Frequency Response Analyzer
User Manual

Moku:Lab's Frequency Response Analyzer can be used to measure a system's frequency response from 10 mHz up to 120 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 or optical components. Frequency Response Analyzers are quite simply an indispensable tool in any electronics and optics lab.

v19-0719

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

www.liquidinstruments.com

Introduction

The Frequency Response Analyzer is an essential item of equipment in almost all engineering laboratories. Moku:Lab implements a frequency response analyzer as one of 12 high quality instruments.

Moku:Lab's Frequency Response Analyzer is a precision yet versatile instrument with a modern, touch based and intuitive interface. The tablet-based interface operates wirelessly, this enables the engineer or technician to operate the instrument fully, while free to move about the working environment.

Extensive measurements are readily available from the touch interface. Data, screenshots and logs can be readily captured to email or cloud-based services for rapid sharing and evaluation.

Moku:Lab's Frequency Response Analyzer also has Python, LabView and MATLAB interfacing capabilities.

Moku:Lab can be reconfigured nearly instantaneously to be one of:

- Oscilloscope
- Spectrum Analyzer
- Phasemeter
- Laser Lock Box
- Frequency Response Analyzer
- FIR Filter Builder
- Digital Filter Box
- Waveform Generator
- Arbitrary Waveform Generator
- PID Controller
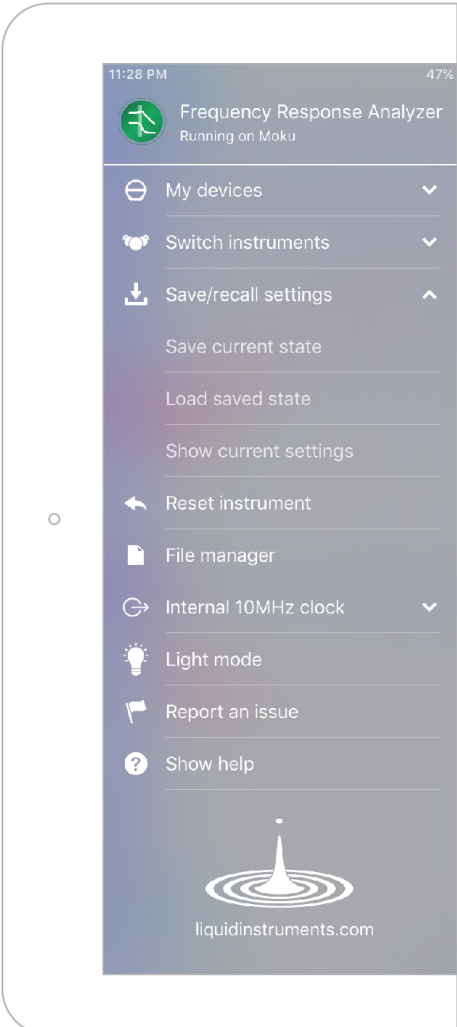- Data Logger
- Lock in Amplifier

User Interface
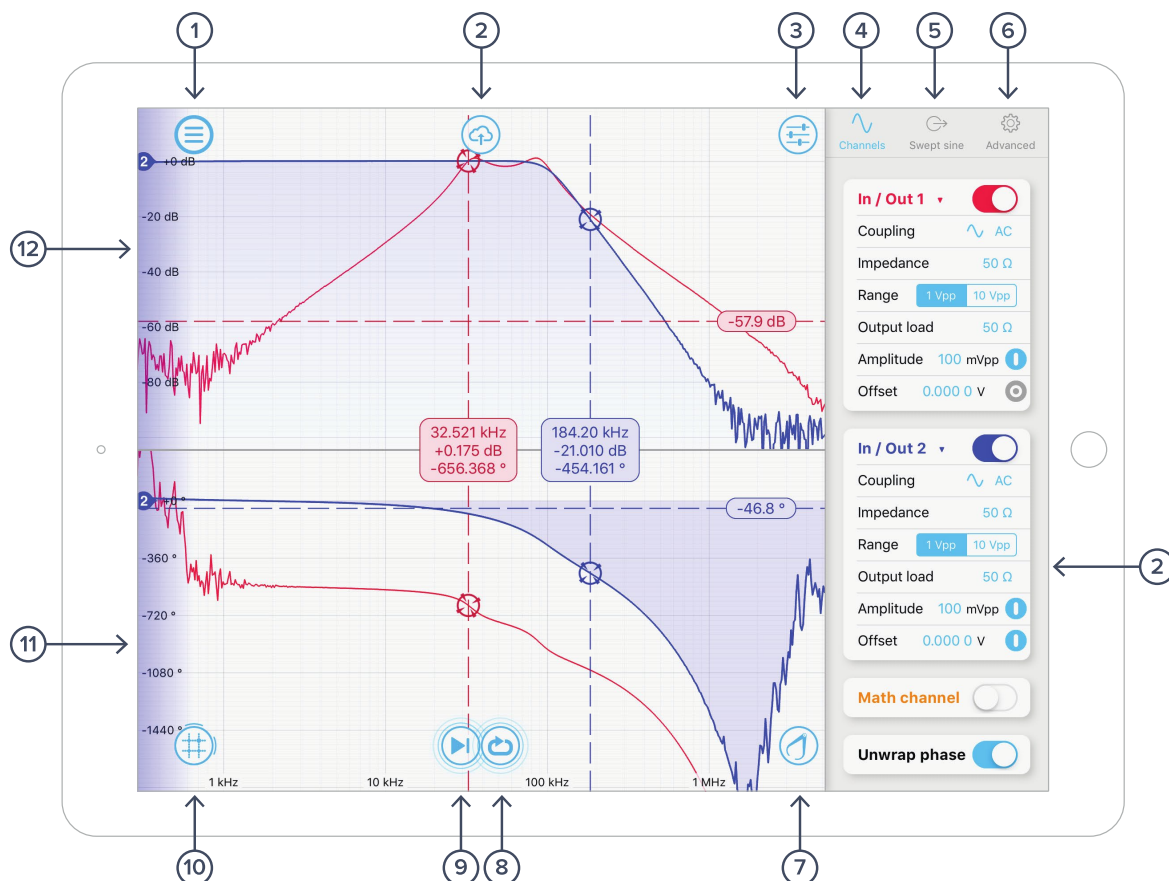
ID	Description	ID	Description
1	Main menu	7	Calibration tool
2	Export data	8	Sweep mode
3	Instrument configuration menu	9	Start / pause sweep
4	Channel settings	10	Cursors
5	Swept sine output settings	11	Phase plot
6	Advanced demodulation settings	12	Magnitude plot

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 file manager

Enable or disable external 10 MHz reference clock

Switch between light and dark user interface modes

Notify the Liquid Instruments development team of an issue

Get some help on how to use various instrument features

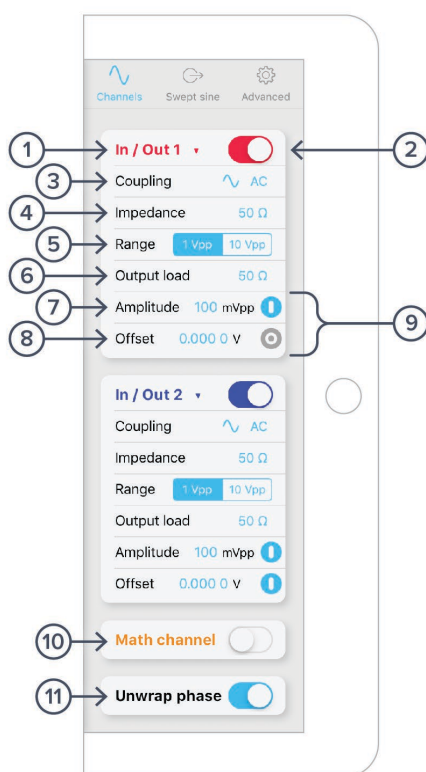Launch the liquidinstruments.com website

Instrument Configuration

The instrument configuration 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 configuration menu by pressing the ⊕ icon.

Channels

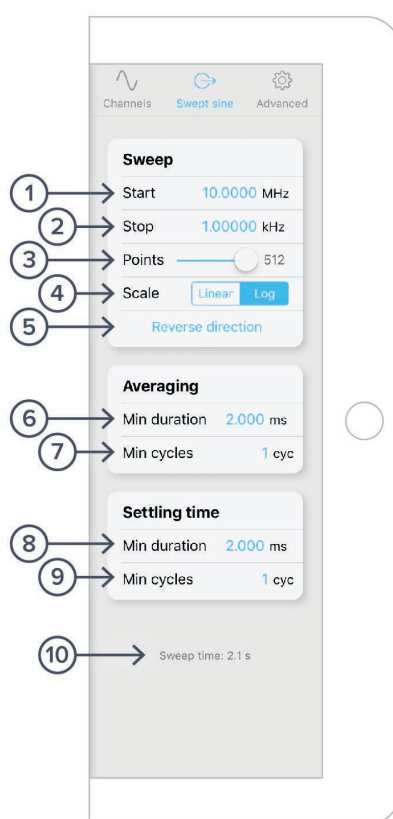| ID	Description	ID	Description
1	Select to display In1 or In1/Out1	7	Swept sine amplitude
2	Toggle channel on/off	8	Swept sine offset
3	Select AC or DC coupling	9	Turn on/off amplitude and/or offset
4	Select 1MΩ or 50Ω input impedance	10	Enable/disable Math channel
5	Select input range 1V or 10V p-p	11	Unwrap/wrap phase
6	Select 11MΩ or 50Ω output load		

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.

Swept Sine

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

- 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 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:Lab's Frequency 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 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 Frequency Reference Analyzer will wait for the greater effective duration of the two settings before beginning a measurement at each point in the sweep.
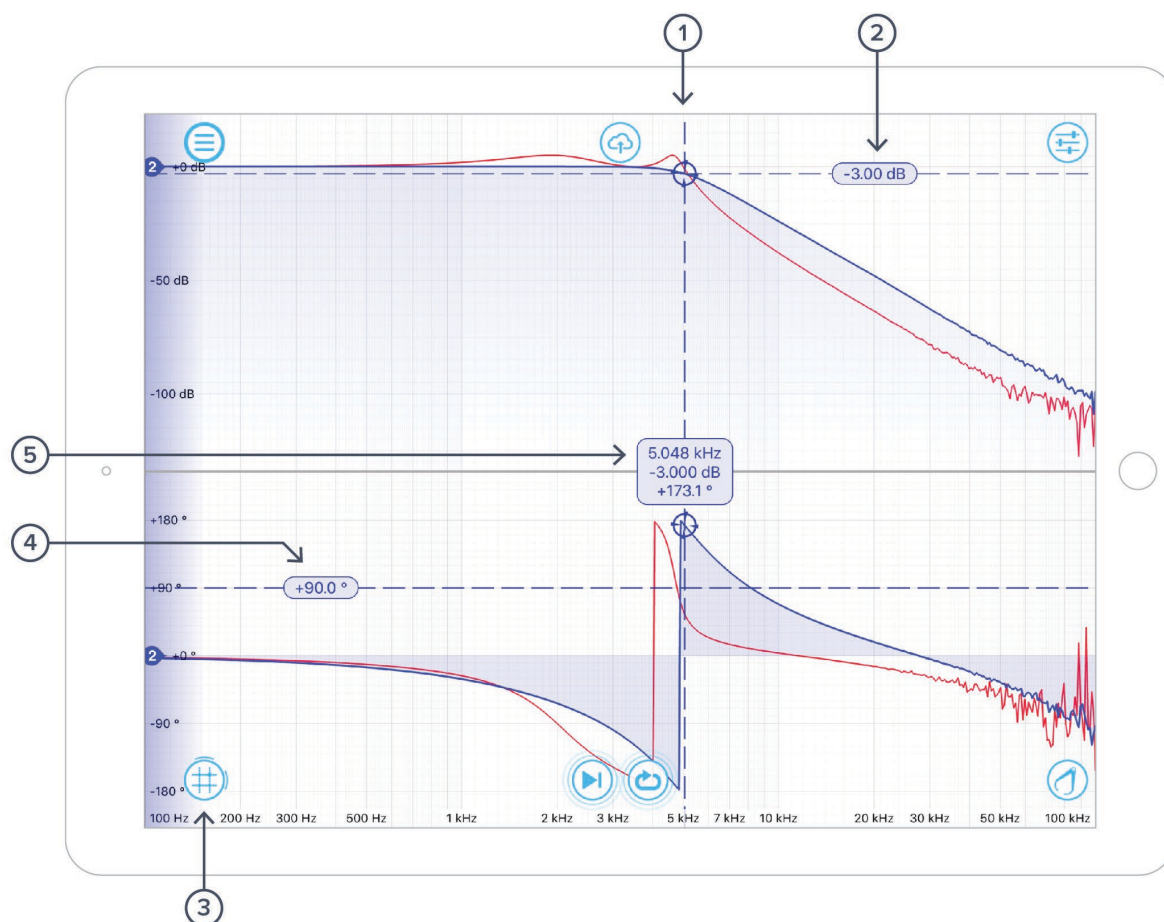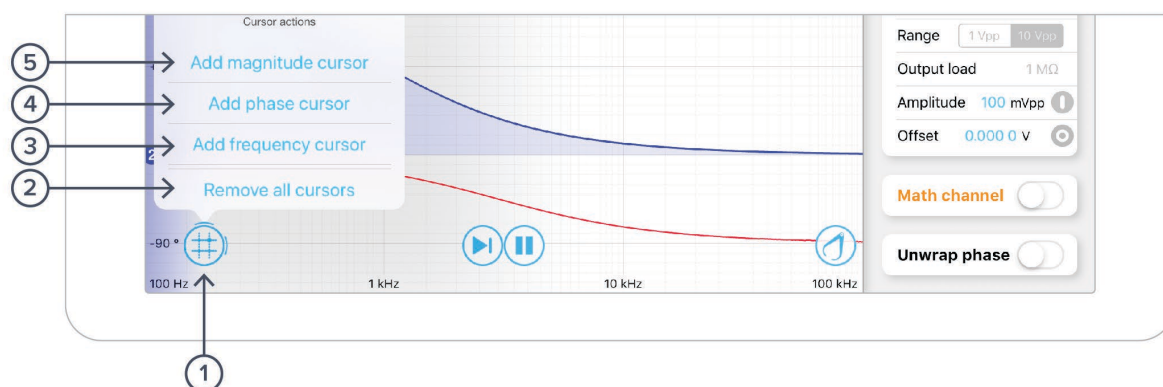
Cursors

Magnitude and phase cursors can be added to the Frequency Response plot by pressing the button.

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

ID	Cursor item	Description
1	Frequency cursor	Drag to adjust frequency, tap and hold to hide channel
2	Amplitude cursor	Drag to adjust tap to set magnitude manually & other options
3	Create cursor	Tap to create, or drag up or drag right for magnitude/frequency cursor
4	Phase cursor	Drag to adjust, tap to set phase manually & other options
5	Cursor label	Label depicting frequency, amplitude and phase of cursor. Drag to adjust. Tap to manually adjust or remove

ID	Description	ID	Description
1	Cursor action buttons	**4**	Add phase cursor
2	Remove all cursors	**5**	Add magnitude cursor
3	Add frequency cursor		

Magnitude cursors

Magnitude cursors can be added to the Magnitude 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 Phase 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 Frequency 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 Frequncy and Phase plots 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.
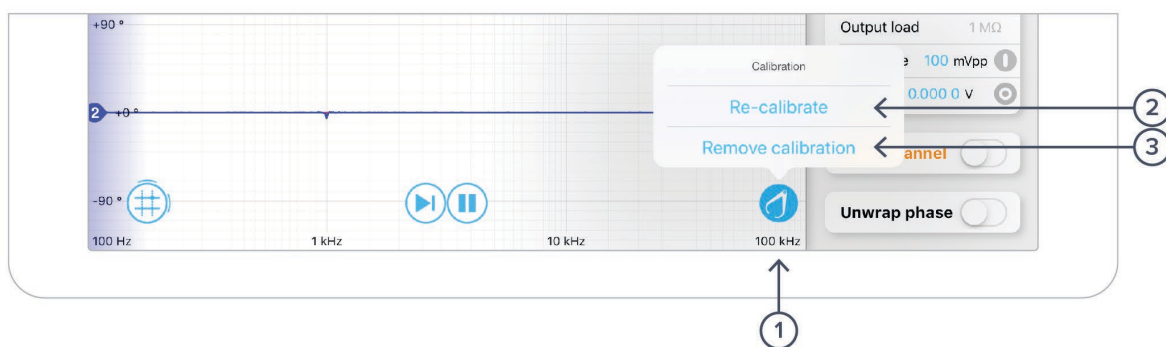
Tapping the ▶| or ↻ icons will restart the sweep.
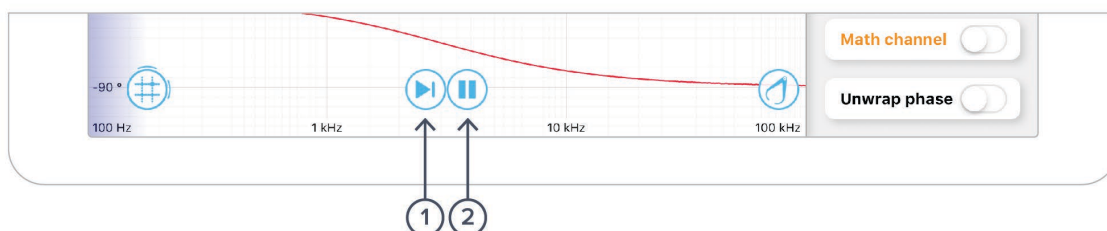
ID	Description	ID	Description
1	Start single sweep	2	Stop sweep

Calibration

Moku:Lab'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.

ID	Description	ID	Description
1	Calibrate menu	3	Remove calibration
2	Recalibrate		

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.
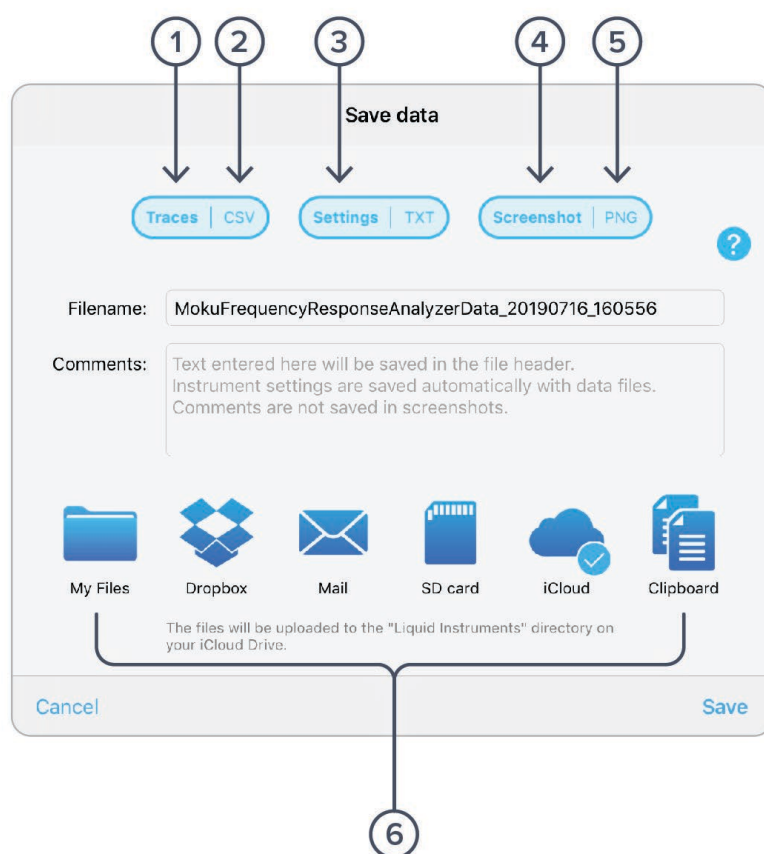
Exporting Data

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

The frequency analyser instruments settings can also be exported for future reference.

To export a measurement trace, press the ⬆ icon at the top of the Frequency response plot.

ID	Button	Description
1	Traces data	Select to enable saving of Trace data
2	Traces format	Tap to select CSV or MATLAB format
3	Settings data	Select to save instrument settings
4	Screenshot capture	Select to capture screenshot
5	Screenshot format	Tap to select JPG or PNG screenshot format
6	Saved data destination	Select data destination

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