



Laser Lock Box

Moku:Go User Manual

The Moku:Go Laser Lock Box enables you to stabilize a laser's frequency to a reference cavity or atomic transition using high-performance modulation locking techniques. The Laser Lock Box is designed with the concept of staged locking and a “Lock Assist”, enabling a user-defined locking process to quickly lock to any zero-crossing on the demodulated error signal. It also features an integrated two-channel Oscilloscope, allowing you to observe signals at any point in the signal processing chain at up to 125 MSa/s. Additionally, the built-in Data Logger enables long-term recording of signals.





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Introduction

Laser locking systems are used to control and match a laser's frequency to an optical frequency reference, such as an optical reference cavity or atomic transition. Such systems are vital for high-resolution interferometric measurements, spectroscopy, and time and frequency standards.

Locking a laser by forcing the laser and reference frequencies to be equal allows for two scenarios:

- The locking system steers the laser frequency to be equal to the reference frequency, which is referred to as frequency stabilization; and
- The locking system forces the reference frequency to follow the laser frequency, which is referred to as frequency tracking.

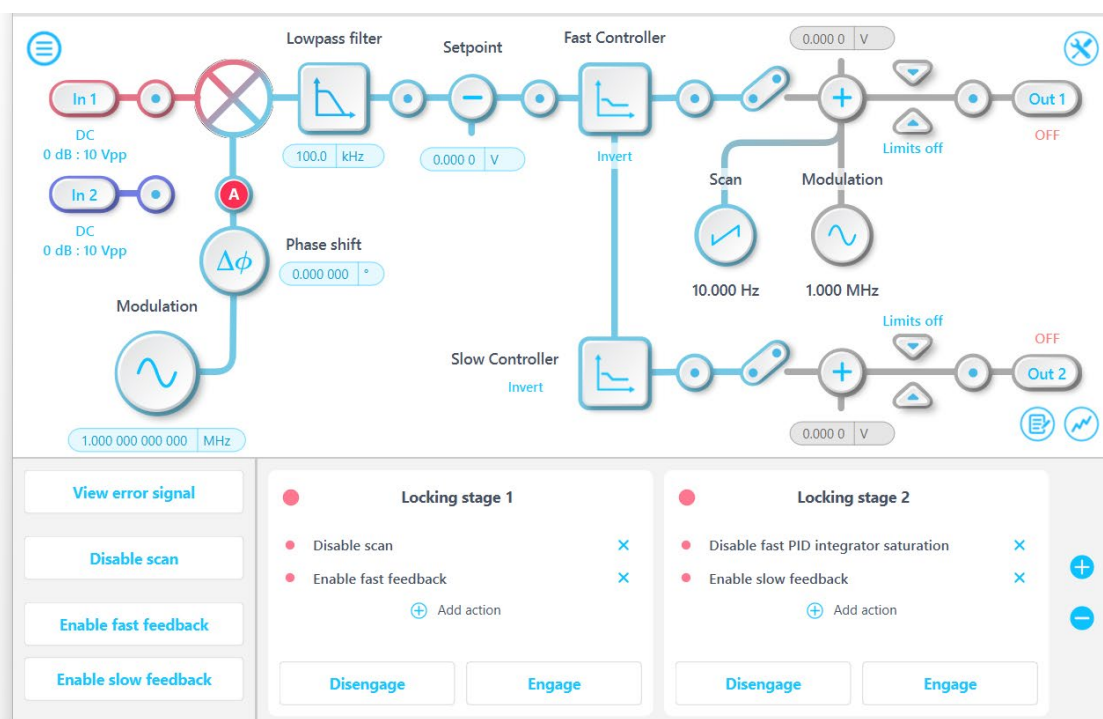
Whether used for frequency stabilization or frequency tracking, the Moku:Go Laser Lock Box is designed to assist in laser locking systems. It offers compact setup, acquisition, and diagnostic features that makes it easier and quicker to set up and characterize laser locking systems.





User interface

The main user interface is divided into upper and lower screen sections. The upper user interface displays the processing chain and principal controls of the Laser Lock Box.





The lower half is readily set to display one of three parameter control panels: locking stages, Oscilloscope, and Data Logger.



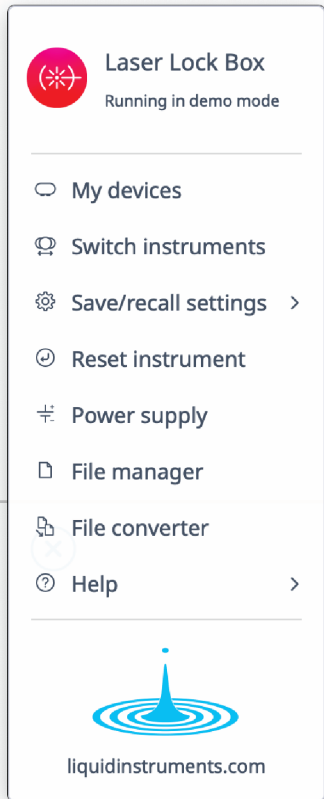
ID	Description
1	Locking stages
2	Oscilloscope
3	Data Logger





Main menu

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



← Select device or return to selection screen

← Select instrument or return to selection screen

← Save and load instrument settings

← Reset the instrument to its default state (cannot be undone)

← Access the power supply control window

← Launch the file manager

← Launch the file converter

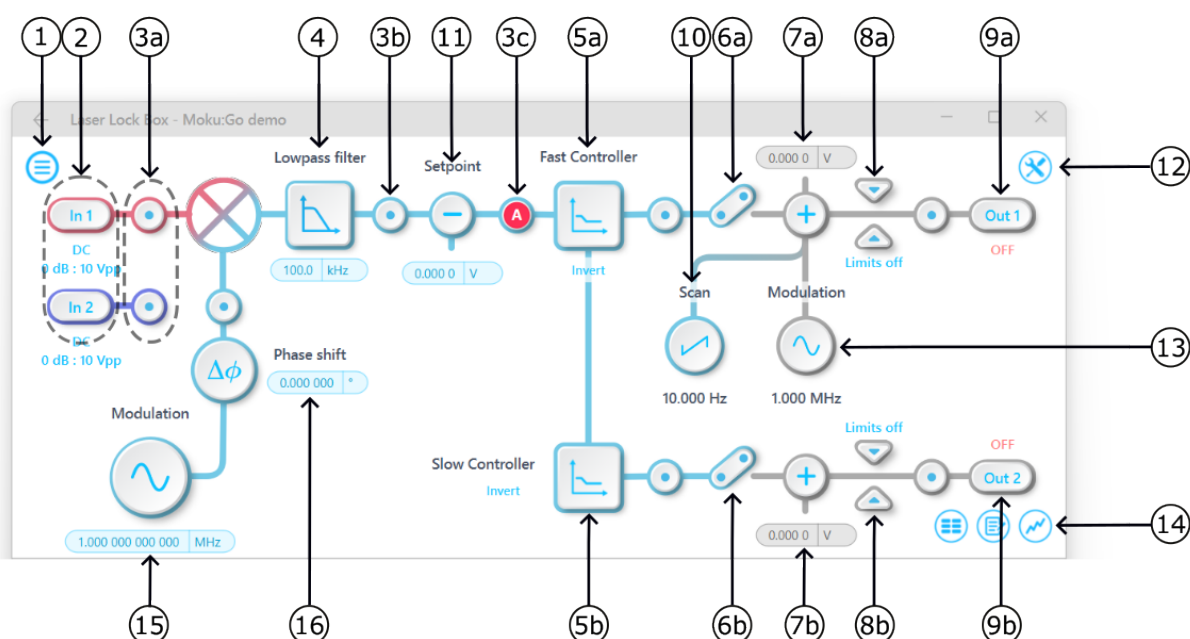
← Get help on how to use various instrument features

← Launch the liquidinstruments.com website





Upper user interface



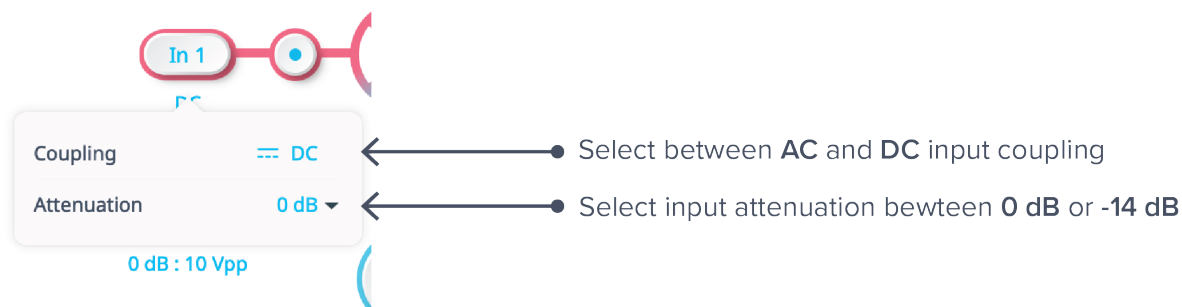
ID	Description	ID	Description
1	Main menu	8b	Output limiter on slow PID chain
2	Input settings	9a	Turn output 1 on/off
3a-c	Tap to drop oscilloscope probe points to examine signals along the processing chain	9b	Turn output 2 on/off
4	Tap to configure the digital filter	10	Configure scanning signal*
5a	Tap to configure fast PID controller	11	Apply input offset
5b	Tap to configure slow PID controller	12	Configure local oscillator
6a	Connect fast PID chain to output	13	Configure the modulation signal*
6b	Connect slow PID chain to output	14	Tap to choose the control panel
7a	Apply output offset to fast PID chain	15	Control local oscillator frequency
7b	Apply output offset to slow PID chain	16	Control local oscillator phase
8a	Output limiter on fast PID chain		





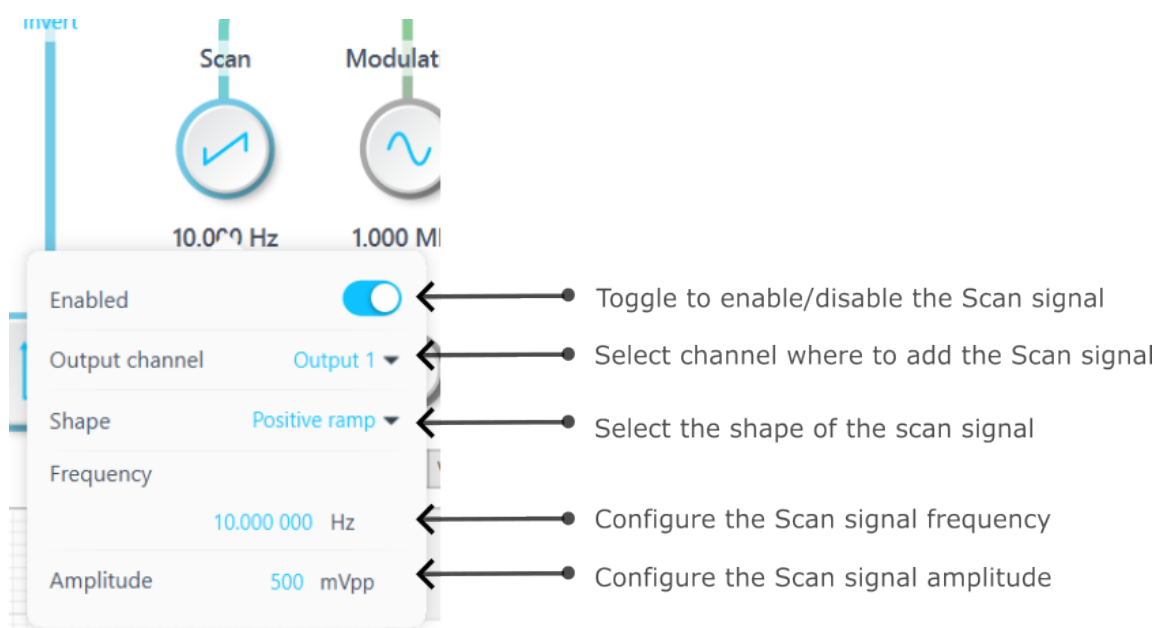
Signal input

Tap the **In 1** icon to configure the input settings for the signal input. Make similar configurations on input 2.



Scan configurations

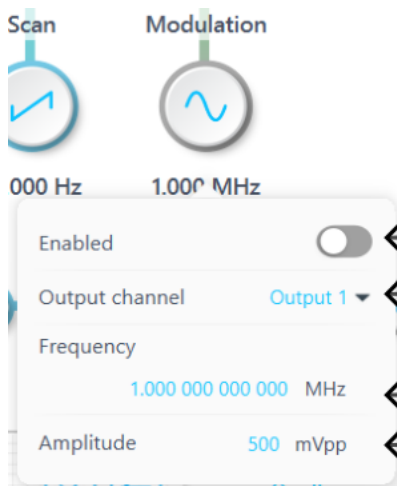
Tap the **Scan** icon to configure the settings for the scan signal.





Modulation configuration

Tap the  icon to configure the settings for the modulation signal.



The screenshot shows the 'Modulation' configuration menu. At the top, there are two icons: 'Scan' (a circle with a blue line graph) and 'Modulation' (a circle with a blue sine wave). Below the icons, the frequency is set to '1.000 MHz' and the amplitude is set to '500 mVpp'. The menu is divided into four sections, each with an annotation:

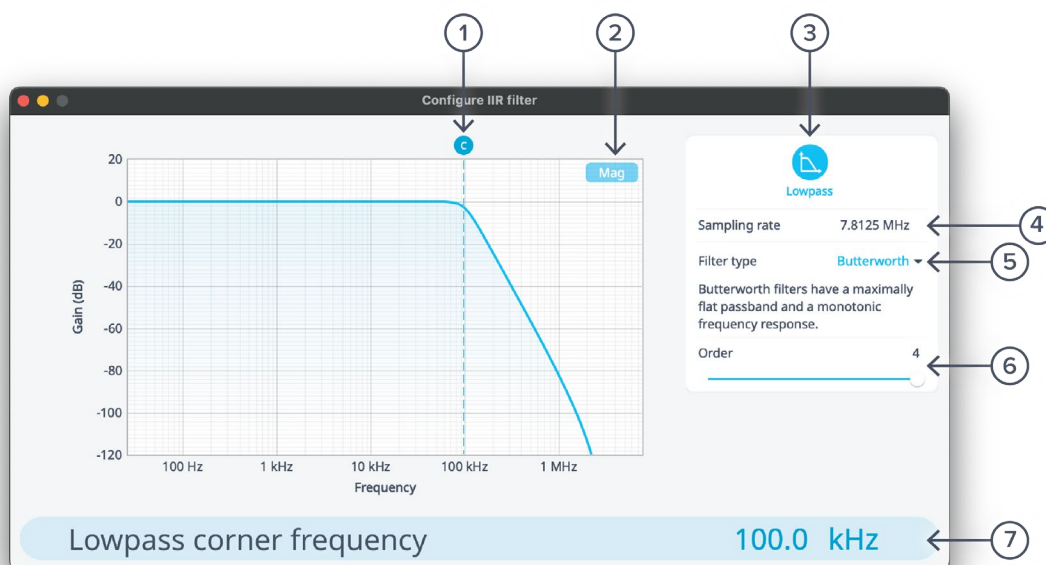
- Enabled:** A toggle switch. Annotation: "Toggle to enable/disable the Modulation signal".
- Output channel:** A dropdown menu showing 'Output 1'. Annotation: "Select channel where to add the Modulation signal".
- Frequency:** A text field showing '1.000 000 000 000 MHz'. Annotation: "Configure the Modulation signal frequency".
- Amplitude:** A text field showing '500 mVpp'. Annotation: "Configure the Modulation signal amplitude".





Digital filter configuration

Immediately after the demodulator function, there is a digital filter designed to remove unwanted signal components. This is highly configurable; just tap the lowpass filter icon.



ID	Description	ID	Description
1	Configure lowpass filter corner frequency: tap to enter frequency or touch and drag	5	Tap to select filter type
2	Toggle between magnitude or phase plots	6	Tap to select filter order
3	Tap to select filter shape	7	Tap to enter corner frequency
4	Fixed sample rate of 7.8125 MHz		

Filter shapes

Select the shape of the filter by tapping the filter icon. There are two pre-defined filter shapes and a fully customizable filter option.



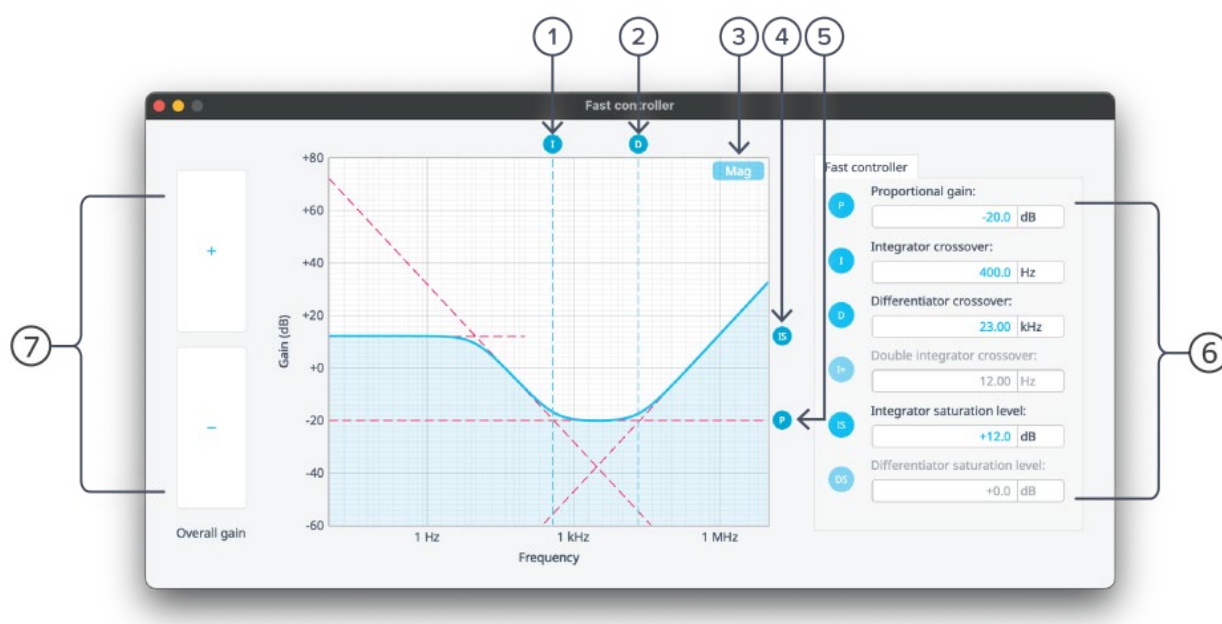


PID controllers

The Moku:Go Laser Lock Box implements two cascaded PID controllers: a fast controller and a slow controller. The input of the slow PID controller is the output of the fast PID controller.

Both the fast and slow PID controllers can be configured graphically by dragging interactively on the magnitude chart or by tapping on cross-over tabs and entering frequency or gain on the soft keypad.

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



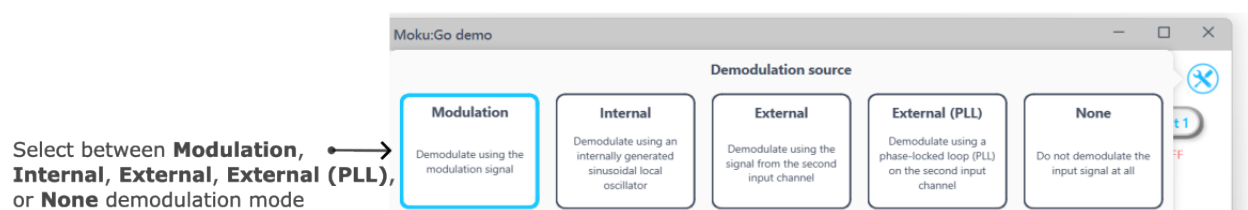
ID	Description	ID	Description
1	Drag or tap to enter integrator crossover frequency	5	Drag or tap to enter proportional gain
2	Drag or tap to enter differentiator crossover frequency	6	Proportional, integrator, differentiator, double integrator (only on the fast controller), integrator saturation, and differentiator saturation settings
3	Toggle between magnitude or phase plots	7	Swipe to adjust selected PID parameter
4	Drag or tap to enter integrator saturation		





Local oscillator

Configure the demodulation signal source in the settings dialog.



Demodulation

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

Modulation

The input signal can be demodulated with the modulation signal, which is user-configured [here](#). This local oscillator is locked to the modulation signal with a frequency range from 1 mHz to 30 MHz.

Internal

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

External

The input signal can be demodulated by a direct external reference, permitting the use of non-sinusoidal demodulation with the input signal applied on input 2.

External (PLL)

External (PLL) mode enables the Laser Lock Box to lock to an externally sourced demodulation reference applied to input 2. This mode uses a digitally implemented phase-locked loop (PLL) to track the phase of the external reference with a user configurable bandwidth. To configure the bandwidth of the PLL, tap the PLL icon to select the bandwidth between 1 Hz to 100 kHz. The PLL will automatically lock to the strongest harmonic of the external reference in the range of 10 Hz to 20 MHz with a manually configurable local phase shift. The PLL can be manually set as low as 10 Hz. The PLL can be frequency multiplied up to 250x or divided down to 1/8x with the Multiplier for use as local oscillator, minimum Multiplier step size is 1/8th. The reacquire button can be used to relock to the external reference.

None

Bypass the demodulation step by selecting “None.” This enables modulation-free locking techniques such as DC locking, fringe-side locking, and tilt locking.

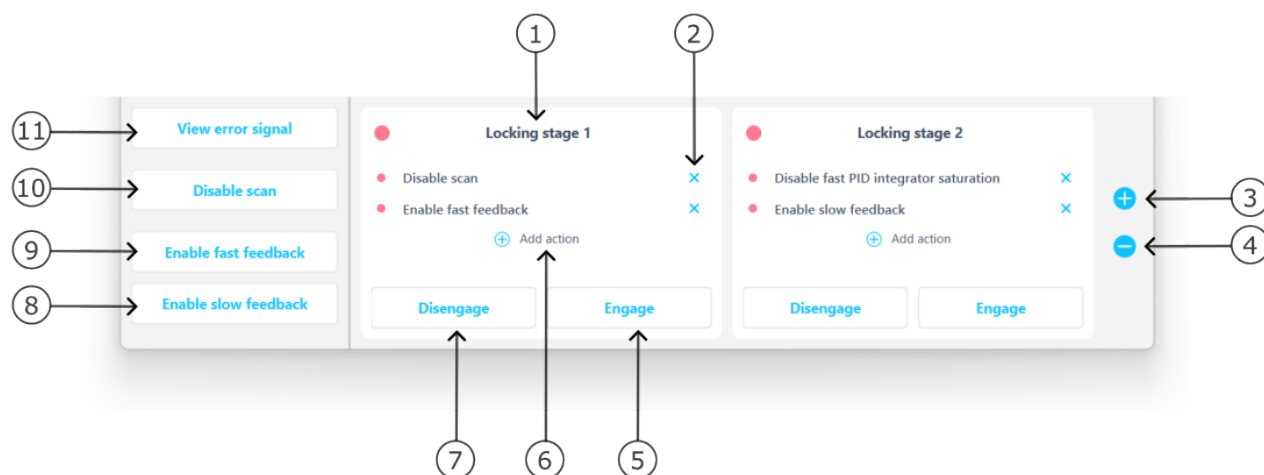




Lower user interface

Use the lower user interface to either configure the locking stages or display the half screen Oscilloscope or Data Logger.

Locking stage



ID	Description	ID	Description
1	Lock stage 1 of (up to) 3	7	Disengage the actions defined in the locking stage
2	Remove a certain action in the locking stage	8	Tap to connect the slow PID to Output 1 to enable the slow feedback
3	Add a new locking stage (allows up to 3 stages at maximum)	9	Tap to connect the fast PID to Output 2 to enable the fast feedback
4	Remove a certain locking stage	10	Tap to enable/disable the scan signal
5	Engage the actions defined in the locking stage	11	Tap to switch to the Oscilloscope to view the error signal, where the user can select the locking point
6	Add a new action in the locking stage		

Add action

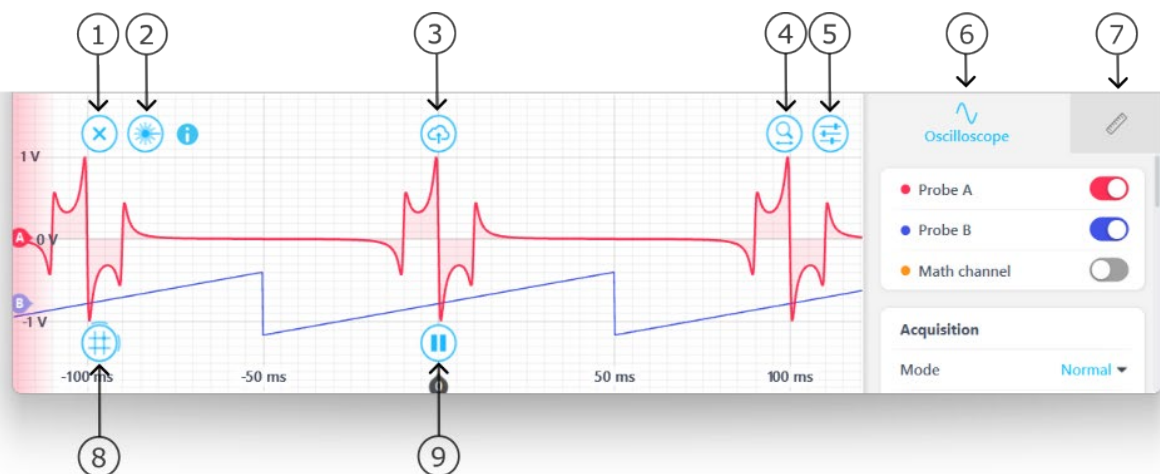
Choose any of the available actions to add to each locking stage. When engaged, all of the actions associated with that stage will be enabled simultaneously.





Oscilloscope

The Moku:Go Laser Lock Box includes a built-in Oscilloscope, enabling you to observe and record data of up to two signals at a time in the Laser Lock Box's processing chain.



ID	Description	ID	Description
1	Close Oscilloscope panel	6	Tap to configure Oscilloscope settings, including Acquisition, Timebase, Trigger, Type, and Sensitivity
2	Select Lock Assist	7	Tap to select measurements tab
3	Share Oscilloscope data	8	Tap to add time/voltage cursors, or drag right or drag up to create a cursor
4	Zoom in/out of the waveform	9	Pause/run Oscilloscope
5	Reveal/hide settings sidebar		

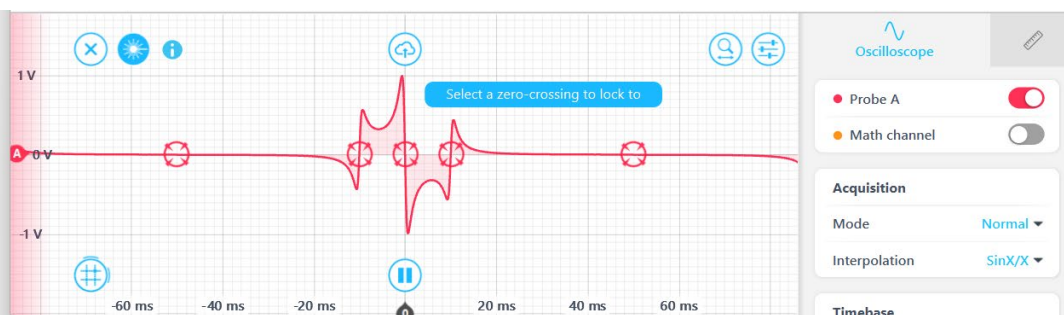
The Oscilloscope will appear automatically when a probe point  is activated.

You can hide the Oscilloscope by pressing the  icon and reveal it by pressing the  icon.

Lock Assist feature

The Lock Assist can only be enabled after the locking stage is configured. When the Lock Assist is enabled, the trigger settings will be configured to synchronize the oscilloscope traces with the scan waveform. Selecting one of the error signal's zero crossings will then adjust the output offset to the corresponding voltage and engage the first locking stage which is not already fully engaged.





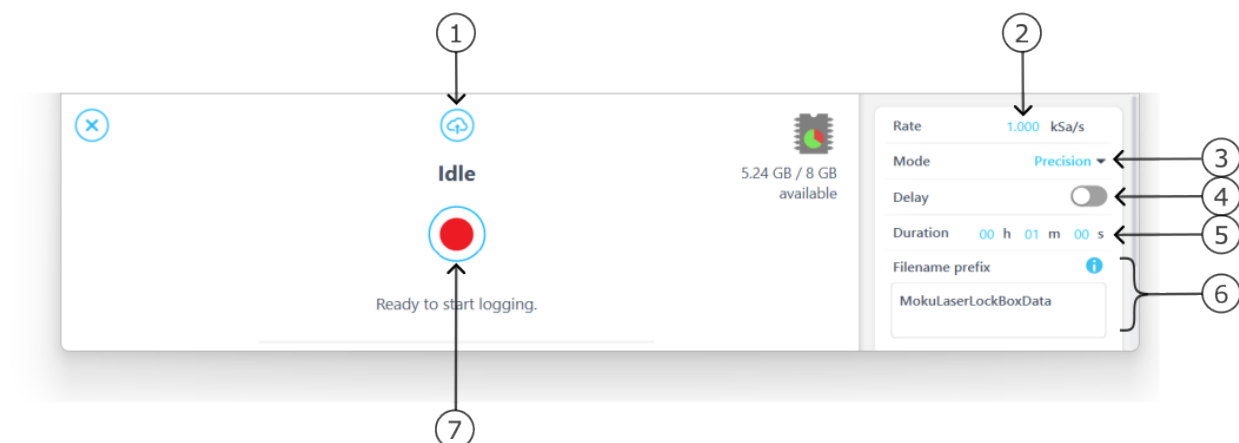
Additional details about the Oscilloscope can be found in the **Moku:Go Oscilloscope** manual.





Data Logger

The built-in Data Logger allows you to acquire data from up to four probe points at a time at a maximum sampling rate of 500 kSa/s with 2 channels and 1 MSa/s with 1 channel. To access the data acquisition menu, press the  icon. More details about Data Logger are available in the **Moku:Go Data Logger** manual.



ID	Description
1	Upload saved data
2	Select the sampling rate at which your measurement is recorded
3	Select between Normal , Precision , or Peak Detection acquisition modes
4	Configure when to begin recording data
5	Configure measurement duration
6	Change filename and comments for the logged file
7	Record a new measurement

The embedded Data Logger can stream over a network or save data on Moku:Go. For details, refer to the Data Logger user manual. More streaming information is in our API documents at apis.liquidinstruments.com

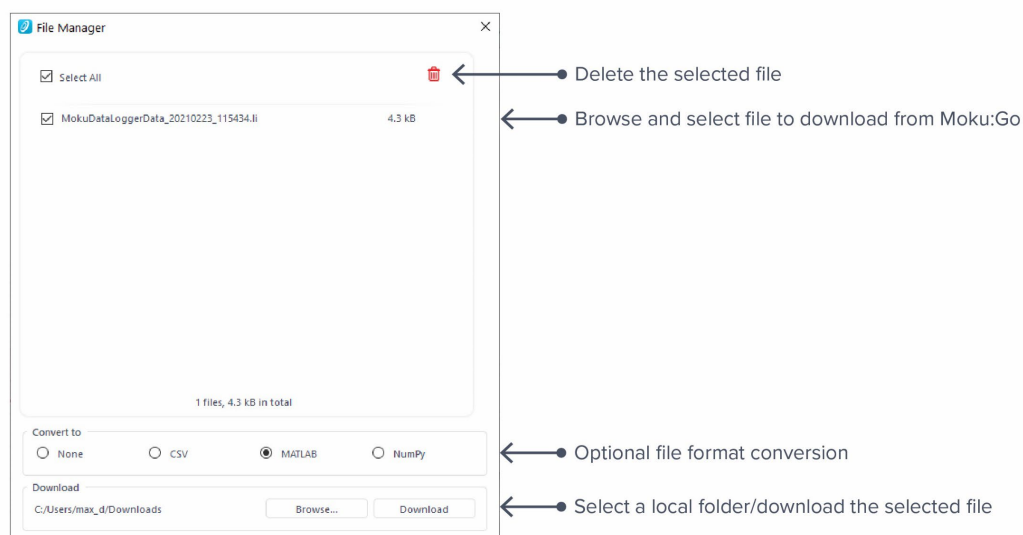




Additional tools

The Moku:Go 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 binary (.li) format on the local computer to either .csv, .mat, or .npz format.

File Manager

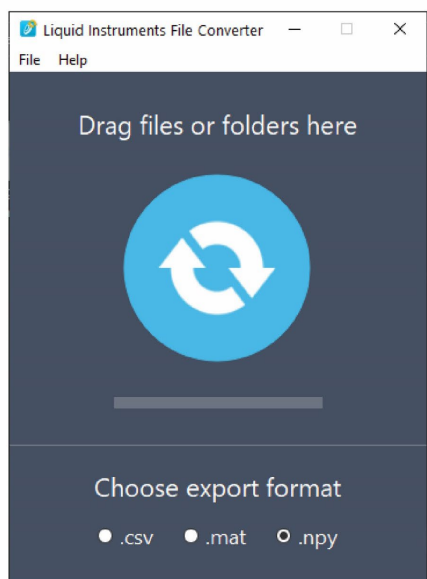


Once a file is transferred to the local computer, a  icon shows up next to the file.





File Converter



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

The 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 the Liquid Instruments website.
• Report an issue		Report a bug to Liquid Instruments.
• About		Show app version, check update, or license information.

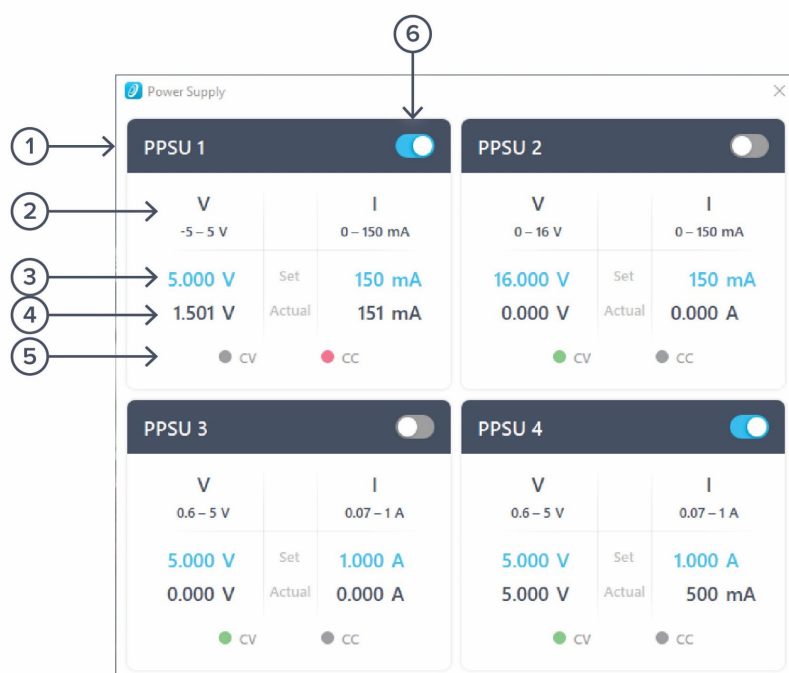




Power Supply

The 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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