PID Controller
Moku:Go User Manual

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

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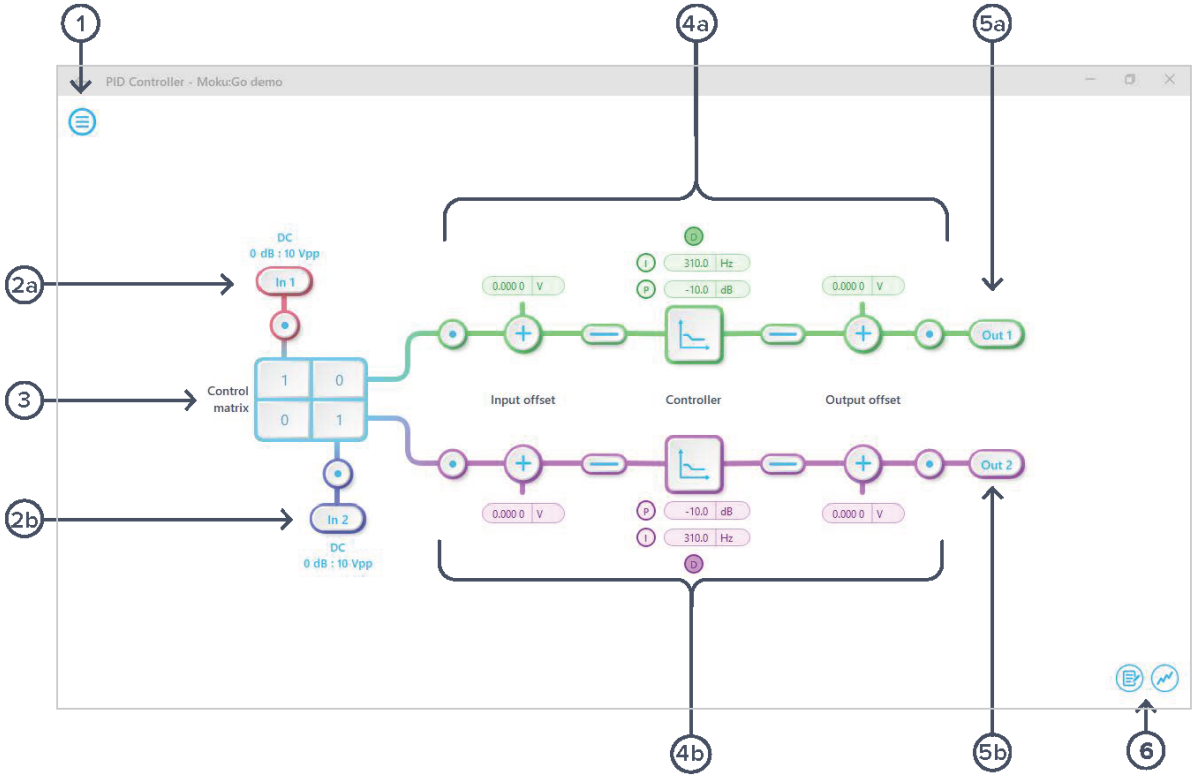
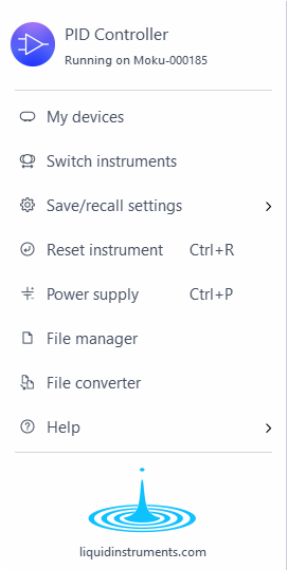
User interface



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	Switch between integrated Oscilloscope and Data Logger.

Main menu

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



This menu provides the following options:

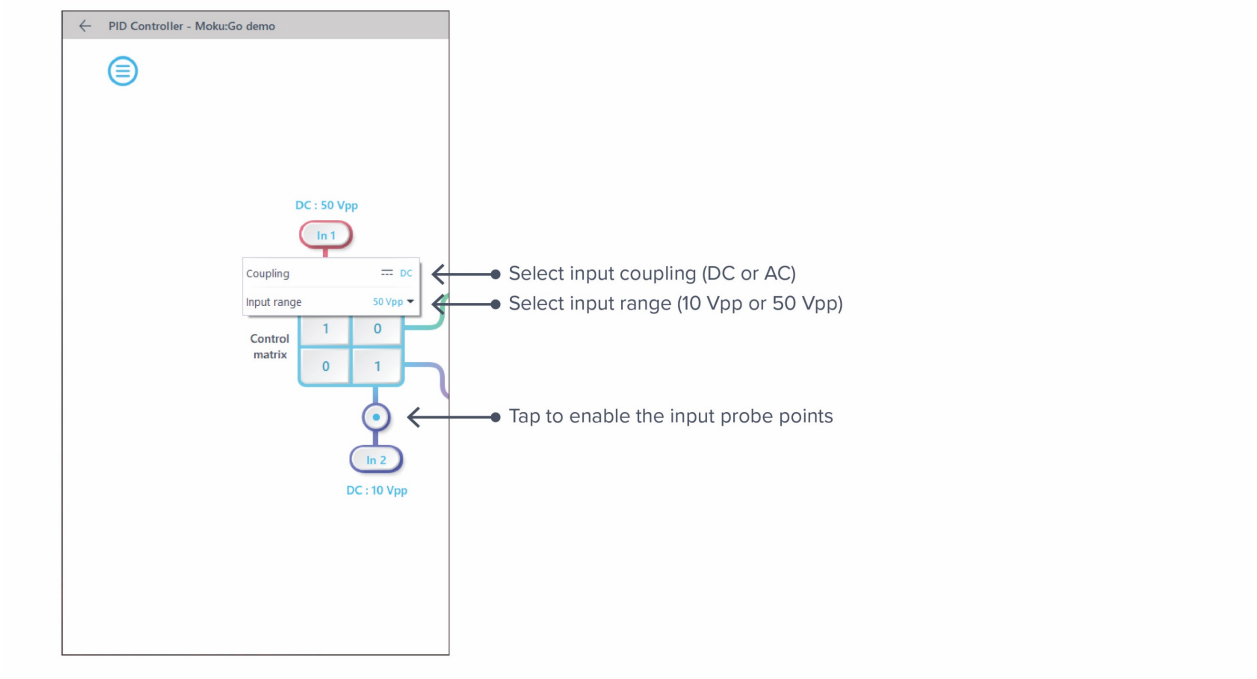
Options	Shortcuts	Description
My devices		Return to device selection.
Switch instruments		Switch to another instrument.
Save/recall settings:		
• **Save instrument state**	Ctrl/Cmd+S	Save the current instrument settings.
• **Load instrument state**	Ctrl/Cmd+O	Load the last saved instrument settings.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

* Power Supply is available on the Moku:Go M1 and M2 models. Detailed information about the Power Supply can be found on page 18 of this user manual.

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

Input configuration

Access the **input configuration** 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.

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.

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

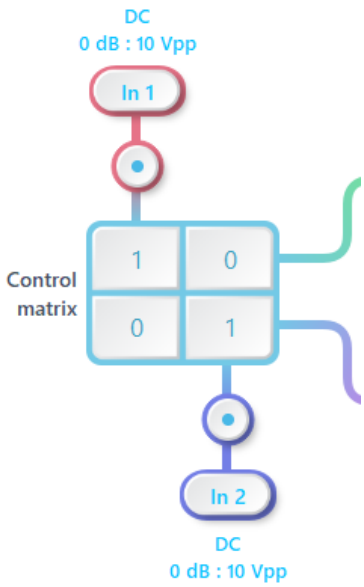
where

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

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

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).

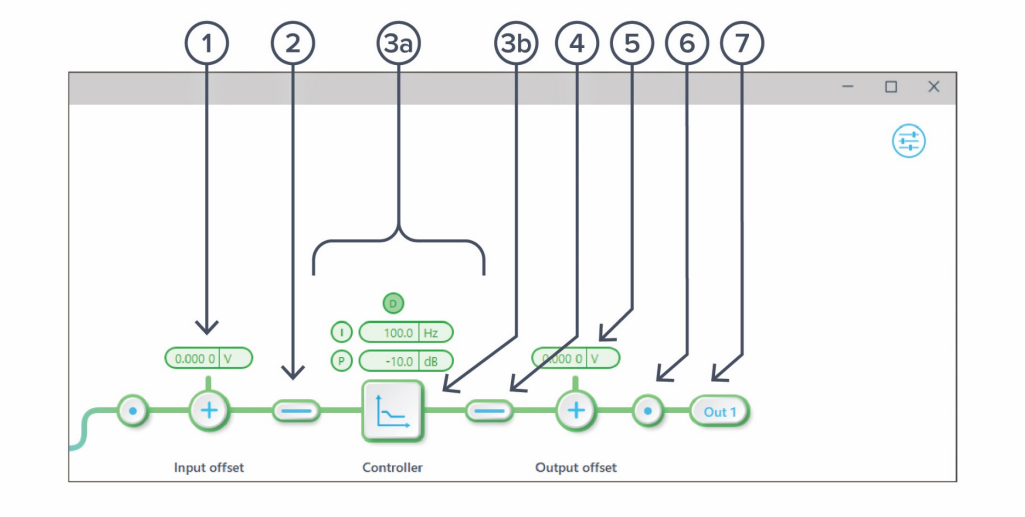
The value of each element in the control matrix can be set between -20 to +20 with 0.1 increments when the absolute value is less than 10, or 1 increment when the absolute value is between 10 and 20. Tap the element to adjust the value.



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 (-2.5 to +2.5 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 (-2.5 to +2.5 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 output.

Input / output switches

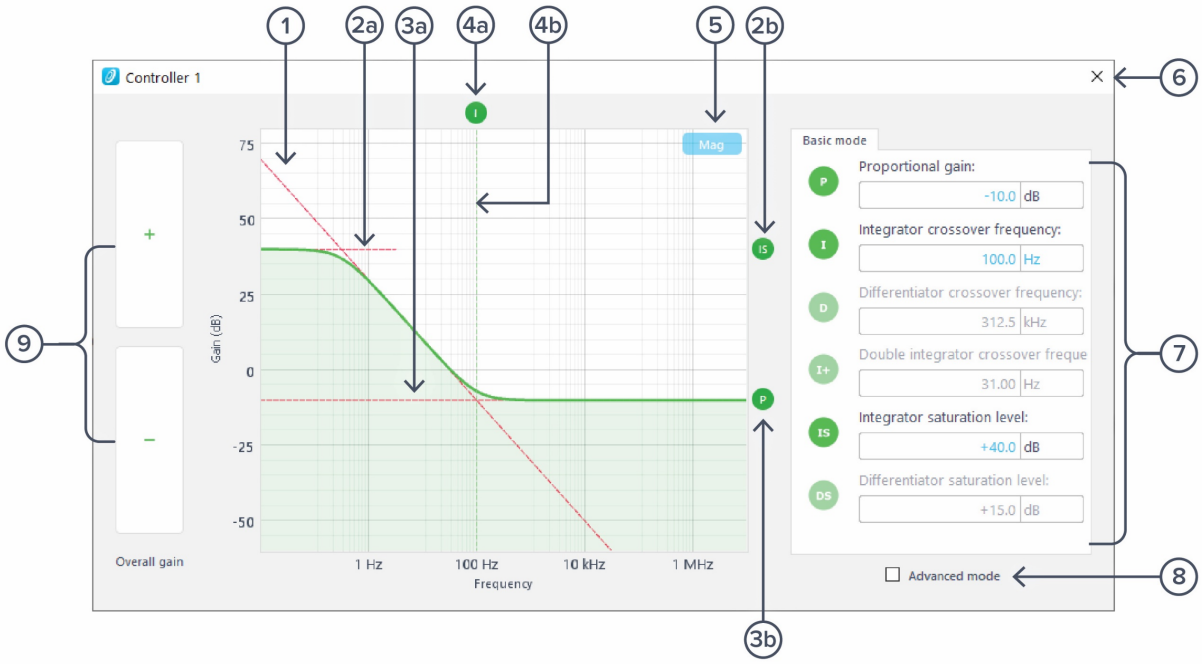
Closed/enable

Open/disable

Controller (basic mode)

Controller interface

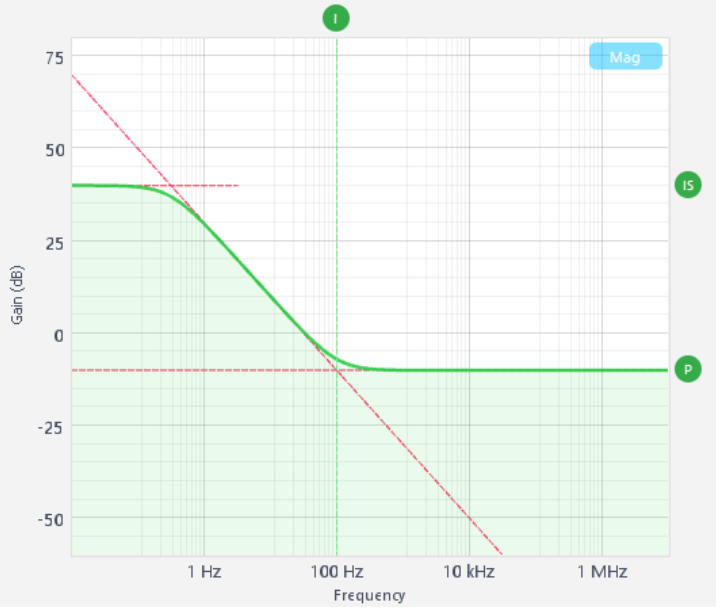
Tap the  icon to open the full controller view.



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.

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

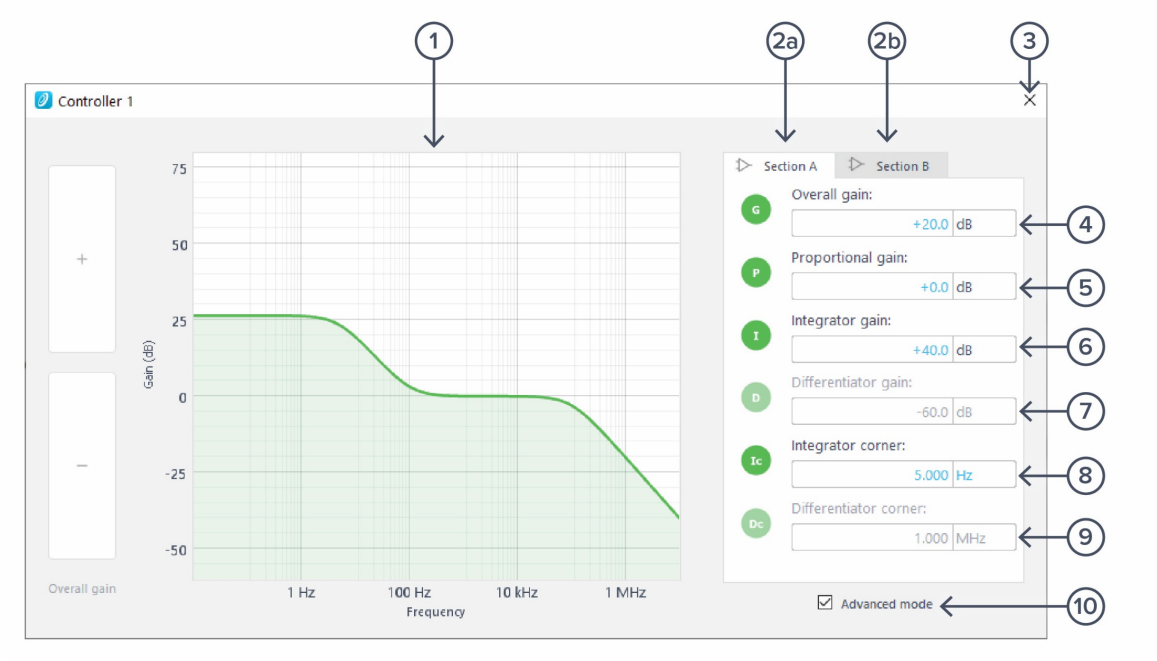
ID	Description	ID	Description
P	Proportional gain	**I+**	Double integrator crossover frequency
I	Integrator crossover frequency	**IS**	Integrator saturation level
D	Differentiator	**DS**	Differentiator saturation level

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

Controller (Advanced Mode)

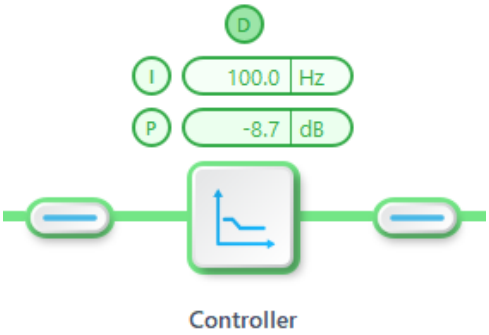
In **Advanced Mode**, users can build fully customized controllers with two independent sections (A and B), and six adjustable parameters in each section. Tap the **Advanced Mode** button in the full controller view to switch to the **Advanced Mode**.



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.

Quick PID Control

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



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

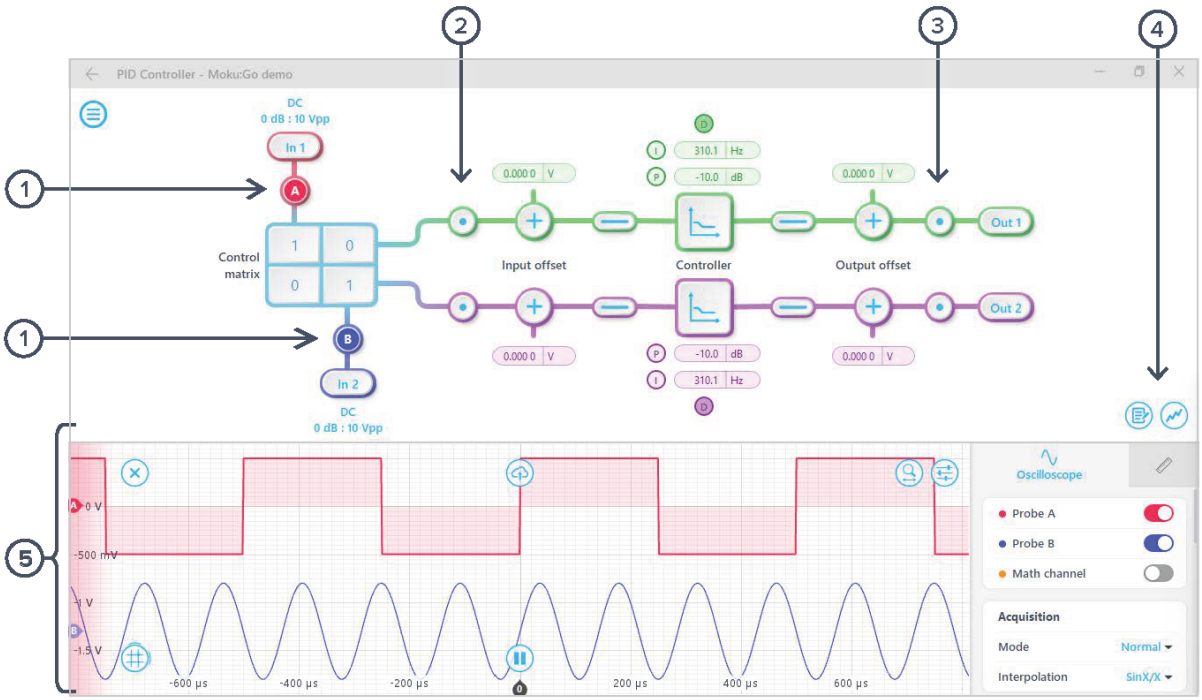
Click the shaded icon (i.e. D to enable the path.

Click the active controller path icon (i.e. I 100.0 Hz to enter the value.

Probe points

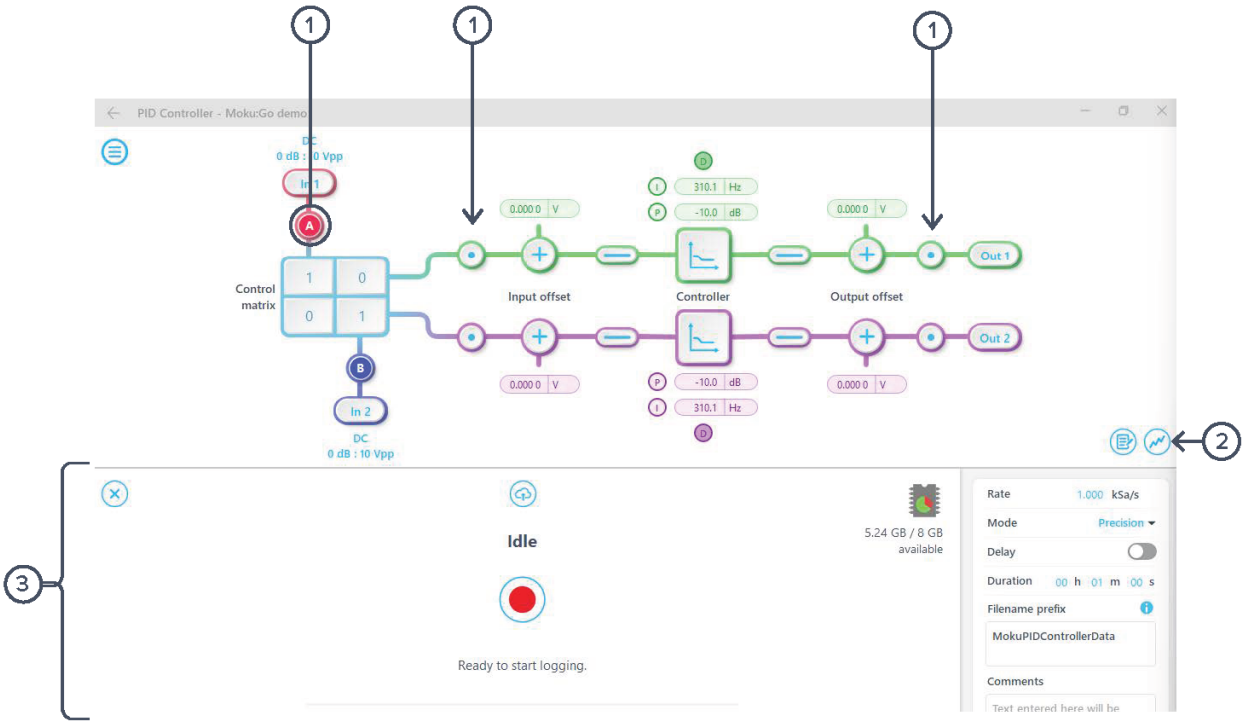
The Moku:Go PID controller has an integrated oscilloscope that can be used to probe the signal at the input, pre-PID, and output stages. Add the probe points by tapping the icon.

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/Data Logger toggle	Switch between the integrated Oscilloscope and Data Logger.
5	Oscilloscope	Refer to the **Moku:Go Oscilloscope** manual for further details.

Data Logger



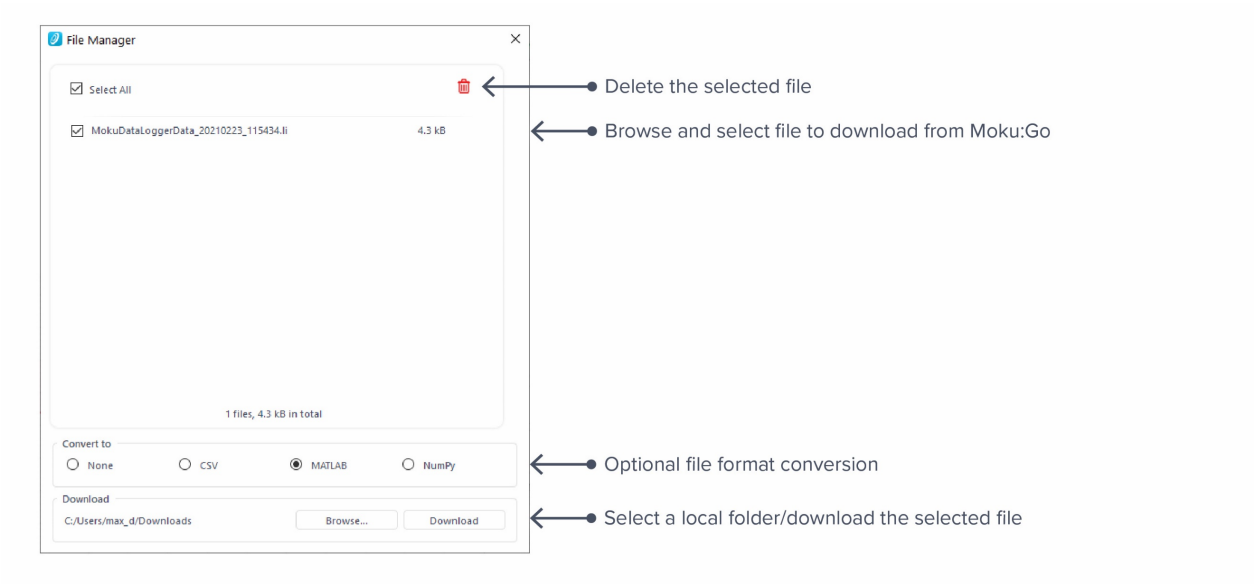
ID	Parameter	Description
1	Probe points	Click to place the probe point. You can enable up to two probe points at a time.
2	Oscilloscope/Data Logger toggle	Toggle between the built-in Oscilloscope or Data Logger.
3	Data Logger	Refer to the **Moku:Go Data Logger** manual for further details.

The Embedded Data Logger can stream over a network or save data on the 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

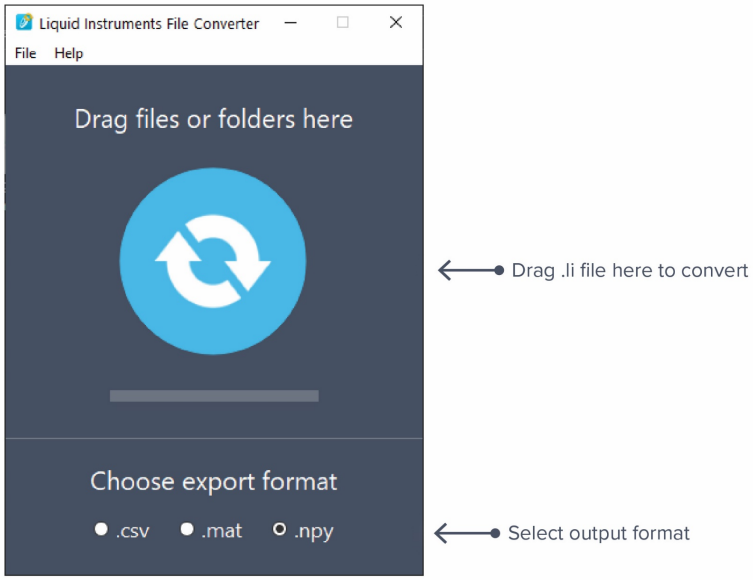
The Moku:Go app has two built-in file management tools: File manager and File converter. The File Manager allows users to download the saved data from Moku:Go to a local computer, with optional file format conversion. The File Converter converts the Moku:Go binary (.li) format on the local computer to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

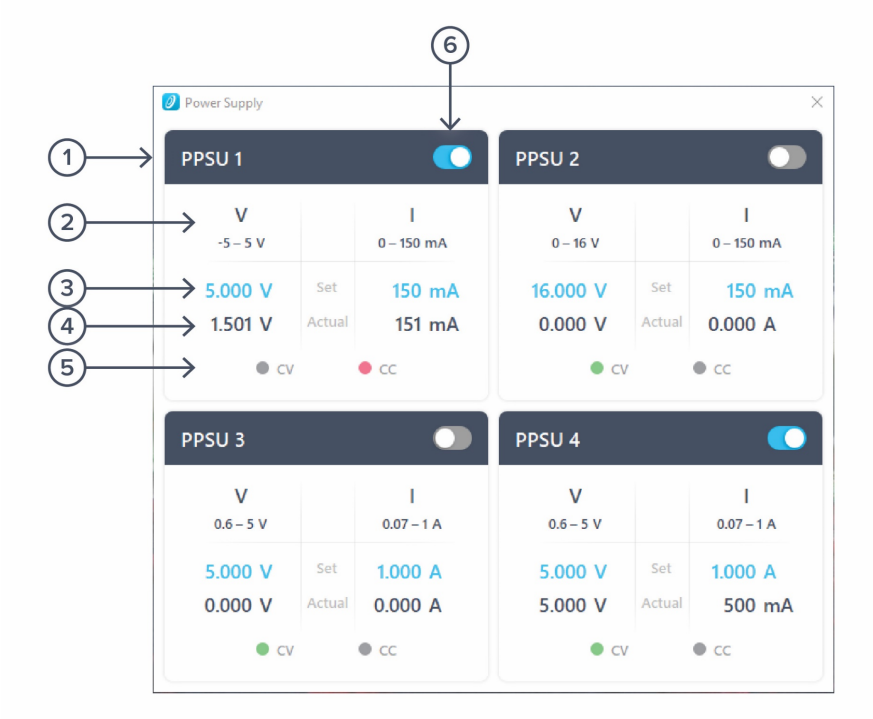
Liquid Instruments File Converter has the following menu options:

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

Power Supply

The Moku:Go Power Supply is available on M1 and M2 models. M1 features a two-channel Power Supply, while M2 features a four-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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