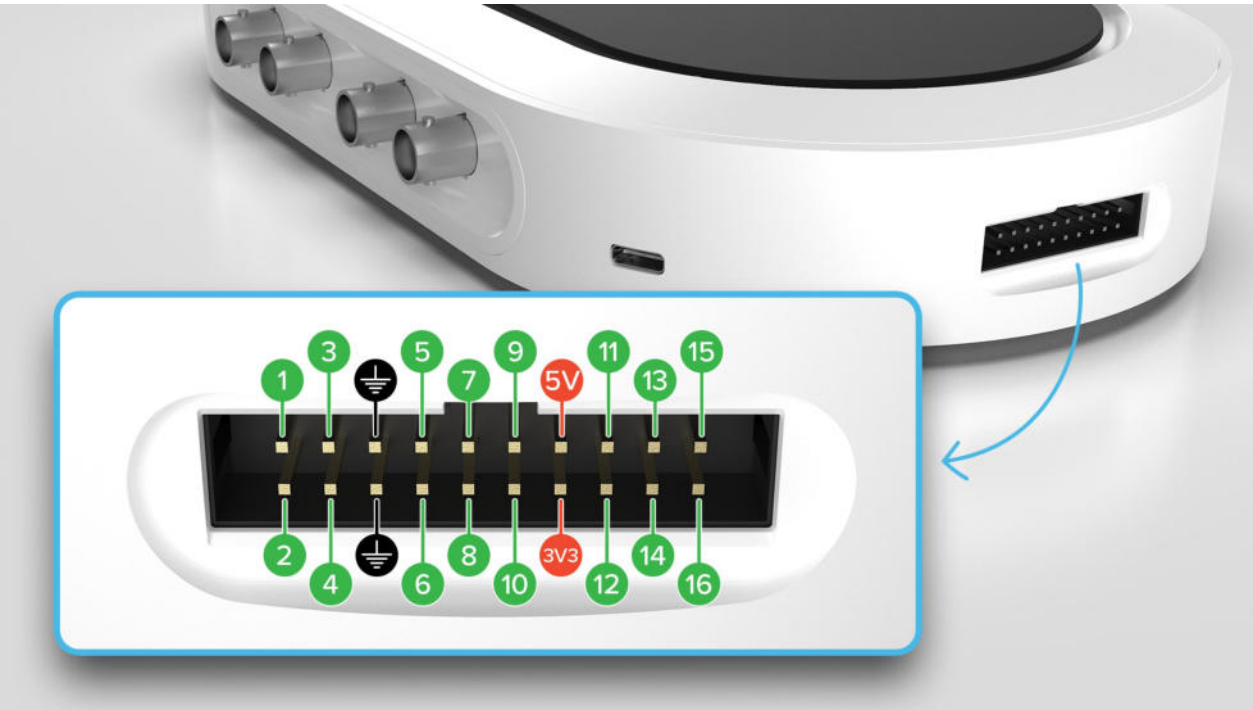
Physical Interface

Moku:Go is equipped with a 20-pin digital I/O interface. 16 of the 20 pins are the bidirectional digital I/O. There are two ground pins, one 5 V, and one 3.3 V output. A detailed layout can be found in the following figure.



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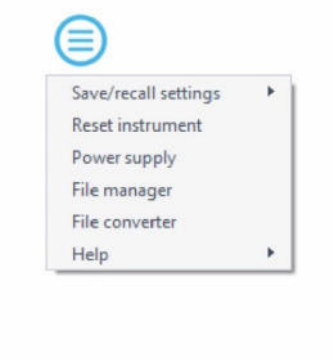
Main Menu

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



This menu provides the following options:

Options	Shortcuts	Description
Save/recall settings:		
• **Save instrument state**	Ctrl+S	Save the current instrument settings.
• **Load instrument state**	Ctrl+O	Load last saved instrument settings.
• **Show current sate**		Show the current instrument settings.
Reset instrument	Ctrl+R	Reset the instrument to its default state.
Power supply		Access power supply control window.*
File manager		Open file manager tool.**
File converter		Open file converter tool.**
Help		
• **Liquid Instruments website**		Access Liquid Instruments website.
• **Shortcuts list**	Ctrl+H	Show Moku:Go app shortcuts list.
• **Manual**	F1	Access instrument manual.
• **Report an issue**		Report bug to Liquid Instruments.
• **About**		Show app version, check update, or license information.

* Power supply is available on Moku:Go M1 and M2 models. Detailed information about power supply can be found in Moku:Go power supply manual.

**Detailed information about the file manager and file converter can be found at the end of this user manual.

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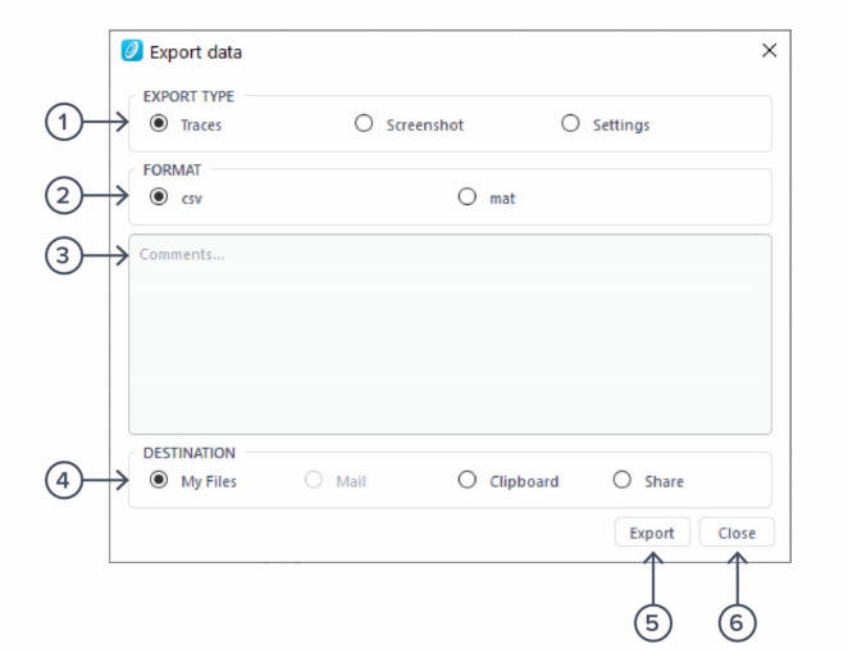
Export data

The **export data** options can be accessed by pressing the icon, allowing you to:



ID	Description
1	Select the type of data to export.
2	Select the exporting format (CSV or MAT).
3	Enter additional comments for the saved file.
4	Select the exporting location on your local computer.
5	Click to export data.
6	Click to close the export data window.

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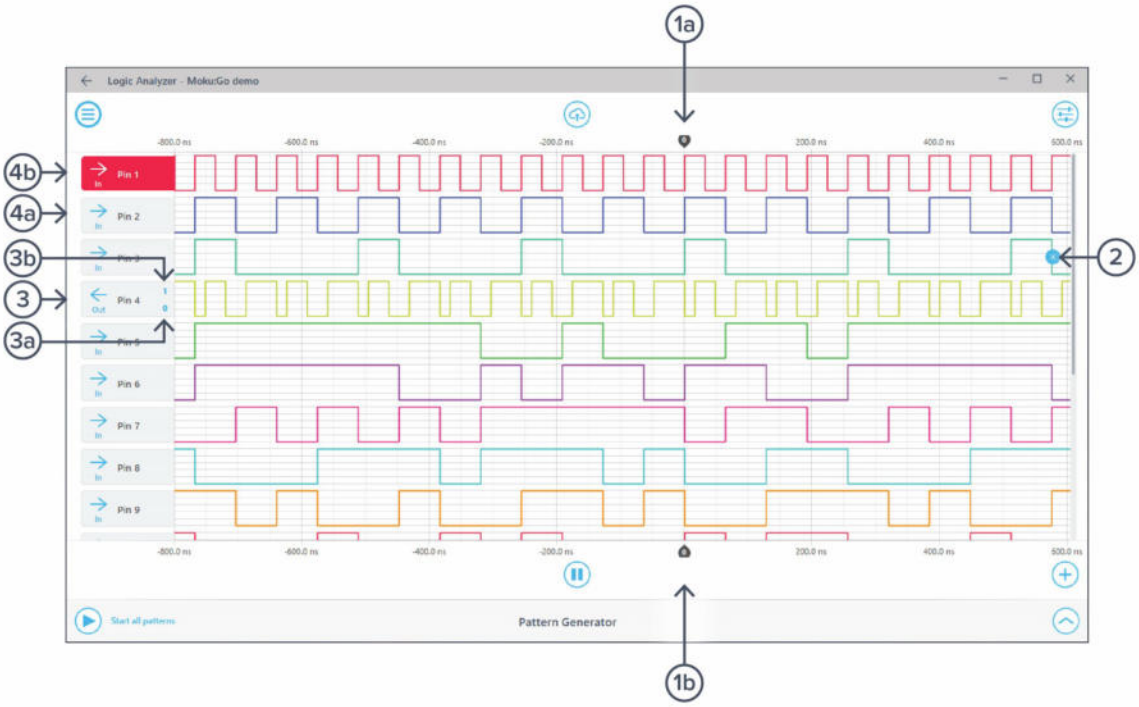
Signal Display and Signal Navigation

Signal display



ID	Button	Description
1a	Top time origin mark	Marks the “zero second” point on the time scale. This will be the trigger point if the logic analyzer has triggered.
1b	Bottom time origin mark	Marks the “zero second” point on the time scale. This will be the trigger point if the logic analyzer has triggered.
2	Remove trace	Click here to remove the trace. It will appear when the mouse cursor is over the signal trace area for this pin on the signal display.
3	Output pin header	Signal header for Pin 4. The left pointing arrow indicates it is currently set to be an output channel. Click the arrow to switch direction.
3a	Low override	Click to override this output to Low.
3b	High override	Click to override this output to High.
4a	Input pin header	Signal header for Pin 3. The right pointing arrow indicates it is currently set to be an input channel. Click the arrow to switch direction.
4b	Active pin header	Click the signal trace area or pin header for any pin to make it the active signal. This allows user to access settings and pattern editor for this pin. Click the header again to deselect the active pin.

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Signal display navigation

The displayed signal can be moved around the screen by clicking anywhere on the signal display window and dragging to the new position.

Scrolling the mouse wheel zooms in and out along the time axis.

Add channel

Additional channels can be added to the screen by the icon. It gives you the following options:

Options	Shortcuts	Description
Add pin		Select a specific pin to add.
Add next available pin	Ctrl+N	Add the next pin that is not currently in use.
Add math channel	Ctrl+M	Add a math channel.

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Settings

The **settings** options can be accessed by clicking the icon, allowing you to reveal or hide the controls drawer, giving you access to all instrument settings. The controls drawer contains settings, and measurement.

ID	Description
1	Settings
2	Measurements

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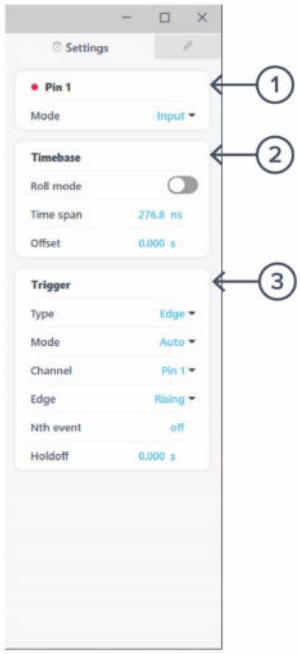
Settings

The **settings** pane allows you to configure the active pin, timebase, and trigger settings.



ID	Button	Description
1	Active pin settings	Different options are available for input, output pins, and math channel.
2	Timebase	**Roll mode:** Toggle between roll and sweep mode. **Timespan:** Horizontal screen scale. Changes dynamically when zooms in and out a trace or can be entered manually. **Offset:** Horizontal trigger point offset. Changes dynamically when horizontally-dragging a trace or can be set manually.
3	Trigger	**Type:** Select between edge and pulse triggering. **Mode:** Switches between auto, normal and single trigger modes. **Channel:** Select the source for the trigger circuit. **Edge:** Select to trigger on rising, falling, or both edge. It is only available for edge trigger. **Polarity and Width:** Select the trigger polarity and width condition. It is only available for pulse trigger. **Nth event :** Select up to 65,535 trigger events before actually triggering. **HoldOff :** Select a time to holdoff trigger post trigger event

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Active input pin settings

Options	Description
Mode	Select between input and output mode.

Active output pins settings

Options	Description
Mode	Select between input and output mode.
Output override	Select to override the output with ‘Low’ or ‘High’

Active math pins settings

Options	Description
Source A	Select the first source for the math operation.
Operation	Select from AND, OR, XOR, NAND, NOR, XNOR operation.
Source B	Select the second source for the math operation.

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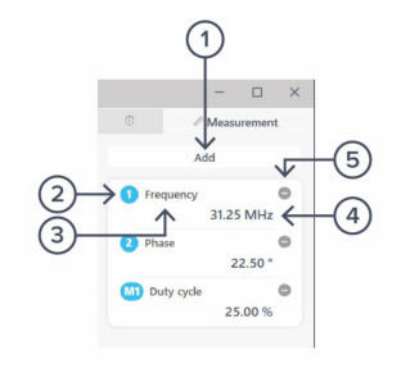
Measurement

The measurement pane allows you to add/remove measurements. A measurement can be assigned to a specific input, output, math channel, or difference between any two channels.



ID	Description
1	Click to add additional measurement tile.
2	Measurement source. Click to loop through the measurement sources.
3	Measurement type.
4	Measurement value.
5	Click to remove the measurement tile.

Click a measurement tile to open the menu to adjust the measurement. The following options are available:

Options	Description
Type	Select the measurement type.
• **Frequency**	
• **Phase**	
• **Period**	
• **Duty cycle**	
• **Pulse width**	
• **Neg width**	
Channels	Select measurement source.
Difference Channels	Measure the difference between the measurement source to another channel.
Remove	Remove the measurement tile.

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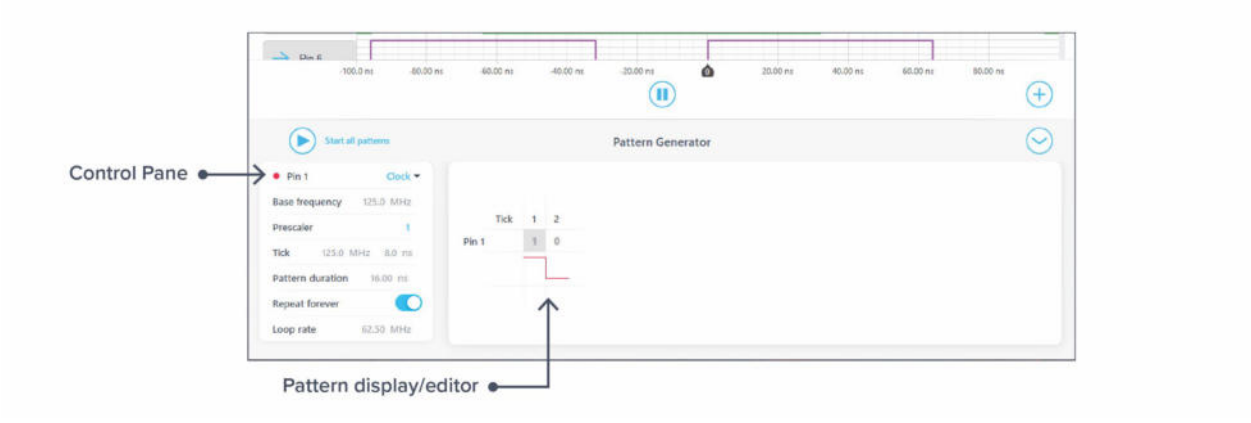
Pattern Editor

The output pattern can be accessed by clicking the icon. The editor only acts on the selected active output channel. There are in total four output modes: clock, pulse, random, and custom.

Clock mode



In the clock mode, the user can view (gray numbers) and adjust (blue numbers) the following parameters under the control pane:

Parameter	Description
Base frequency	The base frequency of the Go, which is the fastest operational frequency.
Prescaler	Divider to scale down the base frequency to the tick frequency. For example, a prescaler number of 2 provides 62.5 MHz tick frequency.
Pattern duration	Total duration of the pattern (1 cycle), calculated based on the current user settings.
Repeat forever	Change between repeat mode or n-iteration mode.
Loop rate	In the repeat mode, it displays the loop rate based on the current user settings.
Iterations	In the n-iteration mode, set the number of pattern iterations to output.

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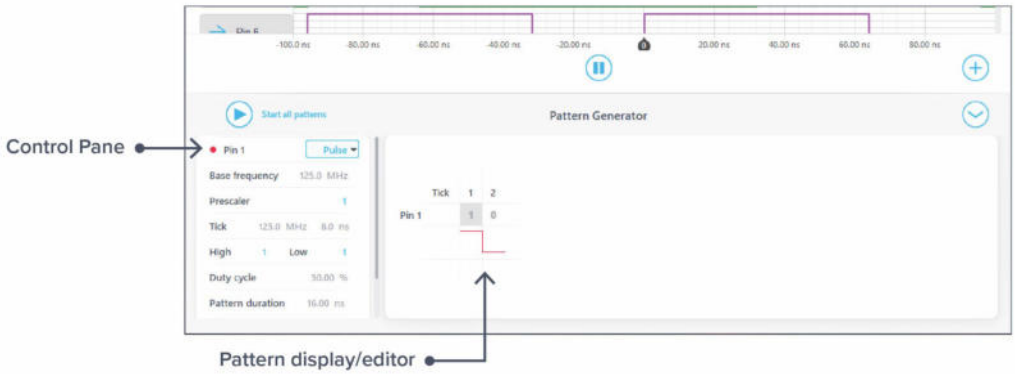
Pulse mode



With the pulse mode, the user can output a pattern with a set number of high and low ticks. A few additional parameters are avaiable in the pulse mode:

Parameter	Description
High	Number of ticks for high.
Low	Number of ticks for low.
Duty cycle	Percentage of the pattern that is high during the pulse pattern.

Random mode

In the random mode, the user can generate a random pattern with a set number of ticks. A few additional parameters are avaiable in the pulse mode:

Parameter	Description
Number of values	Total number of ticks for the random pattern.
New random seed	Generate new random pattern.

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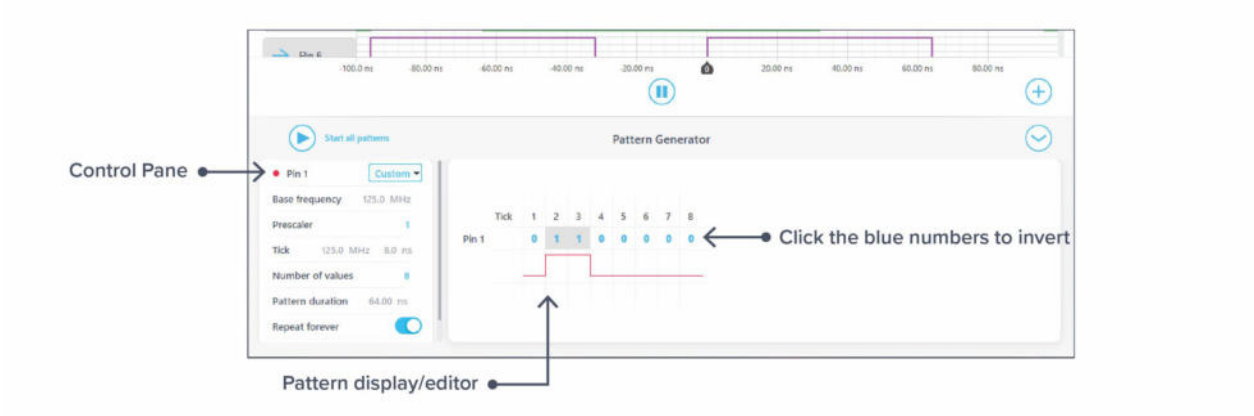
Custom mode



In the custom mode, the user can design a pattern with the pattern designer. You can click the blue number in the pattern display/editor area to invert the polarity for the tick.

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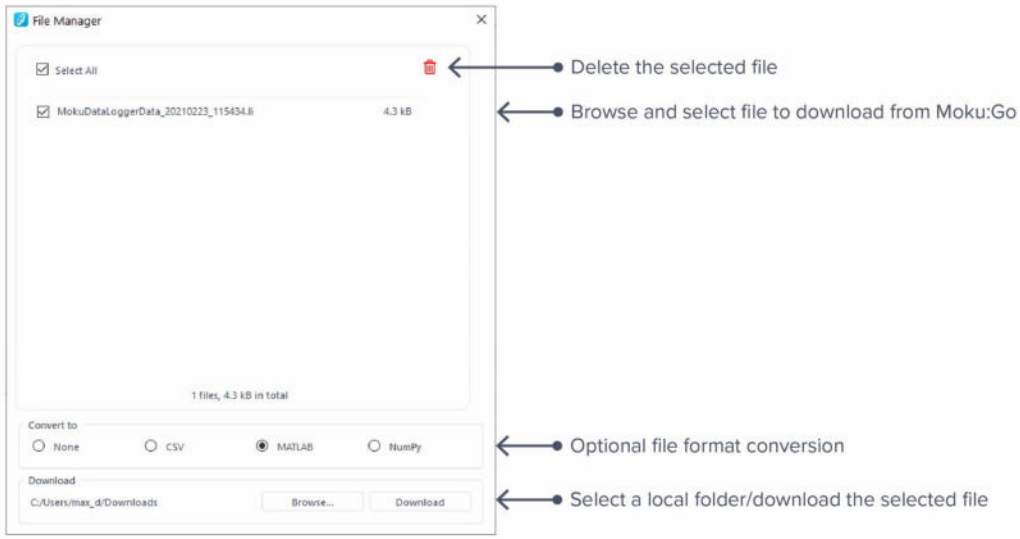
Additional Tools

Moku:Go app has two built-in file management tools: file manager and file converter.

File Manager

The file manager allows the user to download the saved data from Moku:Go to the local computer, with optional file format conversion.



Once a file is transferred to the local computer, a icon shows up next to the file.

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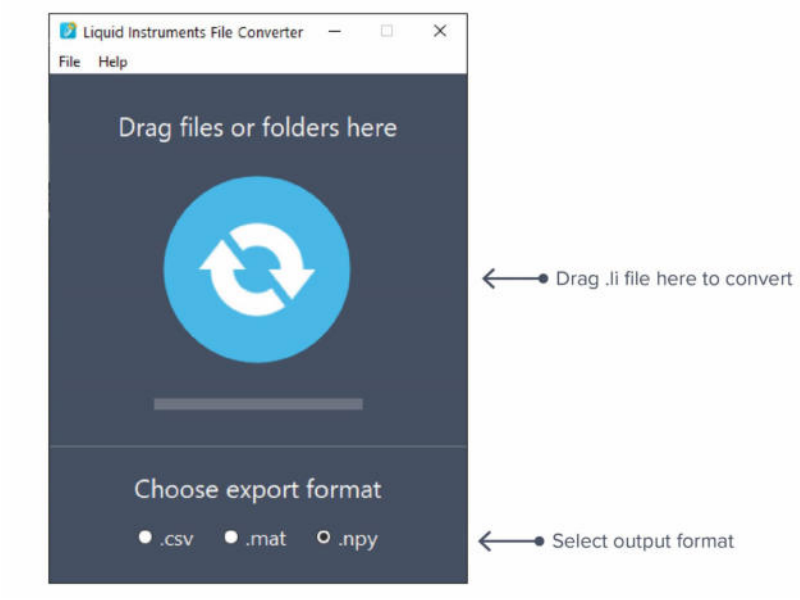
File Converter

The file converter converts the Moku:Go's binary (.li) format on the local computer to either .csv, .mat, or .npy format.



The converted file is saved in the same folder as the original file.

Liquid Instruments File Converter has the following menu options:

Options	Shortcut	Description
File		
• **Open file**	Ctrl+O	Select a .li file to convert
• **Open folder**	Ctrl+Shift+O	Select a folder to convert
• **Exit**		Close the file converter window
Help		
• **Liquid Instruments website**		Access Liquid Instruments website
• **Report an issue**		Report bug to Liquid Instruments
• **About**		Show app version, check update, or license information

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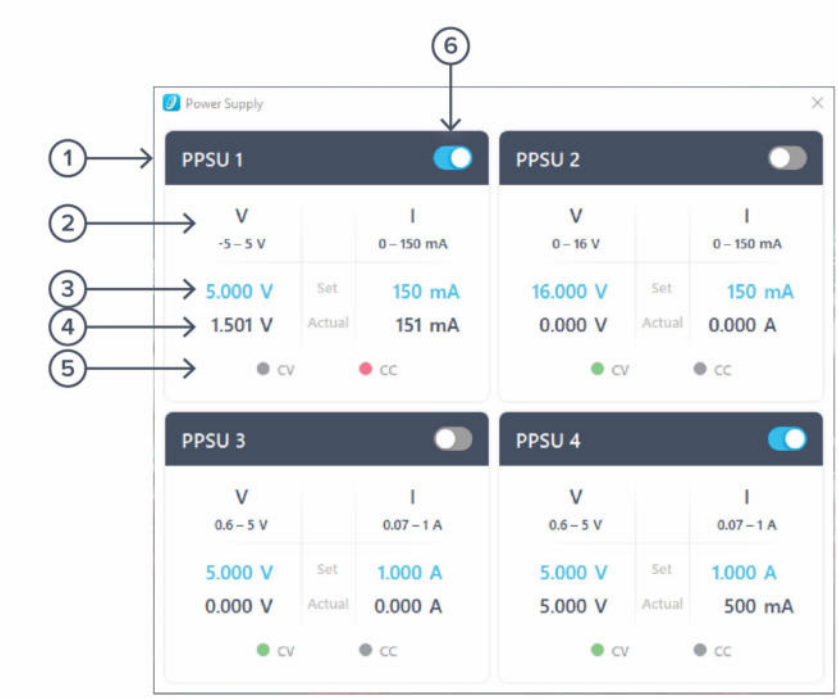
Power Supply

Moku:Go Power supply is available on M1 and M2 models. M1 features a 2-channel power supply, while M2 features a 4-channel power supply. The power supply control window can be accessed in all instruments under the main menu.

The power supply operates in two modes: **constant voltage (CV)** or **constant current (CC)** mode. For each channel, the user can set a current and voltage limit for the output. Once a load is connected, the power supply operates either at the set current or set voltage, whichever comes first. If the power supply is voltage limited, it operates in the CV mode. If the power supply is current limited, it operates in the CC mode.



ID	Function	Description
1	Channel name	Identifies the power supply being controlled.
2	Channel range	Indicates the voltage/current range of the channel.
3	Set value	Click the blue numbers to set the voltage and current limit.
4	Readback numbers	Voltage and current readback from the power supply, the actual voltage and current being supplied to the external load.
5	Mode indicator	Indicates if the power supply is in CV (green) or CC (red) mode.
6	On/Off Toggle	Click to turn the power supply on and off.

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Frequency Response Analyzer

Moku:Go User Manual

Moku:Go's Frequency Response Analyzer can be used to measure a system's frequency response from 10 mHz up to 30 MHz.

Frequency Response Analyzers are commonly used to measure the transfer functions of electrical, mechanical or optical systems by injecting a swept sinewave into the system and then comparing the output voltage to the input voltage. The resulting measurements of the system's magnitude and phase response can be used to optimise the closed-loop response of control systems, characterize resonant behaviour in non-linear systems, design filters, or measure the bandwidth of different electronic components. Frequency Response Analyzers are quite simply an indispensable tool in any electronics lab.

LIQUID INSTRUMENTS

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V21-0322

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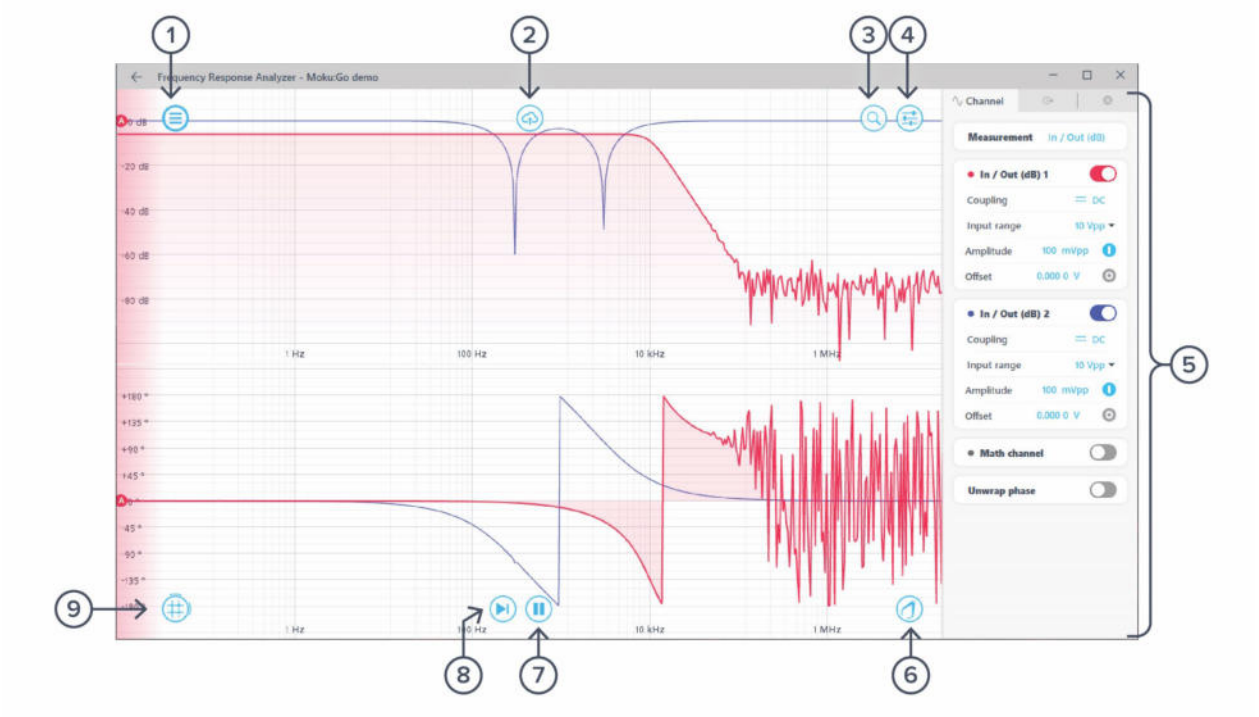
User Interface



ID	Description	ID	Description
1	Main menu	6	Calibration*
2	Export data	7	Single/continuous mode switch*
3	Signal display navigation	8	Start / pause sweep*
4	Settings	9	Cursors
5	Control pane		

*Detailed information can be found in the Sweep mode section.

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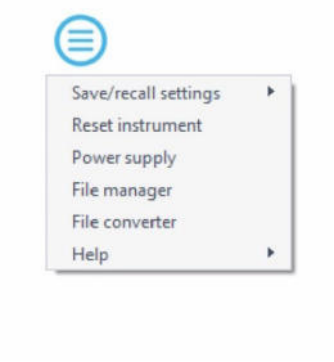
Main Menu

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



This menu provides the following options:

Options	Shortcuts	Description
Save/recall settings:		
• **Save instrument state**	Ctrl+S	Save the current instrument settings.
• **Load instrument state**	Ctrl+O	Load last saved instrument settings.
• **Show current sate**		Show the current instrument settings.
Reset instrument	Ctrl+R	Reset the instrument to its default state.
Power supply		Access power supply control window.*
File manager		Open file manager tool.
File converter		Open file converter tool.
Help		
• **Liquid Instruments website**		Access Liquid Instruments website.
• **Shortcuts list**	Ctrl+H	Show Moku:Go app shortcuts list.
• **Manual**	F1	Access instrument manual.
• **Report an issue**		Report bug to Liquid Instruments.
• **About**		Show app version, check update, or license information.

* Power supply is available on Moku:Go M1 and M2 models. Detailed information about power supply can be found in Moku:Go power supply manual.

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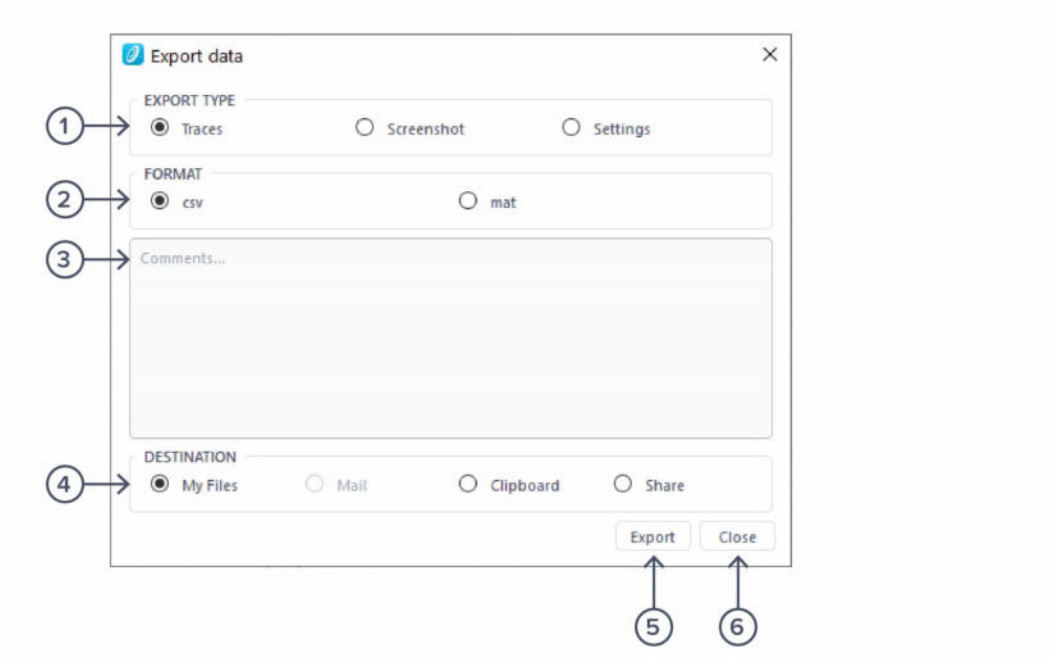
Export data

The **export data** options can be accessed by clicking the icon, allowing you to:



ID	Description
1	Select the type of data to export.
2	Select the file format (CSV or MAT).
3	Enter additional comments for the saved file.
4	Select the exporting location on your local computer.
5	Click to execute data export.
6	Click to close the export data window.

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Signal Display Navigation

Signal display position

The displayed siganl can be moved around the screen by clicking anywhere on the signal display window and dragging to the new position. The cursor will turn into a icon once clicked, drag horizontally to shift along the frequency axis and drag vertically to shift along the amplitude/power axis.

The signal display can also be moved hotizontally and vertically with arrow keys.

Display scale and zoom

Scrolling the mouse wheel zooms in and out along the primary axis. Access the scroll setting by hovering the cursor over the icon.

Icons	Description
	Assign the horizonal axis as the primary axis.
	Assign the vertical axis as the primary axis.
	Rubber band zoom: hold the primary mouse button to draw a region to zoom-in, release the button to execute.

Additional keyboard combinations are also available.

Actions	Description
Ctrl + Scroll Wheel	Zoom secondary axis.
+/-	Zoom primary axis with keyboard.
Ctrl +/-	Zoom secondary axis with keyboard.
Shift + Scroll Wheel	Zoom primary axis towards the center.
Ctrl + Shift + Scroll Wheel	Zoom secondary axis towards the center.
R	Rubber band zoom.

Auto scale

Double click anywhere on the signal display window to auto scale the traces.

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Settings

The instrument control menu allows you to configure the Frequency Response Analyzer for your measurement, which will vary depending on the specific characteristics of the system under test.

Access the instrument Control menu by clicking the icon.

ID	Description
1	Channel
2	Swept sine
3	Advanced

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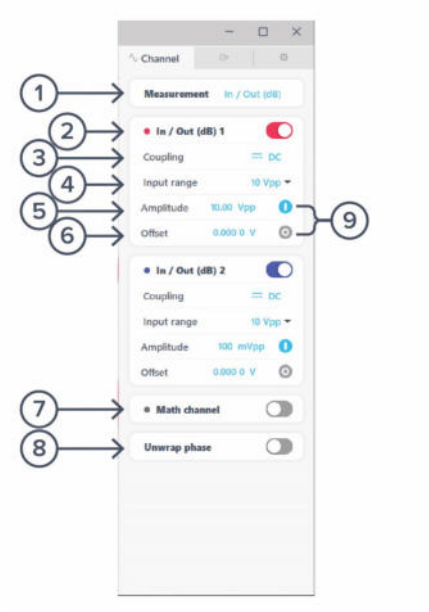
Channels



ID	Description	ID	Description
1	Select to display In (dBm) or In/Out (dB)	6	Swept sine (output) offset
2	Toggle channel on/off	7	Enable/disable Math channel
3	Select AC or DC coupling	8	Unwrap/wrap phase
4	Select input range 10 Vpp or 50 Vpp	9	Turn on/off amplitude and/or offset
5	Swept sine (output) amplitude		

Math channel

- Select between addition, subtraction, multiplication and division of the two channels.
- Compare transfer functions of channel 1 and 2 by configuring them identically.

Unwrap phase

- Phase is measured as a modulo of 2π. Enabling unwrapping will display an estimate of the total accumulated phase of the system.

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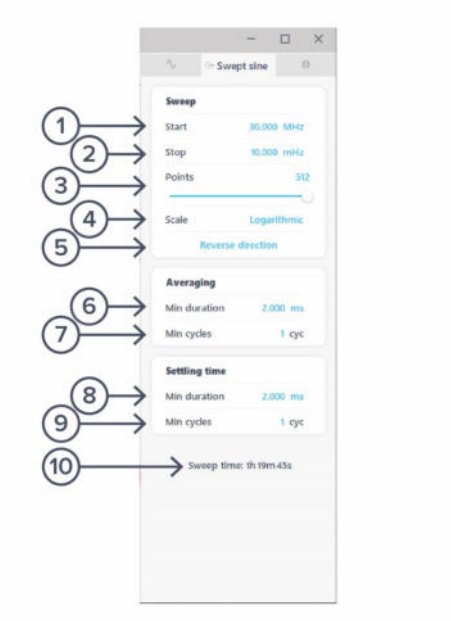
Swept Sine



ID	Description	ID	Description
1	Configure the sweep start frequency	6	Configure the minimum averaging time
2	Configure the sweep stop frequency	7	Configure the minimum averaging cycles
3	Select the number of sweep point	8	Configure the minimum settling time
4	Select Linear or Log scale	9	Configure the minimum settling cycles
5	Reverse sweep direction	10	Total sweep time based on selected parameters

Sweep points

- Increasing the number of points in the sweep increases frequency resolution of the measurement allowing narrower features to be detected over a wider frequency range but will increase the total measurement duration.

Sweep scale

- The discrete points in the swept sine output can be spaced linearly or logarithmically. Logarithmic sweeps provide greater measurement resolution at lower frequencies.

Averaging

- Measurements at each point in the frequency sweep are averaged to improve accuracy and precision. You can configure the period over which each measurement is averaged to control the signal-to-noise ratio (SNR). Longer averaging times result in higher SNRs, allowing small features to be detected with greater precision. Shorter averaging times result in lower SNR measurements but the reduce total sweep time.
- The total averaging time is determined based on the **minimum duration** and **minimum number of cycles** over which each point in the sweep is averaged. Moku:Go's Frequency

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Reference Analyzer averages for the greater of the two values rounded up to the nearest number of integer cycles in order to avoid spectral leakage.

Settling time

- The settling time determines how long the Frequency Reference Analyzer waits before performing measurements at each frequency in the sweep. Settling time is important when characterizing resonant systems with high Q-factors in order to allow excitations to 'settle' between measurements. It can also be used to account for transmission delays in cables. When measuring a non-resonant system, the settling time should be set to equal the total propagation delay through the system.
- The total settling time is determined based on the **minimum duration** and **minimum number of cycles** over which the instrument will wait before beginning a measurement at each frequency in the sweep. The Frequency Response Analyzer will wait for the greater effective duration of the two settings before beginning a measurement at each point in the sweep.

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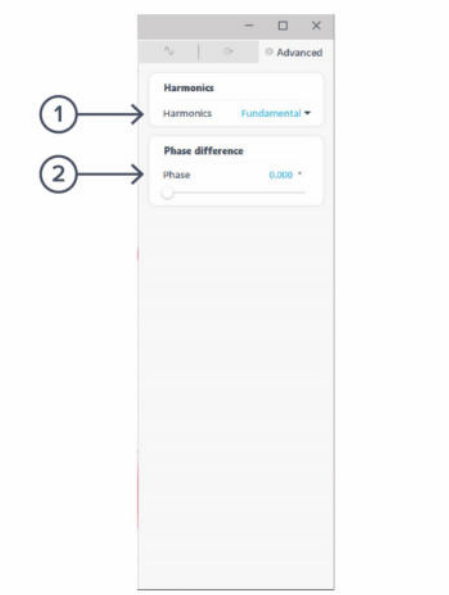
Advanced



ID	Description
1	Set the harmonic to demodulate for the frequency response
2	Set the phase difference between the output and local oscillator

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Calibration

Moku:Go's Frequency Reference Analyzer features a calibration tool that can be used to normalize subsequent measurements. Calibration is useful when compensating for cables delays and comparing different devices under test.

Clicking the icon will bring up the calibration menu. **Re-calibrate** will replace the current calibration trace with a new one. **Remove calibration** will erase all stored calibration settings and cannot be undone.

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Sweep modes

Single

Clicking the icon will enable single sweep mode, which will pause the swept sine source at the end of the next full sweep. The swept sine signal will be turned off after the sweep completes and displayed data will not be updated.

Continuous

Clicking the icon will enable continuous sweep mode, which will perform a new measurement as soon as the previous one has finished. This mode is commonly used to monitor systems with transfer functions that may change over time (e.g., control loops).

Pause / Restart

Clicking the icon will immediately pause the current sweep. While paused, you can zoom in on features for more details, but no new data will be captured. Pressing the icon will also pause capture.

clicking the or icons will restart the sweep.

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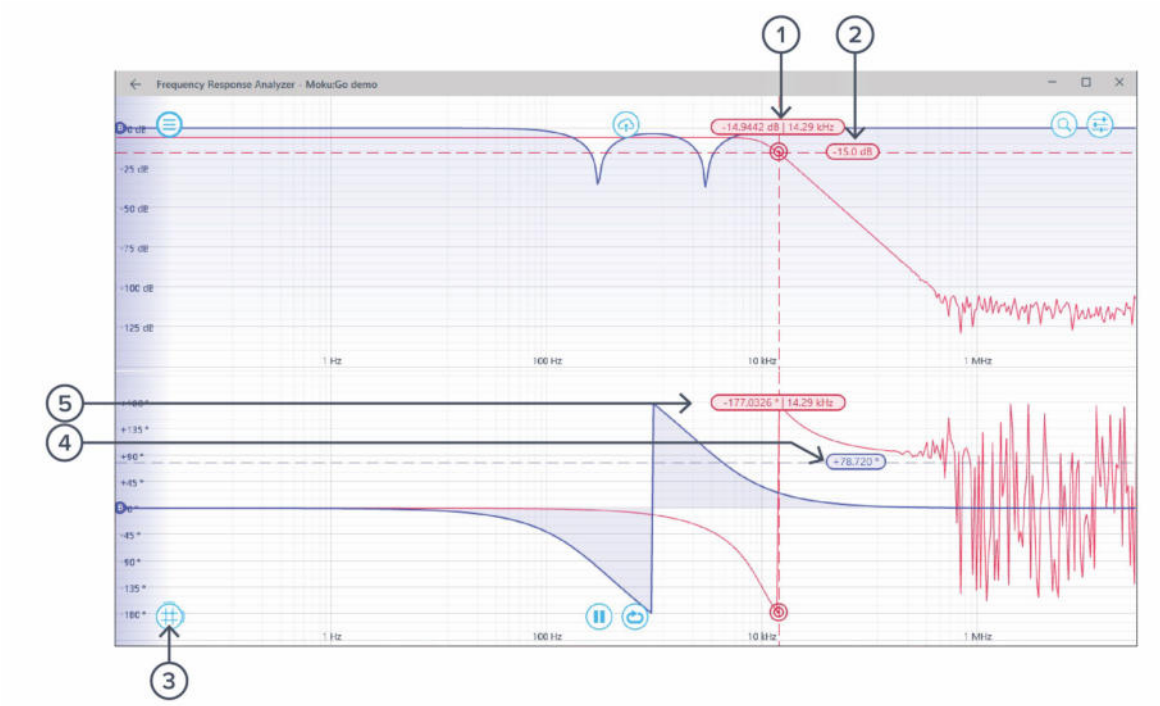
Cursors

Cursors can be accessed by clicking the on, allowing you to add power or frequency cursors, or remove all cursors. In addition, you can click and hold the cursors icon, and drag horizontally to add a frequency cursor, or drag vertically to add a magnitude or phase cursor.

User Interface



ID	Cursor item	Description
1	Frequency/Tracking cursor	Drag to reposition the cursor (Gray – Unattached, Red – channel 1, Blue – channel 2, Yellow – math).
2	Amplitude cursor	Drag to reposition, right click to set magnitude manually & other options.
3	Create cursor	Cursor options.
4	Phase cursor	Drag to adjust, right click to set phase manually & other options
5	Cursor label	Label depicting frequency, magnitude and phase of cursor. Drag to reposition.

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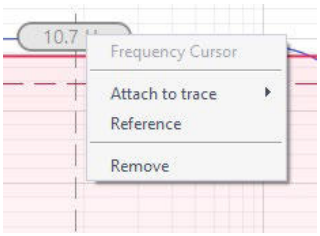
Frequency Cursor

Right-click (secondary click) to reveal frequency cursor options:



Options	Description
Frequency Cursor	Cursor type.
Attach to trace	Choose to attach the frequency cursor to channel A, channel B, or the math channel. Once the cursor is attached to a channel, it becomes to a tracking cursor.
Reference	Set the cursor as the reference cursor. All other cursors in the same domain and channel measure the offset to the reference cursor.
Remove	Remove the frequency cursor

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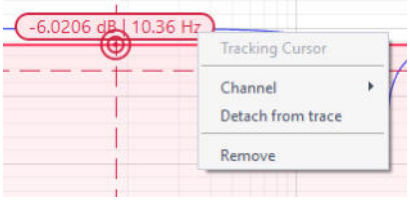
Tracking Cursor

Once a frequency cursor is attached to a channel, it becomes to a tracking cursor. It displays the frequency and power level of the signal at the set frequency.



Options	Description
Tracking Cursor	Cursor type.
Channel	Assign tracking cursor to a specific channel.
Detach from trace	Detach the tracking cursor from the channel to a frequency cursor.
Remove	Remove the tracking cursor.

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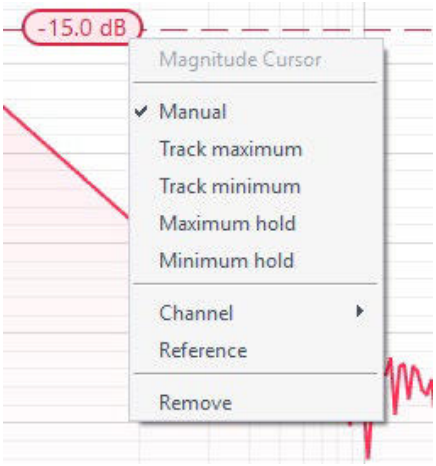
Magnitude/Phase Cursor

Right-click (secondary click) to reveal power cursor options:



Options	Description
Manual	Manually set the vertical position of the cursor.
Track maximum	Track the maximum magnitude/phase.
Track minimum	Track the minimum magnitude/phase.
Maximum hold	Set the cursor to hold at the maximum magnitude/phase level.
Minimum hold	Set the cursor to hold at the minimum magnitude/phase level.
Channel	Assign the power cursor to a specific channel.
Reference	Set the cursor as the reference cursor.
Remove	Remove the magnitude/phase cursor.

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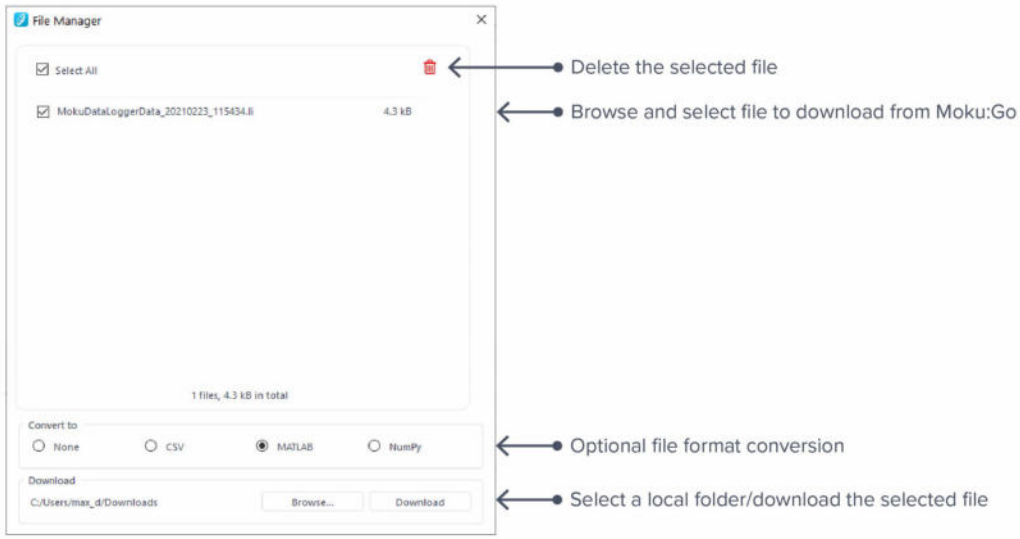
Additional Tools

Moku:Go app has two built-in file management tools: file manager and file converter.

File Manager

The file manager allows the user to download the saved data from Moku:Go to local computer, with optional file format conversion.



Once a file is transferred to the local computer, a icon shows up next to the file.

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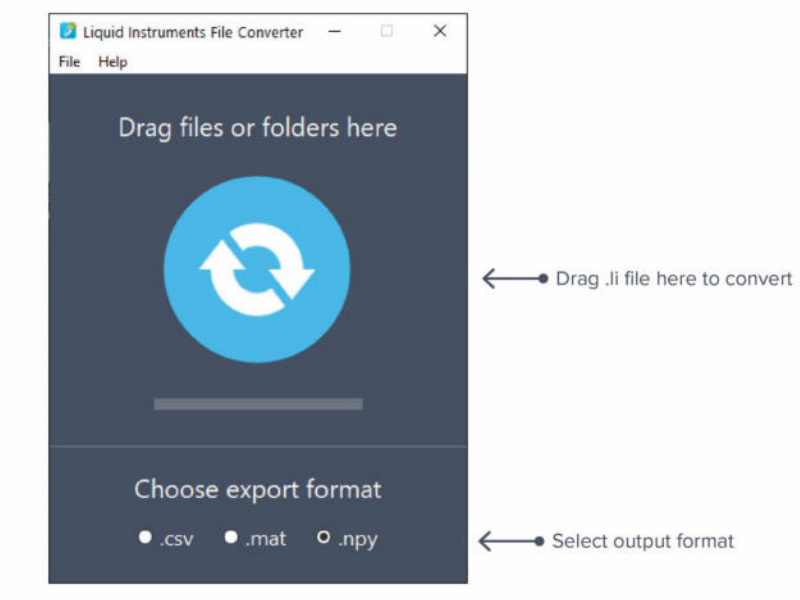
File Converter

The file converter converts the Moku:Go's binary (.li) format on the local computer to either .csv, .mat, or .npy format.



The converted file is saved in the same folder as the original file.

Liquid Instruments File Converter has the following menu options:

Options	Shortcut	Description
File		
• **Open file**	Ctrl+O	Select a .li file to convert
• **Open folder**	Ctrl+Shift+O	Select a folder to convert
• **Exit**		Close the file converter window
Help		
• **Liquid Instruments website**		Access Liquid Instruments website
• **Report an issue**		Report bug to Liquid Instruments
• **About**		Show app version, check update, or license information

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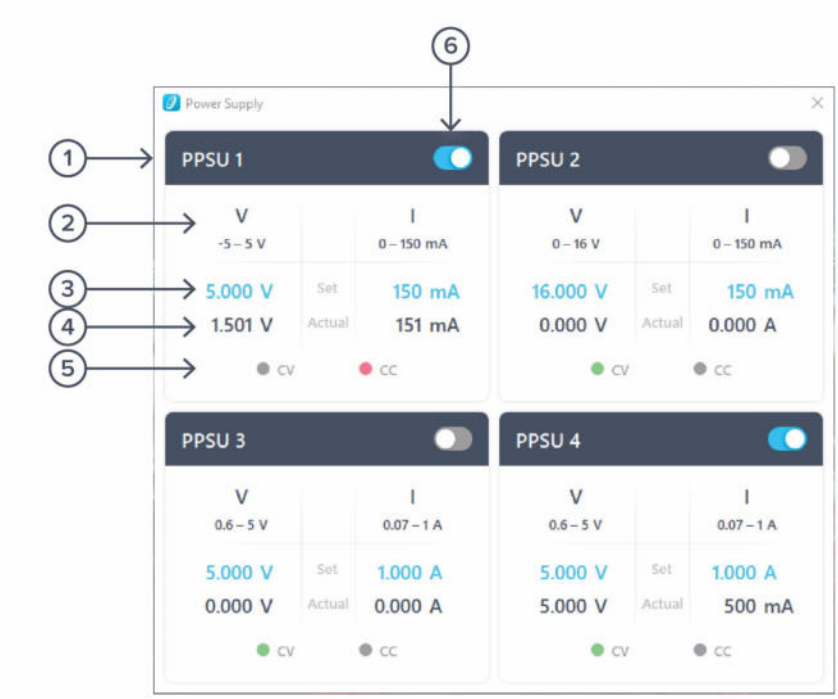
Power Supply

Moku:Go Power supply is available on M1 and M2 models. M1 features a 2-channel power supply, while M2 features a 4-channel power supply. The power supply control window can be accessed in all instruments under the main menu.

The power supply operates in two modes: **constant voltage (CV)** or **constant current (CC)** mode. For each channel, the user can set a current and voltage limit for the output. Once a load is connected, the power supply operates either at the set current or set voltage, whichever comes first. If the power supply is voltage limited, it operates in the CV mode. If the power supply is current limited, it operates in the CC mode.



ID	Function	Description
1	Channel name	Identifies the power supply being controlled.
2	Channel range	Indicates the voltage/current range of the channel.
3	Set value	Click the blue numbers to set the voltage and current limit.
4	Readback numbers	Voltage and current readback from the power supply, the actual voltage and current being supplied to the external load.
5	Mode indicator	Indicates if the power supply is in CV (green) or CC (red) mode.
6	On/Off Toggle	Click to turn the power supply on and off.

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PID Controller

Moku:Go User Manual

Moku:Go's PID (Proportional-Integrator-Differentiator) Controller features two fully real-time configurable PID controllers with an output sample rate of 2.5 MSa/s. This enables them to be used in applications requiring both low and high feedback bandwidths such as temperature and laser frequency stabilization. The PID Controller can also be used as a lead-lag compensator by saturating the integral and differential controllers with independent gain settings.

LIQUID INSTRUMENTS

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V21-0322

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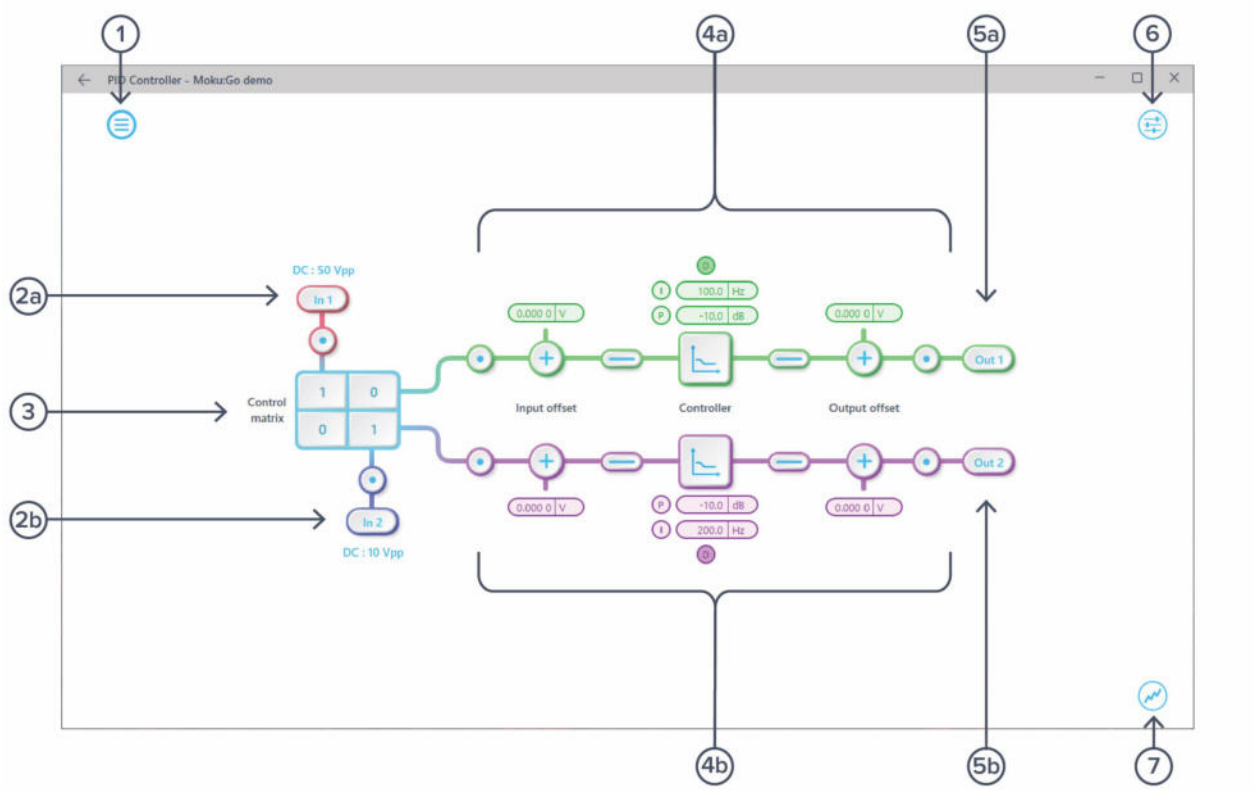
User Interface



ID	Description
1	Main menu
2a	Input configuration for Channel 1
2b	Input configuration for Channel 2
3	Control matrix
4a	Configuration for PID Controller 1
4b	Configuration for PID Controller 2
5a	Output switch for Channel 1
5b	Output switch for Channel 2
6	Settings
7	Enable/disable the oscilloscope view

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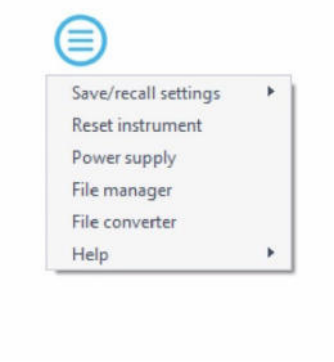
Main Menu

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



This menu provides the following options:

Options	Shortcuts	Description
Save/recall settings:		
• **Save instrument state**	Ctrl+S	Save the current instrument settings.
• **Load instrument state**	Ctrl+O	Load last saved instrument settings.
• **Show current sate**		Show the current instrument settings.
Reset instrument	Ctrl+R	Reset the instrument to its default state.
Power supply		Access power supply control window.*
File manager		Open file manager tool.**
File converter		Open file converter tool.**
Help		
• **Liquid Instruments website**		Access Liquid Instruments website.
• **Shortcuts list**	Ctrl+H	Show Moku:Go app shortcuts list.
• **Manual**	F1	Access instrument manual.
• **Report an issue**		Report bug to Liquid Instruments.
• **About**		Show app version, check update, or license information.

* Power supply is available on Moku:Go M1 and M2 models. Detailed information about power supply can be found in Moku:Go power supply manual.

**Detailed information about the file manager and file converter can be found toward the end of this user manual.

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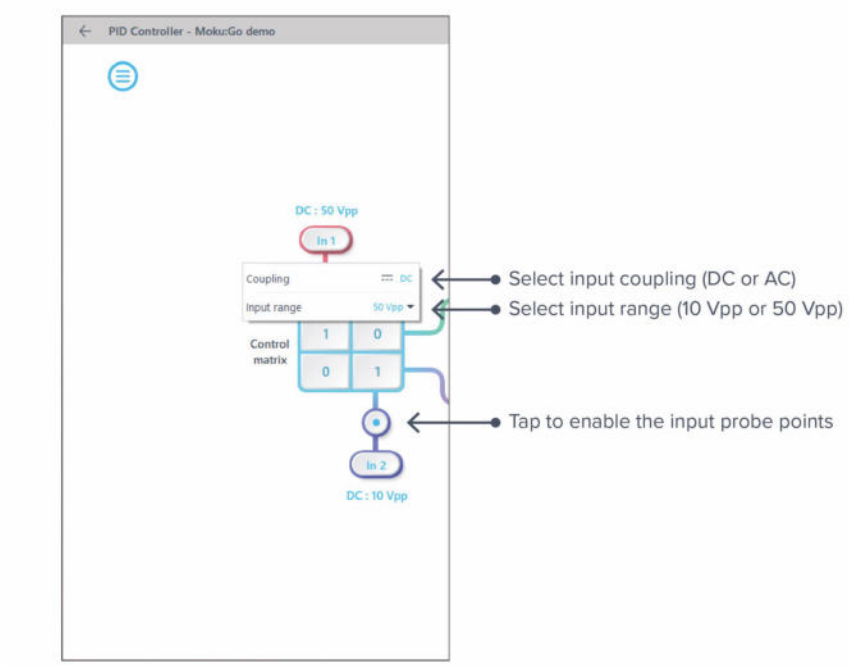
Input Configuration

The **input configuration** can be accessed by tapping the In 1 or In 2 icon, allowing you to adjust the coupling, and input range for each input channel.



Details about the probe points can be found in the Probe Points section.

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Control Matrix

The **control matrix** combines, rescales, and redistributes the input signal to the two independent PID controllers. The output vector is the product of the control matrix multiplied by the input vector.

$$\begin{bmatrix} Path1 \\ Path2 \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \times \begin{bmatrix} In1 \\ In2 \end{bmatrix}$$

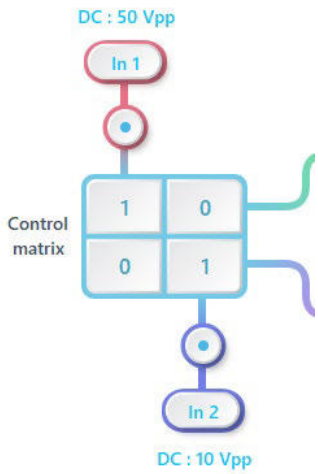
where

$$Path1 = a \times In1 + b \times In2$$

$$Path2 = c \times In1 + d \times In2$$

For example, a control matrix of $\begin{bmatrix} 1 & 1 \\ 0 & 2 \end{bmatrix}$ equally combines the Input 1 and Input 2 to the top *Path1* (PID Controller 1); multiples Input 2 by a factor of two, and then sends it to the bottom *Path2* (PID Controller 2).

The value of each element in the control matrix can be set between -20 to +20 with 0.1 increments when the absolute value is less than 10, or 1 increment when the absolute value is between 10 and 20. Tap the element to adjust the value.



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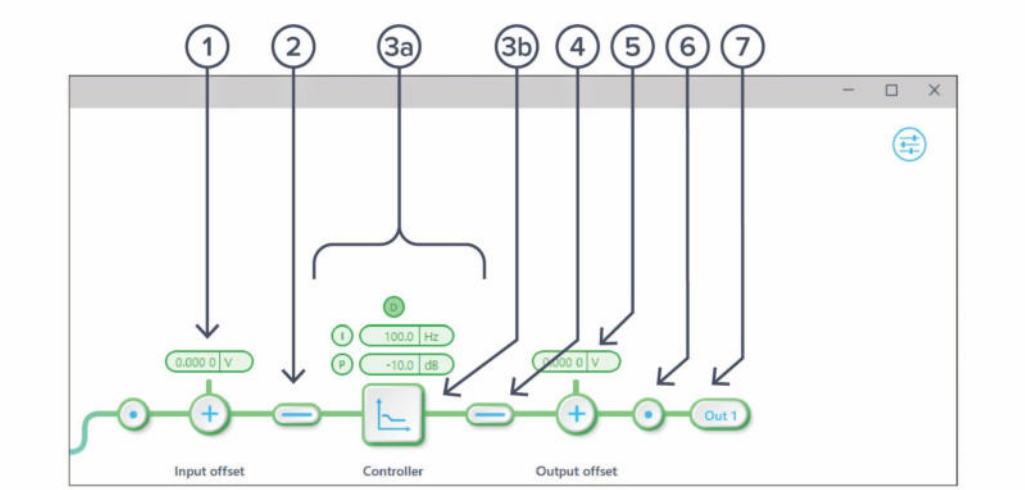
PID Controller

The two independent, fully real-time configurable PID controller paths follow the control matrix in the block diagram, represented in green and purple for controller 1 and 2, respectively.

User Interface



ID	Function	Description
1	Input offset	Click to adjust the input offset (-1 to +1 V).
2	Input switch	Click to zero the input signal.
3a	Quick PID control	Click to enable/disable controllers and adjust the parameters. Not available in advanced mode.
3b	Controller view	Click to open full controller view.
4	Output switch	Click to zero the output signal.
5	Output offset	Click to adjust the output offset (-1 to +1 V).
6	Output probe	Click to enable/disable the output probe point. See Probe Points section for details.
7	Moku:Go output switch	Click to enable/disable the Moku:Go's output.

Input / Output Switches

Closed/Enable

Open/disable

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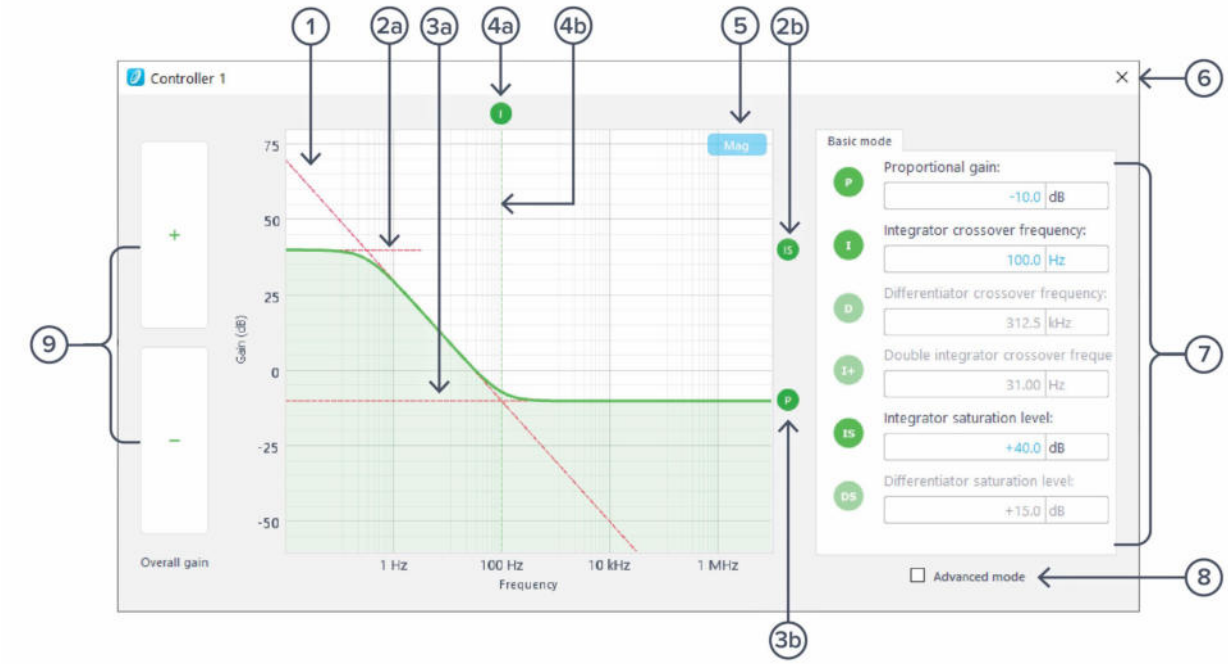
Controller (Basic Mode)

Controller Interface

Tap the icon to open the full controller view.



ID	Function	Description
1	Design cursor 1	Cursor for Integrator (I) setting.
2a	Design cursor 2	Cursor for Integrator Saturation (IS) level.
2b	Cursor 2 indicator	Drag to adjust cursor 2 (IS) level.
3a	Design cursor 3	Cursor for Proportional (P) gain.
3b	Cursor 3 indicator	Drag to adjust curser 3 (P) level.
4a	Cursor 4 indicator	Drag to adjust curser 4 (I) frequency.
4b	Design cursor 4	Cursor for I crossover frequency.
5	Display toggle	Toggle between magnitude and phase response curve.
6	Close controller view	Click to close the full controller view.
7	PID control	Turn on/off individual controller, and adjust the parameters.
8	Advanced mode	Click to switch to the advanced mode.
9	Overall gain control	Click to adjust overall gain of the controller.

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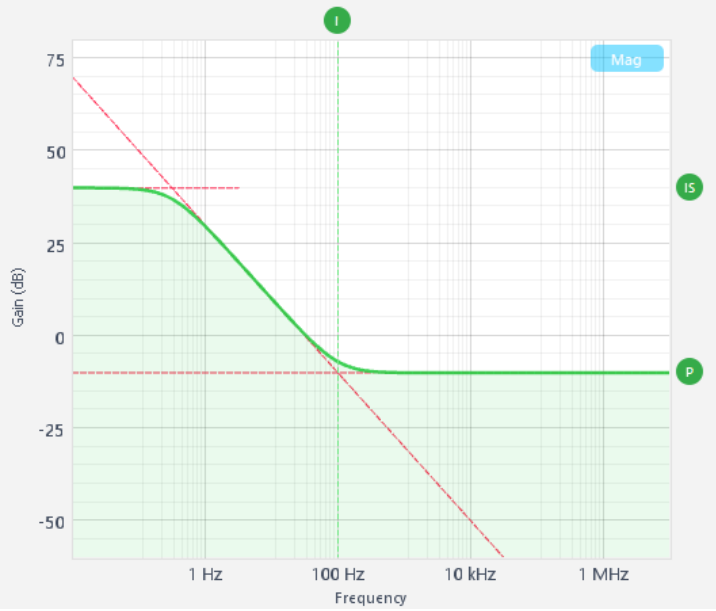
PID Response Plot

The PID Response Plot provides an interactive representation (gain as a function of frequency) of the controller.



The green/purple solid curve represents the active response curve for PID Controller 1 and 2, respectively.

The green/purple dashed vertical lines (④) represent the cursors crossover frequencies, and/or unity gain frequencies for PID Controller 1 and 2, respectively.

The red dashed lines (①, ②, and ③) represent the cursors for each controller.

Letter Abbreviations for Controllers

ID	Description	ID	Description
P	Proportional gain	**I+**	Double integrator crossover frequency
I	Integrator crossover frequency	**IS**	Integrator saturation level
D	Differentiator	**DS**	Differentiator saturation level

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List of Configurable Parameters in Basic Mode

Parameters	Range
Overall gain	± 60 dB
Proportional gain	± 60 dB
Integrator crossover frequency	312.5 mHz to 31.25 kHz
Differentiator crossover frequency	3.125 Hz to 312.5 kHz
Integrator saturation level	± 60 dB or limited by the crossover frequency/proportional gain
Differentiator saturation level	± 60 dB or limited by the crossover frequency/proportional gain

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Controller (Advanced Mode)

In **Advanced Mode**, users can build fully customized controllers with two independent sections (A and B), and six adjustable parameters in each section. Tap the **Advanced Mode** button in the full controller view to switch to the **Advanced Mode**.

ID	Function	Description
1	Frequency response	Frequency response of the controller.
2a	Section A pane	Click to select and configure Section A.
2b	Section B pane	Click to select and configure Section B.
3	Close controller view	Click to close the full controller view.
4	Overall gain	Click to adjust the overall gain.
5	Proportional panel	Click the icon to enable/disable proportional path. Click the number to adjust the gain.
6	Integrator panel	Click the icon to enable/disable integrator path. Click the number to adjust the gain.
7	Differentiator panel	Click the icon to enable/disable differential path. Click the number to adjust the gain.
8	Integrator saturation corner frequency	Click the icon to enable/disable integrator saturation path. Click the number to adjust the frequency.
9	Differentiator saturation corner frequency	Click the icon to enable/disable differentiator saturation path. Click the number to adjust the frequency.
10	Basic mode	Tap to switch to the basic mode.

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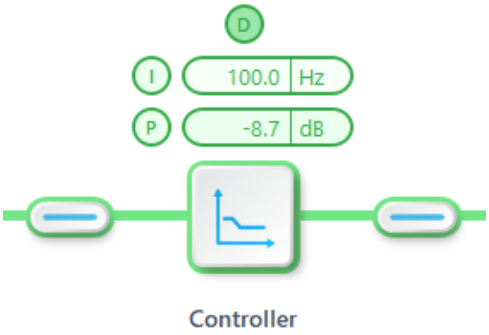
Quick PID Control

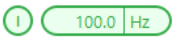
This panel allows user quickly to view, enable, disable, and adjust the PID controller without open the controller interface. It is only available in basic PID mode.



Click the P, I, or D icon to disable active controller path.

Click the shaded icon (i.e.

) to enable the path.

Click the active controller path icon (i.e. 

) to enter the value.

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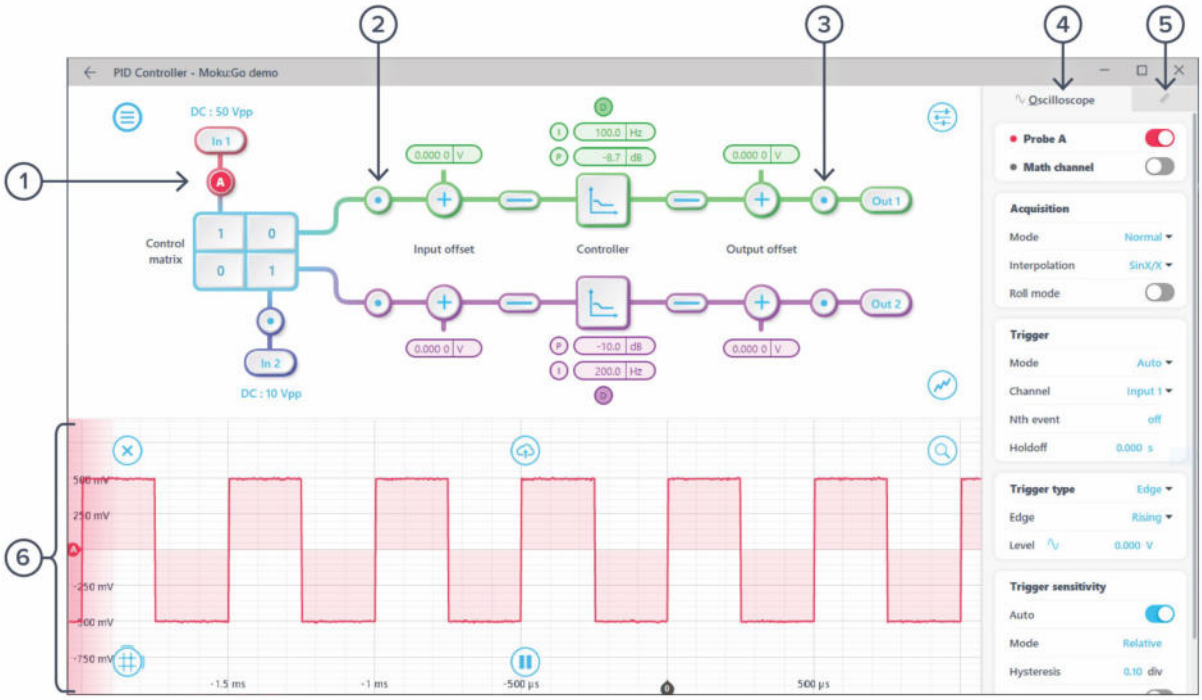
Probe Points

Moku:Go's PID controller has an integrated oscilloscope that can be used to probe the signal at the input, pre-PID, and output stages. The probe points can be added by tapping the icon.

Oscilloscope



ID	Parameter	Description
1	Input probe point	Click to place the probe point at input.
2	Pre-PID probe point	Click to place the probe after the control matrix.
3	Output probe point	Click to place the probe at output.
4	Oscilloscope settings*	Additional settings for built-in oscilloscope.
5	Measurement*	Measurement function for built-in oscilloscope.
6	Oscilloscope*	Signal display area for oscilloscope.

*Detailed instructions for the oscilloscope instrument can be found in Moku:Go oscilloscope manual.

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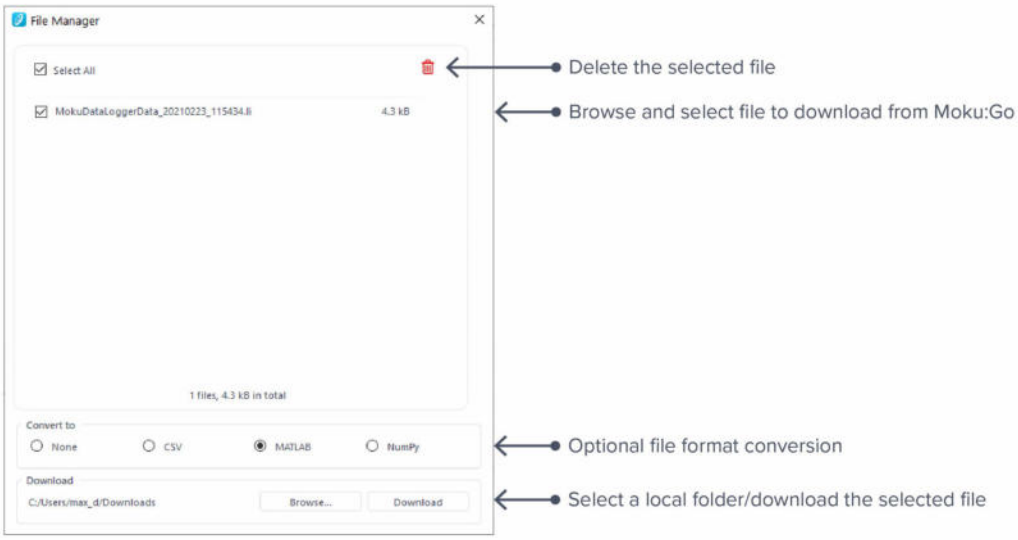
Additional Tools

Moku:Go's app has two built-in file management tools: file manager and file converter. The file manager allows users to download the saved data from Moku:Go to a local computer, with optional file format conversion. The file converter converts the Moku:Go's binary (.li) format on the local computer to either .csv, .mat, or .npy format.

File Manager



Once a file is transferred to the local computer, a icon shows up next to the file.

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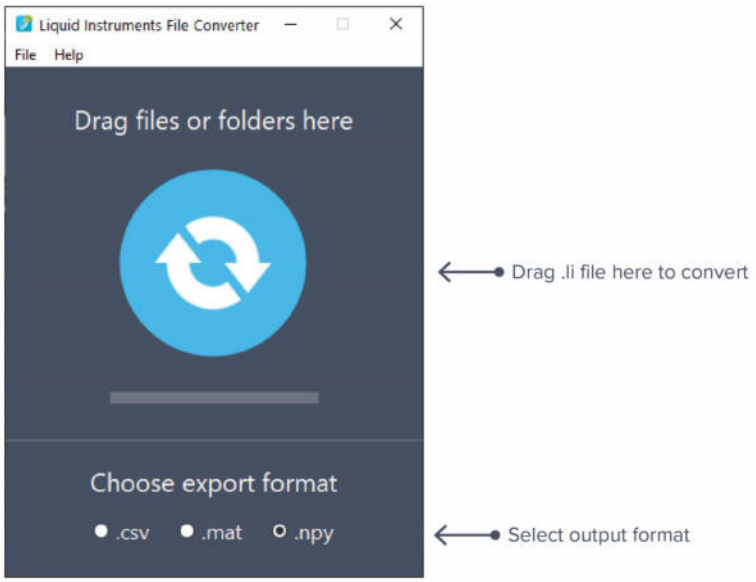
File Converter



The converted file is saved in the same folder as the original file.

Liquid Instruments File Converter has the following menu options:

Options	Shortcut	Description
File		
• **Open file**	Ctrl+O	Select a .li file to convert
• **Open folder**	Ctrl+Shift+O	Select a folder to convert
• **Exit**		Close the file converter window
Help		
• **Liquid Instruments website**		Access Liquid Instruments website
• **Report an issue**		Report bug to Liquid Instruments
• **About**		Show app version, check update, or license information

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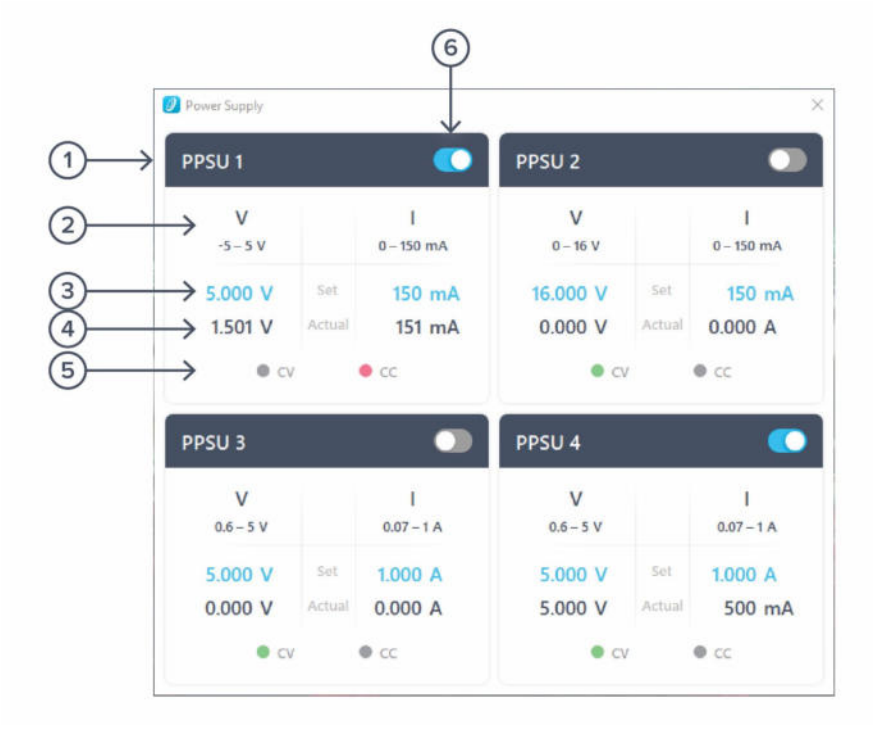
Power Supply

Moku:Go Power supply is available on M1 and M2 models. M1 features a 2-channel power supply, while M2 features a 4-channel power supply. The power supply control window can be accessed in all instruments under the main menu.

The power supply operates in two modes: **constant voltage (CV)** or **constant current (CC)** mode. For each channel, the user can set a current and voltage limit for the output. Once a load is connected, the power supply operates either at the set current or set voltage, whichever comes first. If the power supply is voltage limited, it operates in the CV mode. If the power supply is current limited, it operates in the CC mode.



ID	Function	Description
1	Channel name	Identifies the power supply being controlled.
2	Channel range	Indicates the voltage/current range of the channel.
3	Set value	Click the blue numbers to set the voltage and current limit.
4	Readback numbers	Voltage and current readback from the power supply, the actual voltage and current being supplied to the external load.
5	Mode indicator	Indicates if the power supply is in CV (green) or CC (red) mode.
6	On/Off Toggle	Click to turn the power supply on and off.

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Data Logger

Moku:Go User Manual

Moku:Go's Data Logger instrument records time series voltages from 1 or 2 channels at rates from 1 sample per second up to 1 MSa/s. The data can be logged to RAM in a variety of formats.

Moku:Go's Data Logger also includes an embedded waveform generator.

LIQUID INSTRUMENTS

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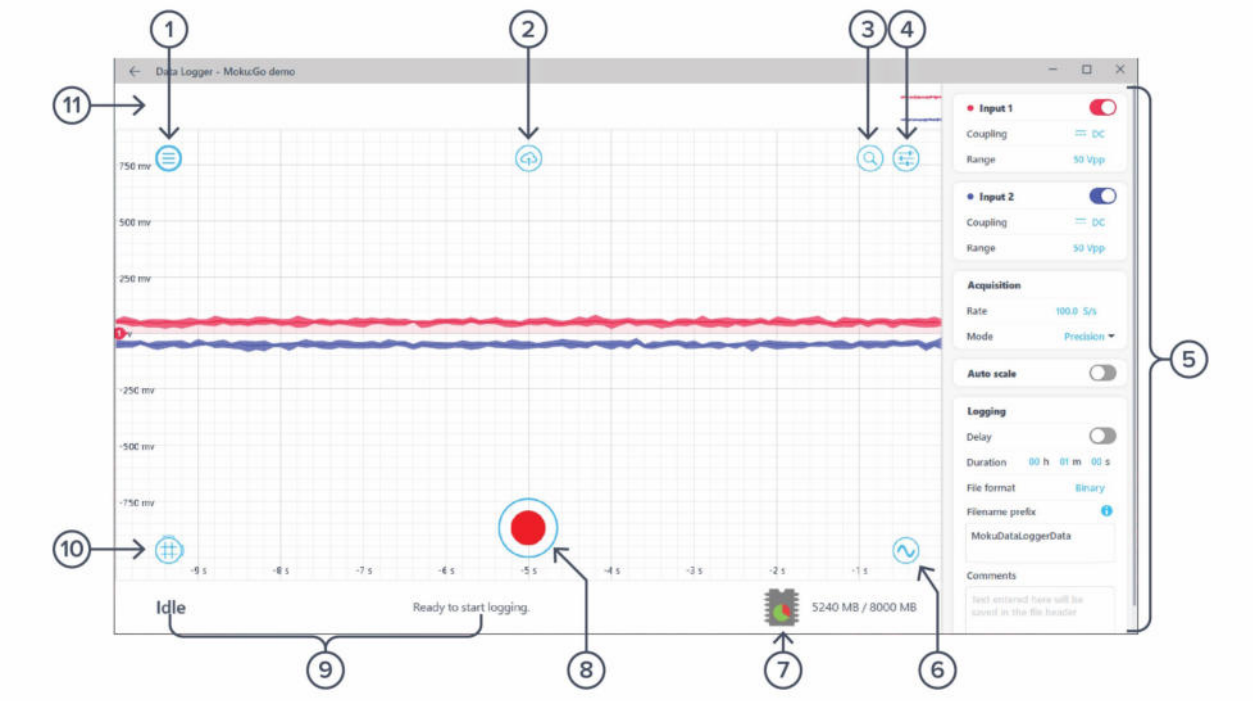
User Interface



ID	Description	ID	Description
1	Main menu	7	Storage indicator
2	Save data	8	Start logging
3	Screen navigation	9	Status indicator
4	Settings	10	Cursors
5	Settings pane	11	Zoom-out preview
6	Waveform generator		

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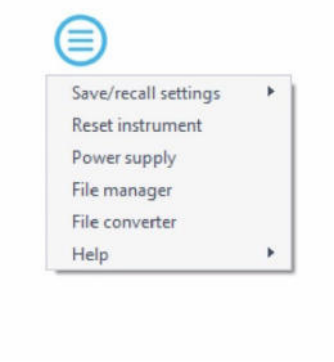
Main Menu

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



This menu provides the following options:

Options	Shortcuts	Description
Save/recall settings:		
• **Save instrument state**	Ctrl+S	Save the current instrument settings.
• **Load instrument state**	Ctrl+O	Load last saved instrument settings.
• **Show current sate**		Show the current instrument settings.
Reset instrument	Ctrl+R	Reset the instrument to its default state.
Power supply		Access power supply control window.*
File manager		Open file manager tool.**
File converter		Open file converter tool.**
Help		
• **Liquid Instruments website**		Access Liquid Instruments website.
• **Shortcuts list**	Ctrl+H	Show Moku:Go app shortcuts list.
• **Manual**	F1	Access instrument manual.
• **Report an issue**		Report bug to Liquid Instruments.
• **About**		Show app version, check update, or license information.

* Power supply is available on Moku:Go M1 and M2 models. Detailed information about power supply can be found in Moku:Go power supply manual.

**Detailed information about the file manager and file converter can be found toward the end of this user manual.

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File manager

The file manager can be access by clicking the icon, allowing saving and sharing of the captured data logs. Detailed information about the file manager and file converter can be found toward the end of this user manual.

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Signal Display Navigation

Mouse actions

Navigation can made by holding and draging action with mouse. This can be accomplished by holding the primary mouse button. Once the mouse curser turns to a icon, movement can be made along the horizonal or vertical axes. Horizonal or vertical movement can also be made with arrow keys.

The screen navigation options can be accessed when the mouse cursor hovers the icon.

Icons	Description
	Assign the horizonal axis as the primary axis.
	Assign the vertical axis as the primary axis.
	Rubber band zoom: hold the primary mouse button to draw a region to zoom-in, release the button to execute.

Scrolling the mouse wheel zooms in and out along the primary axis.

Additional combinations

Additional navigation actions are available with keyboard, or combinations of keyboard/mouse actions.

Actions	Description
Ctrl+Scroll Wheel	Zoom secondary axis.
+/-	Zoom primary axis with keyboard.
Ctrl +/-	Zoom secondary axis with keyboard.
Shift+Scroll Wheel	Zoom primary axis towards the center.
Ctrl+Shift+Scroll Wheel	Zoom secondary axis towards the center.
R	Rubber band zoom.

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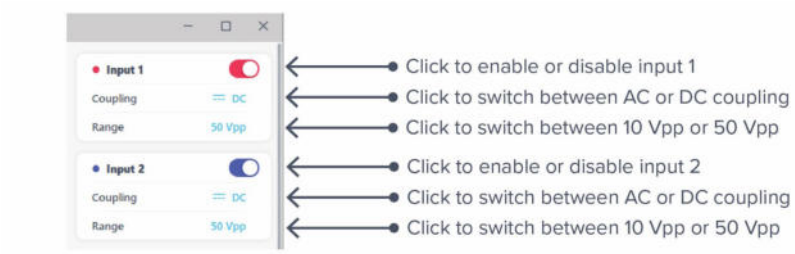
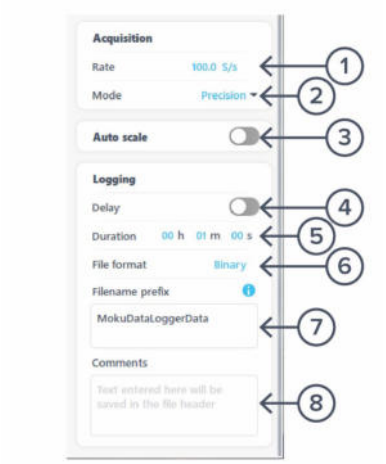
Settings

The **controls** options can be accessed by clicking the icon, allowing you to reveal or hide the control drawer, giving you access to all instrument settings. The controls drawer gives you access to analog front-end settings and data acquisition settings.

Analog front-end settings



Data acquisition settings



ID	Function	Description
1	Acquisition rate	Click to configure acquisition rate.
2	Mode	Set acquisition mode as normal or precision.
3	Auto scale	Toggle continuous autoscaling on/off.
4	Delay	Click to enable or disable delayed start.
5	Duration	Click to set log duration, limited to available memory.
6	File format	Click to select log format, CSV or LI binary format.
7	Filename prefix	Configure the prefix to be used on the data log filenames.
8	Comments	Text entered here will be saved in the file header.

Acquisition Parameters

The acquisition parameters refer to the logging rate and the down-sampling mode used to reduce Moku:Go's native sampling rate to the logging rate.

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The logging rate must be between 10 Sa/s and 1 MSa/s. The actual maximum is only achievable with a single channel, binary file format saved to RAM; other combinations will have lower maximum rates.

Acquisition mode may be either normal or precision. Normal mode down-samples by discarding points between those needed. This causes signals to alias; not desirable for most signals but can be useful for viewing frequency components outside the logging rate.

Precision mode down-samples by averaging, increasing precision and reducing noise. This mode is preferred for most applications.

File Types

Moku:Go's Data Logger can save natively to standard text-based CSV format files. CSV files contain a header that records the current instrument settings as well as any user-entered comments.

The binary file format is proprietary to Moku:Go and has been extensively optimized for speed and size. Using the binary format, Moku:Go is able to reach very high logging rates and very low memory usage.

The binary file can be converted to other formats by the file converter. This software can convert the binary file to CSV, MATLAB, or NPY formats for access in major scientific software. The binary format may also be used in Python through the Liquid Instruments Pymoku software library.

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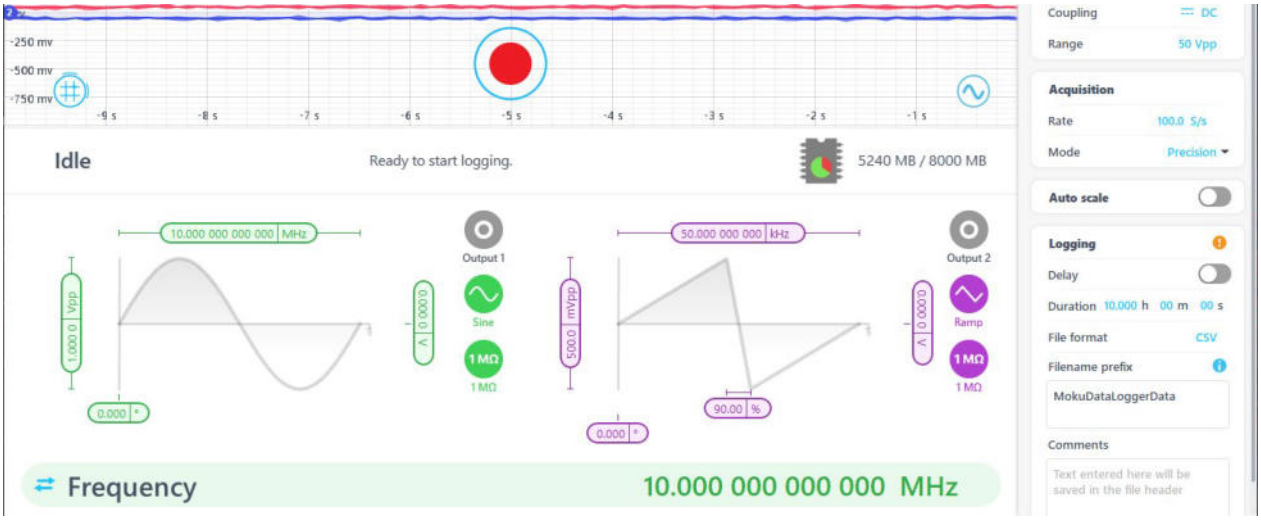
Waveform generator

Moku:Go's Data Logger has a built-in waveform generator capable of generating basic waveforms on the two output channels. Detailed instructions for the waveform generator instrument can be found in Moku:Go waveform generator manual.



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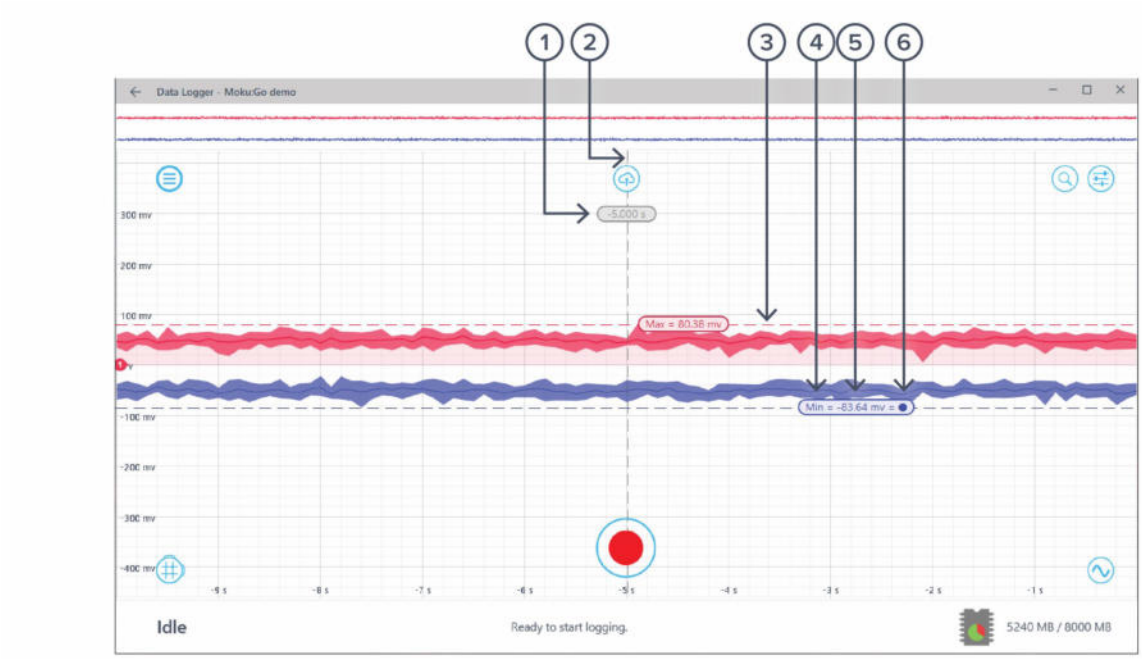
Cursor

The **cursors** can be accessed by clicking the icon, allowing you to add voltage, time cursors, or remove all cursors. In addition, you can click and hold the cursors icon, and drag horizontally to add a time cursor, or vertically to add a voltage cursor.

User Interface



ID	Parameter	Description
1	Time cursor reading	Right-click (secondary click) to reveal time cursor options. Drag left or right to set positions.
2	Time cursor	Color represents the channel of the measurement (Gray – Unattached, Red – channel 1, Blue – channel 2).
3	Voltage cursor	Drag up or down to set positions.
4	Cursor function	Indicates the current cursor function (max, min, max hold, etc).
5	Voltage reading	Right-click (secondary click) to reveal voltage cursor options.
6	Reference indicator	Indicates the cursor is set as reference. All other cursors in the same domain and channel measure the offset to the reference cursor.

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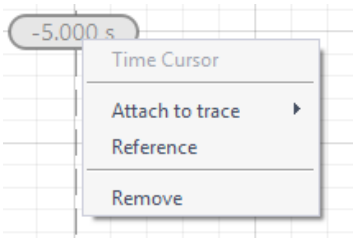
Time Cursor

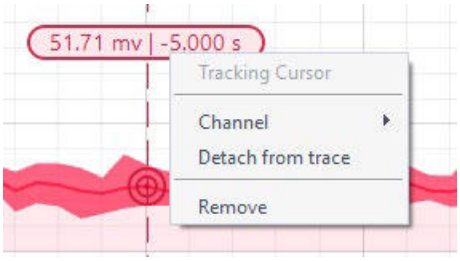
Right-click (secondary click) to reveal time cursor options:



Options	Description
Time Cursor	Cursor type.
Attach to trace	Choose to attach the time cursor to input 1, input 2. Once the cursor is attached to a channel, it becomes a tracking cursor. The tracking cursor gives continuous voltage readings at the set time position.
Reference	Set the cursor as the reference cursor.
Remove	Remove the time cursor

Tracking Cursor

Right-click (secondary click) to reveal tracking cursor options:



Options	Description
Tracking Cursor	Cursor type.
Channel	Assign the tracking cursor to a specific channel.
Detach from trace	Detach the tracking cursor from a channel trace
Remove	Remove the cursor

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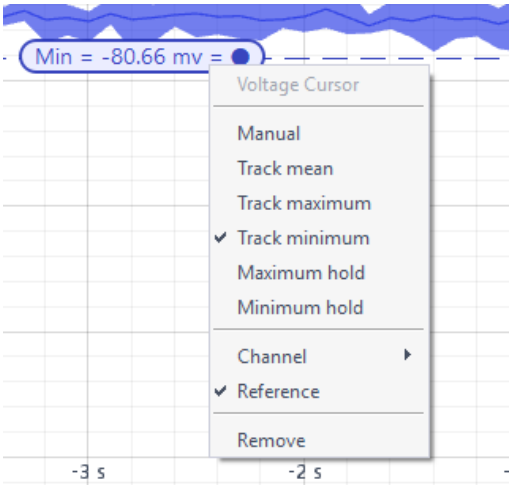
Voltage Cursor

Right-click (secondary click) to reveal voltage cursor options:



Options	Description
Voltage Cursor	Cursor type.
Manual	Manually set the vertical position of the cursor.
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 at the maximum voltage level.
Minimum hold	Set the cursor to hold at minimum voltage level.
Channel	Assign the voltage cursor to a specific channel.
Reference	Set the cursor as the reference cursor.
Remove	Remove the cursor.

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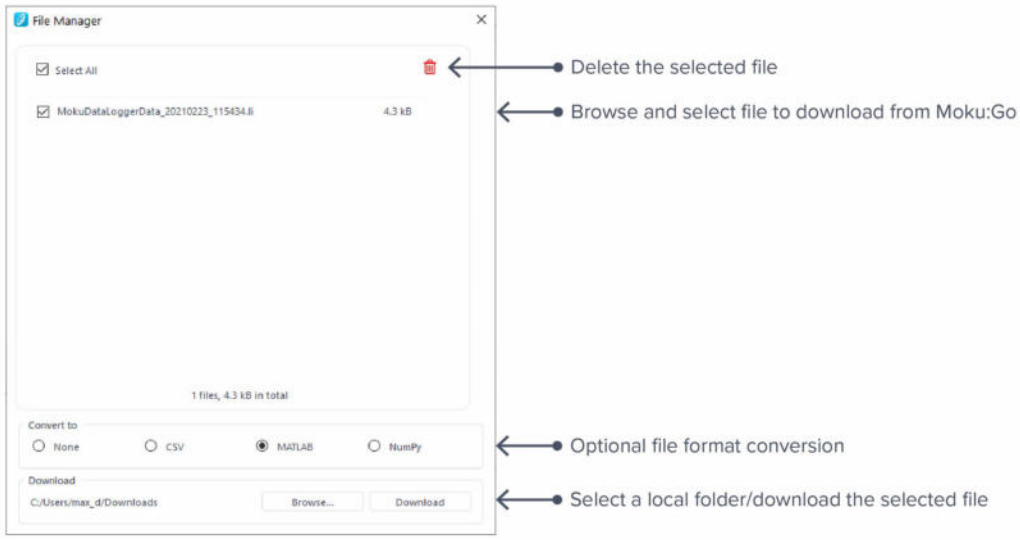
Additional Tools

Moku:Go app has two built-in file management tools: file manager and file converter. The file manager allows user to download the saved data from Moku:Go to the local computer, with optional file format conversion. The file converter converts the Moku:Go's binary (.li) format on the local computer to either .csv, .mat, or .npy format.

File Manager



Once a file is transferred to the local computer, a icon shows up next to the file.

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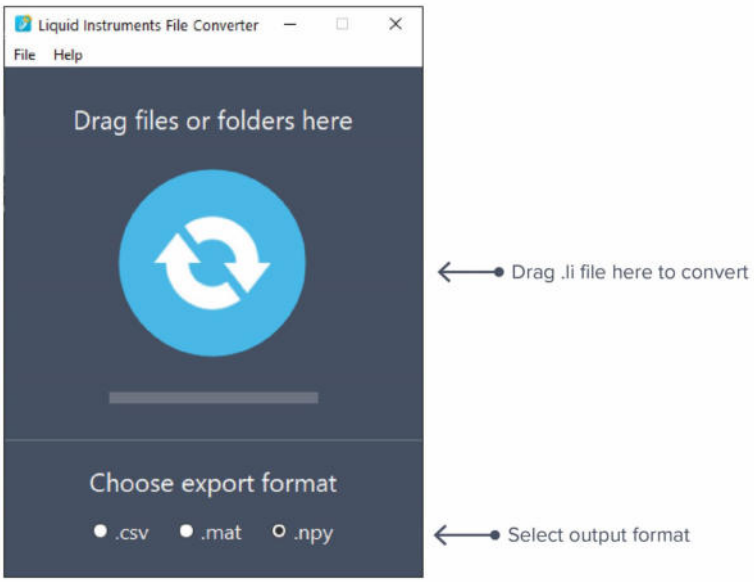
File Converter



The converted file is saved in the same folder as the original file.

Liquid Instruments File Converter has the following menu options:

Options	Shortcut	Description
File		
• **Open file**	Ctrl+O	Select a .li file to convert
• **Open folder**	Ctrl+Shift+O	Select a folder to convert
• **Exit**		Close the file converter window
Help		
• **Liquid Instruments website**		Access Liquid Instruments website
• **Report an issue**		Report bug to Liquid Instruments
• **About**		Show app version, check update, or license information

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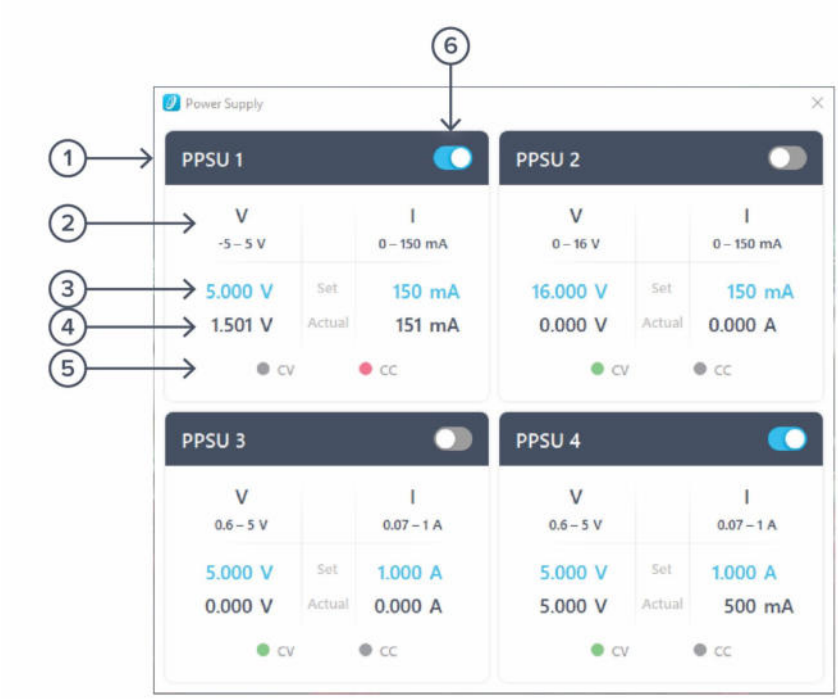
Power Supply

Moku:Go Power supply is available on M1 and M2 models. M1 features a 2-channel power supply, while M2 features a 4-channel power supply. The power supply control window can be accessed in all instruments under the main menu.

The power supply operates in two modes: **constant voltage (CV)** or **constant current (CC)** mode. For each channel, the user can set a current and voltage limit for the output. Once a load is connected, the power supply operates either at the set current or set voltage, whichever comes first. If the power supply is voltage limited, it operates in the CV mode. If the power supply is current limited, it operates in the CC mode.



ID	Function	Description
1	Channel name	Identifies the power supply being controlled.
2	Channel range	Indicates the voltage/current range of the channel.
3	Set value	Click the blue numbers to set the voltage and current limit.
4	Readback numbers	Voltage and current readback from the power supply, the actual voltage and current being supplied to the external load.
5	Mode indicator	Indicates if the power supply is in CV (green) or CC (red) mode.
6	On/Off Toggle	Click to turn the power supply on and off.

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Arbitrary Waveform Generator

Moku:Go User Manual

Moku:Go's Arbitrary Waveform Generator can generate custom waveforms with up to 65,536 points at update rates of up to 125 MSa/s. Waveforms can be loaded from a file, or input as a piece-wise mathematical function with up to 32 segments, enabling you to generate truly arbitrary waveforms. In pulsed mode, waveforms can be output with more than 250,000 cycles of dead time between pulses, allowing you to excite your system with an arbitrary waveform at regular intervals over extended periods of time.

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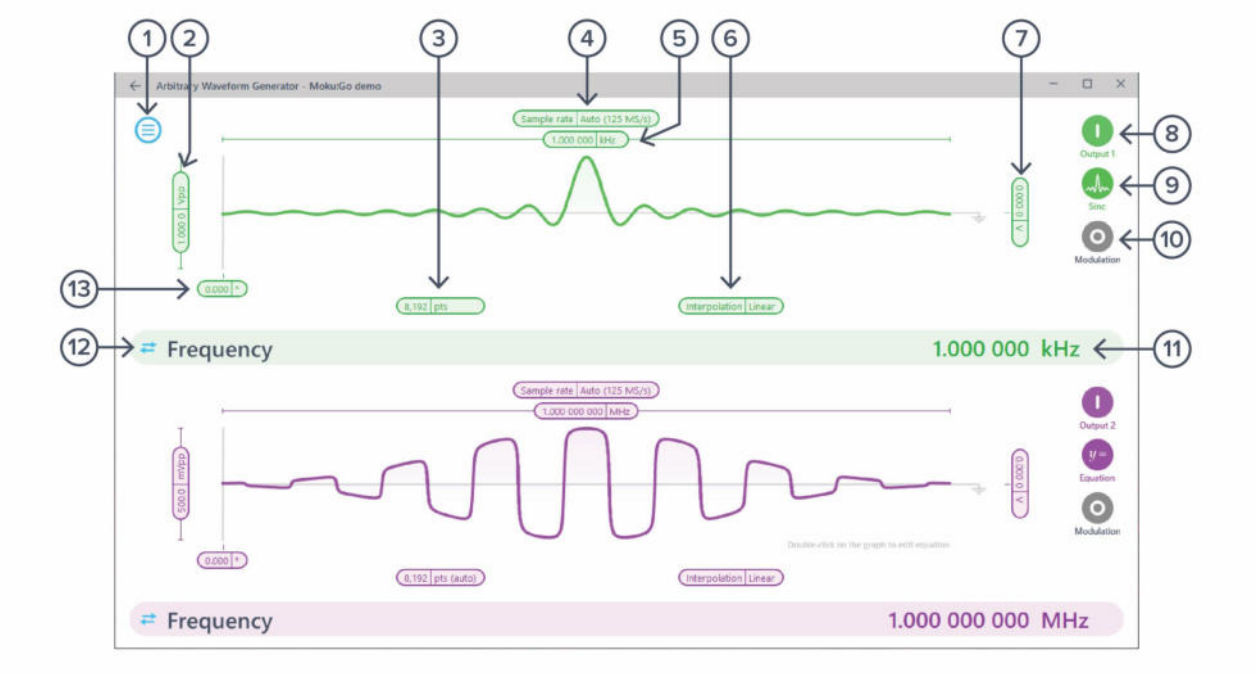
User Interface



ID	Description	ID	Description
1	Main menu	8	Enable/disable output
2	Configure amplitude / high level	9	Configure waveform shape
3	Configure number of points	10	Enable/disable modulation
4	Configure sample rate	11	Active parameter*
5	Configure frequency / period / update rate	12	Switch between representations*
6	Turn linear interpolation on or off	13	Configure phase
7	Configure offset		

*Click the amplitude, offset, frequency, or phase number to make it the active parameter. For amplitude and offset, click the swap button to switch between Vpp/offset or high/low level representations. For frequency, click the swap button to switch between frequency or period representations.

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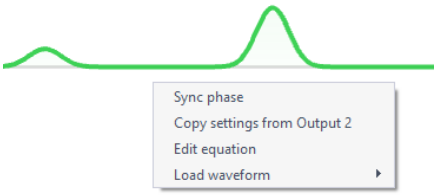
Secondary click

Sync phase with copy settings between channels can be accessed by right click (secondary click) menu on the main user interface. The settings on one output can be instantly applied to the other output with copy settings. And the phase between two channels can be aligned with sync phase. In additional, you can edit the equation or load your custom waveform via this menu. Detailed information about the equation editor and custom waveform can be found in a later section.



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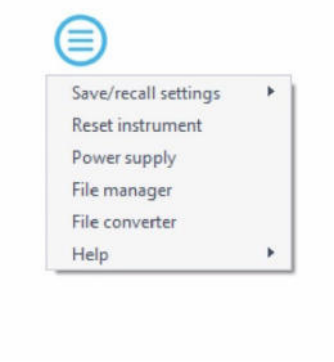
Main Menu

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



This menu provides the following options:

Options	Shortcuts	Description
Save/recall settings:		
• **Save instrument state**	Ctrl+S	Save the current instrument settings.
• **Load instrument state**	Ctrl+O	Load last saved instrument settings.
• **Show current sate**		Show the current instrument settings.
Reset instrument	Ctrl+R	Reset the instrument to its default state.
Power supply		Access power supply control window.*
File manager		Open file manager tool.
File converter		Open file converter tool.
Help		
• **Liquid Instruments website**		Access Liquid Instruments website.
• **Shortcuts list**	Ctrl+H	Show Moku:Go app shortcuts list.
• **Manual**	F1	Access instrument manual.
• **Report an issue**		Report bug to Liquid Instruments.
• **About**		Show app version, check update, or license information.

* Power supply is available on Moku:Go M1 and M2 models. Detailed information about power supply can be found in Moku:Go power supply manual.

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Output Configuration

Enable / Disable Outputs

Enable the output of the selected channel by pressing the icon

Disable the output of the selected channel by pressing the icon

Load Impedance

Moku:Go assumes the external load to have a high load impedance.

Selecting the correct load impedance

Moku:Go's outputs have an impedance of 200 Ω. As such, voltages supplied to a 50 Ω load will be reduced and not recommended.

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Modulation Modes

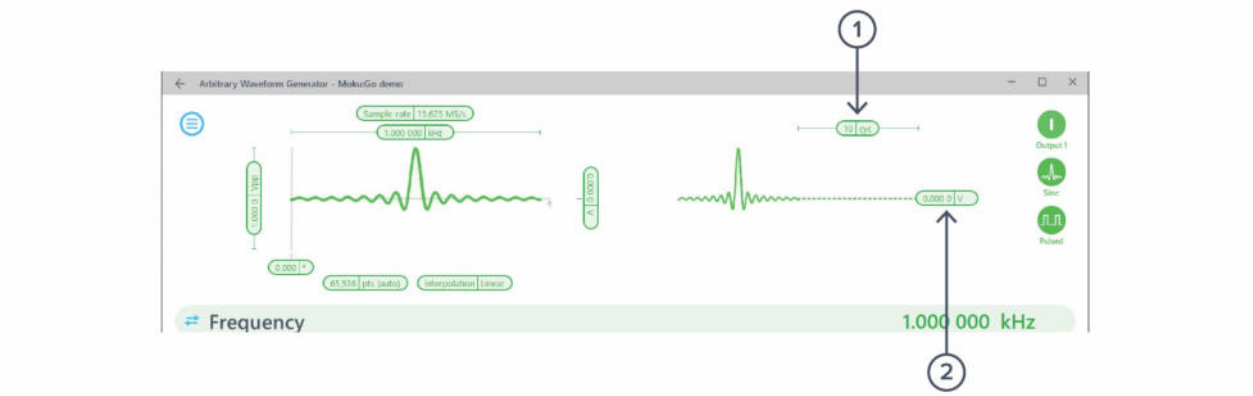
Moku:Go's Arbitrary Waveform Generator supports three modulation modes: Off, Pulsed, and Bursted.

Off

In normal mode, the output waveform is repeated continuously with no dead time between cycles.

Pulsed

In pulsed mode, the output waveform can be configured to have up to 2^{18} = 262144 cycles of dead time between each repetition of the arbitrary waveform.



ID	Parameter	Description
1	Dead cycles	The period of each cycle of dead time is equal to the selected period of the waveform.
2	Dead voltage	The dead time voltage can be configured to equal any DC value between the waveform's minimum and maximum voltages.

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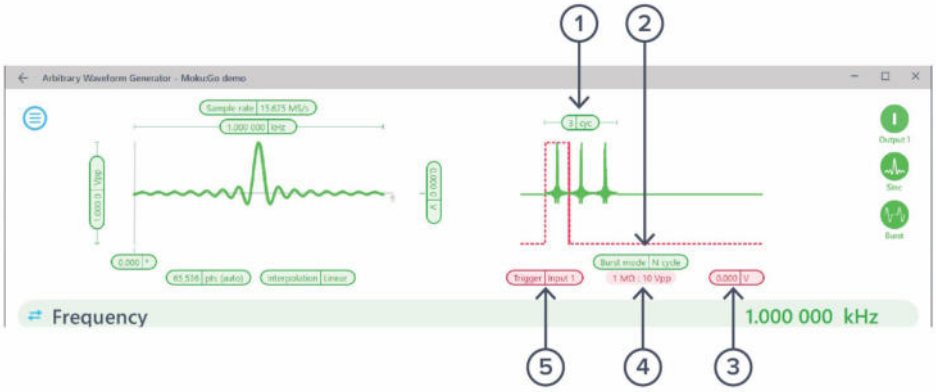
Burst

In burst mode, the output waveform can be triggered from another signal source. The output once triggered varies according to the trigger mode.



ID	Parameter	Description
1	Burst cycle count	N - Cycle mode only. The number of cycles to generate before re-arming.
2	Burst mode	N -Cycle or Start. The Start mode generates infinite loops of the waveform after the trigger event.
3	Trigger level	Set the voltage level to trigger at.
4	Input range	Set the input channel range.
5	Trigger source	Select between input 1 or 2.

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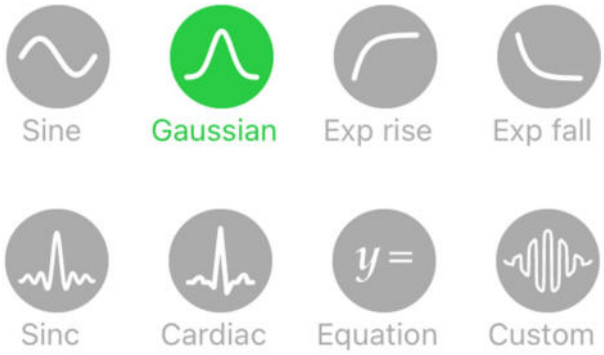
Waveform Types

Generate one of five pre-set waveforms, a custom waveform from a file, or a waveform defined by a series of piece-wise mathematical equations.



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Custom

Uploading custom waveforms

- Upload custom waveforms from comma- or newline-delimited text from a computer file or clipboard.
- Up to 8,192 points can be output at an update rate of 125 MSa/s, up to 16,384 points at 62.5 MSa/s, up to 32768 points at 31.25 MSa/s and up to 65,536 points at 15.625 MS/s

Maximum recommended sampling rate

- The maximum safe frequency of the generated waveform is equal to the sampling rate divided by the number of points in the custom waveform .
    - For example, the maximum safe frequency of a 1000-point waveform is 125 MSa/s ÷ 1000 Samples = 125 kHz .
- Exceeding the maximum recommended frequency will result in some points being skipped.

Amplitude scaling and interpolation

- The amplitude of custom waveforms will be normalized to the range [-1, +1] and then scaled to the desired amplitude and offset.
- Select between linear and no interpolation.

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Equation

The **equation waveform type** enables you to design arbitrary waveforms using up to 32 piece-wise mathematical functions.

Waveform segments

- Add up to 32 waveform segments and define their time fractional time periods within a single period of the total waveform.
- To add or remove segments, press the Add / Remove label and click the + and − icons that appear to the left of the equations.
- To modify the period of an individual segment, click its **time segment** label and type in the desired end time for that period. The starting time for each segment is the end time for the previous segment.

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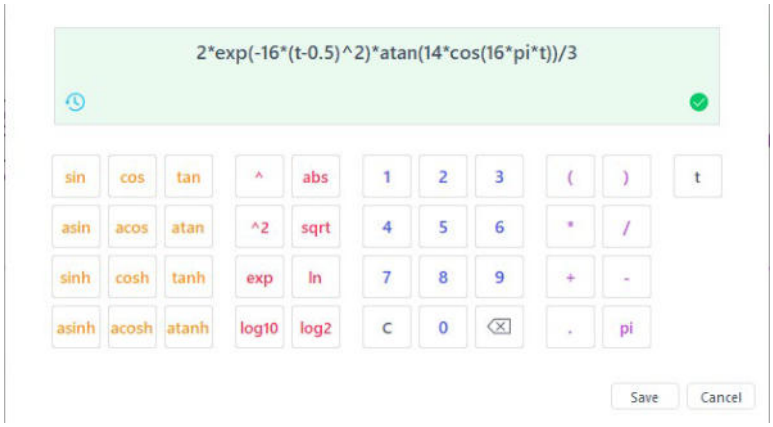
Equation editor

- The equation editor allows you to define arbitrary mathematical functions for each segment in the waveform.
- Select from a range of common mathematical expressions including trigonometric, quadratic, exponential and logarithmic functions.
- The variable **t** represents time in the range from 0 to 1 periods of the total waveform
- Access recently entered equations by pressing the icon.
- The validity of the entered equation is indicated by the and icons that appear to the right of the equation box.



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Power Supply

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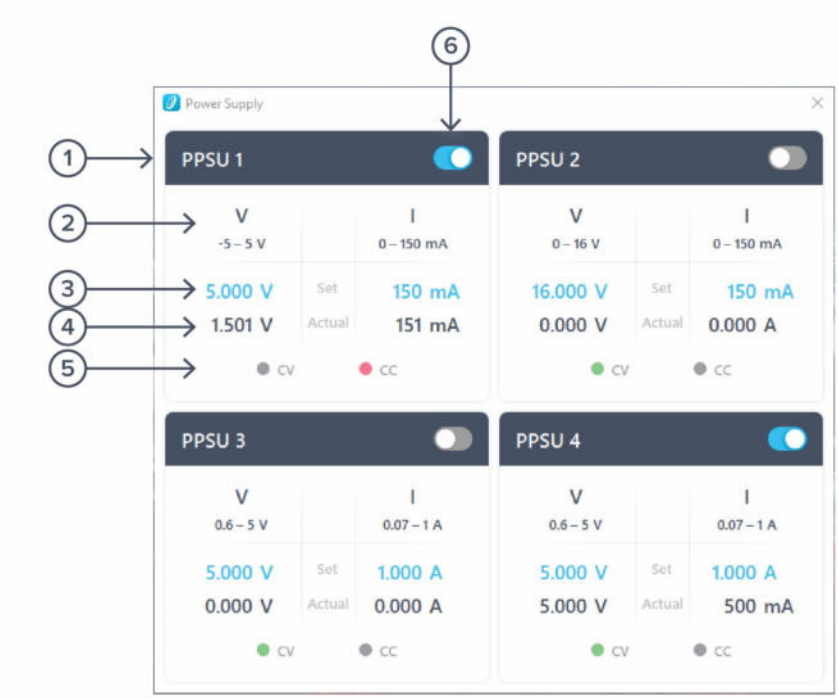

ID	Function	Description
1	Channel name	Identifies the power supply being controlled.
2	Channel range	Indicates the voltage/current range of the channel.
3	Set value	Click the blue numbers to set the voltage and current limit.
4	Readback numbers	Voltage and current readback from the power supply, the actual voltage and current being supplied to the external load.
5	Mode indicator	Indicates if the power supply is in CV (green) or CC (red) mode.
6	On/Off Toggle	Click to turn the power supply on and off.

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Spectrum Analyzer

Moku:Go User Manual

Moku:Go's Spectrum Analyzer allows you to observe input signals in the frequency domain between DC and 30 MHz. View two channels of data simultaneously with a resolution bandwidth as low as 1 Hz over a minimum span of 100 Hz. The Spectrum Analyzer also features two integrated waveform generators capable of producing sine waves at up to 20 MHz.

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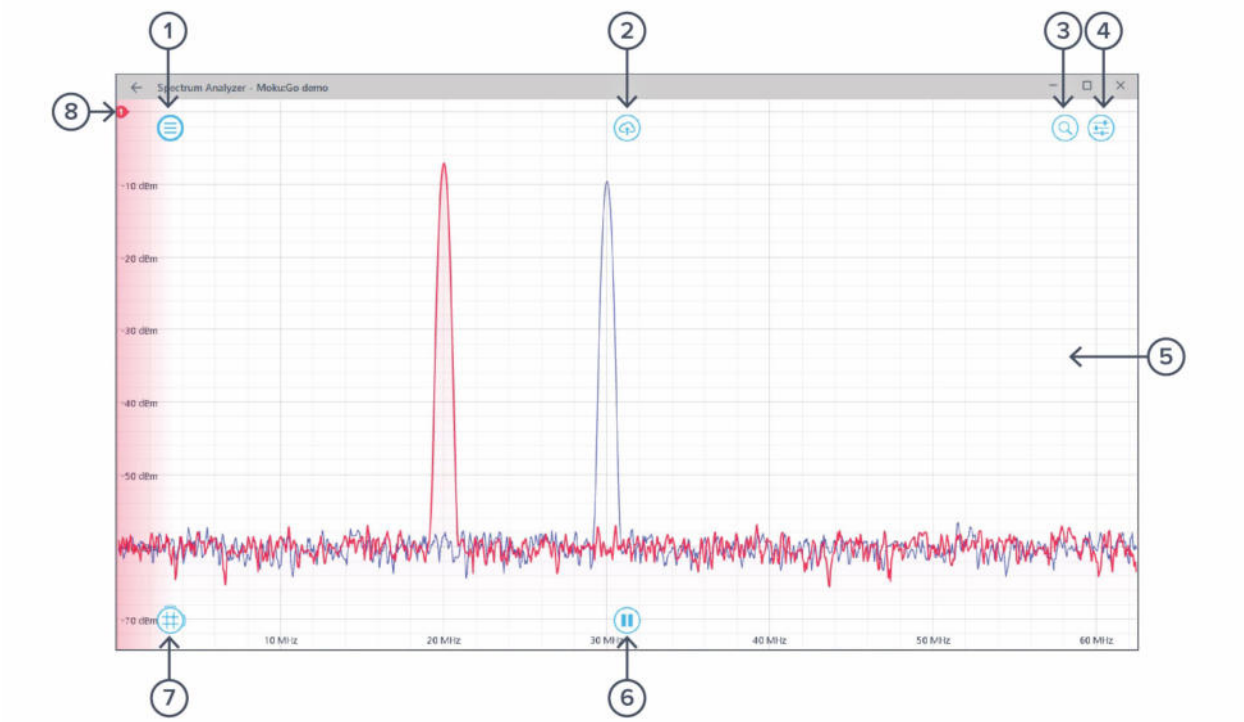
User Interface



ID	Description	ID	Description
1	Main menu	5	Signal display area
2	Save data	6	Play/Pause
3	Signal display navigation	7	Cursors
4	Settings	8	Reference position indicator

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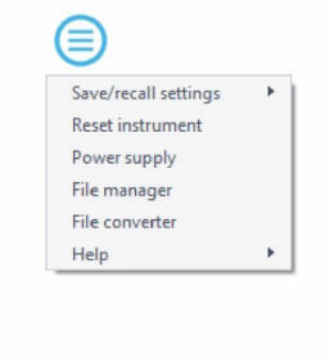
Main Menu

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



This menu provides the following options:

Options	Shortcuts	Description
Save/recall settings:		
• **Save instrument state**	Ctrl+S	Save the current instrument settings.
• **Load instrument state**	Ctrl+O	Load last saved instrument settings.
• **Show current sate**		Show the current instrument settings.
Reset instrument	Ctrl+R	Reset the instrument to its default state.
Power supply		Access power supply control window.*
File manager		Open file manager tool.**
File converter		Open file converter tool.**
Help		
• **Liquid Instruments website**		Access Liquid Instruments website.
• **Shortcuts list**	Ctrl+H	Show Moku:Go app shortcuts list.
• **Manual**	F1	Access instrument manual.
• **Report an issue**		Report bug to Liquid Instruments.
• **About**		Show app version, check update, or license information.

* Power supply is available on Moku:Go M1 and M2 models. Detailed information about power supply can be found in Moku:Go power supply manual.

**Detailed information about the file manager and file converter can be found at the end of this user manual.

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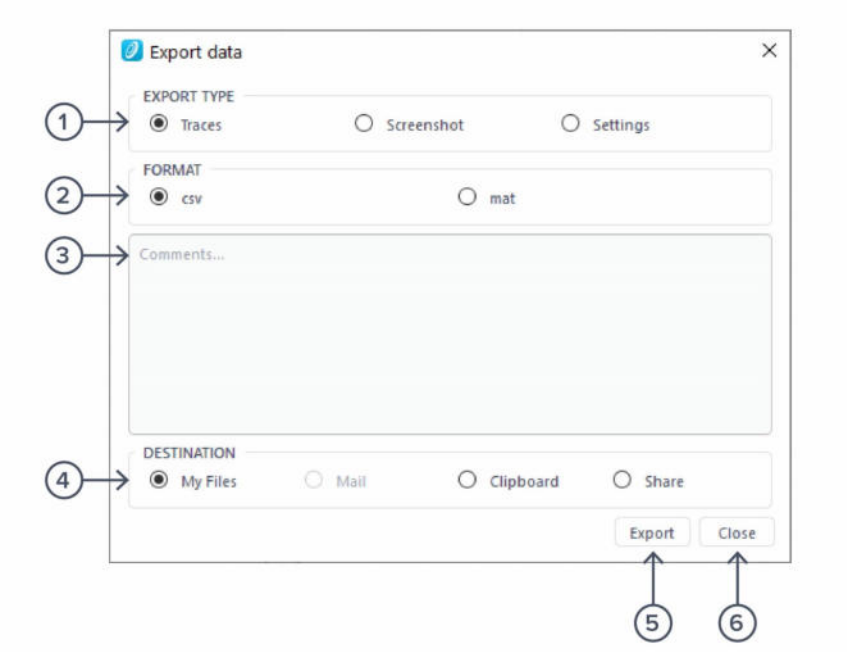
Export data

The **export data** options can be accessed by pressing the icon, allowing you to:



ID	Description
1	Select the type of data to export.
2	Select the exporting format (CSV or MAT).
3	Enter additional comments for the saved file.
4	Select the exporting location on your local computer.
5	Click to execute data export.
6	Click to close the export data window.

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Signal Display Navigation

Signal display position

The displayed siganl can be moved around the screen by clicking anywhere on the signal display window and dragging to the new position. The cursor will turn into a icon once clicked, drag horizontally to shift along the frequency axis and drag vertically to shift along the amplitude/power axis.

The signal display can also be moved hotizontally and vertically with arrow keys.

Display scale and zoom

Scrolling the mouse wheel zooms in and out along the primary axis. Access the scroll setting by hovering the cursor over the icon.

Icons	Description
	Assign the horizonal axis as the primary axis.
	Assign the vertical axis as the primary axis.
	Rubber band zoom: hold the primary mouse button to draw a region to zoom-in, release the button to execute.

Additional keyboard combinations are also available.

Actions	Description
Ctrl + Scroll Wheel	Zoom secondary axis.
+/-	Zoom primary axis with keyboard.
Ctrl +/-	Zoom secondary axis with keyboard.
Shift + Scroll Wheel	Zoom primary axis towards the center.
Ctrl + Shift + Scroll Wheel	Zoom secondary axis towards the center.
R	Rubber band zoom.

Auto scale

Double click anywhere on the signal display window to auto scale the traces.

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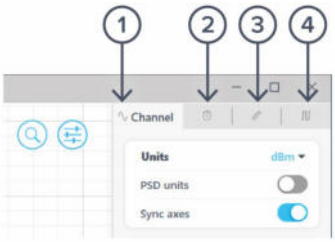
Settings

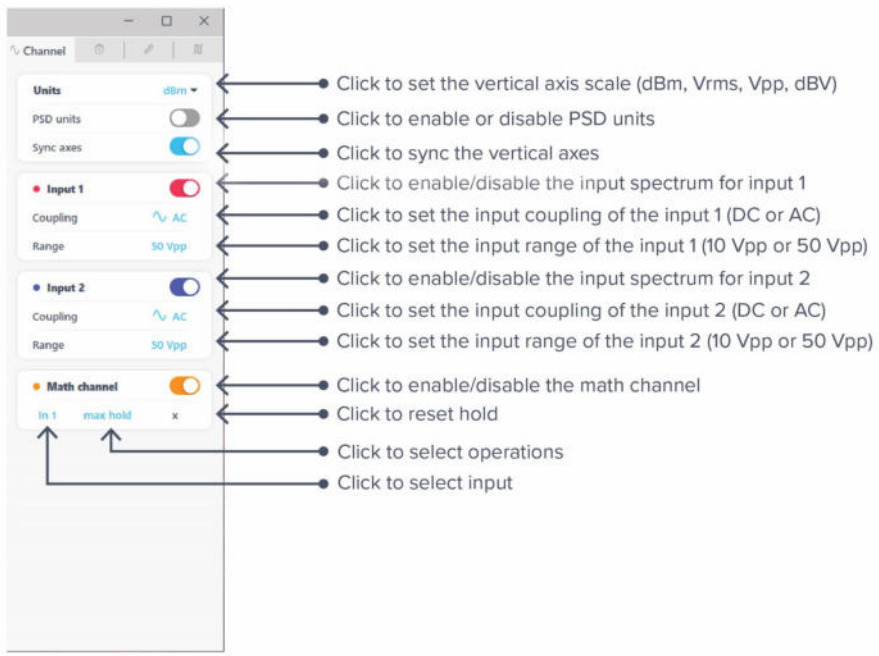
The **controls** options can be accessed by clicking the icon, allowing you to reveal or hide the control drawer, giving you access to all instrument settings. The controls drawer contains channels, frequency, measurement, and output settings.



ID	Description
1	Channel
2	Frequency
3	Measurement
4	Output

Channels

The **channels** pane allows you to change the input settings for each ADC channel, adjust the input scales and coupling, and enable/disable the math channel.



Four operations are currently supported by Moku:Go's Spectrum Analyzer: +, ×, min hold, and max hold.

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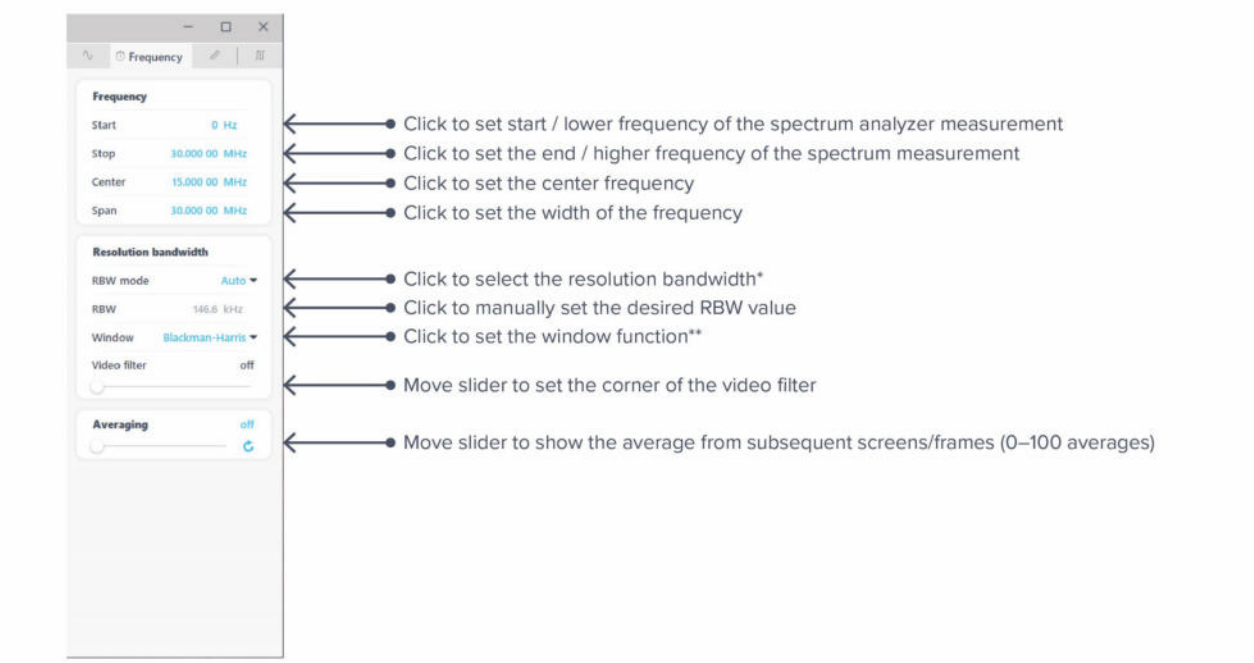
Frequency

The **frequency** pane allows you to change parameters related to the frequency domain (horizontal axis), including frequency span, resolution bandwidth (RBW), and video bandwidth.



Note that [Start, Stop] and [Center, Span] in the frequency panel are equivalent representations of the measured frequency range. Moku:Go will automatically update the other pair if one is changed.

* Auto: determines the best RBW automatically; Manual: manually set the RBW; Min: uses the smallest RBW available.

** Available options: Blackman-Harris, Flat top, Hanning, and None.

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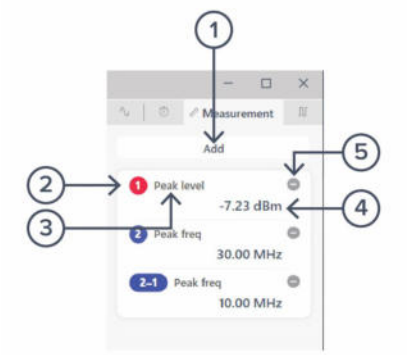
Measurement

The measurement pane allows you to add/remove measurements to probe a spectra's peak level, peak frequency, noise level, etc. A measurement can be assigned to a specific input channel, math channel, or difference between any two channels.



ID	Description
1	Click to add additional measurement tile.
2	Measurement source. Click to loop through the measurement sources.
3	Measurement type.
4	Measurement value.
5	Click to remove the measurement tile.

Click a measurement tile to open the menu to adjust the measurement. The following options are available:

Options	Description
Type	Select the measurement type.
• **Peak level**	Power/voltage level of the highest peak.
• **Peak frequency**	Frequency of the highest peak.
• **Noise level**	Power/voltage level of the average baseline.
• **Peak SNR**	The signal-to-noise ratio of the highest peak to the baseline.
• **Occupied BW**	Occupied bandwidth of the highest peak.
Channels	Select measurement source.
Difference Channels	Measure the difference between the measurement source to another channel.
Remove	Remove the measurement tile.

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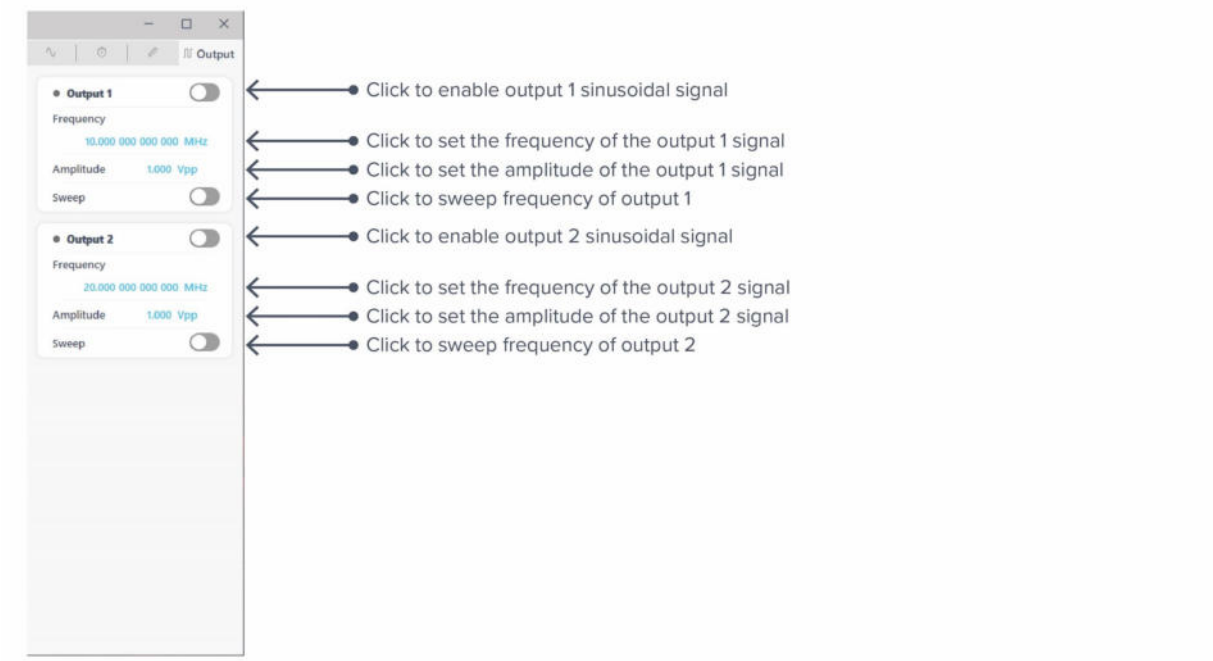
Output

The **output** pane allows you to configure the Spectrum Analyzer's integrated sine wave generator.



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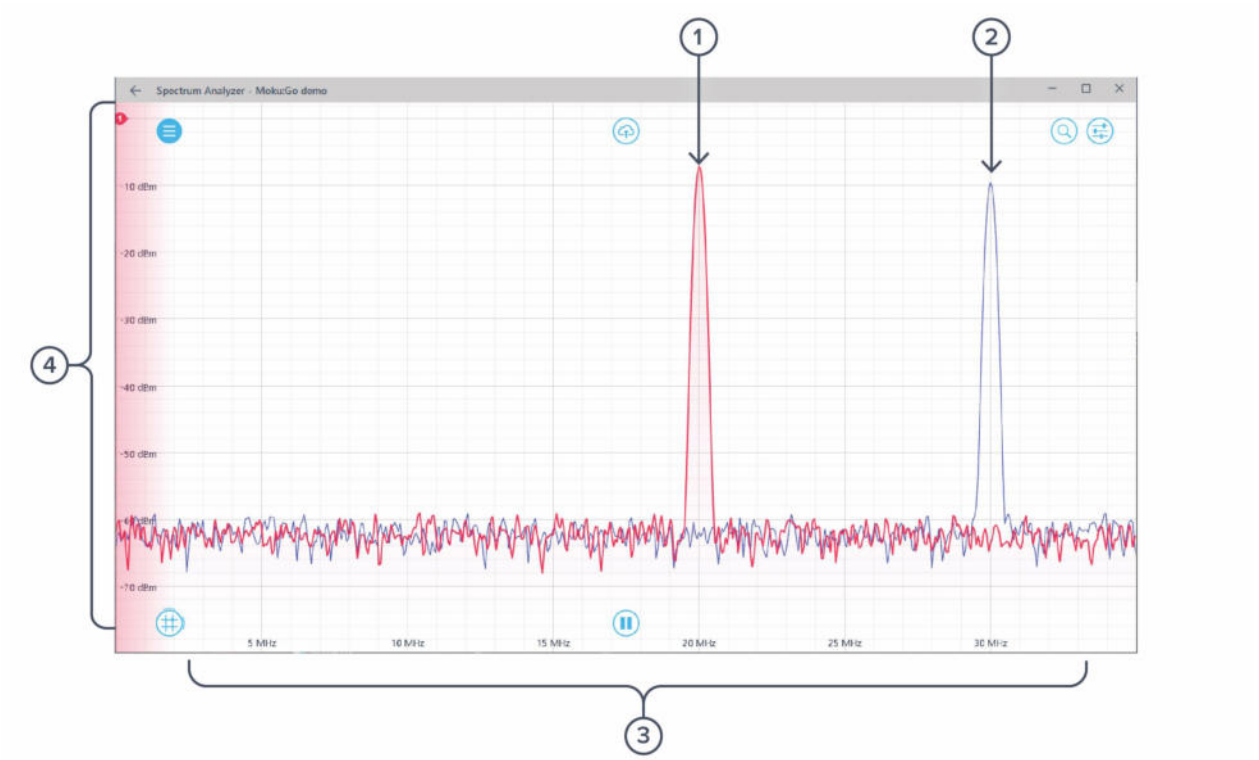
Display

User Interface

This area is intended to display the spectrum of input and math channels, where the horizontal axis is the measured frequency range and the vertical axis is the power or power spectral density (PSD) in linear or log scales.



ID	Description
1	Spectrum for input channel 1.
2	Spectrum for input channel 2.
3	Frequency axis: shows the frequency scale for both channels.
4	Power axis: shows the power scale for the active channel. *

The scales of both axes can be zoom and drag.

* The shaded color near the vertical axis indicates the active channel. Red represents channel 1, blue represents channel 2, and yellow represents the math channel.

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Spectrum Trace

Right-click (secondary click) in the signal display area reveals additional option for the active channel. You can add or remove reference trace, or save the current frame on the display via this menu. Options regarding to cursors is covered in detail in the next section.

Options	Description
Show reference trace	Display the current frame as reference trace.
Clear reference trace	Clear the current reference trace.
Save current frame	Open the export data window.

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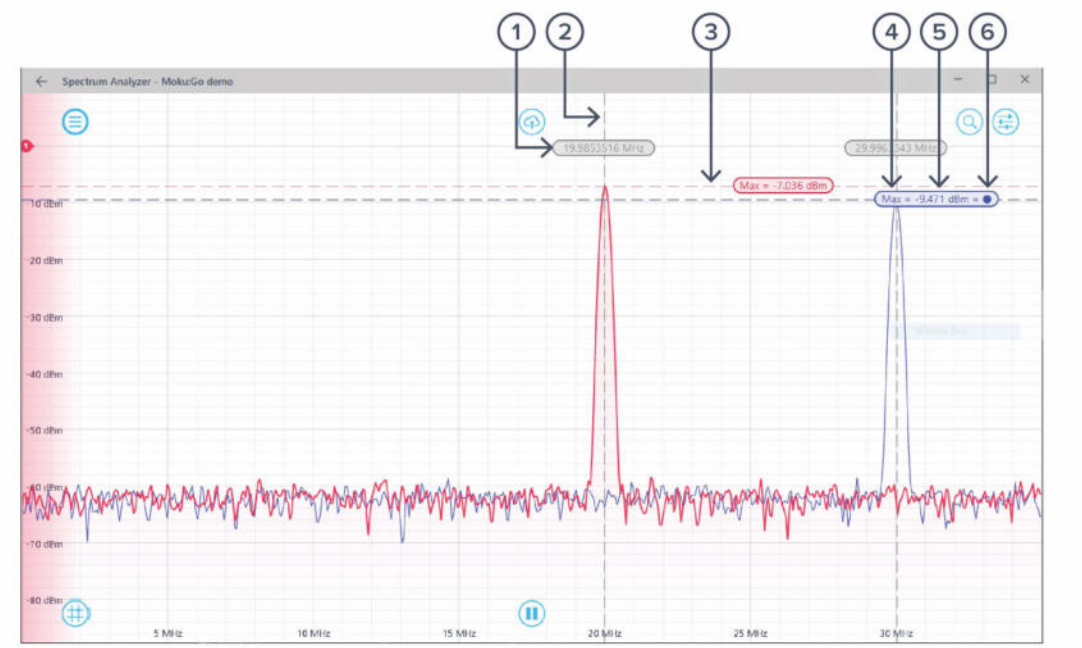
Cursors

The **cursors** can be accessed by clicking the icon, allowing you to add power or frequency cursors, or remove all cursors. In addition, you can click and hold the cursors icon, and drag horizontally to add a frequency cursor, or vertically to add a power cursor.

User Interface



ID	Parameter	Description
1	Frequency reading	Right-click (secondary click) to reveal frequency cursor options. Drag left or right to set positions.
2	Frequency cursor	Color represents the channel of the measurement (Gray – Unattached, Red – channel 1, Blue – channel 2, Yellow - math).
3	Power cursor	Drag up or down to set positions.
4	Cursor function	Indicates the current cursor function (max, min, max hold, etc).
5	Amplitude reading	Right-click (secondary click) to reveal amplitude cursor options.
6	Reference indicator	Indicates the cursor is set as reference. All other cursors in the same domain and channel measure the offset to the reference cursor.

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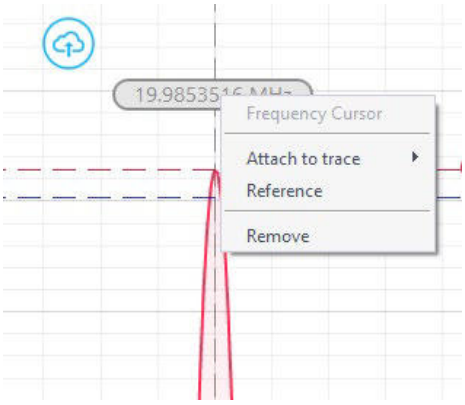
Frequency Cursor

Right-click (secondary click) to reveal frequency cursor options:



Options	Description
Frequency Cursor	Cursor type.
Attach to trace	Choose to attach the frequency cursor to input 1, input 2, or math channel. Once the cursor is attached to a channel, it becomes to a tracking cursor.
Reference	Set the cursor as the reference cursor.
Remove	Remove the frequency cursor

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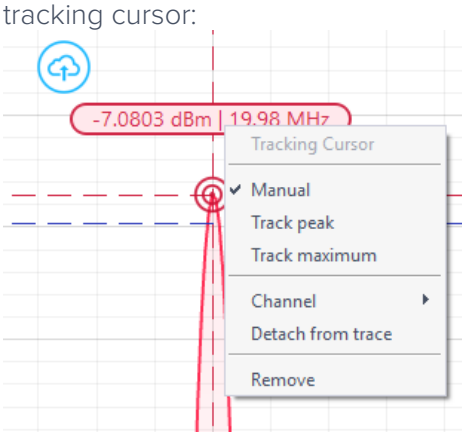
Tracking Cursor

Once a frequency cursor is attached to a channel, it becomes to a tracking cursor. It displays the set frequency, and the signal power level at the set frequency. Additional options are available for tracking cursor:



Options	Description
Tracking Cursor	Cursor type.
Manual	Manually set the tracking cursor frequency.
Track peak	Track the frequency of the closest peak.
Track maximum	Track the frequency of the global maximum.
Channel	Assign tracking cursor to a specific channel.
Detach from trace	Detach the tracking cursor to a frequency cursor.
Remove	Remove the tracking cursor.

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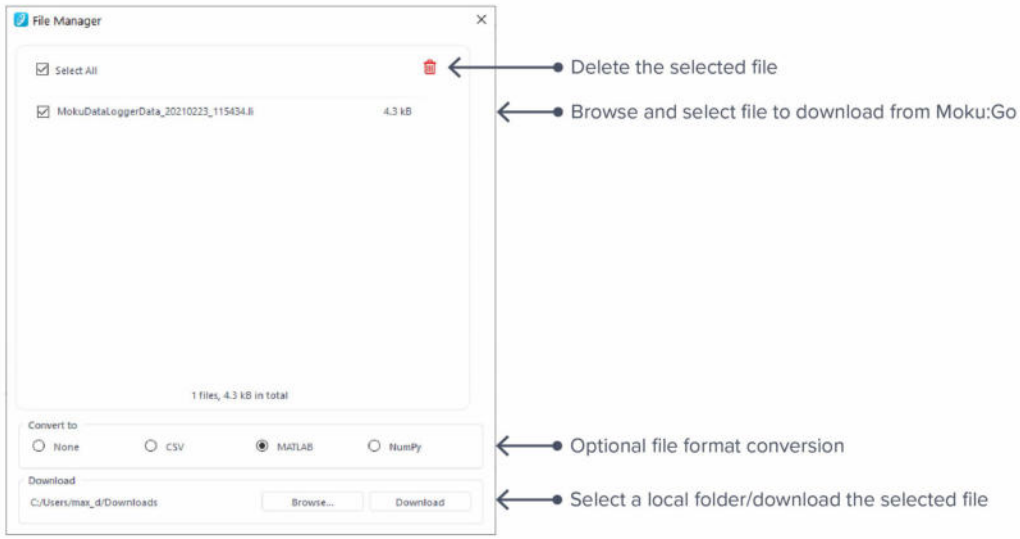
Additional Tools

Moku:Go app has two built-in file management tools: file manager and file converter.

File Manager

The file manager allows the user to download the saved data from Moku:Go to local computer, with optional file format conversion.



Once a file is transferred to the local computer, a icon shows up next to the file.

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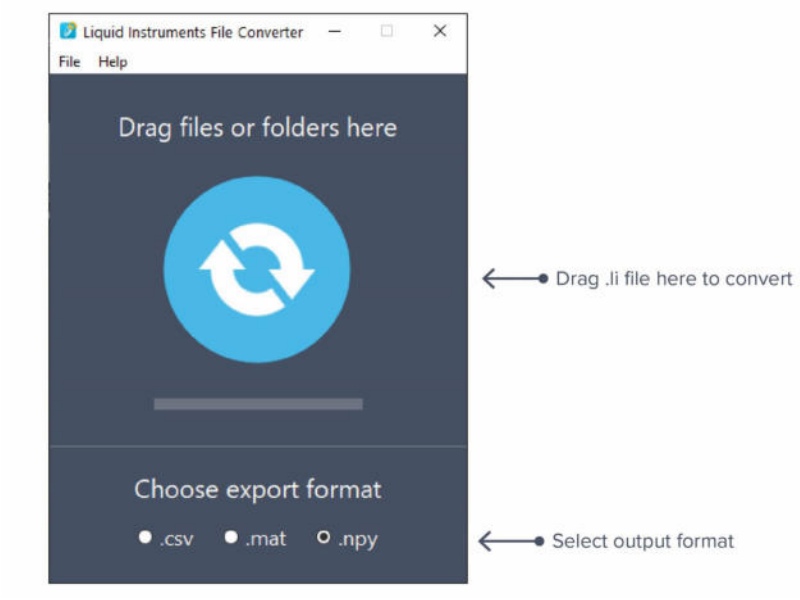
File Converter

The file converter converts the Moku:Go's binary (.li) format on the local computer to either .csv, .mat, or .npy format.



The converted file is saved in the same folder as the original file.

Liquid Instruments File Converter has the following menu options:

Options	Shortcut	Description
File		
• **Open file**	Ctrl+O	Select a .li file to convert
• **Open folder**	Ctrl+Shift+O	Select a folder to convert
• **Exit**		Close the file converter window
Help		
• **Liquid Instruments website**		Access Liquid Instruments website
• **Report an issue**		Report bug to Liquid Instruments
• **About**		Show app version, check update, or license information

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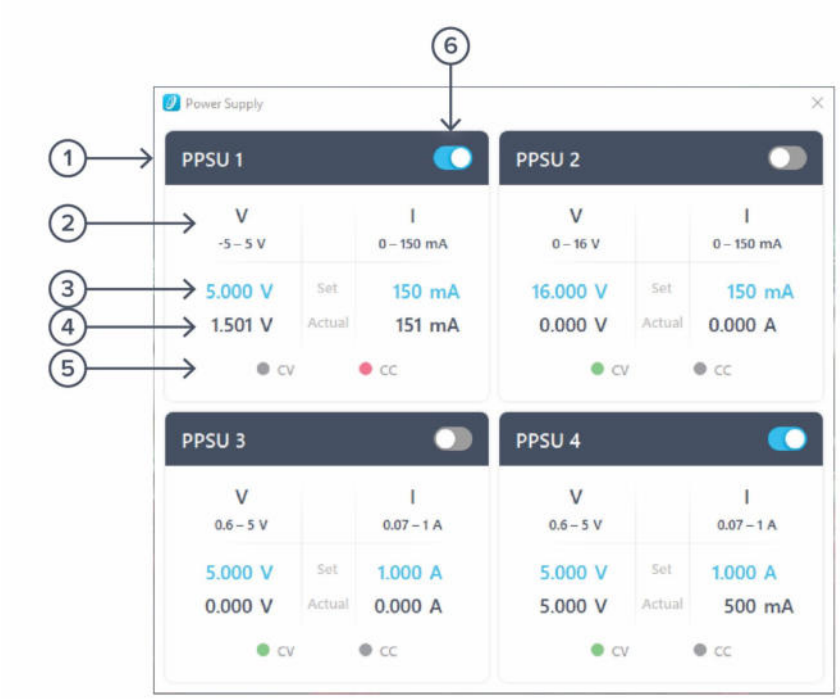
Power Supply

Moku:Go Power supply is available on M1 and M2 models. M1 features a 2-channel power supply, while M2 features a 4-channel power supply. The power supply control window can be accessed in all instruments under the main menu.

The power supply operates in two modes: **constant voltage (CV)** or **constant current (CC)** mode. For each channel, the user can set a current and voltage limit for the output. Once a load is connected, the power supply operates either at the set current or set voltage, whichever comes first. If the power supply is voltage limited, it operates in the CV mode. If the power supply is current limited, it operates in the CC mode.



ID	Function	Description
1	Channel name	Identifies the power supply being controlled.
2	Channel range	Indicates the voltage/current range of the channel.
3	Set value	Click the blue numbers to set the voltage and current limit.
4	Readback numbers	Voltage and current readback from the power supply, the actual voltage and current being supplied to the external load.
5	Mode indicator	Indicates if the power supply is in CV (green) or CC (red) mode.
6	On/Off Toggle	Click to turn the power supply on and off.

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Lock-in Amplifier

Moku:Go User Manual

Moku:Go's digital Lock-in Amplifier supports dual-phase demodulation (XY/Rθ) from DC to 20 MHz. It features an integrated 2-channel oscilloscope and data logger, enabling you to observe signals at up to 125 MSa/s and log data at up to 1 MSa/s. A PID controller can also be placed after the demodulation stage for phase-locked loop applications.

LIQUID INSTRUMENTS

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V22-0317

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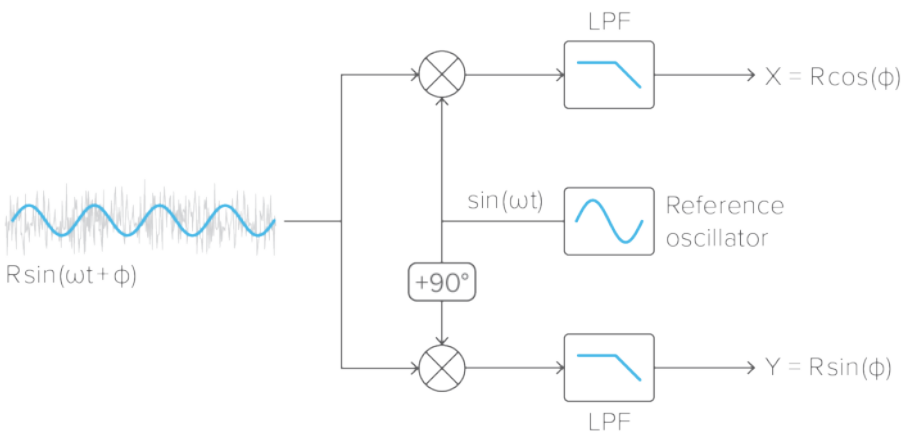
Introduction

Lock-in amplifiers are extremely versatile instruments used primarily to recover the magnitude and phase of weak oscillating signals in the presence of overwhelming noise. They are used in a vast range of applications including atomic physics, radio-frequency engineering, materials science, precision laser metrology, and many more.

Principle of Operation

Lock-in amplifiers work by demodulating an input signal $R\sin(\omega t + \phi)$ with a reference signal $\sin(\omega t)$.



The demodulation process produces two spectral components: an *up-shifted* signal with a frequency equal to the *sum* of the input and reference signals, and a *down-shifted* signal with a frequency equal to the *difference* of the input and reference signals.

If the input and reference signals have the same frequency ω, then the down-shifted component will appear at DC, whereas the up-shifted component will appear at twice the input frequency with additive phase.

A low pass filter is used to attenuate the up-shifted signal and to suppress noise, the output of which is proportional to the amplitude of the input signal scaled by the cosine of the phase difference: $R\cos(\phi)$. In order to reconstruct the magnitude and phase of the input signal, it is necessary to demodulate it with two orthogonal references, sine and cosine, to produce in-phase (X) and quadrature (Y) components relative to the reference. This process is referred to as dual-phase demodulation and is a standard feature of all modern lock-in amplifiers.

With X and Y, the magnitude R and phase ϕ can be calculated as $R = \sqrt{X^2 + Y^2}$ and $\phi = \tan^{-1}(Y/X)$.

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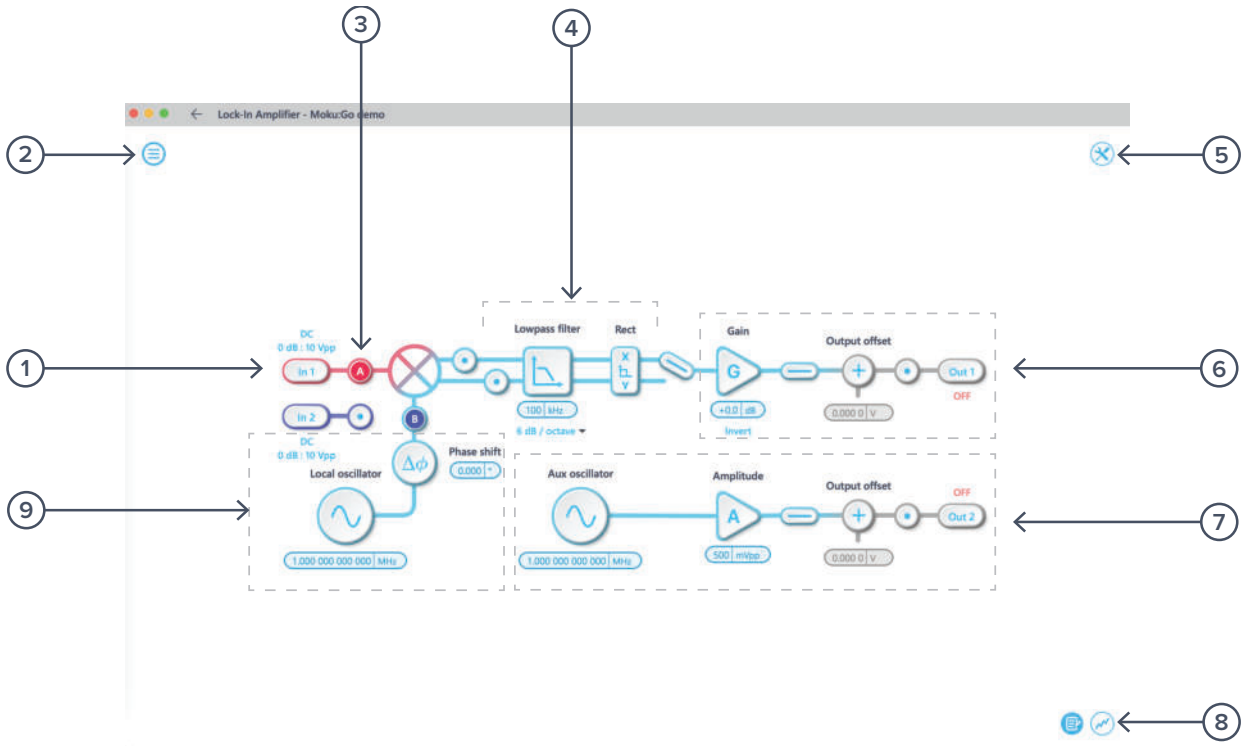
User Interface



ID	Description	ID	Description
1	Input settings	6	Channel 1 output
2	Main menu	7	Channel 2 output
3	Probe point	8	Oscilloscope/Data Logger
4	Filter settings	9	Reference oscillator
5	Advanced configuration menu		

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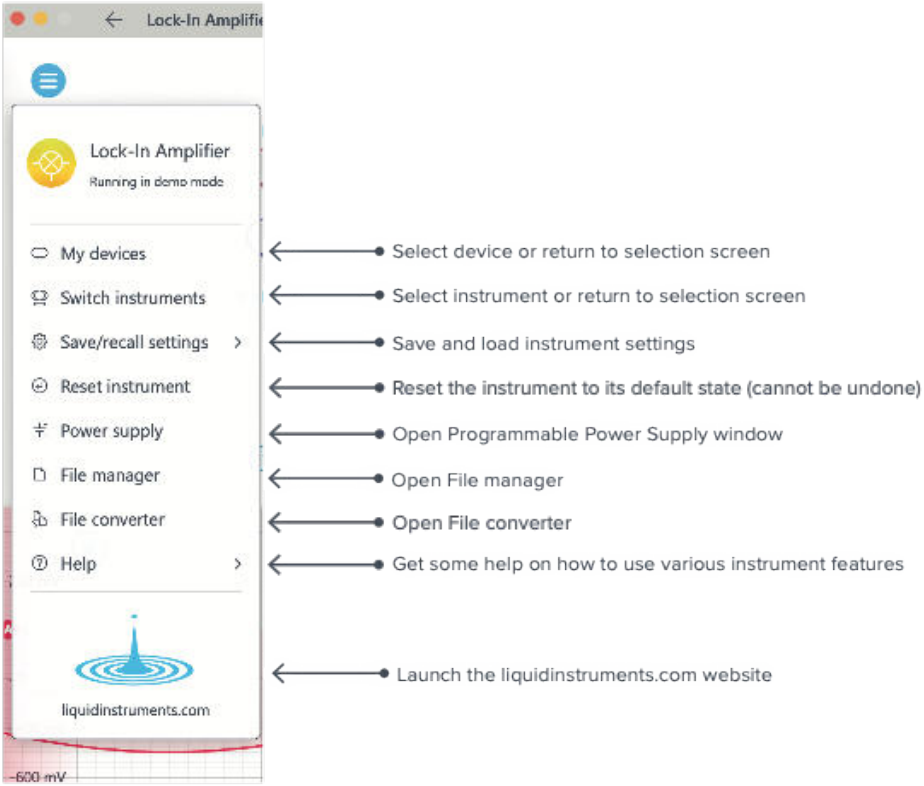
Main Menu

The **main menu** can be accessed by clicking the icon, allowing you to:



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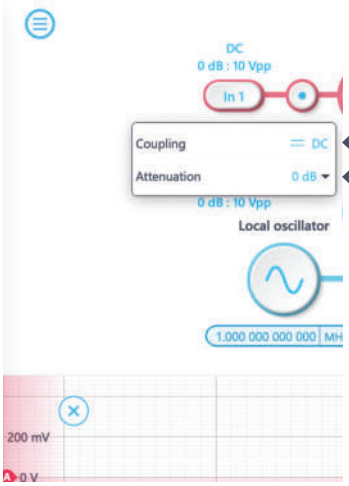
Signal Input

Click the In 1 icon to configure the input settings for the signal input.



- Select between **AC** and **DC** input coupling
- Select input attenuation bewteen **0 dB** or **-14 dB**

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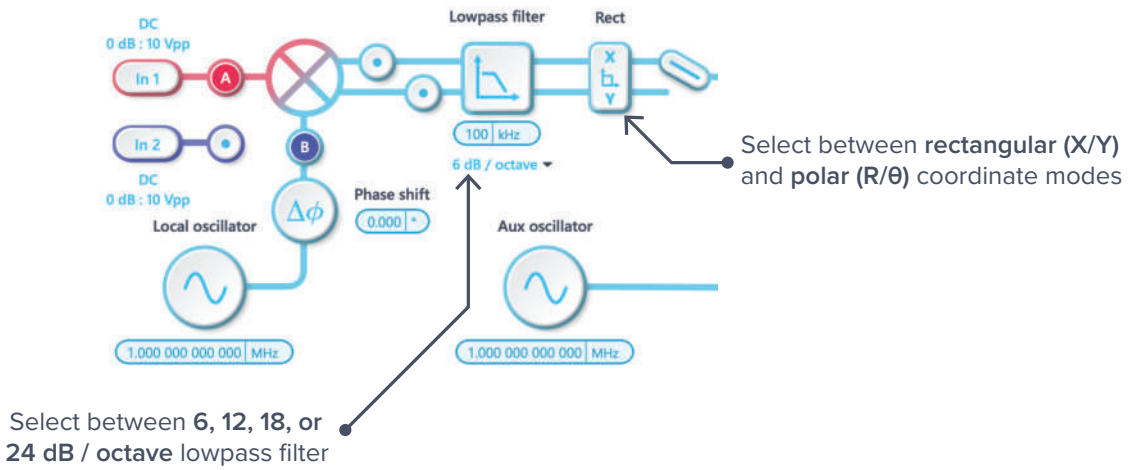
Dual-Phase Demodulator

Moku:Go's Lock-in Amplifier features a dual-phase demodulator with cascaded single pole low pass filters to attenuate the second harmonic and suppress noise in the in-phase and quadrature components.

- Select between **6, 12, 18, or 24 dB / octave** low pass filter slopes.
- Select between rectangular (X/Y) and polar (R/θ) coordinate modes.
- View the demodulated in-phase and quadrature signals prior to the low pass filters using probe points.
- Select which demodulated signal to route to the output. Note: your options depend on how the Lock-in Amplifier is configured.



Rectangular (or Cartesian) coordinate mode measures the input signal with respect to a specific quadrature of the reference signal. When combined with a PID controller, Cartesian mode can be used to perform laser frequency stabilization.

Polar coordinate mode measures the amplitude and phase of the input signal with respect to the reference signal. Polar mode is not available when using external references in straight-through mode due to the lack of a quadrature demodulation signal.

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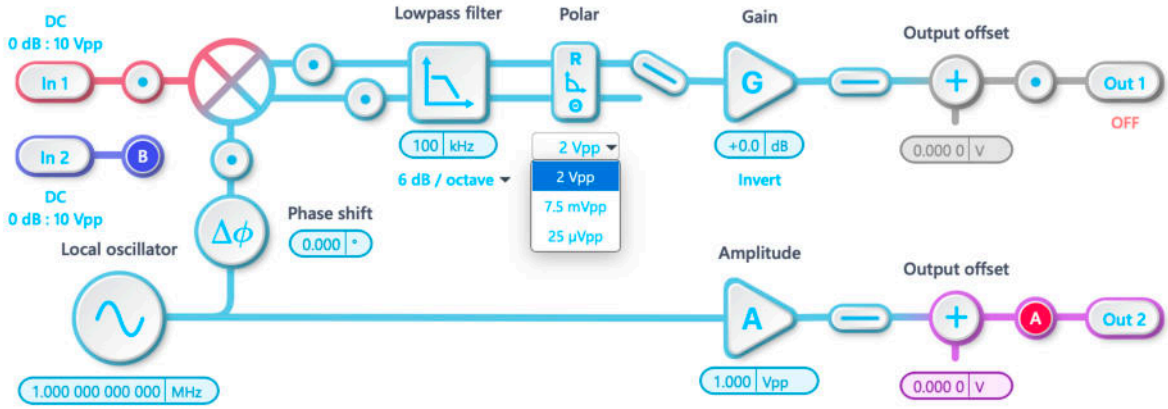
Filter Bandwidth and Time Constant

The filter bandwidth and time constant are equivalent representations for the width of the filter passband. They can be converted using the following equation:

$$Time\ Constant = \frac{1}{2\pi \times Filter\ Bandwidth}$$

Rect-to-Polar Conversion Range

In polar mode, the rectangular-to-polar conversion range allows you to select the signal processing range for optimized system performance. Three ranges are available: 2 V_{pp}, 7.5 mV_{pp}, and 25 μV_{pp}. The smallest range which can accommodate your signal without saturating should be used. For example, if the measured signal has an amplitude of 1 mVpp, the 7.5 mV would be the most suitable range; if a signal has an amplitude of 1 Vpp, the 2 Vpp range would be the most suitable range.



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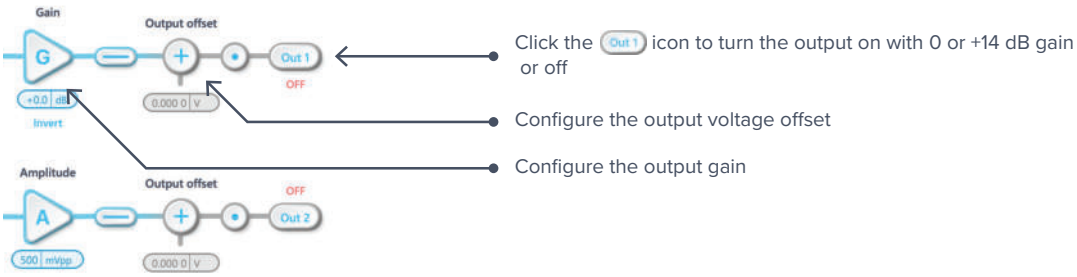
Outputs

Configure the gain / amplitude and voltage offset of the two output channels. Enable / disable either output channel by clicking the Out 1 and Out 2 icons. View the signal at the output of each channel using the probe points .



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Advanced Configuration

The Lock-in Amplifier's digital signal processing layout can be rapidly re-configured to suit different applications. Access the advanced configuration menu using the icon at the top right corner of the interface.

- Select between internal, external (straight-through), or external (phase-locked) demodulation references. Alternatively, you can bypass the demodulation by selecting "none".
- Configure the auxiliary output to generate an independent aux oscillator with adjustable frequency and amplitude, the second output from the demodulator (e.g., generate voltage signals proportional to R and θ from outputs 1 and 2 respectively), or the local oscillator (available in internal demodulation mode only).
- A PID controller can be added to the main output (channel 1) or the auxiliary output (only available when generating a second filtered signal from the auxiliary output).

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Demodulation

The demodulation mode determines which reference signal is used to demodulate the input signal.

Internal

The input signal can be demodulated with an internally generated reference signal. This local oscillator is derived from Moku:Go's internal clock and thus shares the same timebase. The frequency range of the internal reference is 1 mHz to 20 MHz.

External (direct)

The input signal can be demodulated by a direct external reference, permitting the use of non-sinusoidal demodulation of the input signal. This can be used to measure correlation or to recover specific components of complex input signals.

The arbitrary nature of direct external reference signals means that they cannot be used to perform dual-phase (orthogonal) demodulation of the input signal. This prevents external (direct) demodulation mode from be used to measure Y, R, and θ since only one quadrature can be interrogated.

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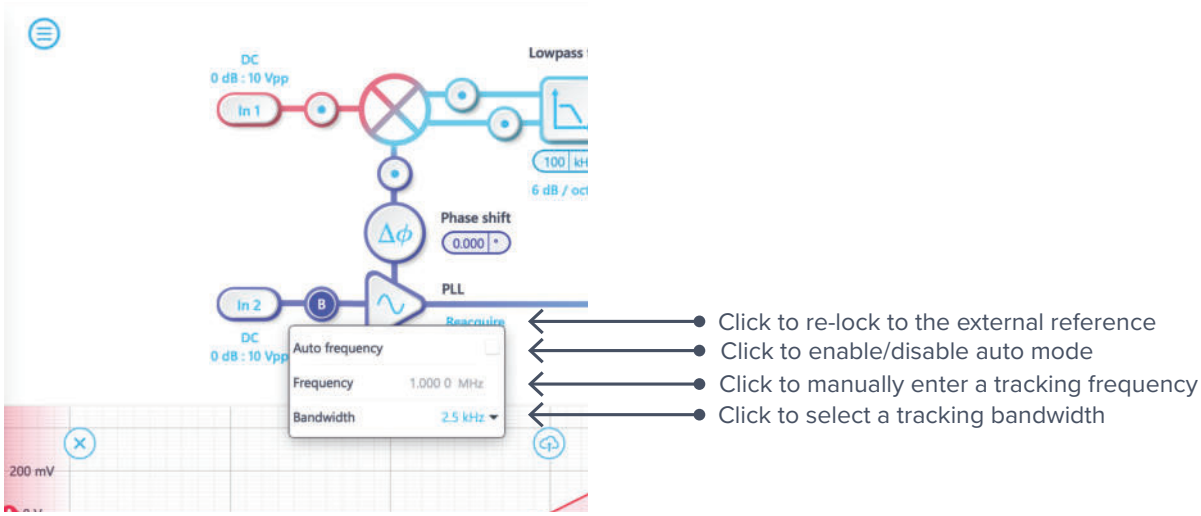
External (PLL)

Dual-phase demodulation of the input signal with an external reference can be performed using phase-locked external reference mode, which constructs two orthogonal reference signals phase-locked to the external reference. This mode uses a digitally implemented phase-locked loop to track the phase of the external reference with a user selectable bandwidth, allowing it to generate phase-locked in-phase and quadrature sinusoids at the same frequency, with adjustable phase.

External (PLL) mode enables the Lock-in Amplifier to recover information in all quadrants (X/Y and R/θ) without requiring Moku:Go to share the same source clock as the external system.

The phase-locked loop will automatically lock to the strongest harmonic of the external reference in the range of 100 Hz to 20 MHz in auto mode. Tracking frequencies between 100 Hz and 20 MHz can be manually entered. The reacquire button can be used to re-lock to the external reference.



None

The demodulation step can be bypassed by selecting “none”. This enables modulation-free locking techniques such as DC locking, fringe-side locking, and tilt locking.

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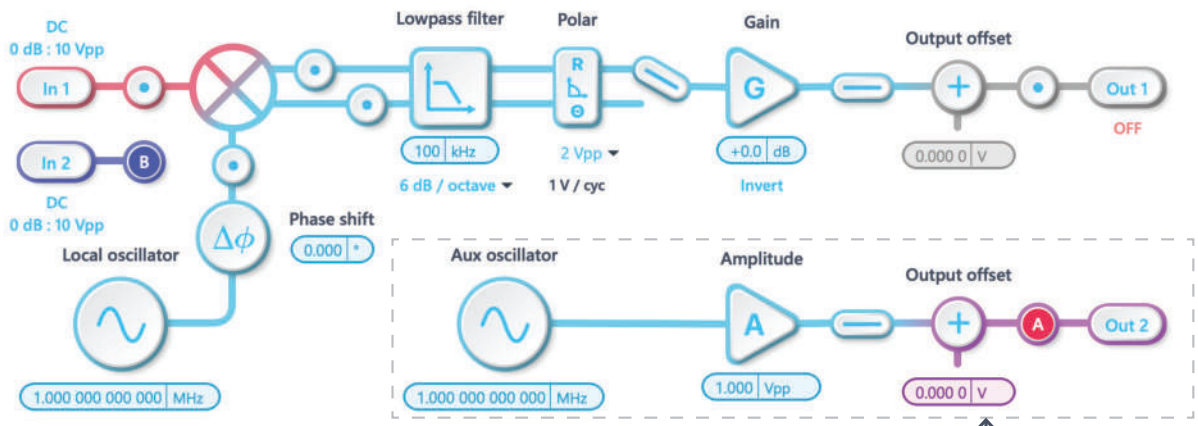
Auxiliary Output

Moku:Go's second output can be configured to generate an additional auxiliary voltage signal.

Aux Oscillator

Aux oscillator mode allows you to generate a sinusoidal signal with independently configurable frequency, amplitude, and voltage offset. The frequency can be adjusted from 1 mHz to 20 MHz and the amplitude range (amplitude + offset) is 5 V_{pp} with 1 mV resolution.

The generated waveform shares the same timebase as the rest of the instrument. When used with internal demodulation, this mode can be used to stimulate a system at one frequency and demodulate at a different frequency, for example in wavelength modulation spectroscopy where it is necessary to demodulate harmonics of the input signal.



The **aux oscillator** auxiliary output mode allows you to generate a local oscillator signal with independent frequency, amplitude, and vertical offset control

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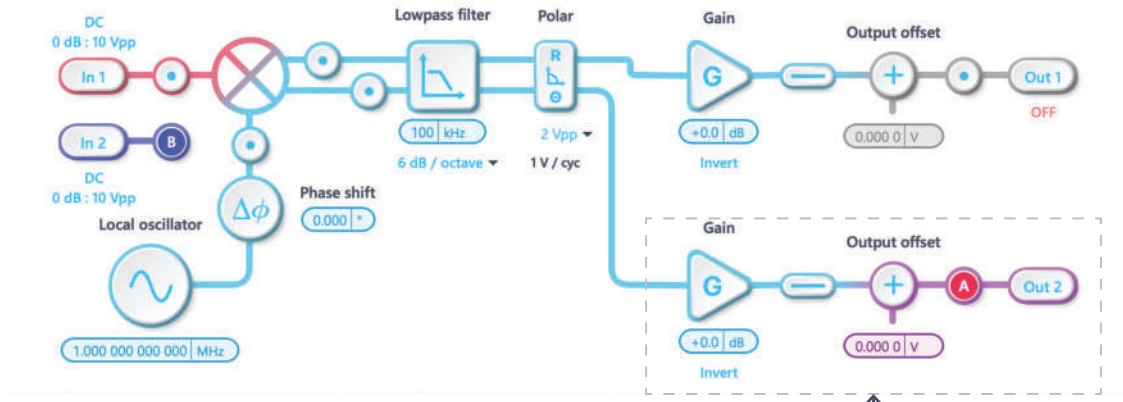
Filtered Signal

The second output of the dual-phase demodulator can be routed to Moku:Go's second output channel to produce a voltage signal proportional to Y or θ.

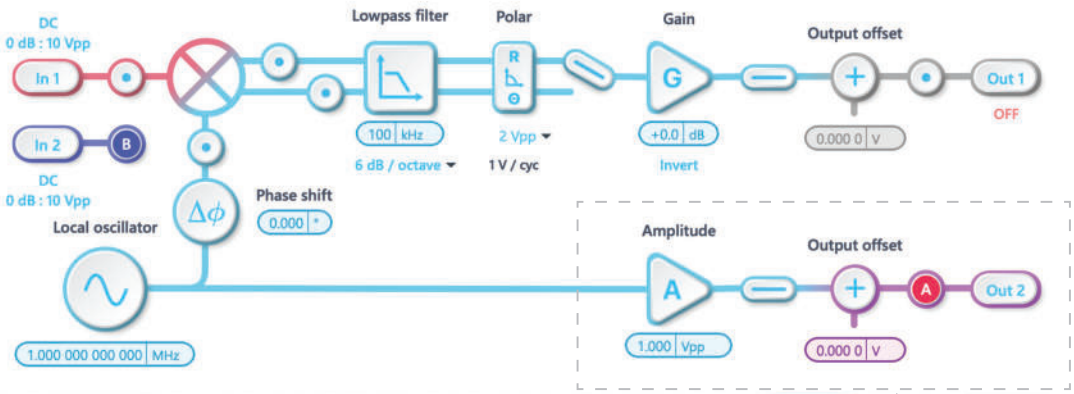
This mode can be used to record both in-phase and quadrature at the same time using probe points.



The **filtered signal** auxiliary output mode generates a second voltage signal proportional to the second low pass filtered output of the demodulator

Local Oscillator

The internal reference used to demodulate the input signal can be used to generate a sinusoidal waveform at the same frequency with configurable amplitude and voltage offset.



The **local oscillator** auxiliary output mode will generate a local oscillator at the same frequency as the demodulation waveform with full amplitude and vertical offset control

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PID Controller

Moku:Go's Lock-In Amplifier can be used to control an external system by acting as both a sensor and controller using a dedicated PID controller. The PID controller's frequency dependent gain can be easily configured to satisfy the stability requirements of the control system.

Note: The Lock-in Amplifier can only implement a single PID controller at a time. This means that when the instrument's auxiliary output is configured to generate a voltage signal proportional to the Y or θ, the PID controller can be used on *either* X/R or Y/θ, but not both.

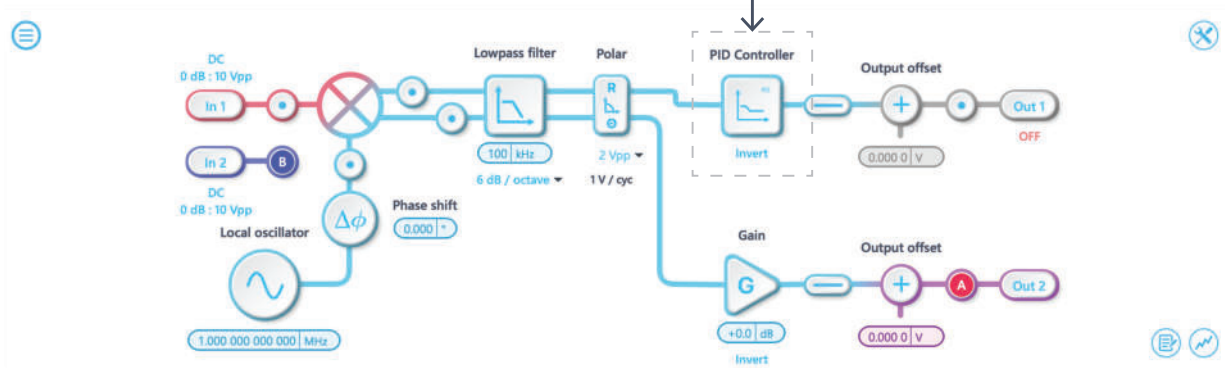
Off

Turns off the full PID controller. A flat gain can still be configured.

Main Output

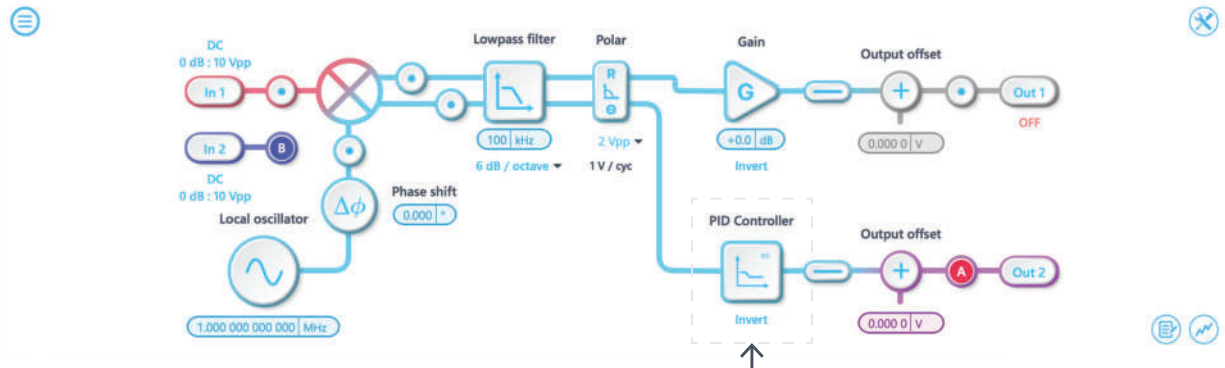
Adds a PID controller to the main output.

A PID controller can be implemented on the main output



Auxiliary Output

Adds a PID controller to the auxiliary output.



A PID controller can be implemented on the auxiliary output

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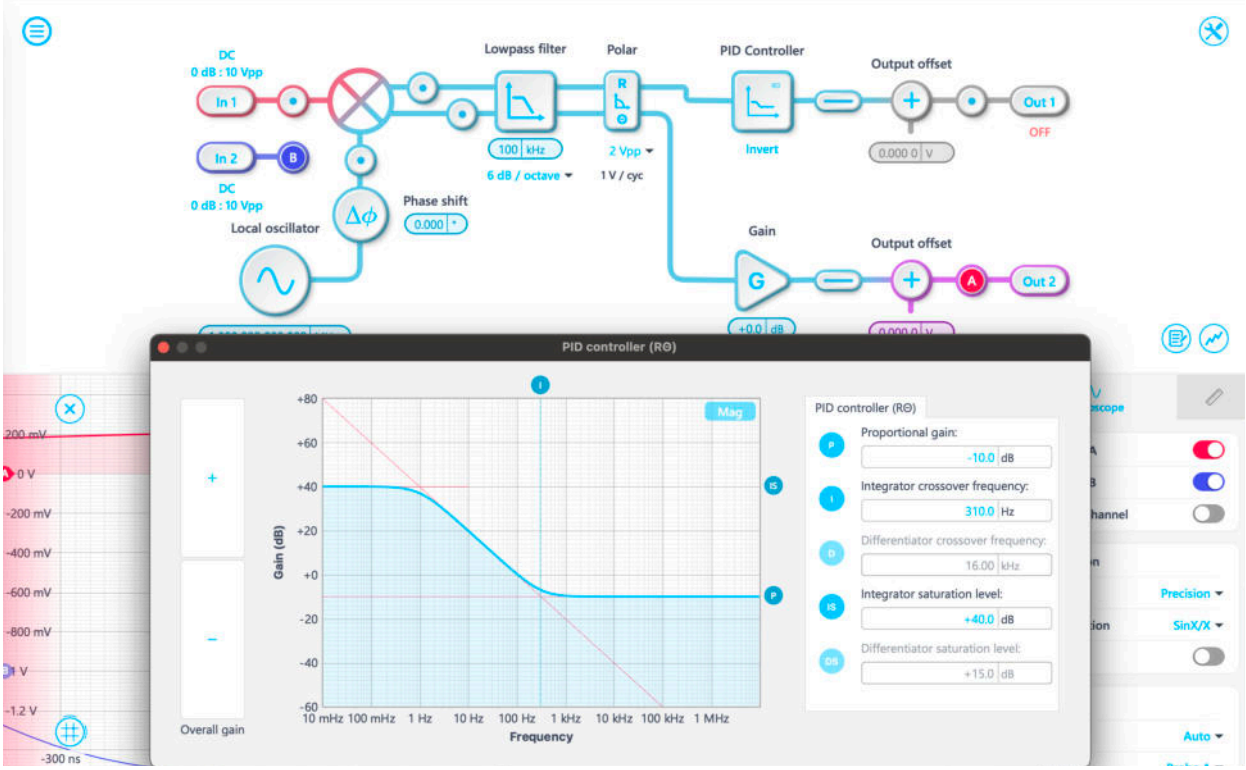
PID Controller

The PID controller provides full control over proportional, integral, and derivative gain profiles with saturation levels available for the integral and derivative controllers. The PID's transfer function is updated in real-time.

The gain of each control stage can be adjusted individually. The following example shows a proportional-plus-integral controller with a unity gain crossover frequency at 310 Hz. It is possible to maintain this crossover frequency with the proportional gain by using the **overall gain** control on the left, which will shift the entire gain profile up and down. More details about the PID controller can be found in Moku:Go's PID Controller manual.



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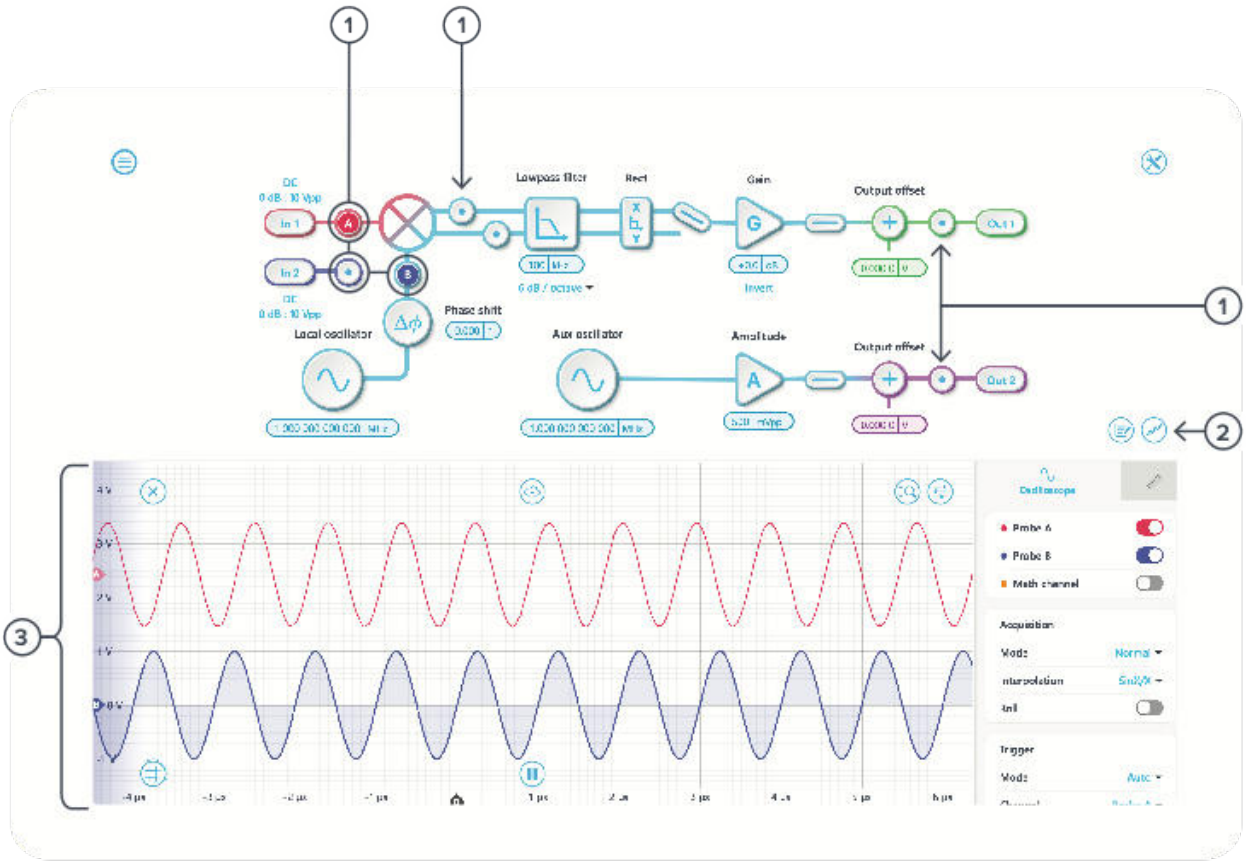
Probe Points

Moku:Go's Lock-in Amplifier has an integrated oscilloscope and data logger that can be used to probe the signal at various stages of the demodulation process. The probe points can be added by clicking the icon. Up to four probe points can be added to monitor or log data.

Oscilloscope



ID	Parameter	Description
1	Probe points	Click to place the probe point. You can enable up to two probe points at a time.
2	Oscilloscope/Data Logger toggle	Toggle between built-in Oscilloscope or Data Logger
3	Oscilloscope	Refer to the **Moku:Go's Oscilloscope** manual for the details

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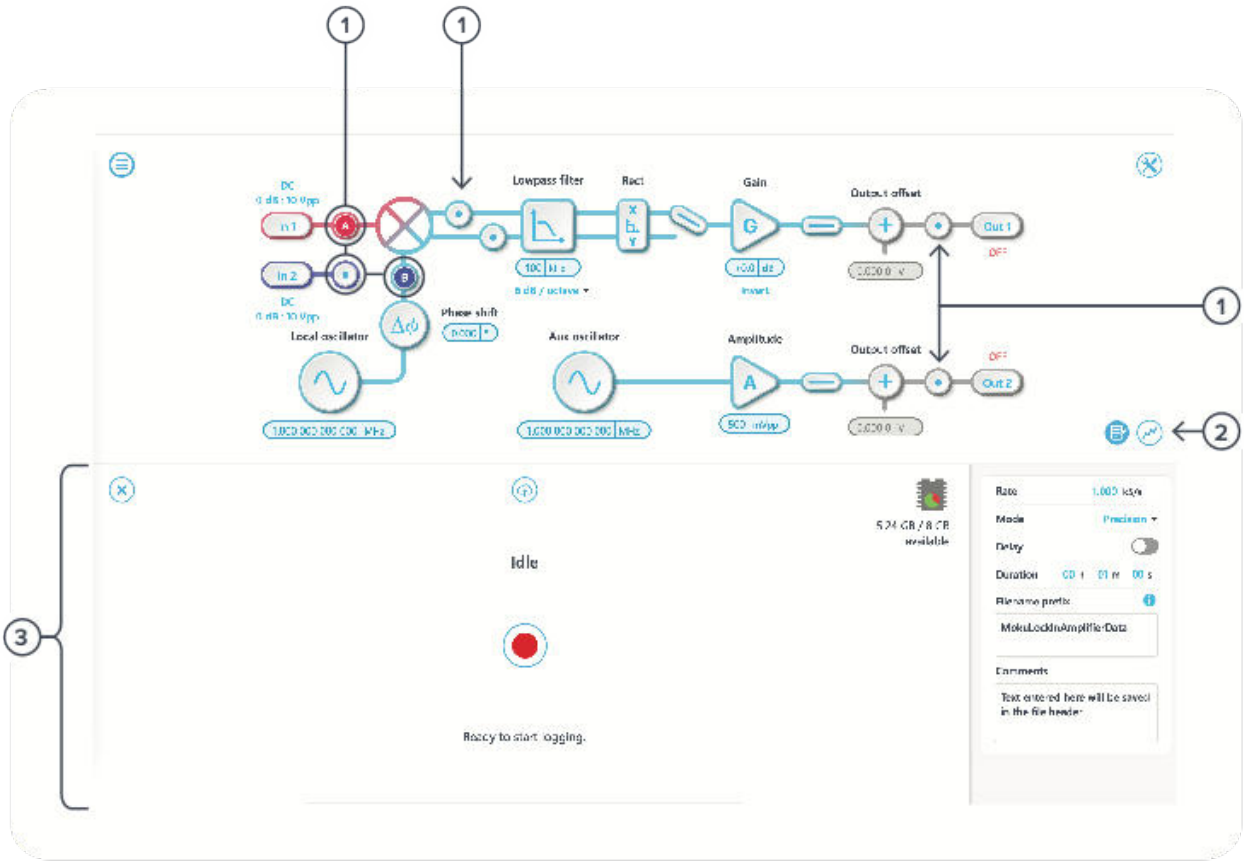
Data Logger



ID	Parameter	Description
1	Probe points	Click to place the probe point. You can enable up to four probe points at a time.
2	Oscilloscope/data logger toggle	Toggle between built-in oscilloscope or data logger
3	Data Logger	Refer to the **Moku:Go's Data Logger** manual for the details

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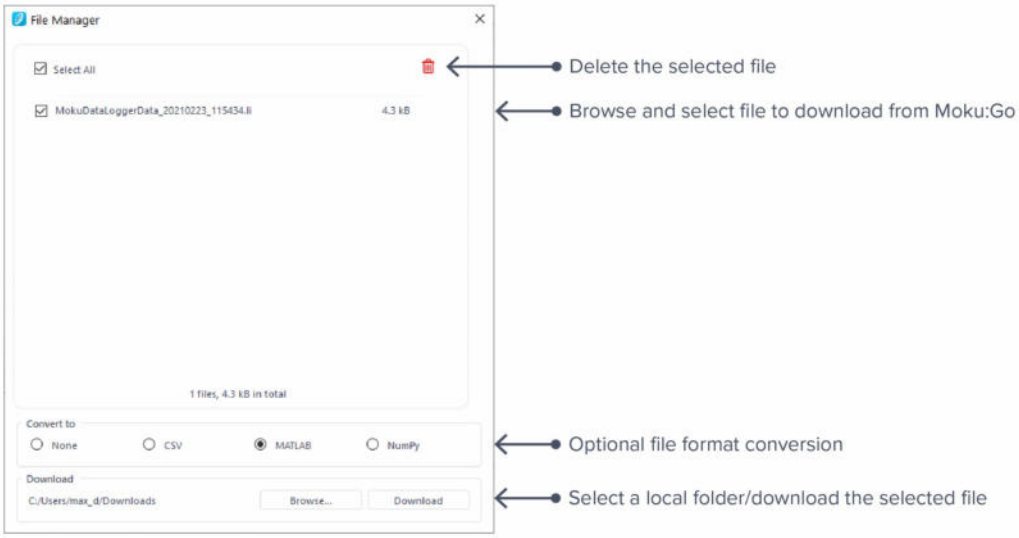
Additional Tools

Moku:Go's app has two built-in file management tools: file manager and file converter. The file manager allows users to download the saved data from Moku:Go to a local computer, with optional file format conversion. The file converter converts the Moku:Go's binary (.li) format on the local computer to either .csv, .mat, or .npy format.

File Manager



Once a file is transferred to the local computer, a icon shows up next to the file.

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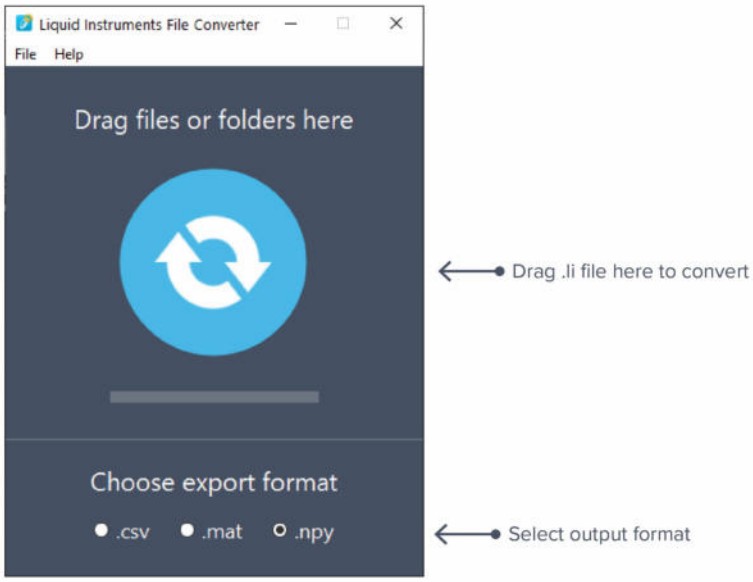
File Converter



The converted file is saved in the same folder as the original file.

Liquid Instruments File Converter has the following menu options:

Options	Shortcut	Description
File		
• **Open file**	Ctrl+O	Select a .li file to convert
• **Open folder**	Ctrl+Shift+O	Select a folder to convert
• **Exit**		Close the file converter window
Help		
• **Liquid Instruments website**		Access Liquid Instruments website
• **Report an issue**		Report bug to Liquid Instruments
• **About**		Show app version, check update, or license information

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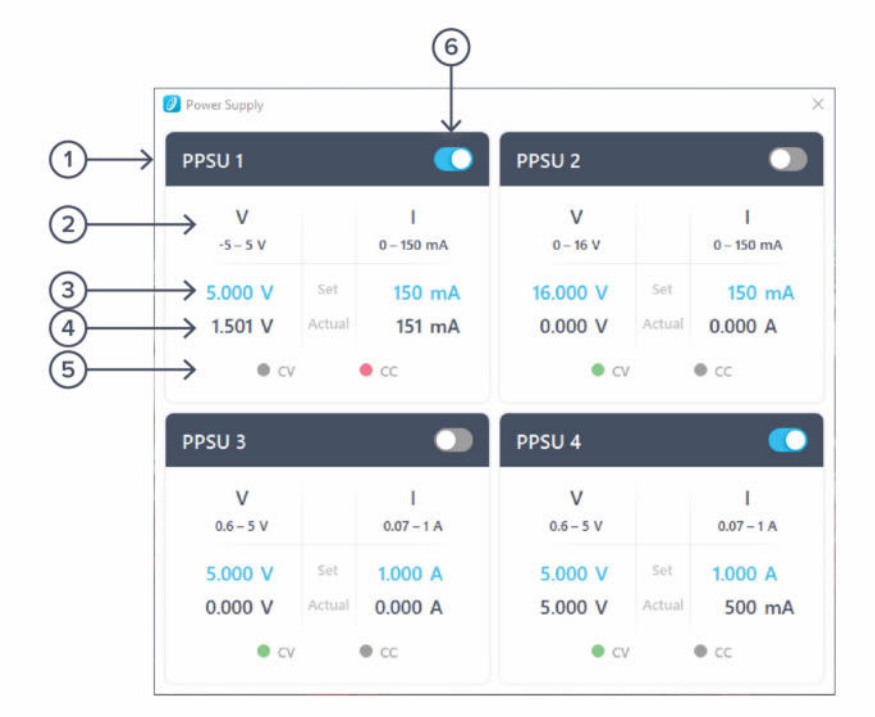
Power Supply

Moku:Go's power supply is available on M1 and M2 models. M1 features a 2-channel power supply, while M2 features a 4-channel power supply. The power supply control window can be accessed in all instruments under the main menu.

The power supply operates in two modes: **constant voltage (CV)** or **constant current (CC)** mode. For each channel, the user can set a current and voltage limit for the output. Once a load is connected, the power supply operates either at the set current or set voltage, whichever comes first. If the power supply is voltage limited, it operates in the CV mode. If the power supply is current limited, it operates in the CC mode.



ID	Function	Description
1	Channel name	Identifies the power supply being controlled
2	Channel range	Indicates the voltage/current range of the channel
3	Set value	Click the blue numbers to set the voltage and current limit
4	Readback numbers	Voltage and current readback from the power supply, the actual voltage and current being supplied to the external load
5	Mode indicator	Indicates if the power supply is in CV (green) or CC (red) mode
6	On/Off Toggle	Click to turn the power supply on and off

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Ensure Moku:Go is fully updated. For the latest information:

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Digital Filter Box

Moku:Go User Manual

With Moku:Go's Digital Filter Box, you can interactively design and generate different types of infinite impulse response filters with sampling rates of 61.035 kHz, 488.28 kHz and 3.9063 MHz. Select between low pass, high pass, band pass, and band stop filter shapes with up to eight fully configurable types including Butterworth, Chebyshev, and Elliptic.

LIQUID INSTRUMENTS

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V22-0323

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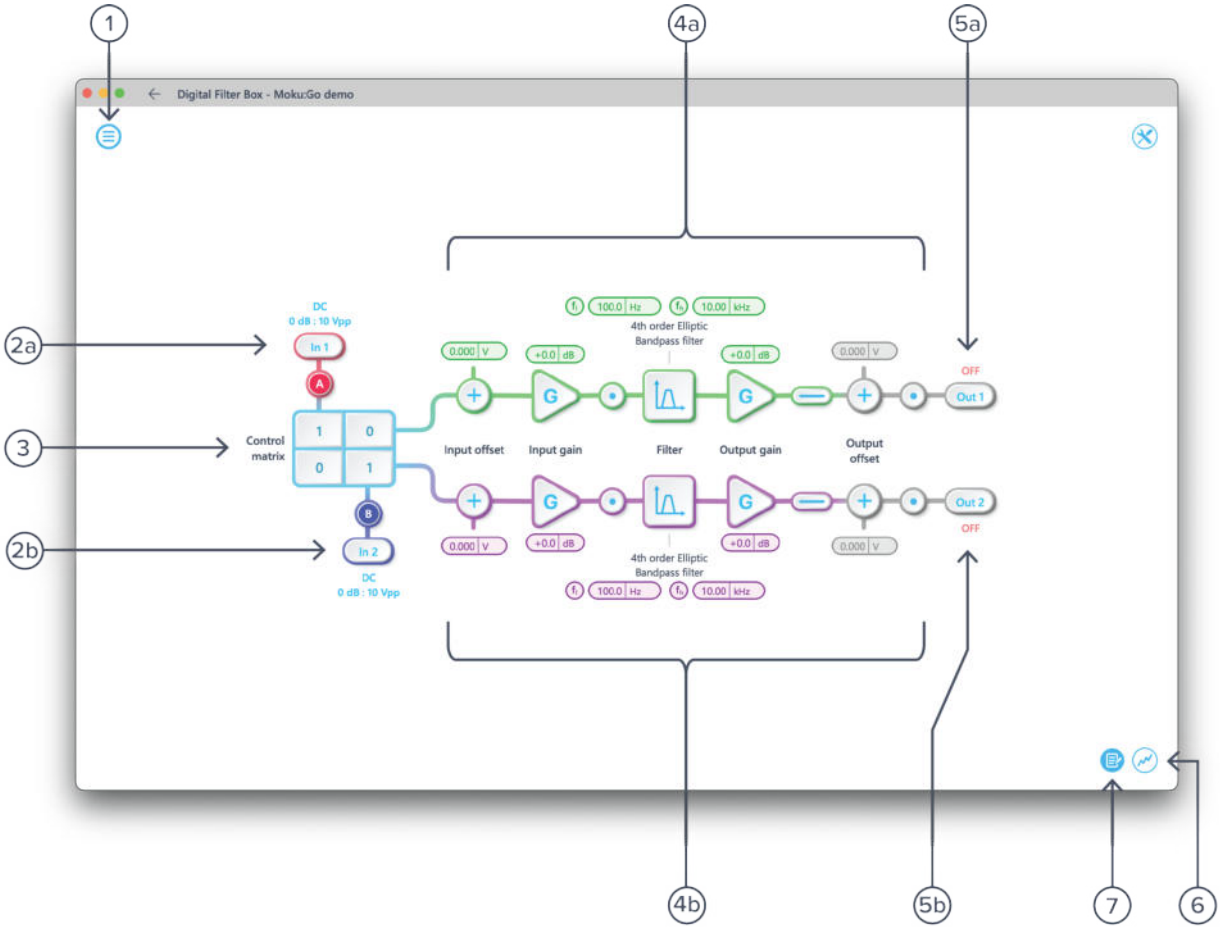
User Interface



ID	Description
1	Main menu
2a	Input configuration for Channel 1
2b	Input configuration for Channel 2
3	Control matrix
4a	Configuration for filter 1
4b	Configuration for filter 2
5a	Output switch for Channel 1
5b	Output switch for Channel 2
6	Enable/disable the oscilloscope view
7	Enable/disable the data logger view

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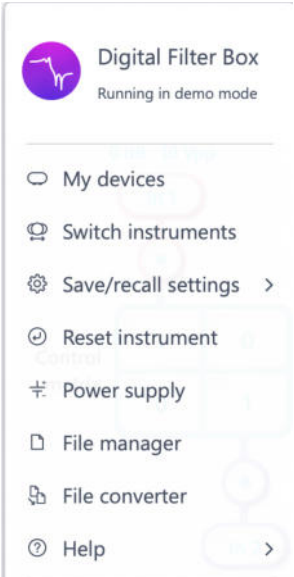
Main Menu

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



Options	Shortcuts	Description
My devices		Search for Moku devices
Switch instruments		Switch instruments on this Moku:Go
Save/recall settings:		
• **Save instrument state**	Ctrl+S	Save the current instrument settings
• **Load instrument state**	Ctrl+O	Load last saved instrument settings
• **Show current sate**		Show the current instrument settings
Reset instrument	Ctrl+R	Reset the instrument to its default state
Power supply		Access power supply control window*
File manager		Open file manager tool**
File converter		Open file converter tool**
Help		
• **Liquid Instruments website**		Access Liquid Instruments website
• **Shortcuts list**	Ctrl+H	Show Moku:Go app shortcuts list
• **Manual**	F1	Access instrument manual
• **Report an issue**		Report bug to Liquid Instruments
• **About**		Show app version, check for updates, or show license information

*Power supply is available on Moku:Go M1 and M2 models. Detailed information about power supply can be found in Moku:Go's power supply manual.

**Detailed information about the file manager and file converter can be found toward the end of this user manual.

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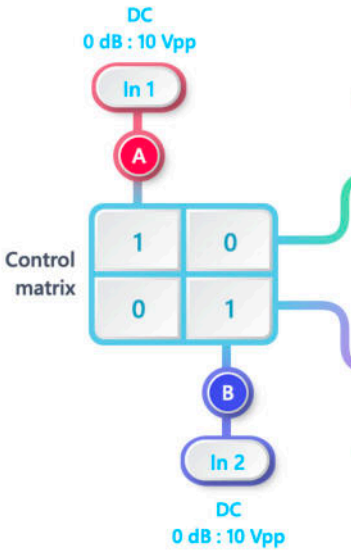
Input Configuration

The **input configuration** can be accessed by clicking the In 1 or In 2 icon, allowing you to adjust the coupling and input attenuation (and therefore voltage range) for each input channel.



Details about the probe points can be found in the Probe Points section.

Control Matrix

The **control matrix** combines, rescales, and redistributes the input signal to the two independent filters. The output vector is the product of the control matrix multiplied by the input vector.

$$\begin{bmatrix} Path1 \\ Path2 \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \times \begin{bmatrix} In1 \\ In2 \end{bmatrix}$$

where

$$Path1 = a \times In1 + b \times In2$$

$$Path2 = c \times In1 + d \times In2$$

For example, a control matrix of $\begin{bmatrix} 1 & 1 \\ 0 & 2 \end{bmatrix}$ equally combines the Input 1 and Input 2 to the top *Path1* (filter 1), multiples Input 2 by a factor of two, and then sends it to the bottom *Path2* (filter 2).

The value of each element in the control matrix can be set between -20 to +20 with 0.1 increments when the absolute value is less than 10, or 1 increment when the absolute value is between 10 and 20. Click the element to adjust the value.

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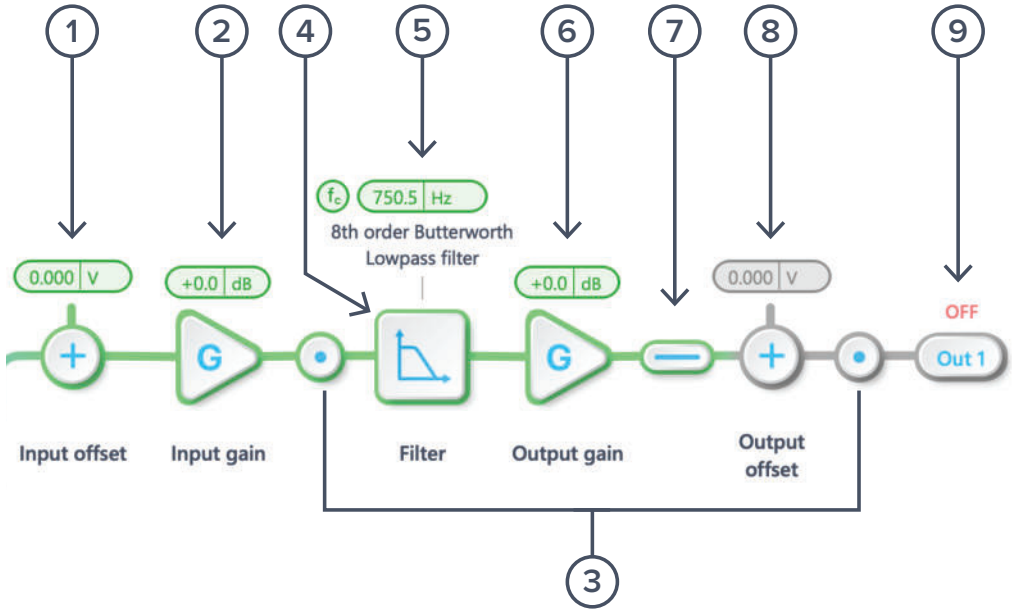
Digital Filters



The two independent, real-time configurable digital IIR filter paths follow the control matrix in the block diagram, represented in green and purple for filters 1 and 2, respectively.

User Interface

ID	Parameter	Description
1	Input offset	Click to adjust the input offset (-2.5 to +2.5 V).
2	Input gain	Click to adjust the input gain (-40 to 40 dB).
3	Probe points	Click to enable/disable the probe points. See Probe Points section for details.
4	Digital filter	Click to view and configure the digital filter builder.
5	Quick filter control	Click or slide to quickly adjust the filter settings
6	Output gain	Click to adjust the output gain (-40 to 40 dB).
7	Output switch	Click to zero the filter output.
8	Output offset	Click to adjust the output offset (-2.5 to +2.5 V).
9	DAC switch	Click to enable/disable Moku:Go's DAC output.

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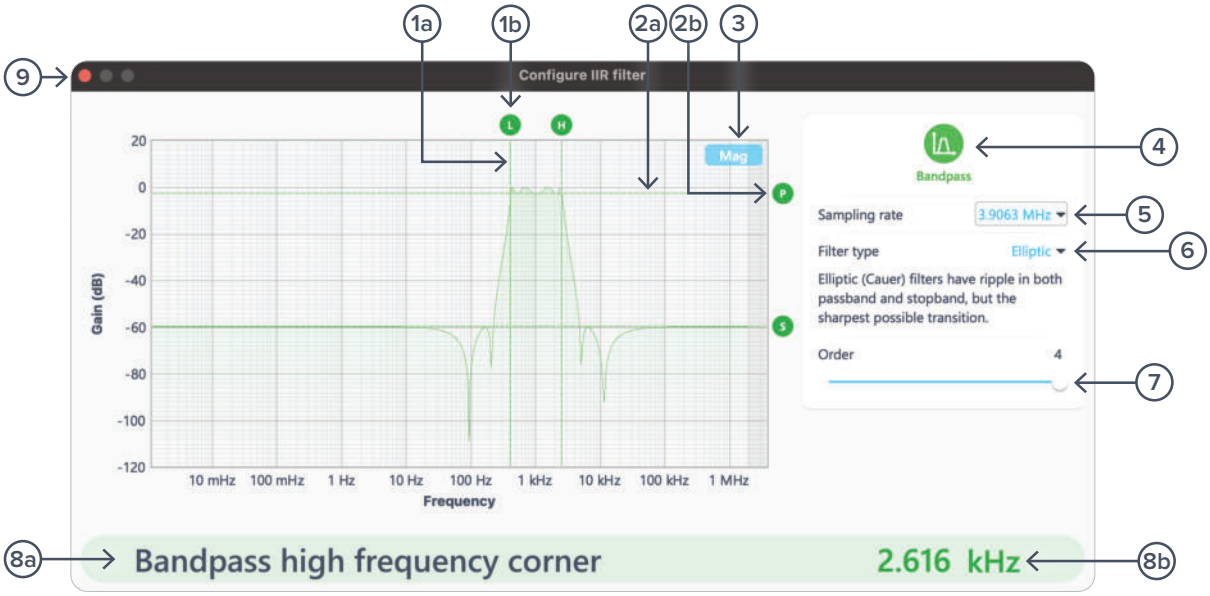
Configure IIR filter characteristics

Detailed filter interface

Click the icon to open the full filter view.



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ID	Parameter	Description
1a	Frequency (horizontal) cursor	Cursor for corner frequency.
1b	Cursor reading	Reading for frequency cursor. Drag to adjust the corner frequency. Click to select and manually enter the corner frequency in 8b.
2a	Gain (vertical) cursor	Cursor for ripple/gain/attenuation level.
2b	Cursor handle	Short name and handle for gain cursor. Drag to adjust the gain/ripple level. Click to select and manually enter passband ripple in 8b.
3	Display toggle	Toggle between magnitude and phase response curve.
4	Filter shape selection	Click to select between lowpass, high pass, band pass, band stop, and custom filters.
5	Sampling rate	Click to select between 3.9063 MHz, 488.28 kHz, or 61.035 kHz.
6	Filter type selection	Click to select between Butterworth, Chebyshev I/II, Elliptic, Bessel, Gaussian, Cascaded or Legendre filters. When selected, a short description of the filter type will be given below.
7	Filter order	Slide to adjust filter orders.
8a	Active configurable parameter	Name of the active configurable parameter.
8b	Parameter value	Click to manually enter the active configurable parameter value.
9	Save and close	Click to save and close the filter builder.

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Filter Shapes

The shape of the filter can be selected by clicking the ④ button (on page 7). There are four pre-defined filter shapes and a fully customizable filter option.

Sampling Rates

Users can select between 3.9063 MHz, 488.28 kHz, or 61.035 kHz of output sampling rate based on the desired corner frequencies. The following table summarizes the lower and upper bounds for each shape of pre-defined filters with different sampling rates:

Shape	Sampling Rate	Minimum corner frequency	Maximum corner frequency
Lowpass	61.035 kHz	11.73 mHz	27.47 kHz
	488.28 kHz	93.81 mHz	219.7 kHz
	3.9063 MHz	750.5 mHz	1.758 MHz
Highpass	61.035 kHz	144.7 mHz	27.47 kHz
	488.28 kHz	1.158 Hz	219.7 kHz
	3.9063 MHz	9.263 Hz	1.758 MHz
Bandpass	61.035 kHz	610.4 mHz	27.47 kHz
	488.28 kHz	4.883 Hz	219.7 kHz
	3.9063 MHz	39.06 Hz	1.758 MHz
Bandstop	61.035 kHz	11.73 mHz	27.47 kHz
	488.28 kHz	93.81 mHz	219.7 kHz
	3.9063 MHz	750.5 mHz	1.758 MHz

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Filter types

The type of filter can be selected by pressing the ⑥ button (on Page 9). There are seven pre-defined filter types with user-selectable filter orders from 2 up to 8, depending on the filter shapes.

Filter Types	Description
Butterworth	Butterworth filters have a maximally flat passband and a monotonic frequency response.
Chebyshev I	Chebyshev I filters have ripple in the passband but a sharper transition than Butterworth filters.
Chebyshev II	Chebyshev II filters have ripple in the stopband but a sharper transition than Butterworth filters.
Elliptic	Elliptic (Cauer) filters have ripple in both passband and stopband, but the sharpest possible transition.
Cascaded	Cascaded first-order filters have zero overshoot in the time domain.
Bessel	Bessel filters have a maximally flat group and phase delay in the passband, thus preserving the wave shape of passed signals.
Gaussian	Gaussian filters have the minimum possible group delay, and a step response with no overshoot and minimum rise and fall time.
Legendre	Legendre (Optimum L) filters have the sharpest possible transition while maintaining a monotonic frequency response.

Filter Orders

For single sided filters, the order of the filter can be set to 2, 4, 6, or 8. For double sided filters, the order of the filter can be 2 or 4.

Ripples

Chebyshev I, II, and Elliptic filters have ripples on either passband, stopband or both. The following table summarize the adjustable range for the passband and stopband ripples for these filter types.

Filter Types	Passband Ripple	Stopband Ripple
Chebyshev I	0.1 dB to 10.0 dB with 0.1 dB increment	N/A
Chebyshev II	N/A	10.0 dB to 100.0 dB with 1 dB increment
Elliptic	0.1 dB to 10.0 dB with 0.1 dB increment	10.0 dB to 100.0 dB with 1 dB increment

Coefficient Quantization

Due to the limited precision with which a coefficient can be digitally represented, quantization error is pronounced at certain IIR filter settings. A red coefficient quantization warning may appear on the

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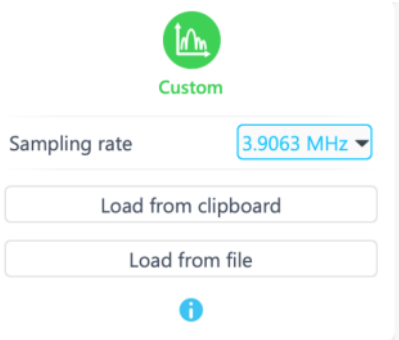
bottom of the response plot and a red trace in the transfer function showing the closest achievable filter response to the ideal value in green.

Custom filter

Additionally, a custom filter type allows for their filter coefficients to be uploaded from the clipboard or a local file. Click the icon to explanation of the coefficients and file format.



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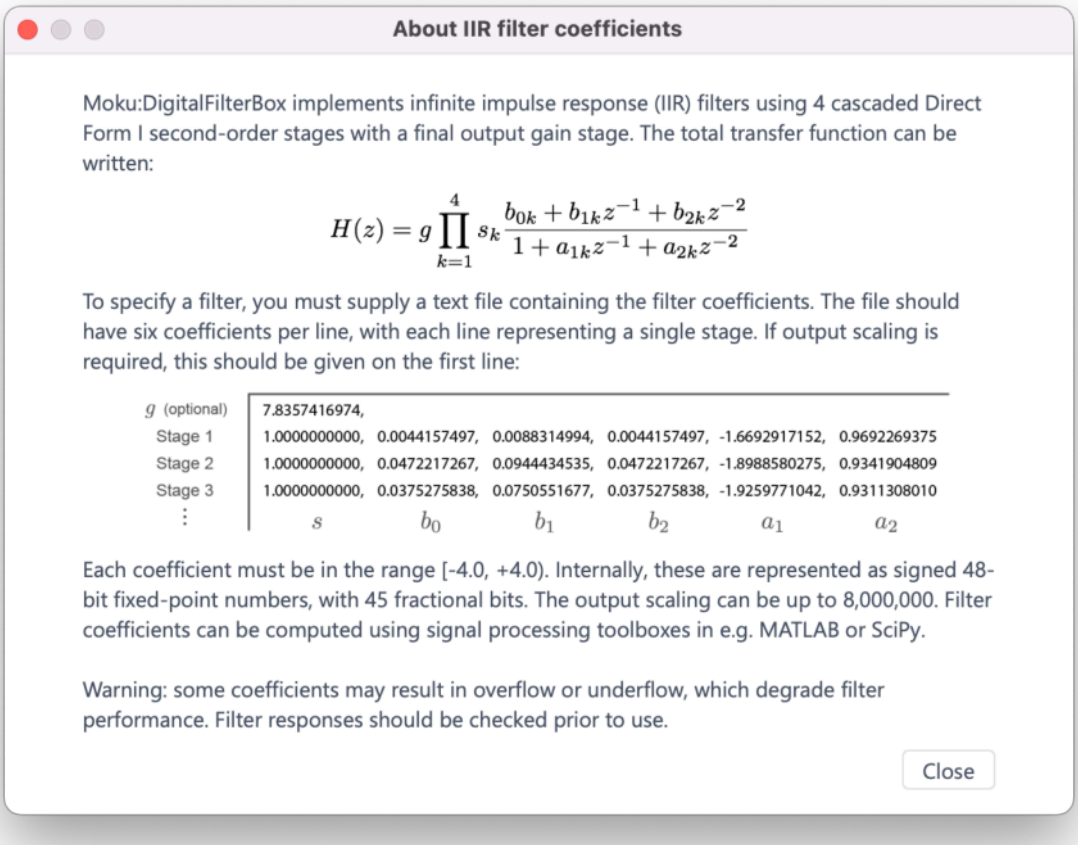
Custom filter details



About IIR filter coefficients

Moku:DigitalFilterBox implements infinite impulse response (IIR) filters using 4 cascaded Direct Form I second-order stages with a final output gain stage. The total transfer function can be written:

$$H(z) = g \prod_{k=1}^{4} s_k \frac{b_{0k} + b_{1k} z^{-1} + b_{2k} z^{-2}}{1 + a_{1k} z^{-1} + a_{2k} z^{-2}}$$

To specify a filter, you must supply a text file containing the filter coefficients. The file should have six coefficients per line, with each line representing a single stage. If output scaling is required, this should be given on the first line:

g (optional)	7.8357416974,					
Stage 1	1.0000000000,	0.0044157497,	0.0088314994,	0.0044157497,	-1.6692917152,	0.9692269375
Stage 2	1.0000000000,	0.0472217267,	0.0944434535,	0.0472217267,	-1.8988580275,	0.9341904809
Stage 3	1.0000000000,	0.0375275838,	0.0750551677,	0.0375275838,	-1.9259771042,	0.9311308010
⋮	s	b_0	b_1	b_2	a_1	a_2

Each coefficient must be in the range [-4.0, +4.0). Internally, these are represented as signed 48-bit fixed-point numbers, with 45 fractional bits. The output scaling can be up to 8,000,000. Filter coefficients can be computed using signal processing toolboxes in e.g. MATLAB or SciPy.

Warning: some coefficients may result in overflow or underflow, which degrade filter performance. Filter responses should be checked prior to use.

Close

Each coefficient must be in the range [-4.0,+4.0). Internally, these are represented as signed 48-bit fixed-point numbers, with 45 fractional bits. The output scaling can be up to 8,000,000. Filter coefficients can be computed using signal processing toolboxes in e.g. MATLAB or SciPy.

Some coefficients may result in overflow or underflow, which degrade filter performance. Filter responses should be checked prior to use.

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Output Switches

Switches can be used to connect or disconnect the output signal. When a switch is in open state, the output signal will be Output offset voltage.

Closed/Enable

Open/Disable

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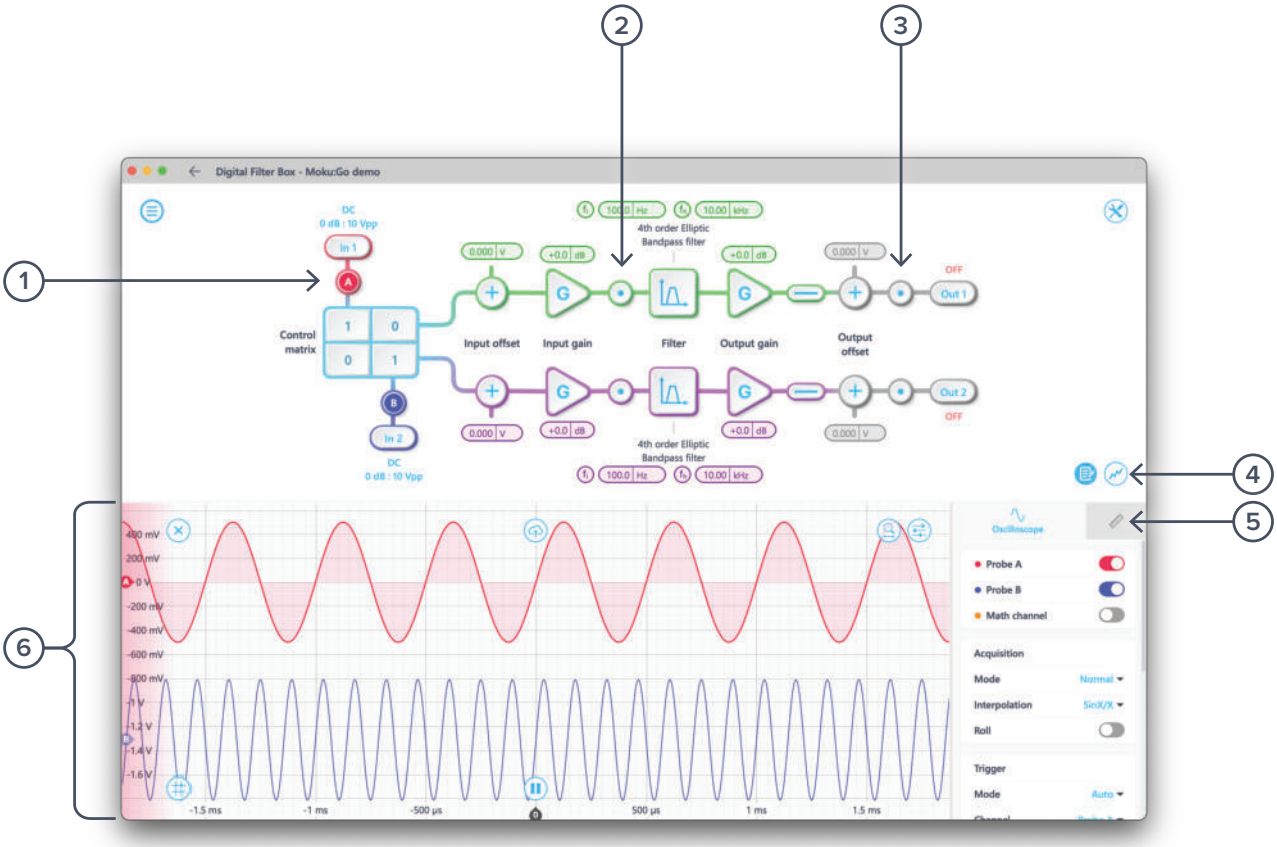
Probe Points

Moku:Go's Digital Filter Box has an integrated oscilloscope that can be used to probe the signal at the input, pre-filter, and output stages. The probe points can be added by Clicking the icon.

Oscilloscope



ID	Parameter	Description
1	Input probe point	Click to place the probe point at input
2	Pre-filter probe point	Click to place the probe after input gain
3	Output probe point	Click to place the probe at output
4	Oscilloscope settings*	Additional settings for built-in oscilloscope
5	Measurement*	Measurement function for built-in oscilloscope
6	Oscilloscope*	Signal display area for oscilloscope

*Detailed instructions for the oscilloscope instrument can be found in Moku:Go's Oscilloscope manual.

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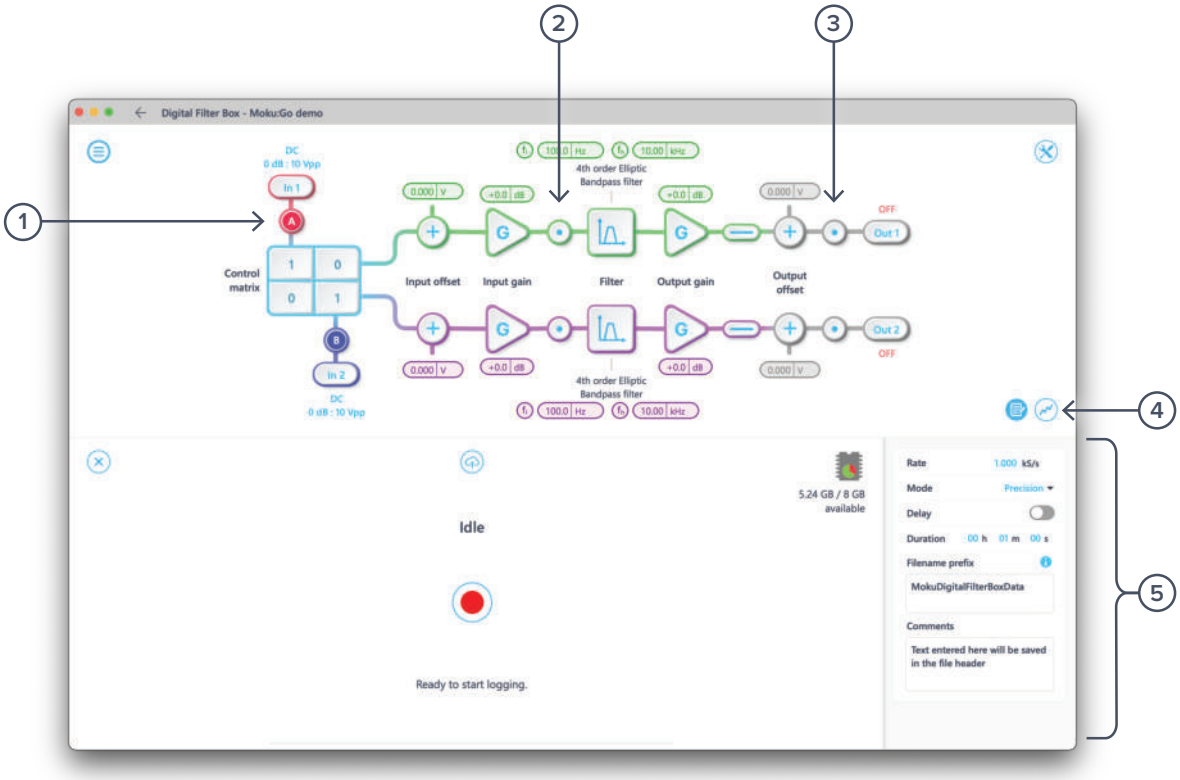
Data Logger



ID	Parameter	Description
1	Input probe point	Click to place the probe point at inputs.
2	Pre-Filter probe point	Click to place the probe before the filter.
3	Output probe point	Click to place the probe at outputs.
4	Oscilloscope/data logger toggle	Toggle between built-in oscilloscope or data logger.
5	Data Logger	Refer to **Moku:Go's Data Logger** manual for the details.

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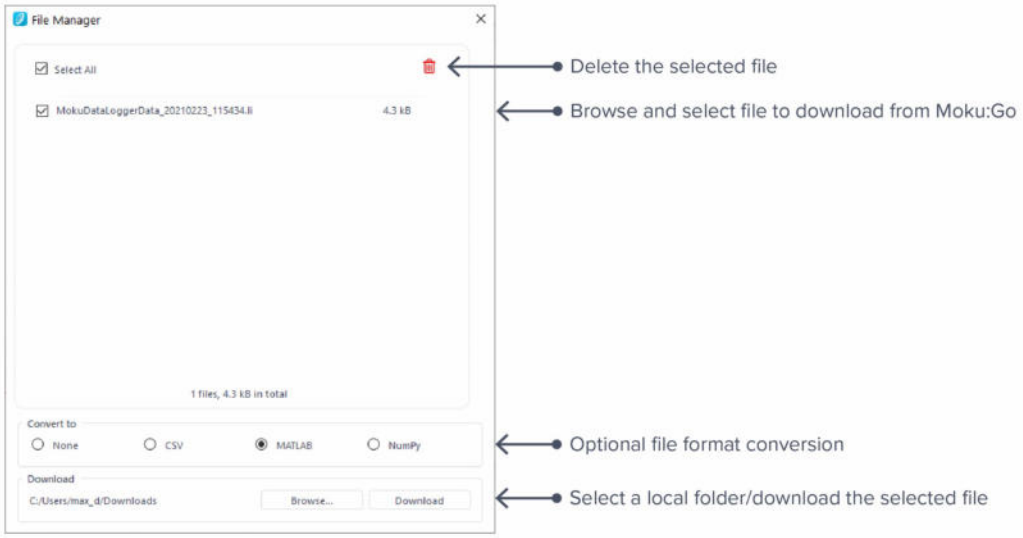
Additional Tools

Moku:Go's app has two built-in file management tools: file manager and file converter. The file manager allows users to download the saved data from Moku:Go to a local computer, with optional file format conversion. The file converter converts the Moku:Go's binary (.li) format on the local computer to either .csv, .mat, or .npy format.

File Manager



Once a file is transferred to the local computer, a icon shows up next to the file.

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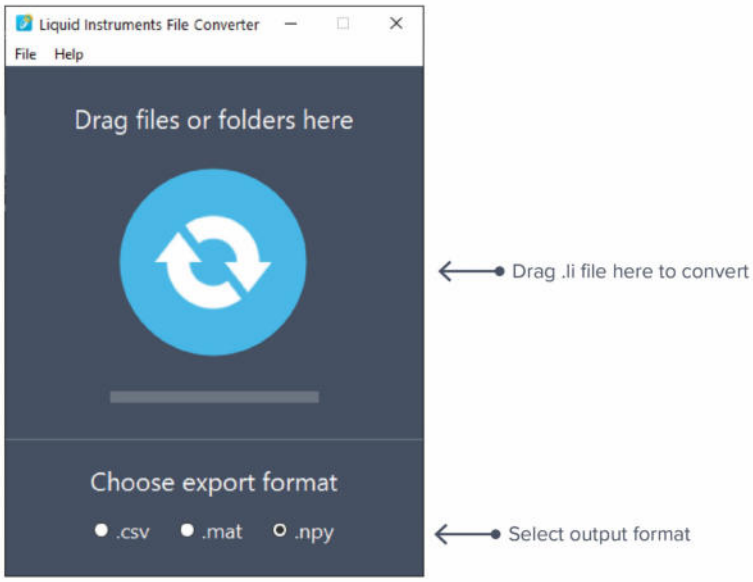
File Converter



The converted file is saved in the same folder as the original file.

Liquid Instruments File Converter has the following menu options:

Options	Shortcut	Description
File		
• **Open file**	Ctrl+O	Select a .li file to convert
• **Open folder**	Ctrl+Shift+O	Select a folder to convert
• **Exit**		Close the file converter window
Help		
• **Liquid Instruments website**		Access Liquid Instruments website
• **Report an issue**		Report bug to Liquid Instruments
• **About**		Show app version, check update, or license information

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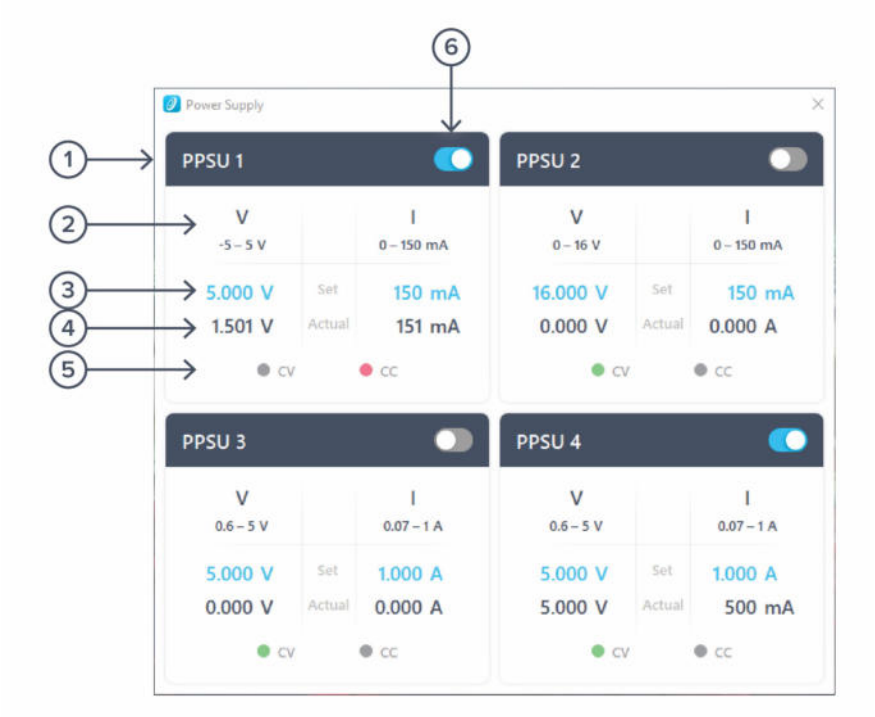
Power Supply

Moku:Go's power supply is available on M1 and M2 models. M1 features a 2-channel power supply, while M2 features a 4-channel power supply. The power supply control window can be accessed in all instruments under the main menu.

The power supply operates in two modes: **constant voltage (CV)** or **constant current (CC)** mode. For each channel, the user can set a current and voltage limit for the output. Once a load is connected, the power supply operates either at the set current or set voltage, whichever comes first. If the power supply is voltage limited, it operates in the CV mode. If the power supply is current limited, it operates in the CC mode.



ID	Function	Description
1	Channel name	Identifies the power supply being controlled
2	Channel range	Indicates the voltage/current range of the channel
3	Set value	Click the blue numbers to set the voltage and current limit
4	Readback numbers	Voltage and current readback from the power supply, the actual voltage and current being supplied to the external load
5	Mode indicator	Indicates if the power supply is in CV (green) or CC (red) mode
6	On/Off Toggle	Click to turn the power supply on and off

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Ensure Moku:Go is fully updated. For the latest information:

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FIR Filter Builder

Moku:Go User Manual

With Moku:Go's FIR Filter Builder, you can design and implement lowpass, highpass, bandpass, and bandstop finite impulse response (FIR) filters with up to 14,819 coefficients at a sampling rate of 30.52 kHz, or 232 coefficients at a sampling rate up to 3.906 MHz. Moku:Go's Windows/MacOS interface allows you to fine tune your filter's response in the frequency and time domains to suit your specific application. Select between four frequency response shapes, five common impulse responses, and up to eight window functions.

LIQUID INSTRUMENTS

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V21-0204

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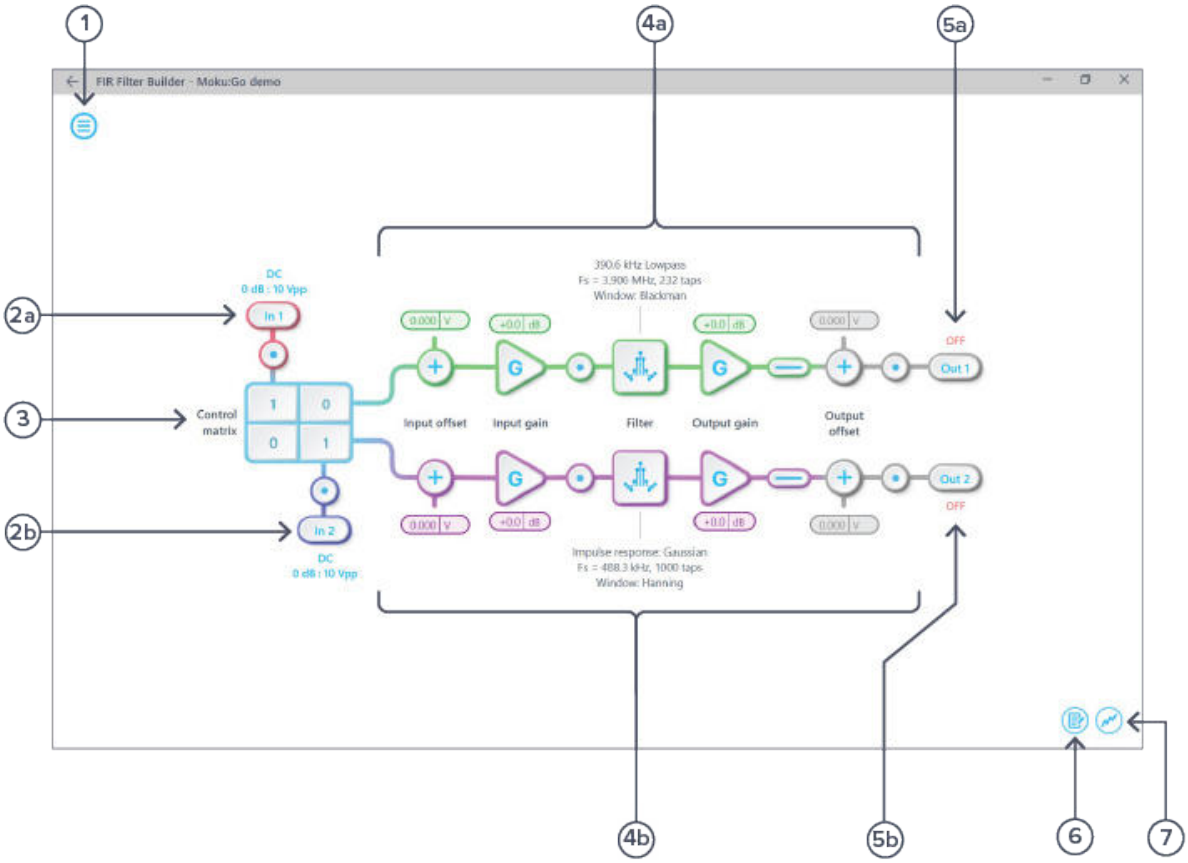
User Interface



ID	Description
1	Main menu
2a	Input configuration for Channel 1
2b	Input configuration for Channel 2
3	Control matrix
4a	Configuration for FIR filter 1
4b	Configuration for FIR filter 2
5a	Output switch for FIR filter 1
5b	Output switch for FIR filter 2
6	Enable the data logger
7	Enable the oscilloscope

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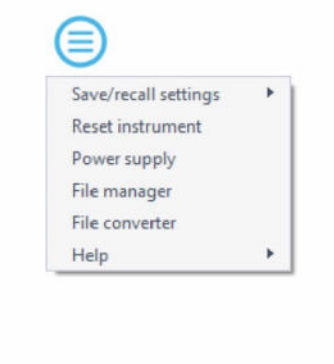
Main Menu

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



This menu provides the following options:

Options	Shortcuts	Description
Save/recall settings:		
• **Save instrument state**	Ctrl+S	Save the current instrument settings
• **Load instrument state**	Ctrl+O	Load last saved instrument settings
• **Show current sate**		Show the current instrument settings
Reset instrument	Ctrl+R	Reset the instrument to its default state
Power supply		Access power supply control window*
File manager		Open file manager tool**
File converter		Open file converter tool**
Help		
• **Liquid Instruments website**		Access Liquid Instruments website
• **Shortcuts list**	Ctrl+H	Show Moku:Go app shortcuts list
• **Manual**	F1	Access instrument manual
• **Report an issue**		Report bug to Liquid Instruments
• **About**		Show app version, check update, or license information

*Power supply is available on Moku:Go M1 and M2 models. Detailed information about the power supply can be found in Moku:Go power supply manual.

**Detailed information about the file manager and file converter can be found at the end of this user manual.

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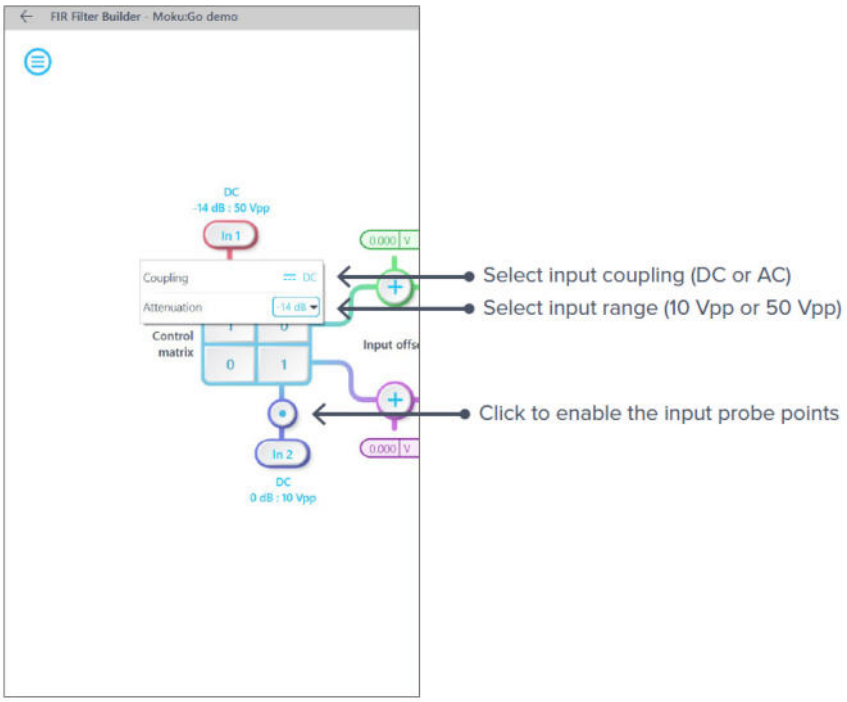
Input Configuration

The **input configuration** can be accessed by clicking the In 1 or In 2 icon, allowing you to adjust the coupling and input range for each input channel.



Details about the probe points can be found in the Probe Points section.

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Control Matrix

The **control matrix** combines, rescales, and redistributes the input signals to the two independent FIR filters. The output vector is the product of the control matrix multiplied by the input vector.

$$\begin{bmatrix} Path1 \\ Path2 \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \times \begin{bmatrix} In1 \\ In2 \end{bmatrix}$$

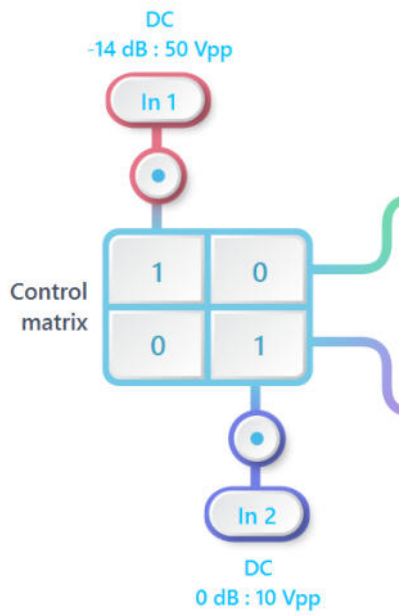
where

$$Path1 = a \times In1 + b \times In2$$

$$Path2 = c \times In1 + d \times In2$$

For example, a control matrix of $\begin{bmatrix} 1 & 1 \\ 0 & 2 \end{bmatrix}$ adds Input 1 and Input 2 and routes to the top *Path1* (FIR Filter 1), multiplies Input 2 by a factor of two, and then routes it to the bottom *Path2* (FIR Filter 2).

The value of each element in the control matrix can be set between -20 to +20 with 0.1 increments when the absolute value is less than 10, or 1 increment when the absolute value is between 10 and 20. The value can be adjusted by clicking on the element.



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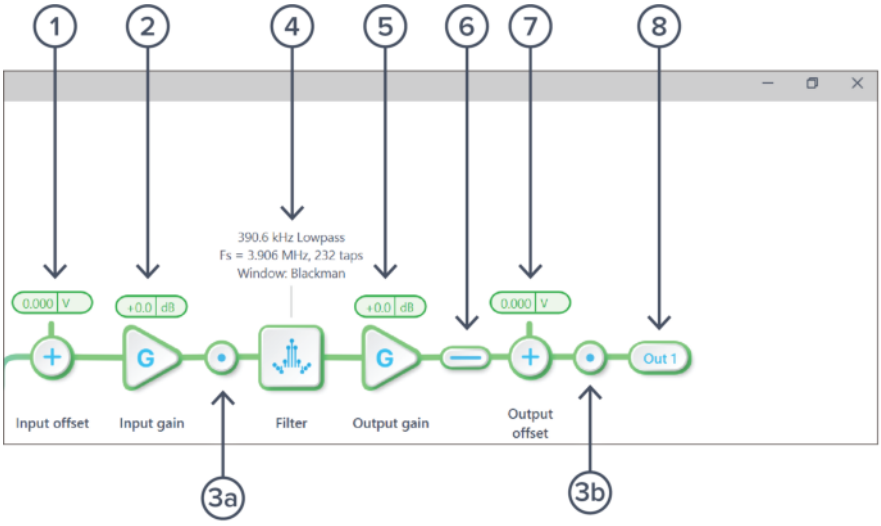
FIR Filter

The two independent, fully real-time configurable FIR filter paths follow the control matrix in the block diagram, represented in green and purple for filter 1 and 2, respectively.

User Interface



ID	Parameter	Description
1	Input offset	Click to adjust the input offset (-2.5 to +2.5 V)
2	Input gain	Click to adjust the input gain (-40 to 40 dB)
3a	Pre-filter probe	Click to enable/disable the pre-filter probe point. See Probe Points section for details.
3b	Output probe	Click to enable/disable the output probe point. See Probe Points section for details.
4	FIR filter	Click to open view and configure the FIR filter builder
5	Output gain	Click to adjust the input gain (-40 to 40 dB)
7	Output switch	Click to zero the filter output
7	Output offset	Click to adjust the input offset (-2.5 to +2.5 V)
8	DAC switch	Click to enable/disable Moku:Go's DAC output

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FIR Filter Builder

Builder Interface

Click the icon to open the full **FIR Filter Builder** view.

ID	Parameter	Description
1a	Plot 1	Impulse response plot
1b	Plot 2	Step reponse plot
2	Plot set selection	Click to select the set of plots to display in the plot area
3	Save & close	Click to save and close the filter builder view
4	Sampling rate	Adjust the sampling rate for the input. Slide between 30.52 kHz and 3.906 MHz. You may also use the scroll wheel on the slider to adjust it.
5	Number of coefficients	Click the number to enter or slide the slider to adjust the number of coefficients. You may also use the scroll wheel on the slider to adjust it.
6	Filter design	Configure the parameters for the FIR filter. Detailed information can be found in a later section.
7	Window function	Click to select the window function

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Filter Characteristic Graphs

A set of two real-time filter characteristic plots can be shown at a time in the FIR filter builder. Click the **plot set selection** buttons to select between **Magnitude/phase**, **Impulse/step response**, and **Group/phase delay** plot sets. Click and drag the c icon in the **Magnitude/phase** to adjust the corner frequency in real-time.

	Magnitude/phase		Impulse/step response		Group/phase delay	
	Plot 1	**Plot 2**	**Plot 1**	**Plot 2**	**Plot 1**	**Plot 2**
X - axis	Frequency (MHz)		Time (µs)		Frequency (MHz)	
Y - axis	Gain (dB)	Phase (°)	Amplitude (V)		Group/phase Delay (µs)	

Magnitude/Phase plot set:

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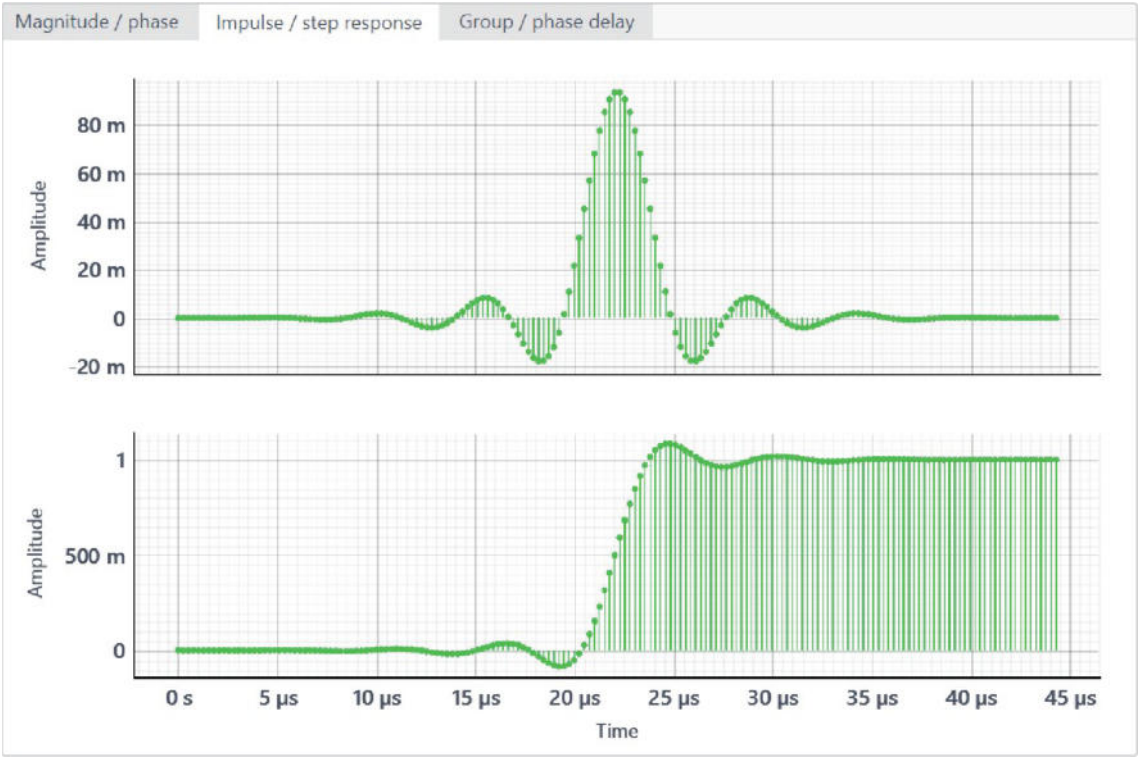
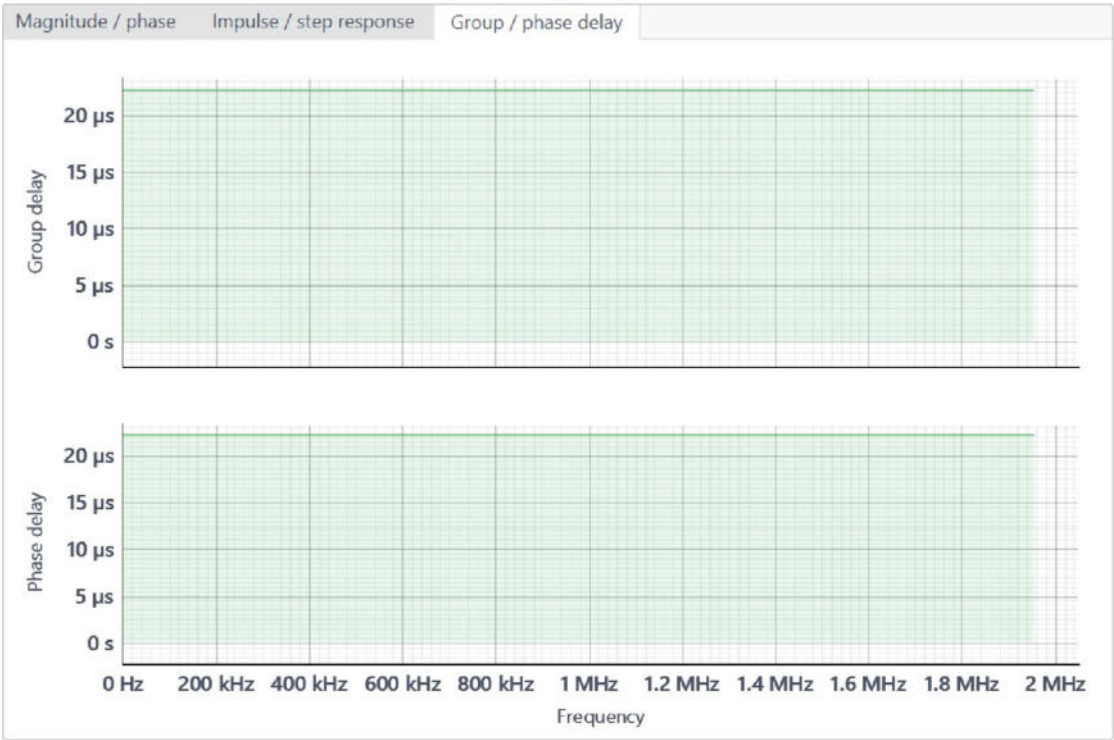
Impulse/step reponse plot set:



Group/phase delay plot sets:



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Sampling Rate/Coefficients

The maximum number of coefficients depends on the chosen sampling rate. Available sampling rates with their corresponding maximum numbers of coefficients are listed in the table below.

Sampling rate	Maximum number of coefficients
30.52 kHz	14,819
61.04 kHz	14,819
122.1 kHz	7,424
244.1 kHz	3,712
488.3 kHz	1,856
976.6 kHz	928
1.953 MHz	464
3.906 MHz	232

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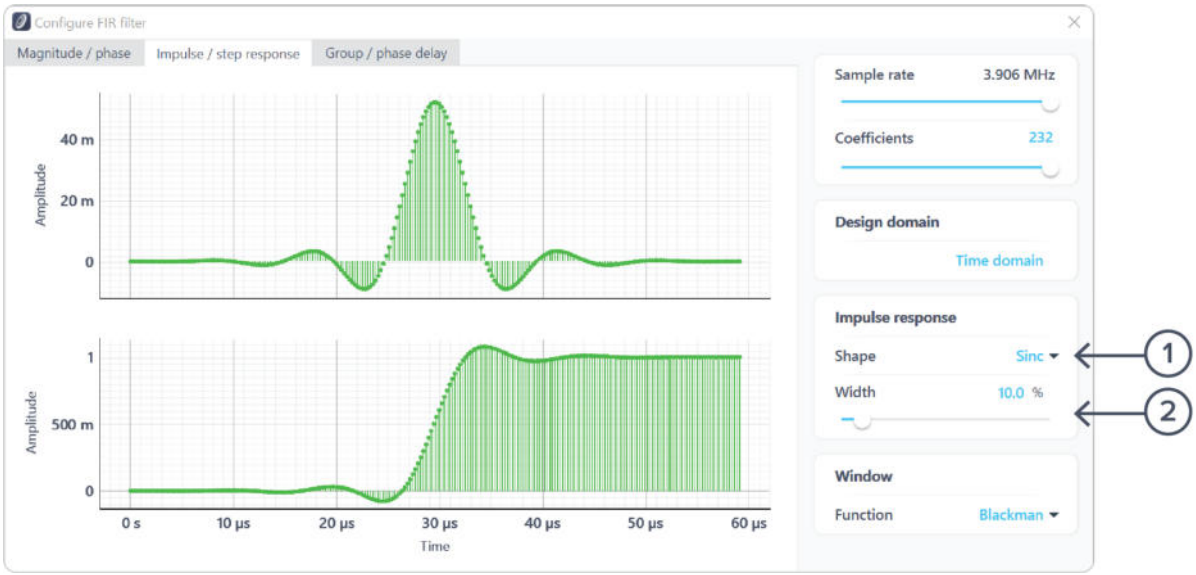
Design Domain

The FIR filter can be designed in either time or frequency domain. In **time domain designer**, an impulse response function builder is accessible. Several predefined functions are available. Users can also enter an equation with the **equation editor** or load their own set of coefficients with the **custom impulse response** option. In **frequency domain designer**, a frequency response builder is accessible. Lowpass, highpass, bandpass, and bandstop filters are available with adjustable cut-off frequencies.

Time Domain Designer



ID	Parameter	Description
1	Impulse shape	Click to select the shape of the impulse response
2	Impulse width	Click the number to enter or slide the slider to adjust the impulse width

List of available shapes

Shape	Note
Rectangular	
Sinc	Width adjustable from 0.1 % to 100 %
Triangular	
Gaussian	Width adjustable from 0.1 % to 100 %
Equation	Click the equation to open the equation editor. Details about the equation editor can be found in the in the **Equation Editor** section.
Custom	Details about the custom impulse response can be found in **Custom Impulse Response** section

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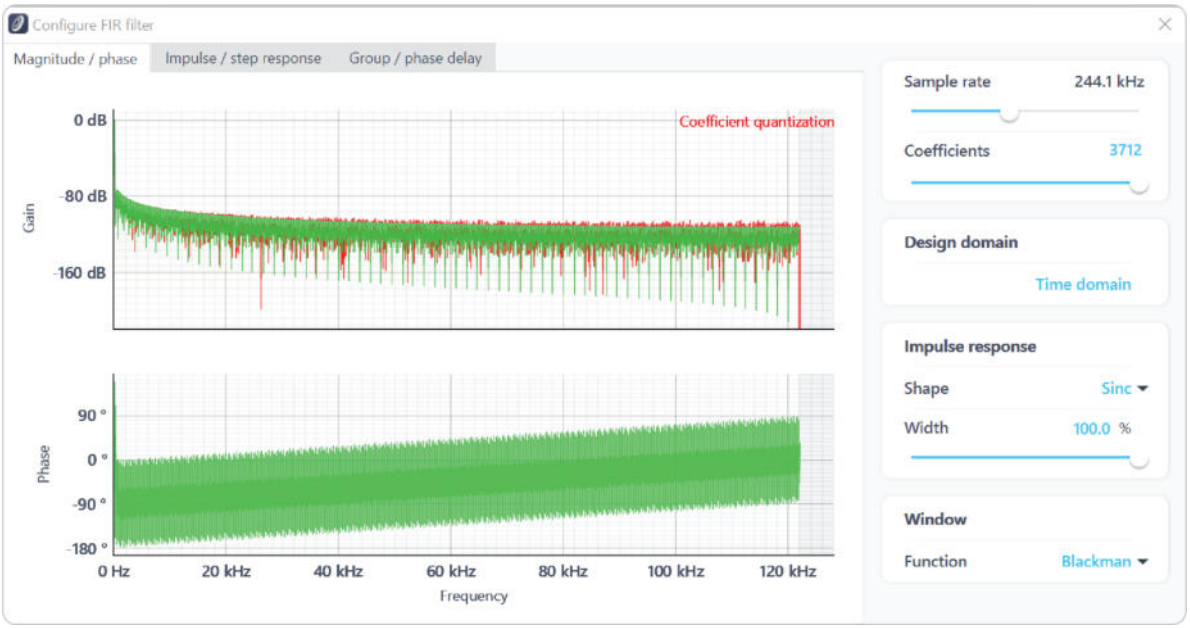
Coefficient Quantization

Due to the limit of digitization depth, the quantization error is pronounced at certain FIR filter settings. A red coefficient quantization warning may appear on the top-right corner of the plot, and the actual response curve will be plotted in red.



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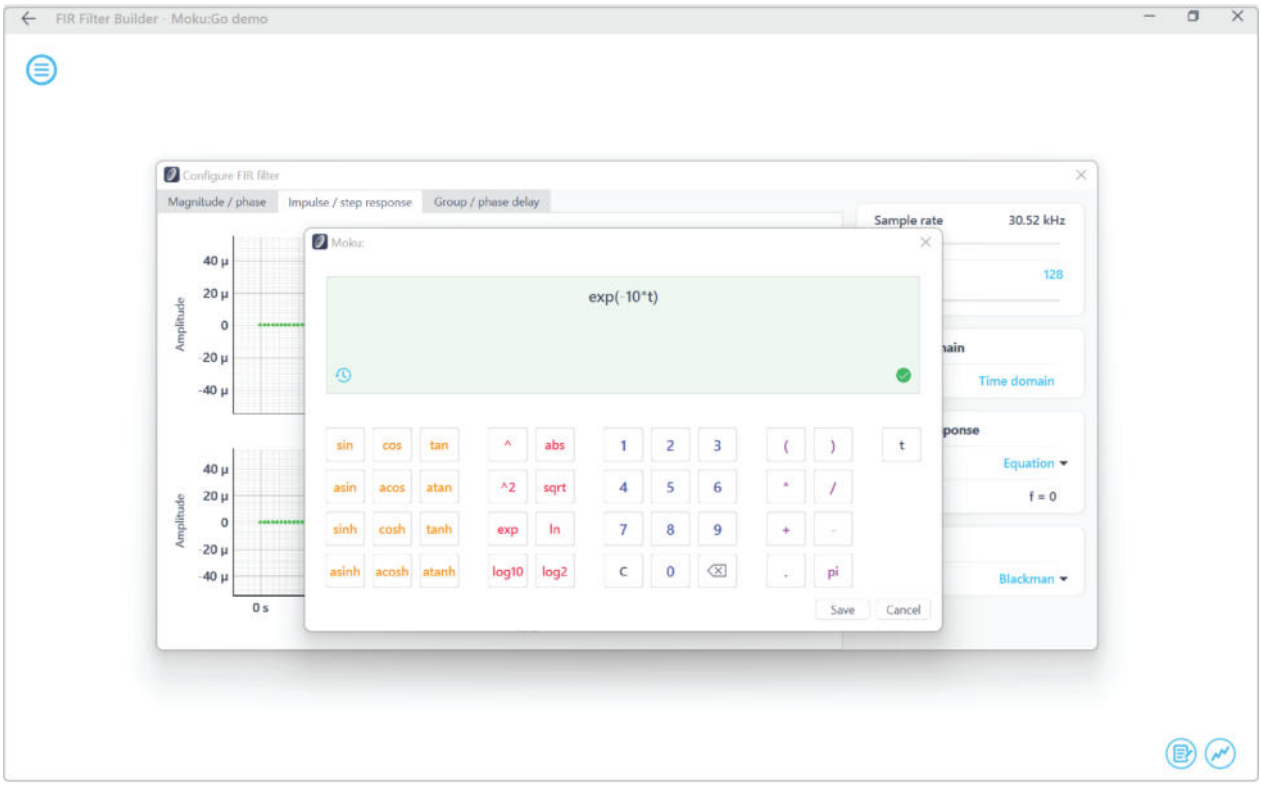
Equation Editor

- The equation editor allows you to define arbitrary mathematical functions for the impulse response.
- Select from a range of common mathematical expressions including trigonometric, quadratic, exponential, and logarithmic functions.
- The variable **t** represents time in the range from 0 to 1 periods of the total waveform.
- Access recently entered equations by pressing the icon.
- The validity of the entered equation is indicated by the and icons that appear to the right of the equation box.



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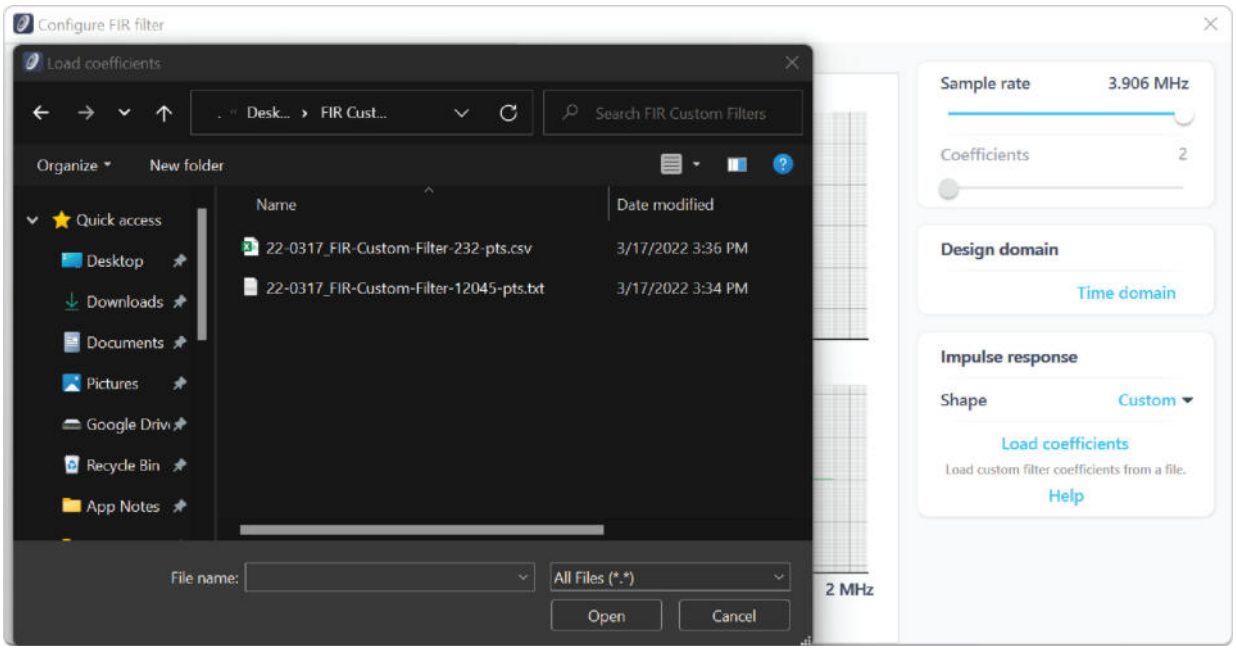
Custom Impulse Response

The output of the FIR filter is a weighted sum of the most recent input values:

$$y[n] = \sum_{i=0}^{N-1} c_i x[n-1]$$

To specify a custom filter, you must supply a text file containing the filter coefficients from your computer that is connected to Moku:Go. The file can contain up to 14,819 coefficients separated by commas or new lines. Each coefficient must be in the range of [-2.5, +2.5]. Internally, these are represented as signed 25-bit fixed-point numbers, with 24 fractional bits. Filter coefficients can be computed using signal processing toolboxes in MATLAB, SciPy, etc.

Some coefficients may result in overflow or underflow, which degrade filter performance. Filter responses should be checked prior to use.



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Frequency Domain Designer

ID	Parameter	Description
1	Cut-off cursor	Click and hold to slide in the frequency axis
2	Impulse width	Click to select the filter shape

List of available shapes:

Shape	Note
Lowpass	Single adjustable cursor
Highpass	Single adjustable cursor
Bandpass	Two adjustable cursors
Bandstop	Two adjustable cursors

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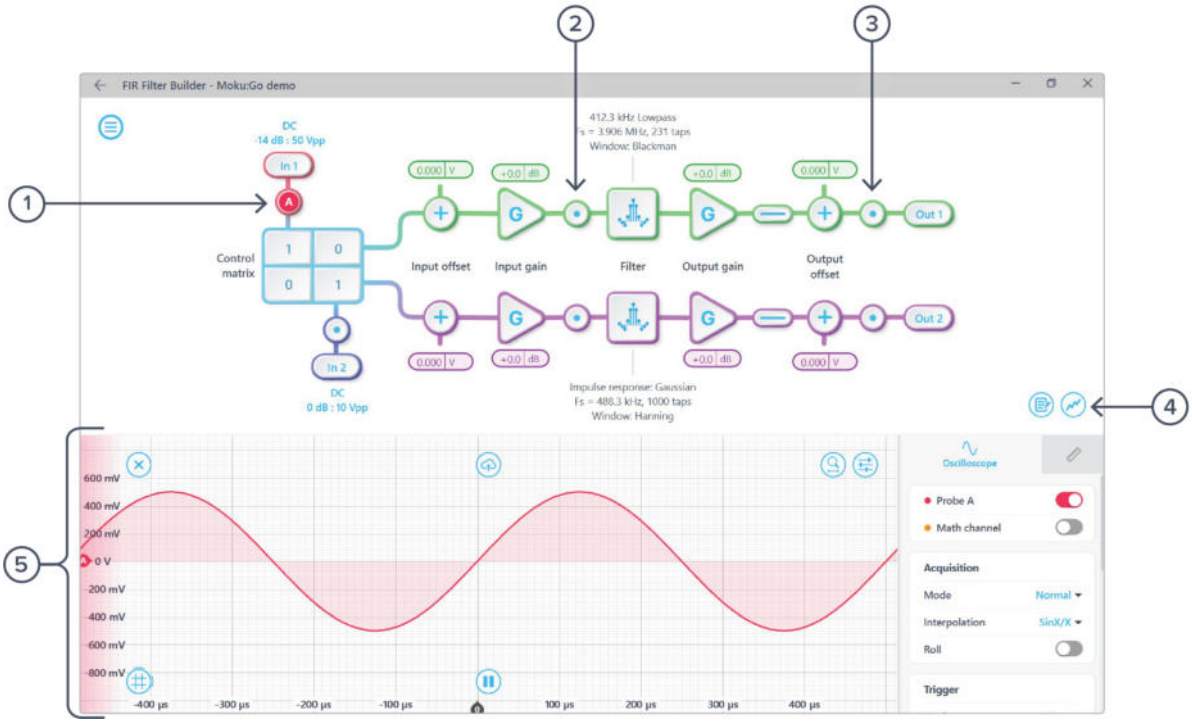
Probe Points

Moku:Go's FIR Filter Builder has an integrated oscilloscope and data logger that can be used to probe the signal at the input, pre-FIR filter, and output stages. The probe points can be added by clicking the icon.

Oscilloscope



ID	Parameter	Description
1	Input probe point	Click to place the probe point at input
2	Pre-FIR probe point	Click to place the probe before the FIR filter
3	Output probe point	Click to place the probe at output
4	Oscilloscope/data logger toggle	Toggle between built-in oscilloscope or data logger
5	Oscilloscope	Refer to Moku:Go's Oscilloscope manual for the details

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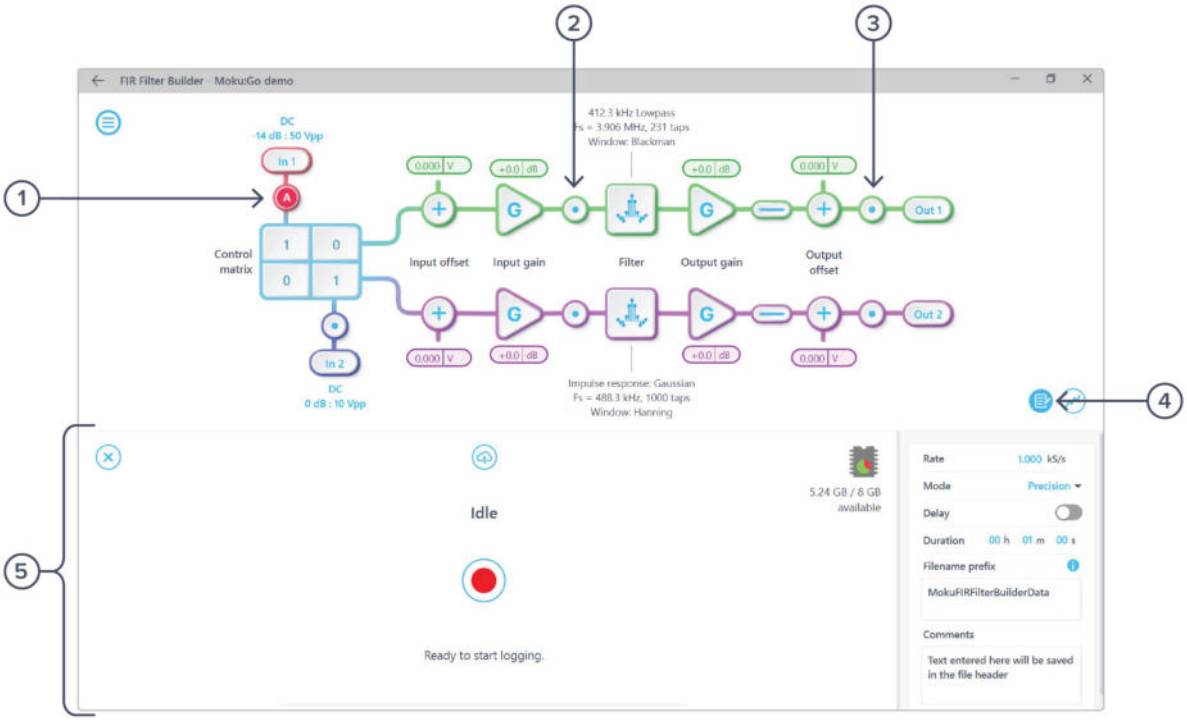
Data Logger



ID	Parameter	Description
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2	Pre-FIR probe point	Click to place the probe before the FIR filter
3	Output probe point	Click to place the probe at output
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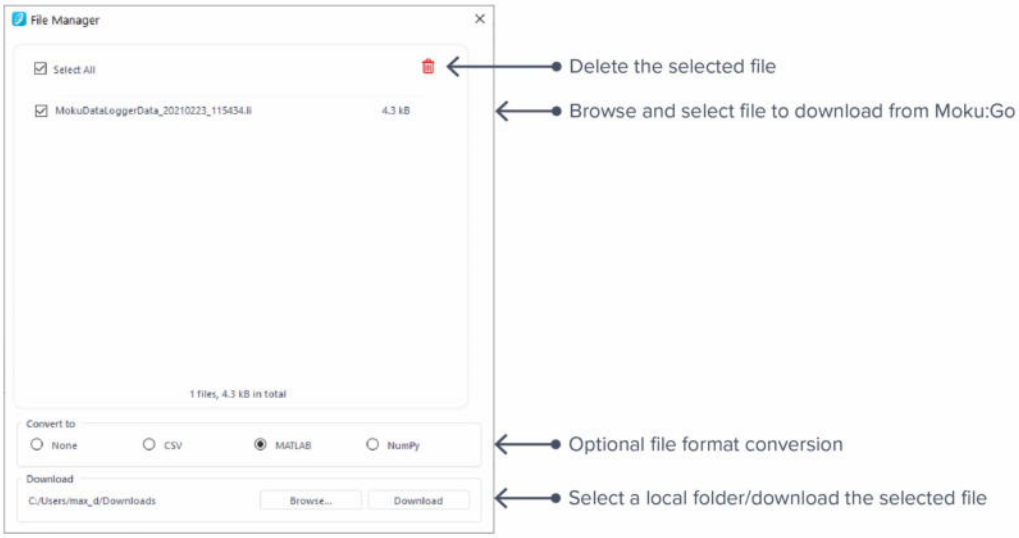
File Manager



Once a file is transferred to the local computer, a icon shows up next to the file.

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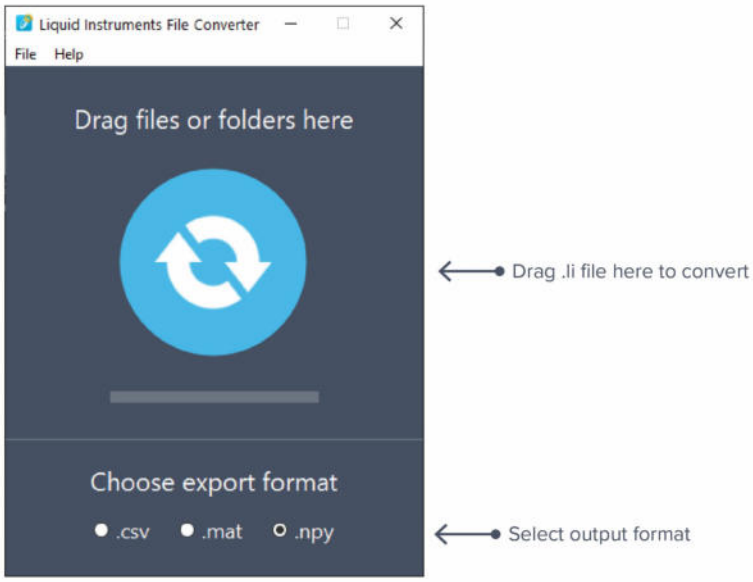
File Converter



The converted file is saved in the same folder as the original file.

Liquid Instruments File Converter has the following menu options:

Options	Shortcut	Description
File		
• **Open file**	Ctrl+O	Select a .li file to convert
• **Open folder**	Ctrl+Shift+O	Select a folder to convert
• **Exit**		Close the file converter window
Help		
• **Liquid Instruments website**		Access Liquid Instruments website
• **Report an issue**		Report bug to Liquid Instruments
• **About**		Show app version, check update, or license information

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Power Supply

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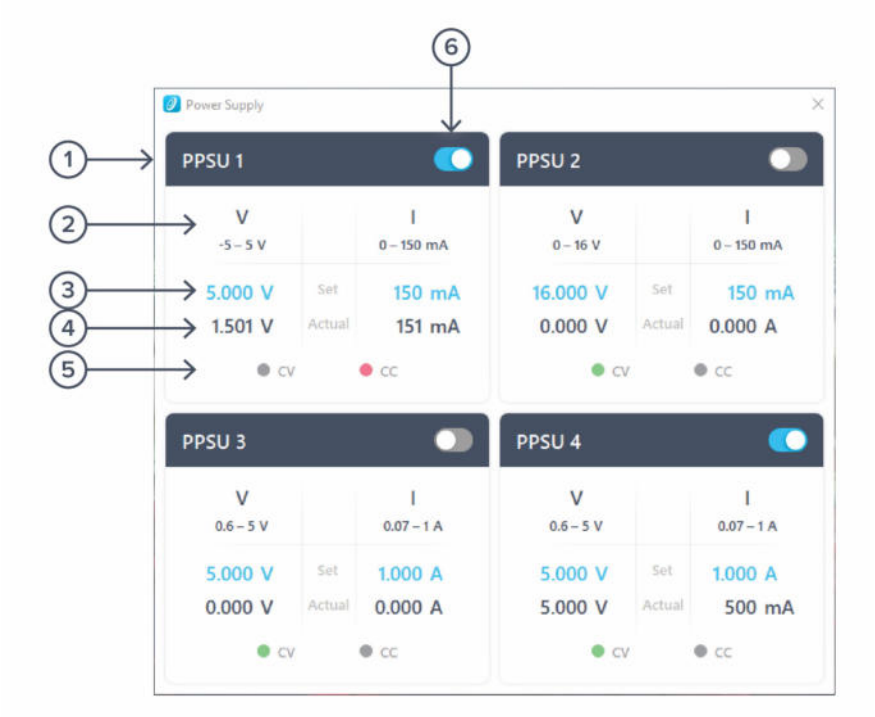

ID	Function	Description
1	Channel name	Identifies the power supply being controlled
2	Channel range	Indicates the voltage/current range of the channel
3	Set value	Click the blue numbers to set the voltage and current limit
4	Readback numbers	Voltage and current readback from the power supply, the actual voltage and current being supplied to the external load
5	Mode indicator	Indicates if the power supply is in CV (green) or CC (red) mode
6	On/Off Toggle	Click to turn the power supply on and off

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