PID Controller

Moku:Lab User Manual

Moku:Lab's PID (Proportional-Integrator-Differentiator) Controller features two fully real-time configurable PID controllers with an output sample rate of 10 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

V21-0204

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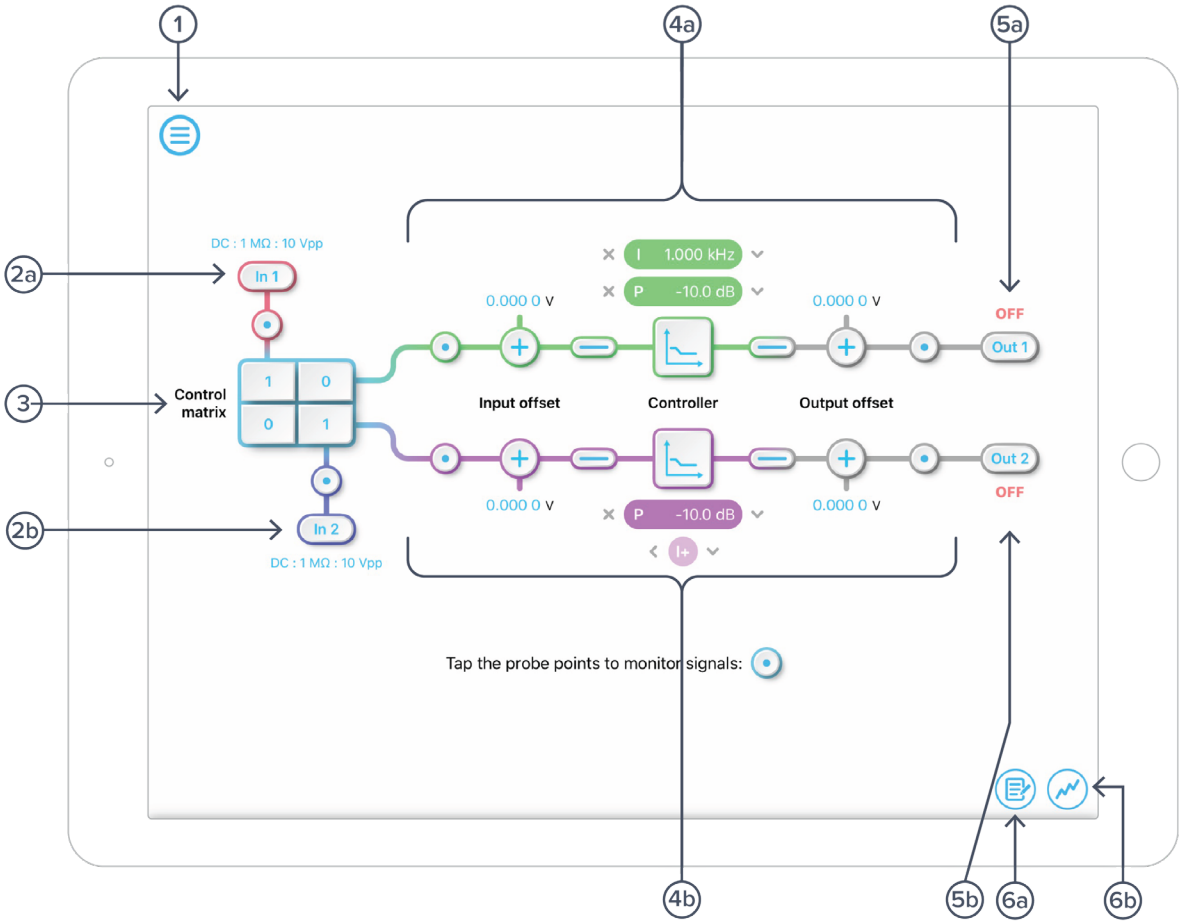
Ensure Moku:Lab is fully updated. For the latest information:

www.liquidinstruments.com

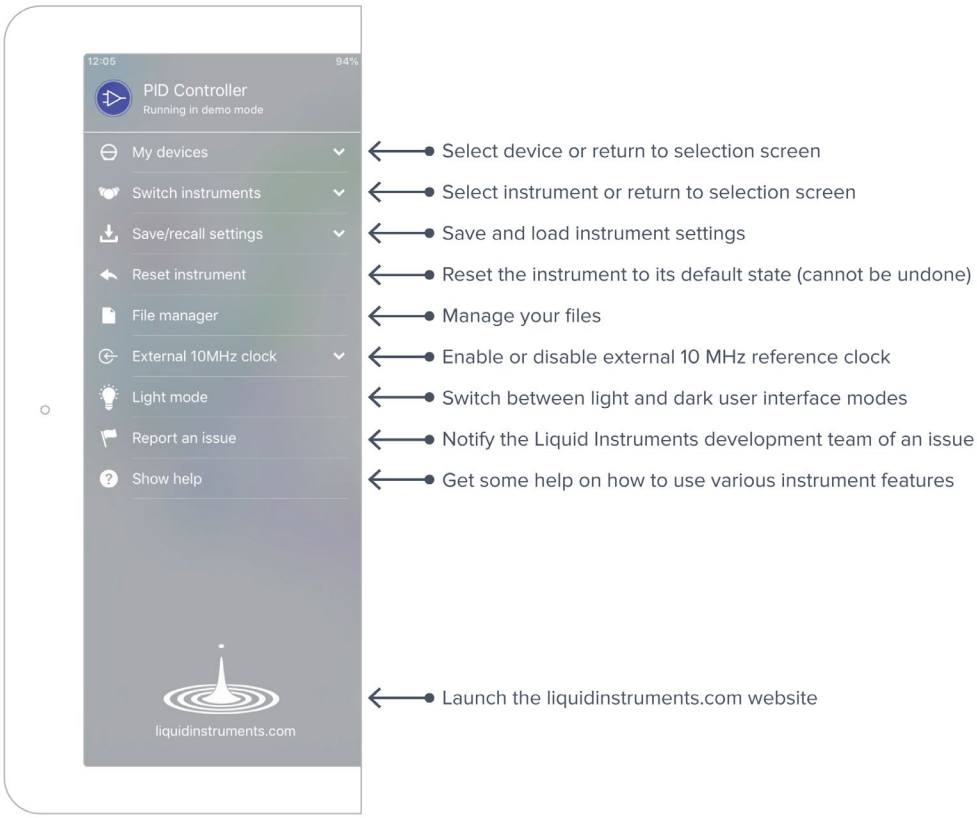
User Interface



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
6a	Enable the data logger
6b	Enable the oscilloscope

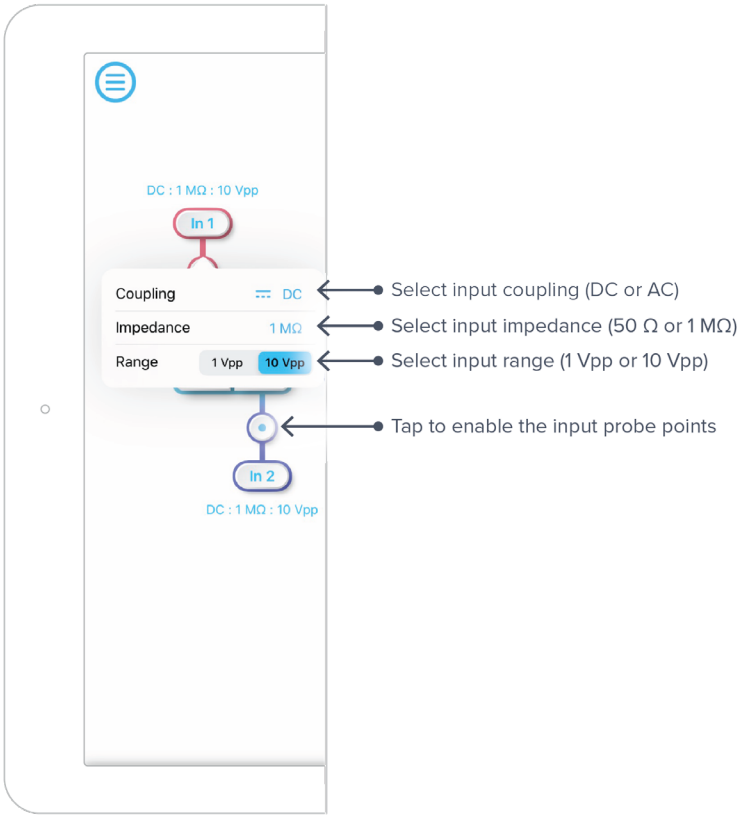
Main Menu

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



Input Configuration

The **input configuration** can be accessed by tapping the In 1 or In 2 icon, allowing you to adjust the coupling, impedance 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.

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

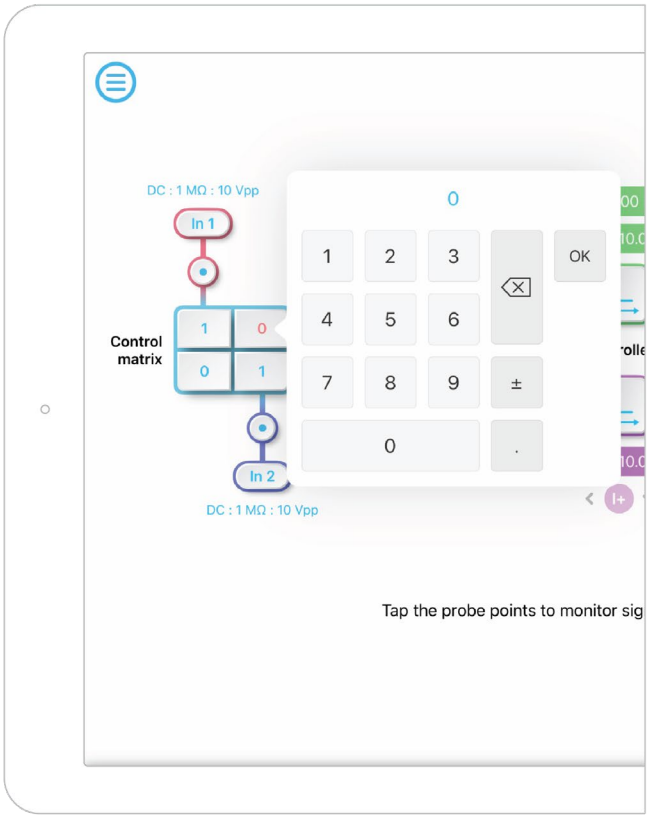
where

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

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

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).

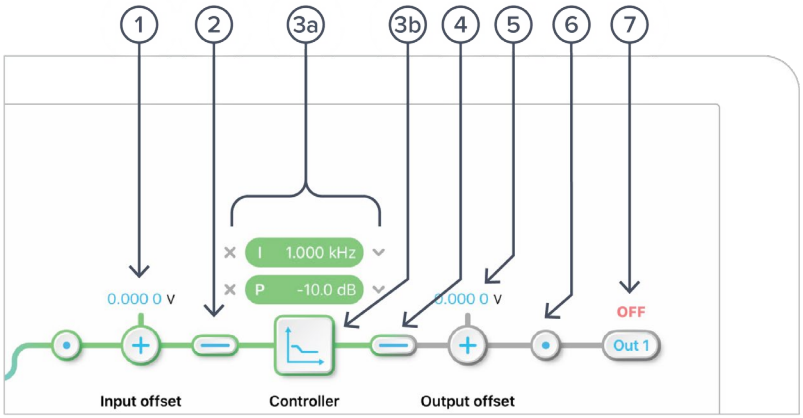
The value of each element in the control matrix can be set between -20 to +20 with 0.1 increments when the absolute value is less than 10, or 1 increment when the absolute value is between 10 and 20. Tap the element to adjust the value.



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. The PID generates a minimum latency of 733 ns. The latency is about 813 ns with all controllers enabled.

User Interface



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

Input / Output Switches

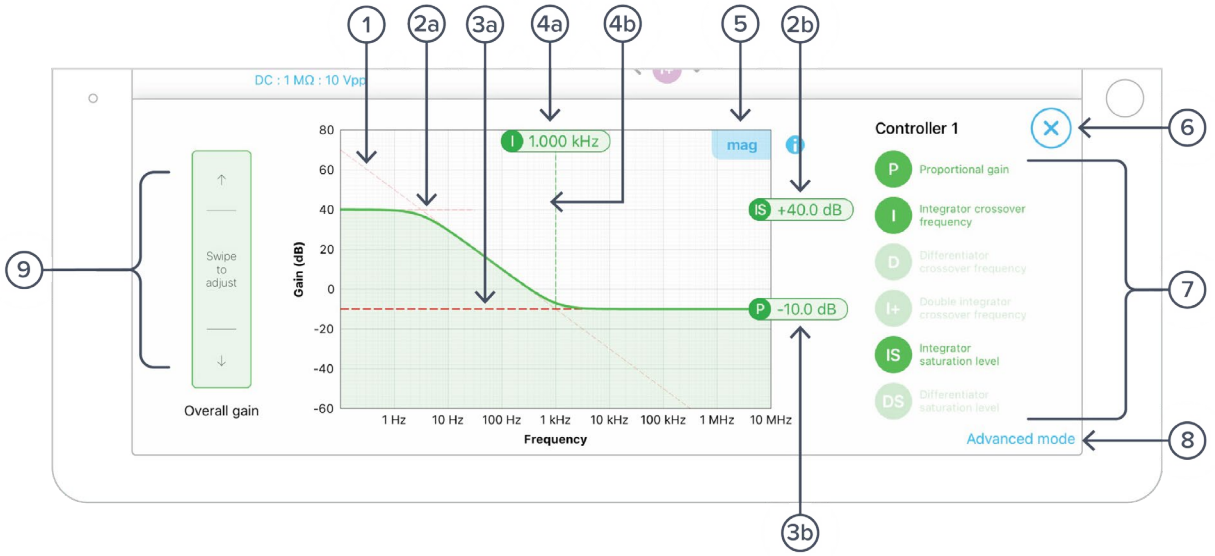
Closed/Enable

Open/disable

Controller (Basic Mode)

Controller Interface

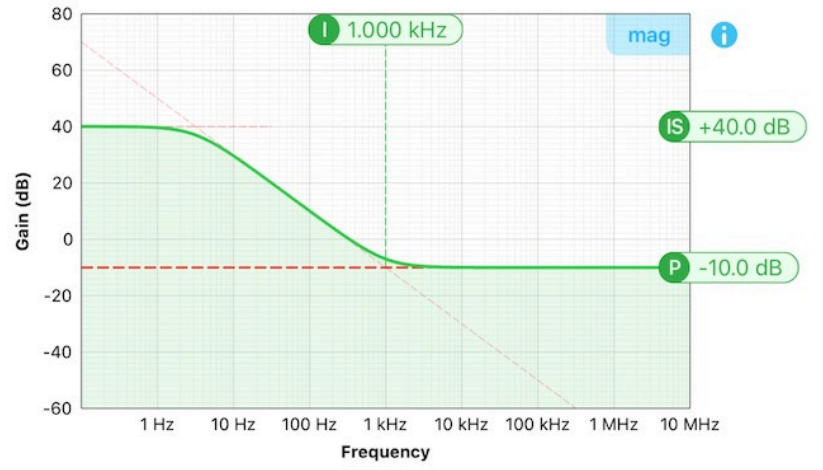
Tap the  icon to open the full controller view.



ID	Parameter	Description
1	Design cursor 1	Cursor for Integrator (I) setting.
2a	Design cursor 2	Cursor for Integrator Saturation (IS) level.
2b	Cursor 2 reading	Reading for IS level. Drag to adjust the gain.
3a	Design cursor 3	Cursor for Proportional (P) gain.
3b	Cursor 3 reading	Reading of the P gain.
4a	Cursor 4 reading	Reading for I crossover frequency. Drag to adjust the gain.
4b	Design cursor 4	Cursor for I crossover frequency.
5	Display toggle	Toggle between magnitude and phase response curve.
6	Close controller view	Tap to close the full controller view.
7	PID control switches	Turn on/off individual controller.
8	Advanced mode	Tap to switch to the advanced mode.
9	Overall gain slider	Swipe 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 and ②) represent the cursors for each controller.

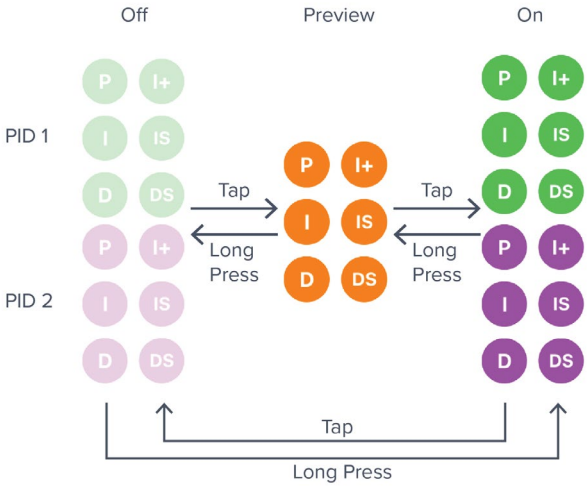
The bold red dashed line (③) represents the cursor for actively selected parameter.

PID Paths

There are in total six switch buttons for the controller paths in area ⑥. The function of each button can be found below:

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

Each button has three states: off, preview, and on. Tap the buttons to circle these states. Long press the buttons to go reverse order.



PID Path Preview

PID path preview allows the user to preview and adjust the settings on the PID response plot before engaging.

Preview

Engaged

List of Configurable Parameters in Basic Mode

Parameters	Range
Overall gain	± 60 dB
Proportional gain	± 60 dB
Integrator crossover frequency	1 Hz to 100 kHz
Differentiator crossover frequency	10 Hz to 1 MHz
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

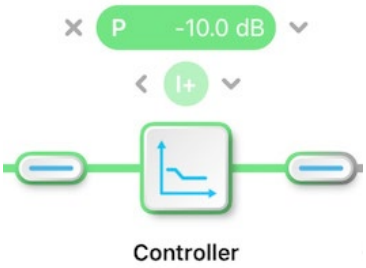
Controller (Advanced Mode)

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	Parameter	Description
1	Display toggle	Toggle between magnitude and phase response curve.
2	Close controller view	Tap to close the full controller view.
3a	Section A pane	Tap to select and configure Section A.
3b	Section B pane	Tap to select and configure Section B.
4	Section A Switch	Master switch for Section A.
5	Overall gain	Tap to adjust the overall gain.
6	Proportional panel	Tap the switch to enable/disable proportional path. Tap the number to adjust the gain.
7	Integrator panel	Tap the switch to enable/disable integrator path. Tap the number to adjust the gain.
8	Differentiator panel	Tap the switch to enable/disable differential path. Tap the number to adjust the gain.
9	Additional Settings	
	Integrator corner frequency	Tap to set the frequency of the integrator corner.
	Differentiator corner frequency	Tap to set the frequency of the differentiator corner.
10	Basic mode	Tap to switch to the basic mode.

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.



Tap the icon to disable active controller path.

Tap the icon to select the controller to adjust.

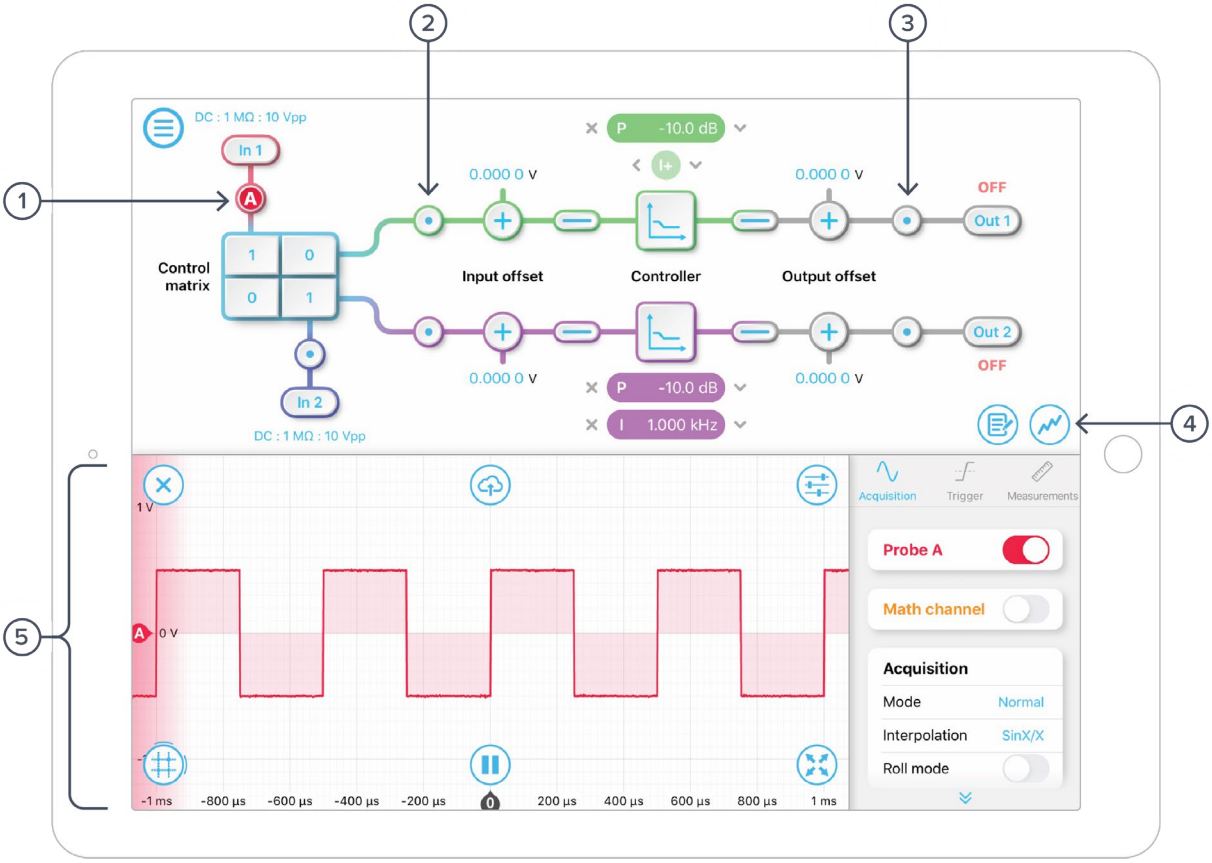
Tap the faded icon (i.e.) to enable the path.

Tap the active controller path icon (i.e. P -10.0 dB) to enter the value. Hold and slide to adjust the value.

Probe Points

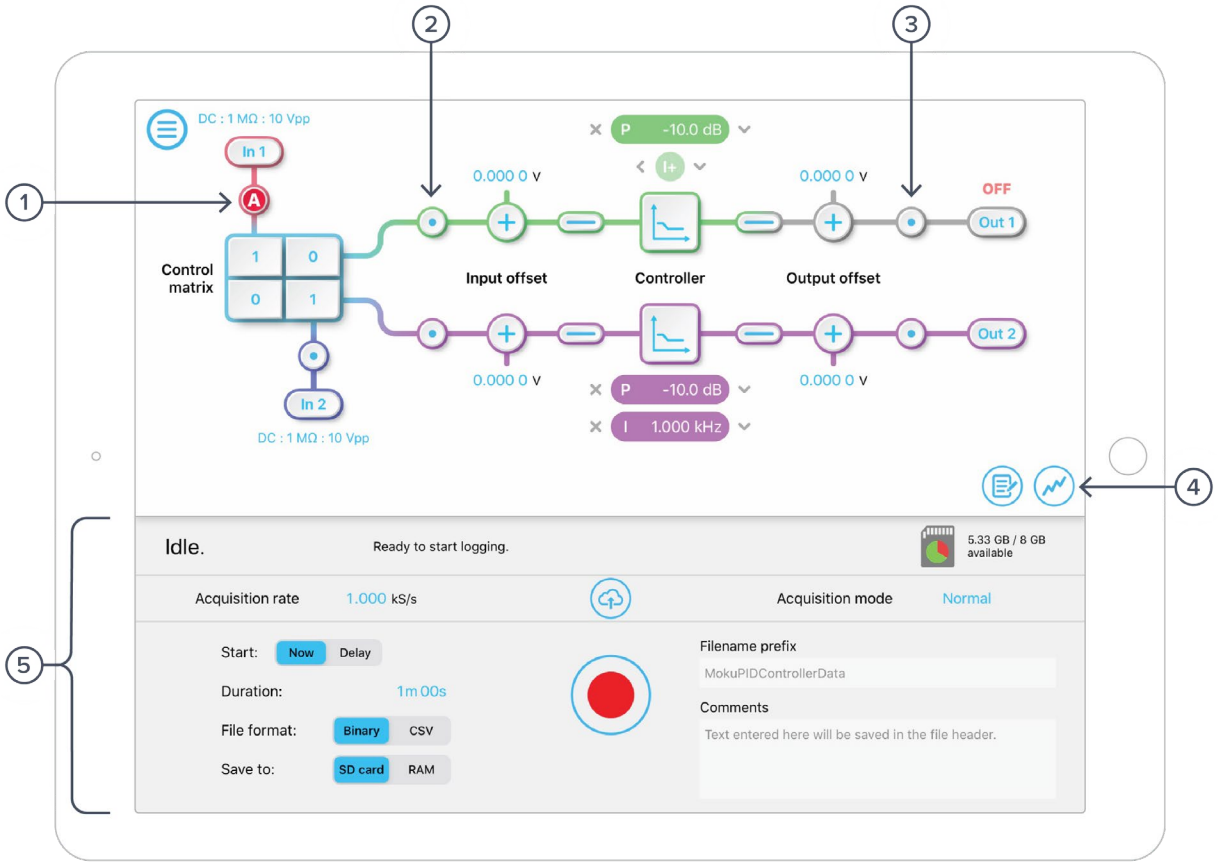
Moku:Lab's PID controller has an integrated oscilloscope and data logger that can be used to probe the signal at the input, pre-PID, and output stages. The probe points can be added by tapping the icon.

Oscilloscope



ID	Parameter	Description
1	Input probe point	Tap to place the probe point at input.
2	Pre-PID probe point	Tap to place the probe after the control matrix.
3	Output probe point	Tap to place the probe at output.
4	Oscilloscope/data logger toggle	Toggle between built-in oscilloscope or data logger.
5	Oscilloscope	Refer to the **Moku:Lab's Oscilloscope** manual for the details.

Data Logger



ID	Parameter	Description
1	Input probe point	Tap to place the probe point at input.
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3	Output probe point	Tap to place the probe at output.
4	Oscilloscope/data logger toggle	Toggle between built-in oscilloscope or data logger.
5	Data Logger	Refer to the **Moku:Lab's Data Logger** manual for the details.

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