



# Bode Analyzer

## User Manual

---

The Moku:Lab's Bode Analyzer can be used to measure a system's frequency response from 10 mHz up to 120 MHz.

Bode Analyzers are commonly used to measure the transfer functions of electrical and 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 or optical components. Bode Analyzer's are quite simply an indispensable tool in any electronics and optics lab.



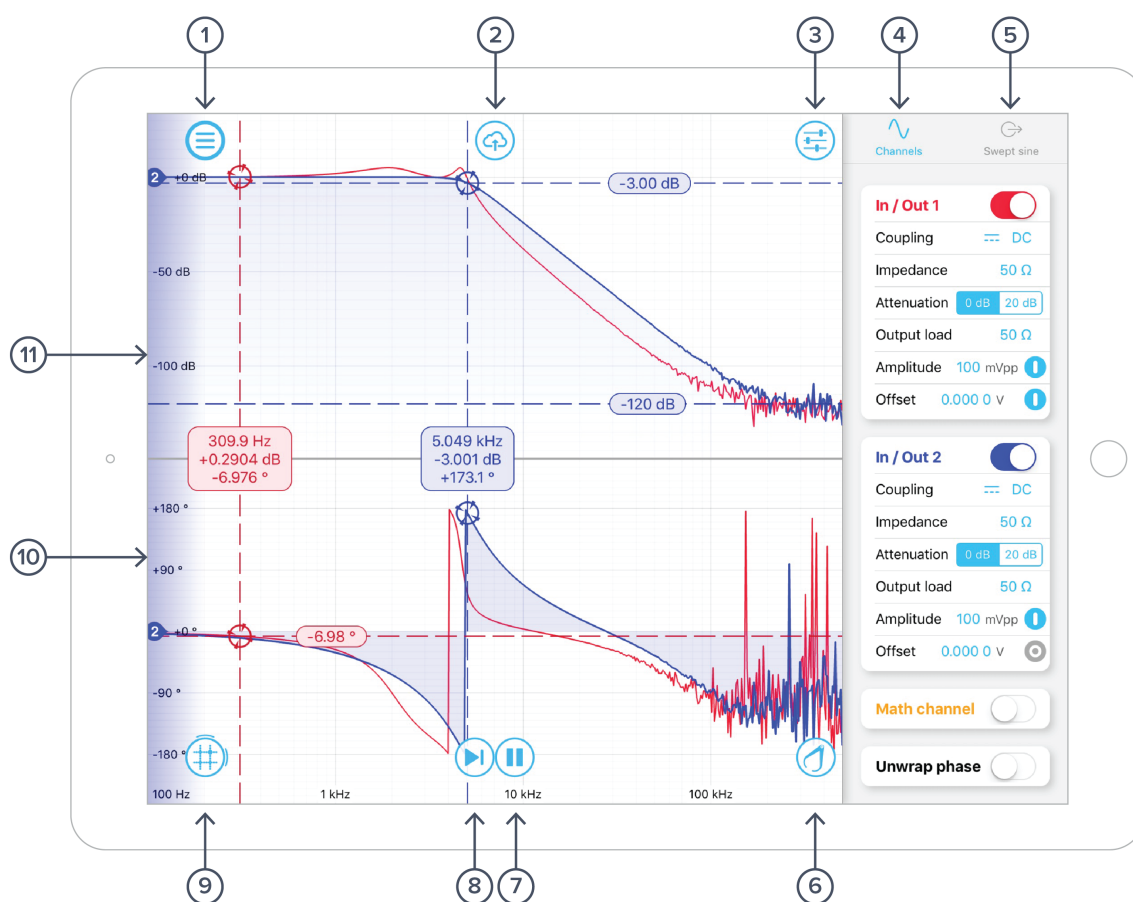


# Table of Contents

<b>User Interface .....</b>	<b>3</b>
<b>Main Menu.....</b>	<b>4</b>
<b>Measurement Configuration .....</b>	<b>5</b>
Channels	5
Math channel	5
Unwrap phase	6
Swept Sine	6
Sweep points	6
Sweep scale	7
Averaging	7
Settling time	7
<b>Cursors .....</b>	<b>8</b>
Magnitude cursors	9
Phase cursors	9
Frequency cursors	9
Removing cursors	9
<b>Sweep modes .....</b>	<b>10</b>
Single	10
Continuous	10
Pause / Restart	10
<b>Calibration .....</b>	<b>11</b>
<b>Exporting Data.....</b>	<b>12</b>
SD card	12
Dropbox	12



# User Interface

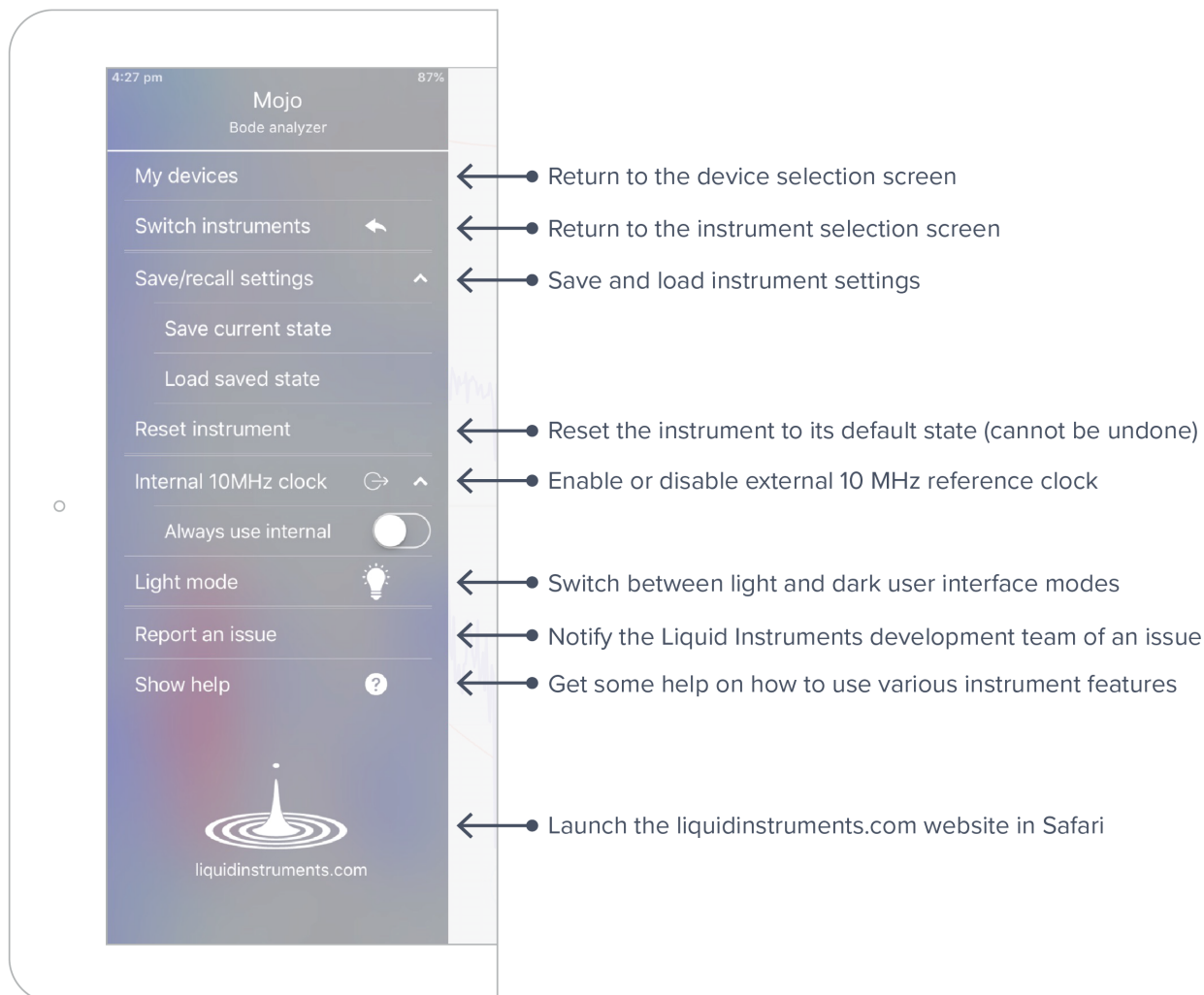


ID	Description	ID	Description
1	Main menu	7	Sweep mode
2	Export data	8	Start / pause sweep
3	Instrument configuration menu	9	Cursors
4	Channel settings	10	Phase plot
5	Swept sine output settings	11	Magnitude plot
6	Calibration tool		



# Main Menu

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



The screenshot shows the main menu of the Mojo Bode analyzer. The menu items and their functions are as follows:

- My devices**: Return to the device selection screen
- Switch instruments**: Return to the instrument selection screen
- Save/recall settings**: Save and load instrument settings
  - Save current state
  - Load saved state
- Reset instrument**: Reset the instrument to its default state (cannot be undone)
- Internal 10MHz clock**: Enable or disable external 10 MHz reference clock
  - Always use internal
- Light mode**: Switch between light and dark user interface modes
- Report an issue**: Notify the Liquid Instruments development team of an issue
- Show help**: Get some help on how to use various instrument features

At the bottom of the menu is the Liquid Instruments logo and the website address: liquidinstruments.com. A callout points to this area with the instruction: Launch the liquidinstruments.com website in Safari.

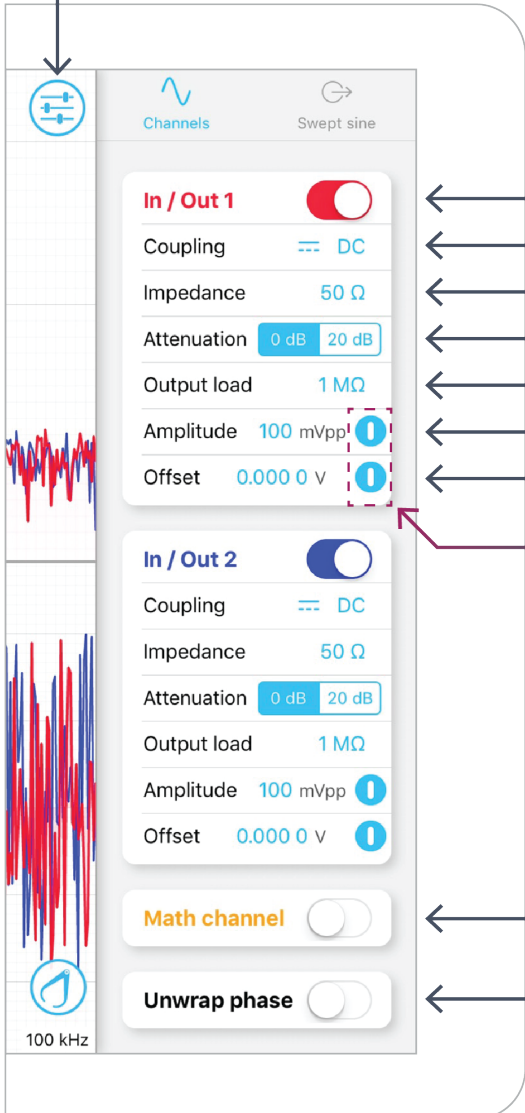


# Measurement Configuration

The **measurement configuration menu** allows you to configure the Bode Analyzer for your measurement, which will vary depending on the specific characteristics of the system under test.

Access the measurement configuration menu by pressing the  icon.

## Channels



• Display the measurement configuration menu

**In / Out 1**

Coupling  $\text{DC}$

Impedance  $50\ \Omega$

Attenuation  $0\ \text{dB}$   $20\ \text{dB}$

Output load  $1\ \text{M}\Omega$

Amplitude  $100\ \text{mVpp}$

Offset  $0.000\ 0\ \text{V}$

**In / Out 2**

Coupling  $\text{DC}$

Impedance  $50\ \Omega$

Attenuation  $0\ \text{dB}$   $20\ \text{dB}$

Output load  $1\ \text{M}\Omega$

Amplitude  $100\ \text{mVpp}$

Offset  $0.000\ 0\ \text{V}$

**Math channel**

**Unwrap phase**

100 kHz

• Activate / deactivate channel 1

• Select between **AC** and **DC** coupling

• Select between **50  $\Omega$**  and **1 M $\Omega$**  input impedance

• Select between **0 dB** and **20 dB** input attenuation

• Select between **50  $\Omega$**  and **1 M $\Omega$**  load impedance

• Configure the **amplitude** of the swept sine source

• Configure the **offset** of the swept sine source

• Turn swept sine **amplitude** and **offset** on / off

• Display a math channel (+ -  $\times$   $\div$ )

• Unwrap phase (wrapped phase from  $-180^\circ$  to  $+180^\circ$ )

## Math channel

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



## Unwrap phase

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

## Swept Sine

Display the measurement configuration menu

Channels Swept sine

**Sweep**

Start 10.0000 MHz

Stop 1.00000 kHz

Points 512

Scale Linear Log

Reverse direction

**Averaging**

Min duration 10.00 ms

Min cycles 1

**Settling time**

Min duration 2.000 ms

Min cycles 1

Sweep time: 6.2 s

10 MHz

- Configure the sweep's **start frequency**
- Configure the sweep's **stop frequency**
- Select the **number of points** in the sweep
- Select between **Linear** and **Logarithmic** scales
- Reverse the direction of the sweep
- Configure the **minimum averaging time**
- Configure the **minimum number of cycles** over which to average
- Configure the **minimum settling time**
- Configure the **minimum number of cycles** over which to settle
- View the **total sweep time** based on selected instrument 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

- Select whether or not the discrete points in the swept sine output are 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 in order to control signal-to-noise ratio. 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 they 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:BodeAnalyzer 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

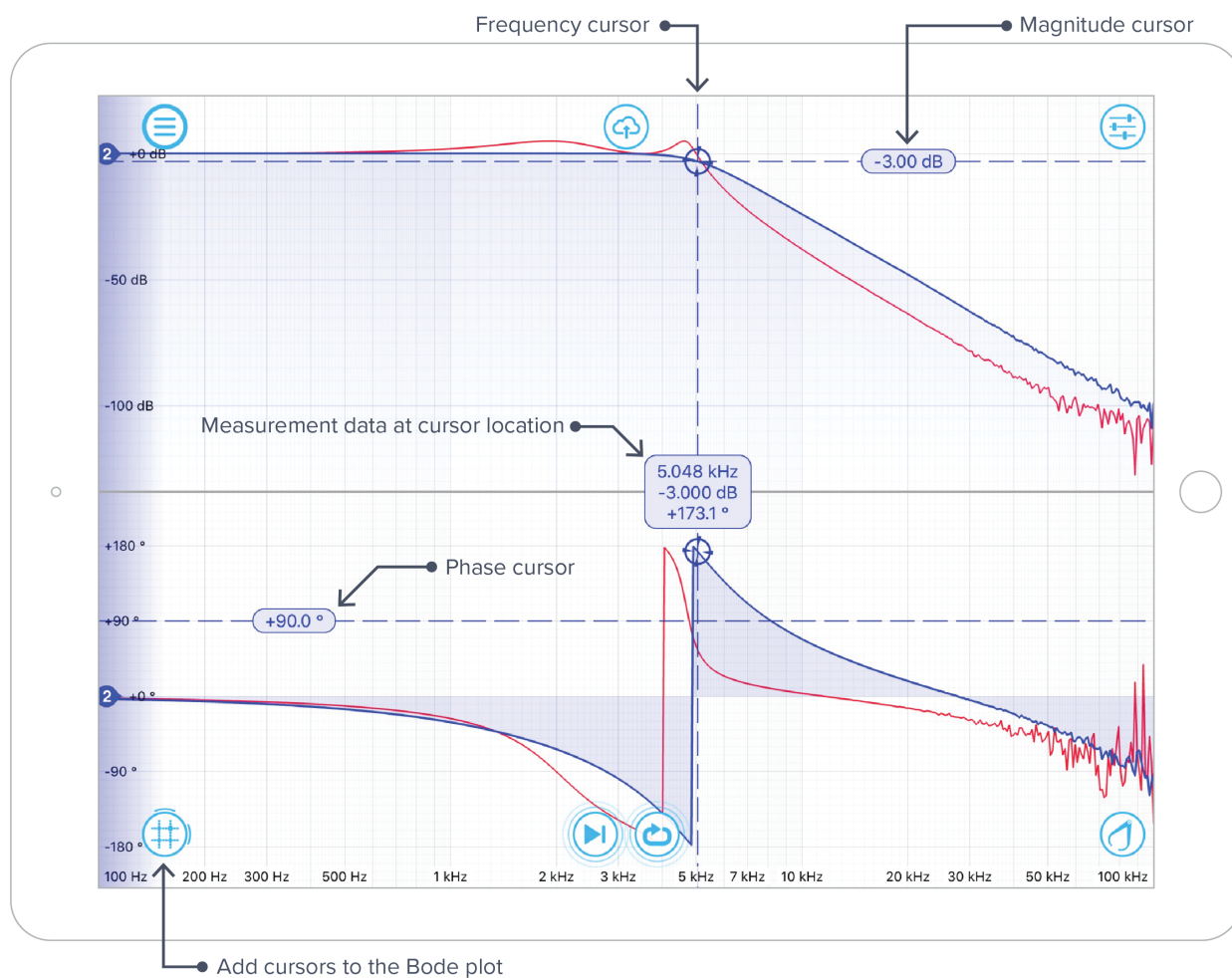
- The settling time determines how long the Bode analyzer waits before performing measurements at each frequency in the sweep. Settling time is important when characterizing resonant systems with high Q-factors in order to allow excitations to ‘settle’ between measurements. It can also be used to account for transmission delays in cables. When interrogating 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 Bode analyzer will wait for the greater effective duration of the two settings before beginning a measurement at each point in the sweep.



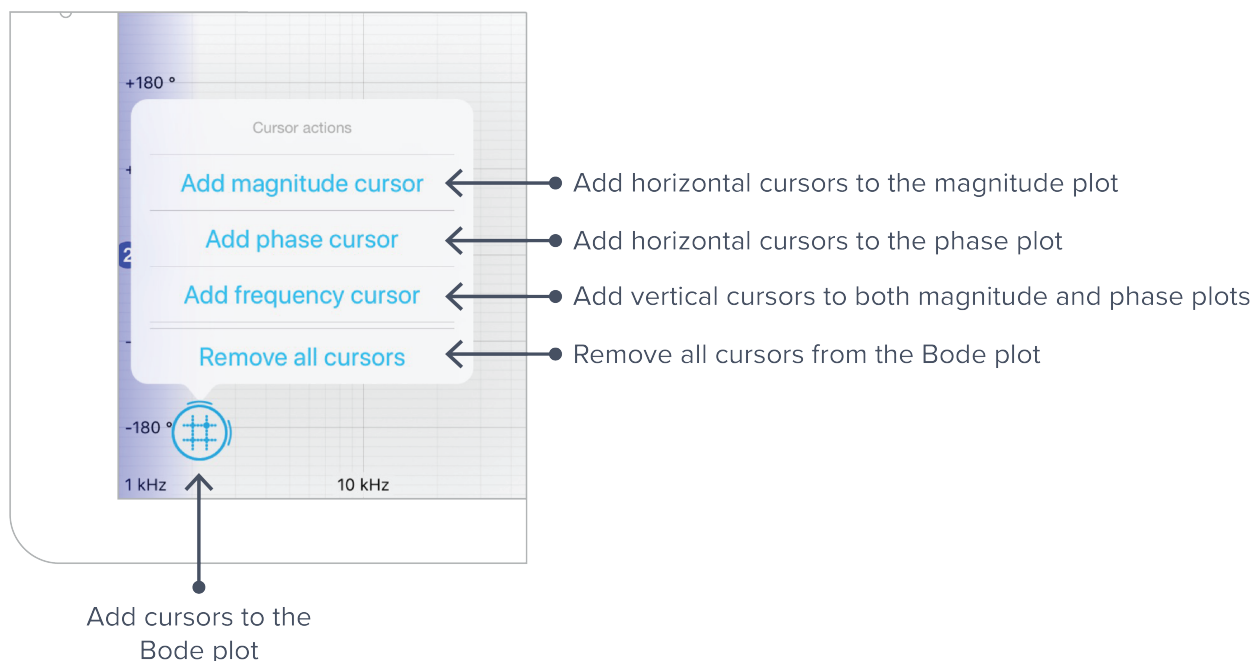
# Cursors

Magnitude and phase cursors can be added to the Bode plot pressing the  icon.


**Tip:** Magnitude and phase cursors can be moved between the two plots by dragging them vertically across the horizontal divider.








### Magnitude cursors

Magnitude cursors can be added to the Bode plot by tapping the  icon and selecting 'Add magnitude cursor'. A magnitude cursor can also be created by dragging your finger up from the cursor icon and then repositioning it on the magnitude plot.


### Phase cursors

Phase cursors can be added to the Bode plot by tapping the  icon and selecting 'Add phase cursor'. A phase cursor can also be created by dragging your finger up from the cursor icon and then repositioning it on the phase plot.

### Frequency cursors

Up to five frequency cursors can be added to the Bode plot by tapping the  icon and selecting 'Add frequency cursor'. Frequency cursors can also be created by dragging your finger to the right from the cursor icon.


### Removing cursors

All active cursors can be removed from the Bode plot by tapping the  icon and selecting 'Remove all cursors'. Individual cursors can be removed by tapping their label and pressing 'Remove'.




# Sweep modes



## Single

Tapping 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.

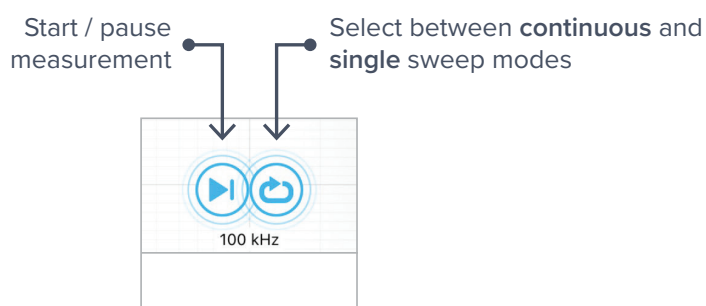
## Continuous

Tapping 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


Tapping 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.

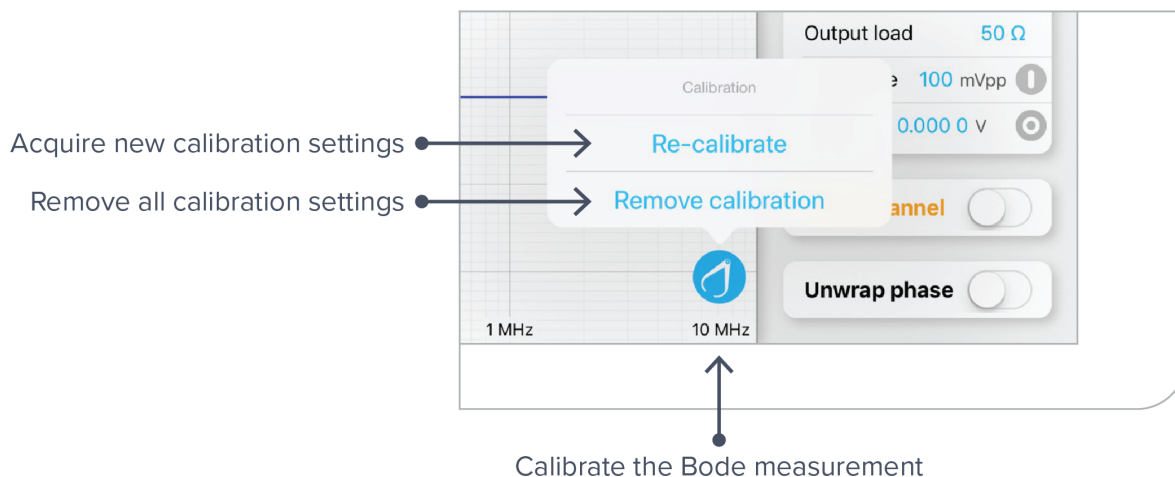
Tapping the  or  icons will restart the sweep.






# Calibration

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



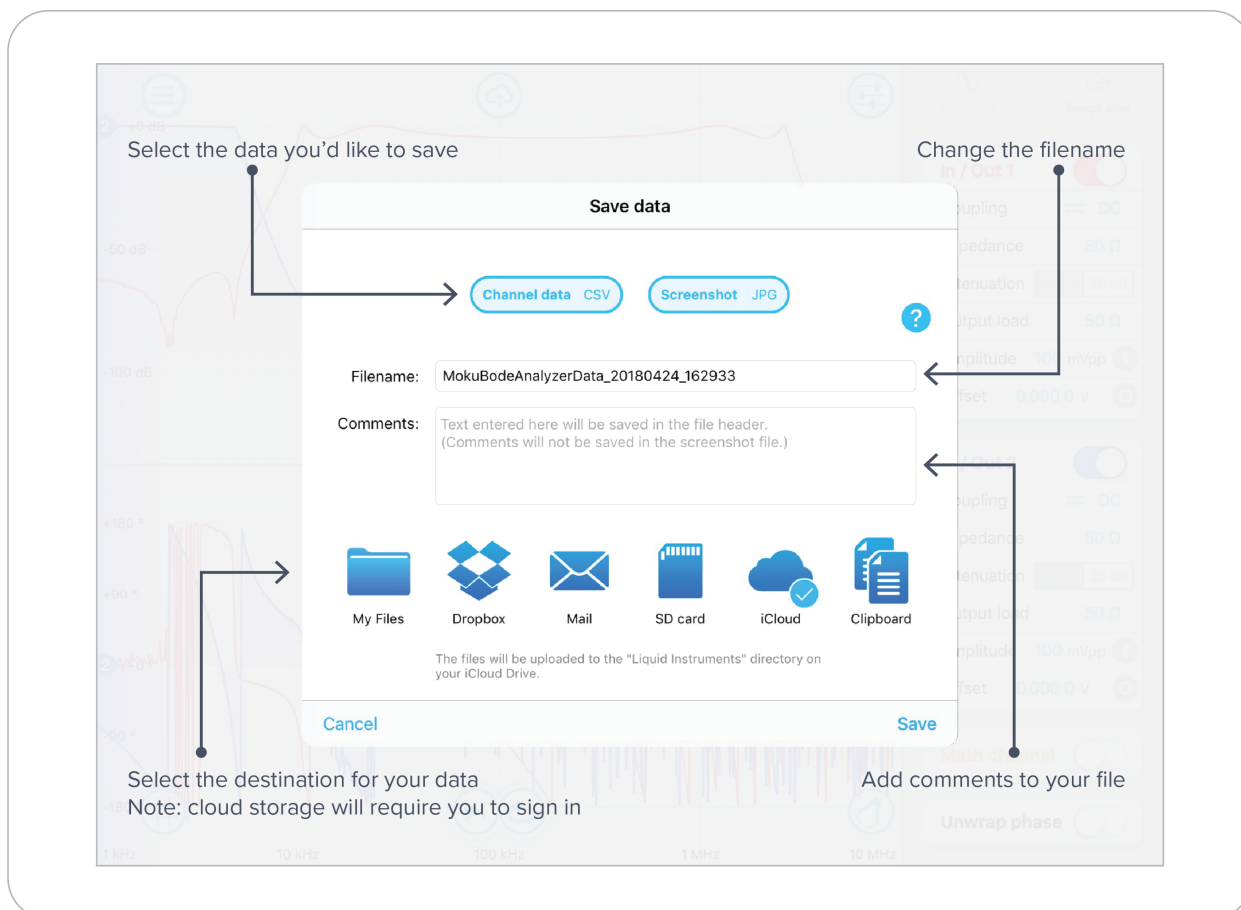
Tapping the  icon will bring up the calibration menu. **Re-calibrate** will replace the current calibration trace with a new one. **Remove calibration** will erase all stored calibration settings and cannot be undone.



## Exporting Data

Measurement traces can be uploaded to My Files (iOS 11 or later), Dropbox, E-mail, SD card, iCloud, Clipboard (screenshot is not copied to the clipboard).

To export a measurement trace, press the  icon at the top of the Bode plot.



### SD card

- Upload files to SD card by inserting a compatible FAT32 formatted drive into the Moku:Lab's SD card slot, located on the rear of the device next to the power connector.

### Dropbox

- Upload files to Dropbox by logging in to your account with the Moku:Lab app on the iPad.