Moku:Lab

Specifications

Revision 2018.2. Last updated 15th April, 2018.

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Hardware

Specifications

Analog I/O

Analog inputs

Channels	2 (BNC)
Bandwidth (-3 dB)	200 MHz into 50 Ω
Sampling rate	500 MS/s per channel
Resolution	12-bit
Voltage range	1 V_{pp} / 10 V_{pp}
Input impedance	50 Ω / 1 MΩ
Input coupling	AC / DC
AC coupling corner (-3 dB)	100 Hz into 50 Ω 30 Hz into 1 MΩ
SNR	60 dBFS (per sample)
Input referred noise	30 nV/√Hz above 100 kHz

Analog outputs

Channels	2 (BNC)
Bandwidth (-3 dB)	>300 MHz
Sampling rate	1 GS/s per channel
Resolution	16-bit
Voltage range	2 V_{pp} into 50 Ω
Output impedance	50 Ω
Output coupling	DC

External trigger input

External trigger

Trigger waveform	TTL compatible
Trigger bandwidth	DC to 5 MHz
Trigger impedance	Hi-Z
Min trigger level	1.9 V
Max trigger level	5 V
Connector	BNC

Clock reference

On-board clock

Frequency	10 MHz

On-board clock

Stability	< 500 ppb

10 MHz reference input

Frequency	10 MHz ± 250 kHz
Input impedance	50 Ω
Input range	-10 dBm to +10 dBm
Connector	BNC

10 MHz reference output

Output frequency	10 MHz
Output level	-3 dBm
Connector	BNC

General characteristics

General and environmental characteristics

Power consumption	20 W typical 30 W when charging USB
Power voltage range	100 to 240 V, 50/60 Hz
Temperature	Operating: 0 to +45 °C Non-operating: -10 to +60 °C

Electromagnetic compliance

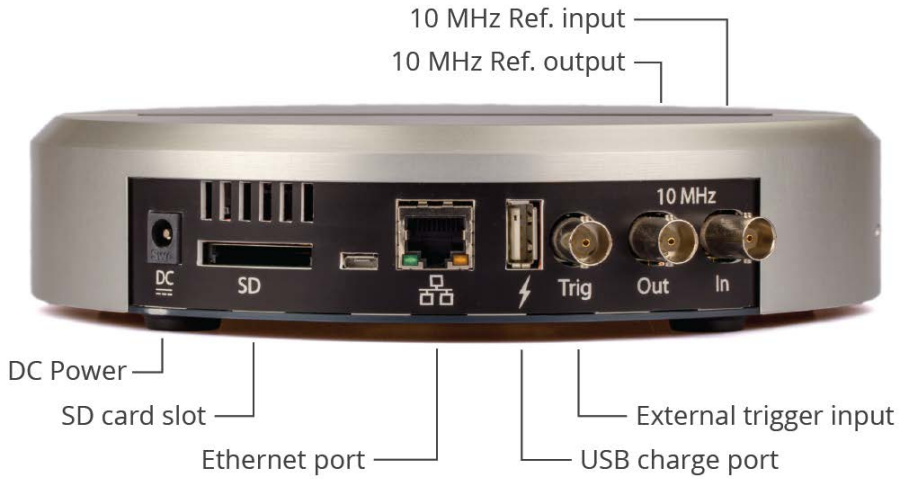
Physical characteristics

Dimensions	Diameter: 22 cm (8.66 in.) Height: 4.3 cm (1.70 in.)
Weight	1.69 kg (3.73 lbs)
Security	Kensington lock compatible

General connectivity

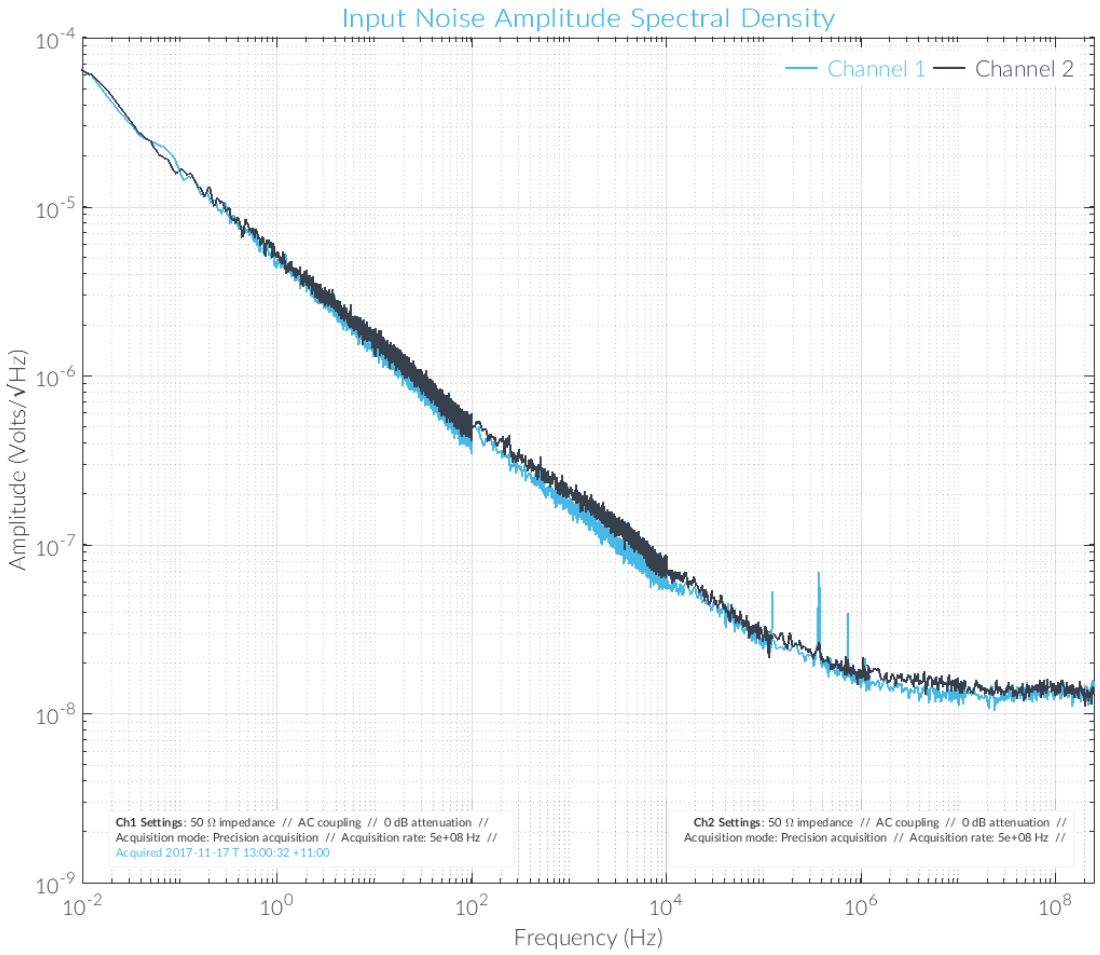
Connectivity

Analog inputs	2 x BNC
Analog outputs	2 x BNC
Network	Ethernet (10/100 Base-T) Wi-Fi 802.11 b/g/n
USB network connection	Micro-USB
USB charge port	10 W
SD card	16 GB class 10 supplied
External trigger input	BNC
10 MHz clock reference input	BNC
10 MHz clock reference output	BNC
DC Power	12 V (power module supplied)



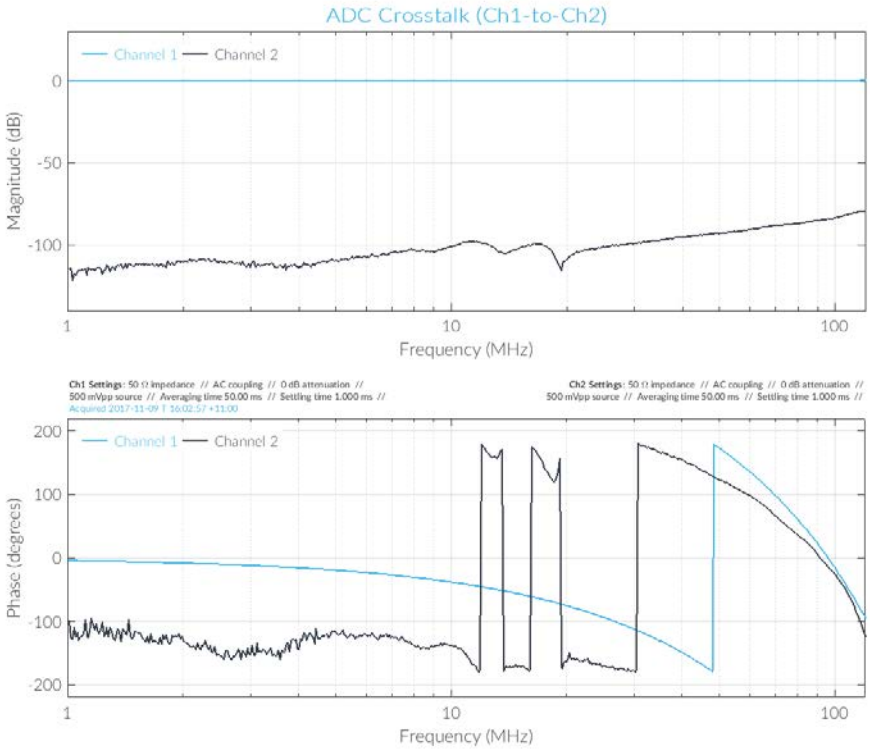
Hardware measurements

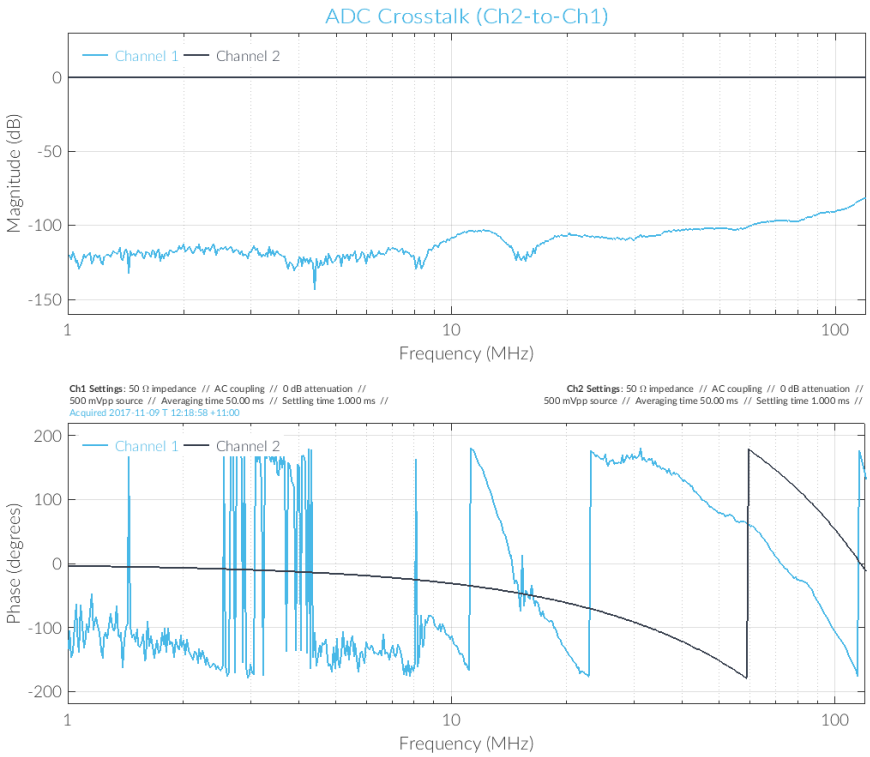
ADC input noise



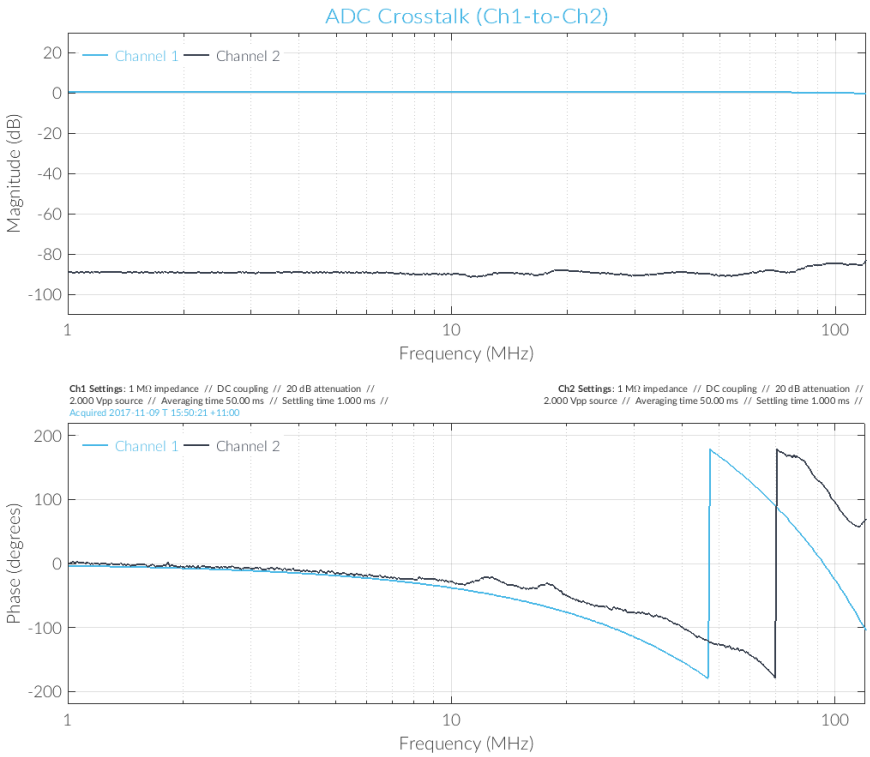
ADC crosstalk

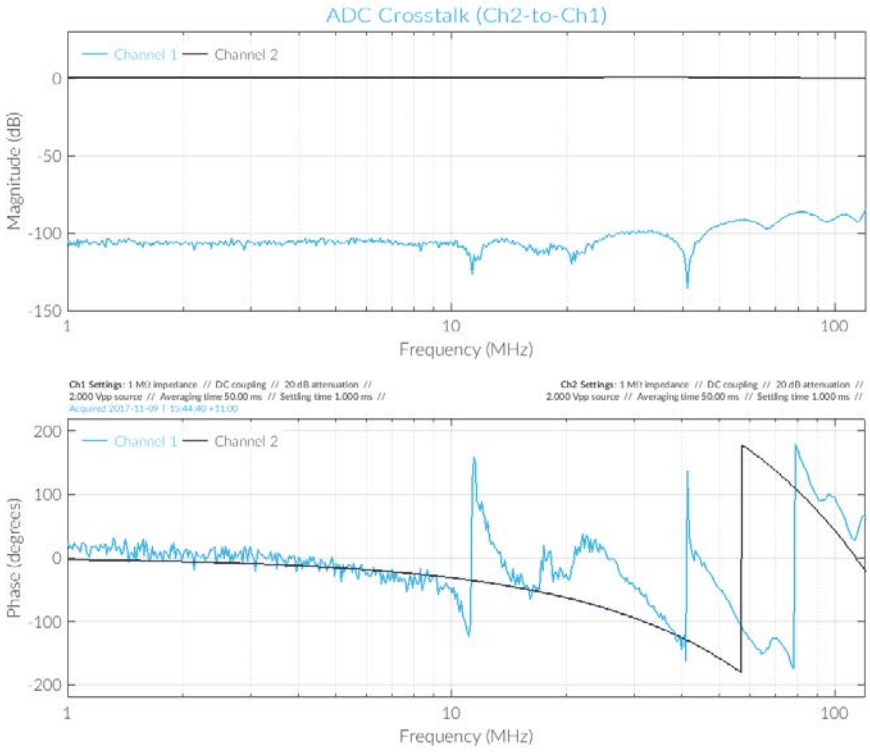
50 Ω // AC coupled // 0 dB attenuation





1 MΩ // DC coupled // 20 dB attenuation

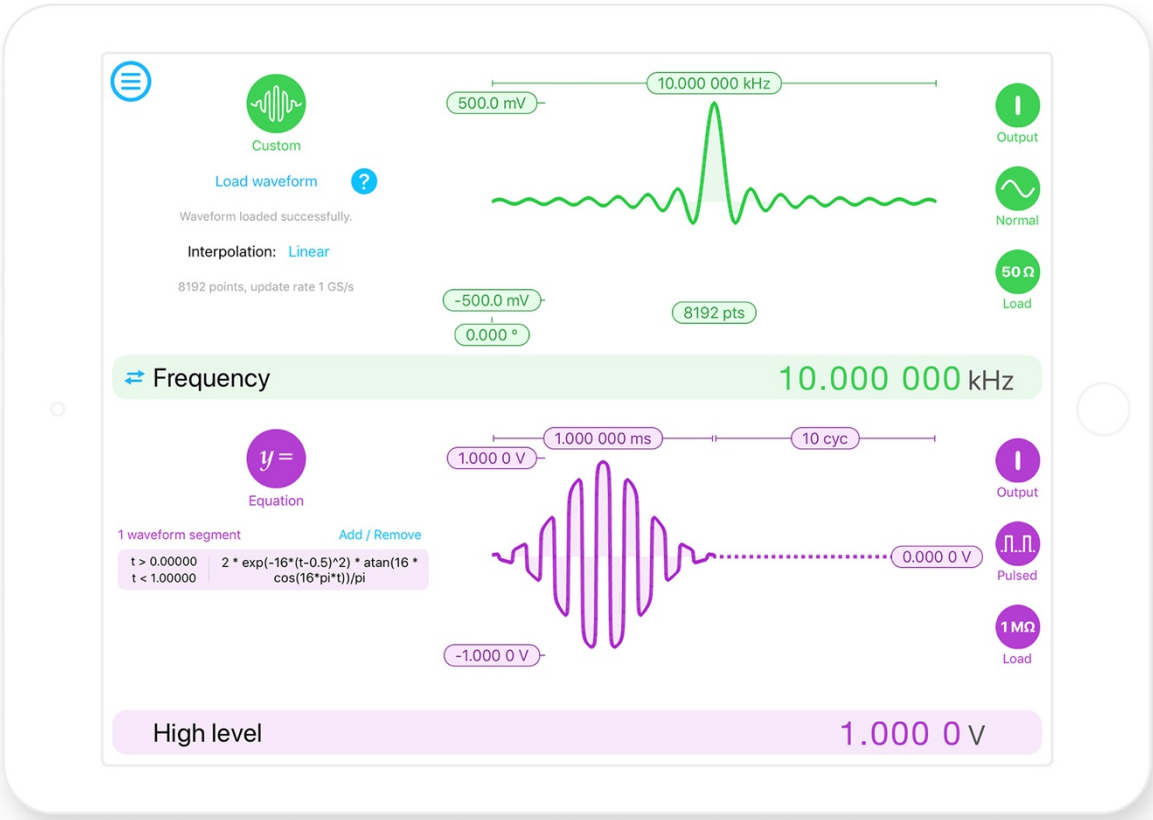




Arbitrary Waveform Generator

Description

The Moku:Lab's Arbitrary Waveform Generator can generate custom waveforms with up to 65,000 points at update rates of up to 1 GS/s. Waveforms can be loaded from a file, or input as a piece-wise mathematical function with up to 32 segments. In pulsed mode, waveforms can be output with more than 250,000 cycles of dead time between pulses.



Features

- Choose between one of the preset waveforms, load points from a file or input an equation directly
- Configure pulsed output with up to 250,000 cycles of dead time between pulses
- Phase-synchronized output between the two channels

Specifications

Common characteristics

Overview

Channels	2
Bandwidth (-3 dB)	> 300 MHz into 50 Ω
Sampling rate	1 GS/s per channel
Output impedance	50 Ω
Waveforms	Sine, Gaussian, Exponential Fall, Sinc, Equation, Custom (from file)

Amplitude

Range	1 mV_{pp} to 2 V_{pp} into 50 Ω
Offset error	1 GS/s per channel
Resolution	100 µV
Units	V_{pp}, dBm

DC offset

Range (peak AC + DC)	± 1 V into 50 Ω ± 2 V into high-impedance
Resolution	100 µV

Phase offset

Range	0° to 360°
Resolution	0.001°

Waveform characteristics

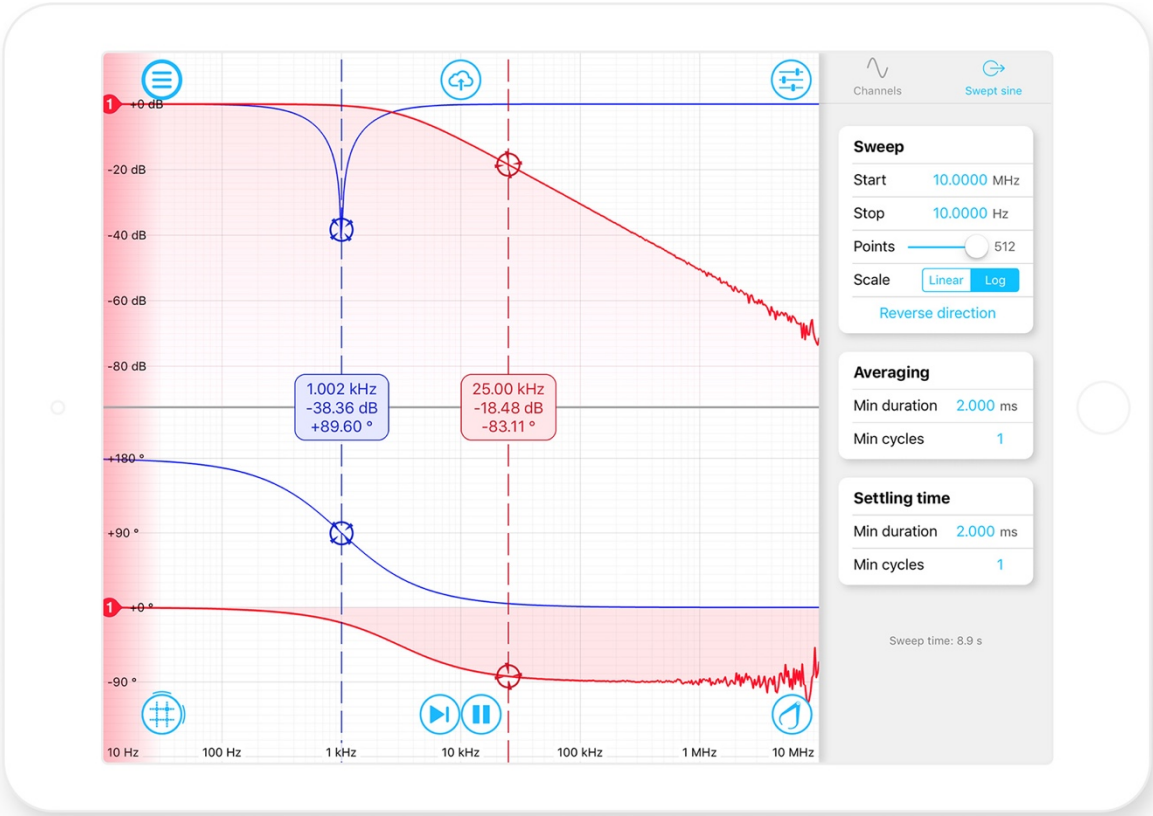
Custom

Maximum output rate	125 MS/s	65536 points
	250 MS/s	32768 points
	500 MS/s	16384 points
	1 GS/s	8192 points
Text file type	Comma- or newline-delimited text	
Interpolation	Linear	
Minimum edge time	2 ns	
Overshoot	≤ 10% for edge times between 2 ns and 8 ns ≤ 2% for edge times greater than 8 ns	
Jitter (cycle-to-cycle)	< 1 ns	
Pulse width	2 ns to period	
Period range	1000 s to 10 ns	

Bode Analyzer

Description

The Moku:Lab's Bode Analyzer can be used to measure the magnitude and phase of a system's transfer function using a swept sine output from 10 mHz to 120 MHz.



Features

- Linear or logarithmic swept sine output
- Probe two systems simultaneously, or one system at two points
- Math channel to add, subtract, multiply or divide response functions as they are acquired
- See magnitude and phase on the interactive Bode plot
- Use cursors and markers to measure exact values on the plots
- Precisely adjust settling and averaging time to suit device under test
- Save a calibration trace to compare systems or compensate for cabling delays
- Easily save data and upload to the cloud

Specifications

Source

Source

Waveform	Sine
Frequency range	10 mHz to 120 MHz
Frequency resolution	3.55 µHz
Sweep type	Linear / Logarithmic
Sweep points	32, 64, 128, 256, 512
Output amplitude range	±0.5 mV to ±1 V into 50 Ω
Source impedance	50 Ω

Input

Input characteristics

Input impedance	50 Ω / 1 MΩ	
Input coupling	AC / DC	
Input attenuation	0 dB / 20 dB	
Input voltage range	± 0.5 V into 50 Ω with 0 dB attenuation	
Input noise	30 nV/√Hz above 100 kHz	
Flatness prior to normalization	10 mHz to 100 kHz	< 0.02 dB into 50 Ω < 0.05 dB into 1 MΩ
	100 kHz to 1 MHz	< 0.02 dB into 50 Ω < 0.03 dB into 1 MΩ
	1 MHz to 50 MHz	< 0.3 dB into 50 Ω < 0.7 dB into 1 MΩ
	1 MHz to 120 MHz	< 0.7 dB into 50 Ω < 2.2 dB into 1 MΩ
Crosstalk	< 80 dB at 50 Ω < 60 dB at 1 MΩ	

Measurement

Measurement characteristics

Settling time	Min.	Greater of 1 µs or 1 cycle
	Max.	10.0 seconds
Averaging time	Min.	Greater of 1 µs or 1 cycle
	Max.	10.0 seconds
Noise-floor • 100 ms averaging time • 500 mV_{pp} amplitude • DC coupled input	10 mHz to 100 kHz	-100 dB into 0 dB attenuation -80 dB into 20 dB attenuation
	100 kHz to 1 MHz	-125 dB into 0 dB attenuation -105 dB into 20 dB attenuation
	1 MHz to 50 MHz	-130 dB into 0 dB attenuation -110 dB into 20 dB attenuation
	50 MHz to 120 MHz	-120 dB into 0 dB attenuation -100 dB into 20 dB attenuation
Normalized gain error	<0.05 dB	
Normalized phase error	< 0.5°	
Normalization	Normalizes magnitude and phase using the most recent full sweep[1].	

Saving Data

Saving data

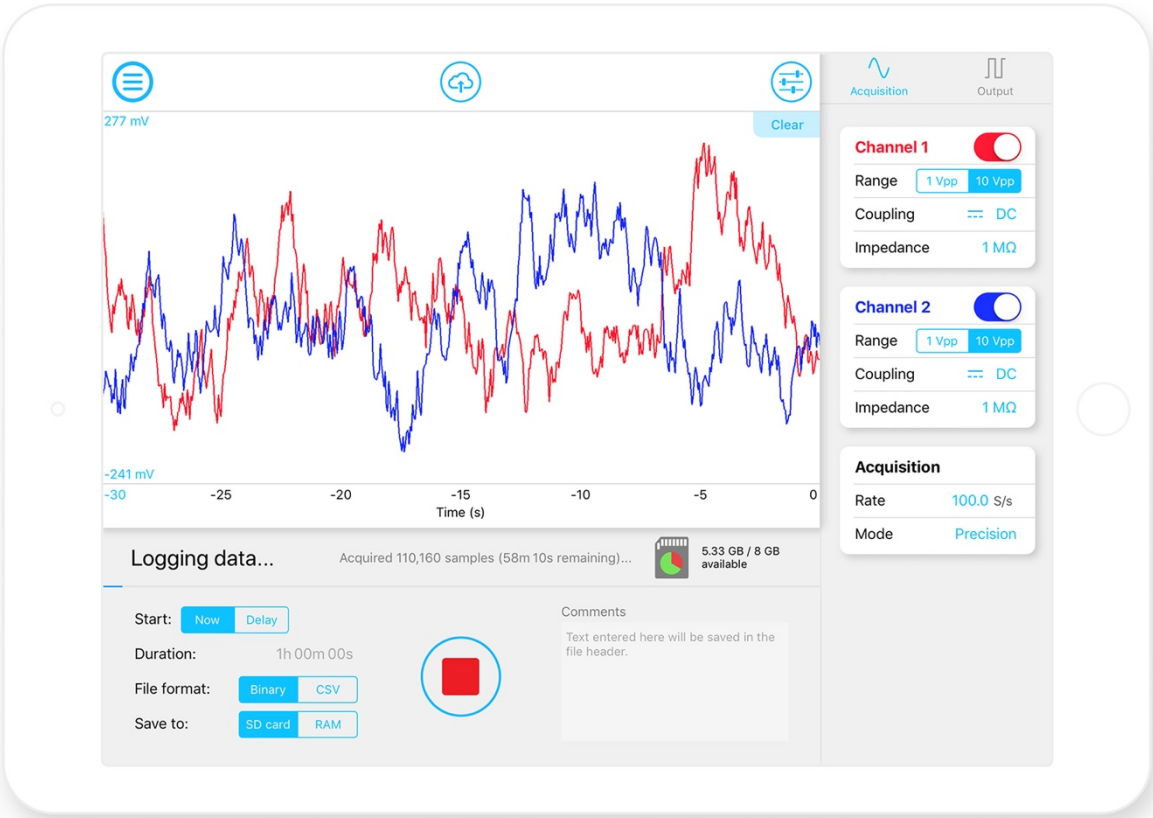
File formats	Plain text: records data using a standard *.csv format
	Binary: records data using MathWorks' *.mat format which can be opened using MATLAB
Export modes	SD Card, Dropbox, E-mail and iCloud, My Files (iOS 11)

[1] The calibration feature can be used to isolate the magnitude and phase response of the system under test by compensating for deviations in magnitude and phase caused by cables and the Moku:Lab's own frequency response.

Data Logger

Description

The Moku:Lab Data Logger lets you log voltage data directly to an SD card for long-term measurements at rates of up to 100 kS/s. The duration is limited only by the capacity of the SD card. Data can also be acquired at up to 1 MS/s by saving directly to the Moku:Lab's 500 MB of internal storage. Data saved to the Moku:Lab's internal storage can be uploaded to the cloud at the end of the measurement.



Features

- Record two channels of data at up to 100 kS/s to SD card and 1 MS/s to internal storage

Specifications

Input

Input characteristics

Input voltage range	± 0.5 V into 50 Ω with 0 dB attenuation
Input impedance	50 Ω / 1 MΩ
Input coupling	AC / DC

Logging

Logging characteristics

File formats	Plain text: records data using a standard *.csv format
	Binary: records data using a proprietary *.li format for high-speed data logging. **Note:** data saved using the *.li format must be converted to plain text using the LI file converter available here: https://github.com/liquidinstruments/lireader
Export modes	SD Card, Dropbox, E-mail and iCloud, My Files (iOS 11)
Maximum sampling rate	1 MS/s into RAM (format: *.li binary) 100 kS/s into SD card (format: *.li binary) 20 kS/s into RAM / SD card (format: *.csv) **Note:** data saved to the Moku:Lab's on-board RAM will be lost when the device is rebooted.
Delayed log start time	Up to 240 hours
Log duration	1 second up to 240 hours

Digital Filter Box

Description

The Moku:Lab's Digital Filter Box allows the user to interactively design and generate low-pass, high-pass, band-pass and band-stop filters with output sampling rates of 122 kHz and 15.625 MHz.

Features

- Design your filter's frequency response using the interactive Bode plot
- Block diagram view of the digital signal processing with built-on probe points for signal monitoring
- Two inputs channels, two output channels with control matrix for blended inputs
- Supports custom filter designs

Specifications

Inputs

Input characteristics

Channels	2
Input control matrix coefficients	-20 to +20
Input impedance	50 Ω / 1 MΩ
Input coupling	AC / DC
Input attenuation	0 dB / 20 dB
Input voltage range	± 0.5 V into 50 Ω with 0 dB attenuation

Filter characteristics

Pre-filter

Input offset range	± 500 mV
Input offset resolution	100 µV
Input gain range	-40 dB to +40 dB
Input gain resolution	0.1 dB

Post-filter

Output offset range	± 500 mV
Output offset resolution	100 µV
Output gain range	-40 dB to +40 dB
Output gain resolution	0.1 dB

General filter characteristics

Filter shapes	Lowpass, Highpass, Bandpass, Bandstop, Custom
Sampling rates	122 kHz, 15.625 MHz
Filter types	Butterworth, Chebyshev I, Chebyshev II, Elliptic, Bessel, Gaussian, Legendre
Passband ripple	0.1 dB to 10 dB
Stopband attenuation	10 dB to 100 dB
Zoom view	Allows the user to zoom in on the filter's frequency response

Low-pass filter

Filter order	2, 4, 6, 8
Low-pass corner frequency	1.221 Hz to 48.83 kHz at 122 kHz sampling rate 156.3 Hz to 6.250 MHz at 15.625 MHz sampling rate

High-pass filter

Filter order	2, 4, 6, 8
High-pass corner frequency	1.221 Hz to 48.83 kHz at 122 kHz sampling rate 156.3 Hz to 6.250 MHz at 15.625 MHz sampling rate

Band-pass / band-stop filter

Filter order	2, 4
Low corner frequency	1.221 Hz to 48.83 kHz at 122 kHz sampling rate 156.3 Hz to 6.250 MHz at 15.625 MHz sampling rate
High corner frequency	2.002 Hz to 48.83 kHz at 122 kHz sampling rate 256.3 Hz to 6.250 MHz at 15.625 MHz sampling rate
Minimum bandwidth	770 mHz at 122 kHz sampling rate 100 Hz at 15.625 MHz sampling rate

Selecting the right IIR filter

Filter type

Butterworth	Butterworth filters have a maximally flat passband and a monotonic frequency response, making them a good all-round filter type suitable for most applications.
Chebyshev I	Chebyshev I filters have ripple in the passband but a sharper transition than Butterworth filters, making them useful for applications requiring aggressive stopband attenuation but can tolerate passband ripple between 0.1 dB and 10 dB.
Chebyshev II	Chebyshev II filters have ripple in the stopband but a sharper transition than Butterworth filters, making them useful in applications requiring flat passbands and aggressive stopband attenuation.
Elliptical	Elliptical (Cauer) filters have ripple in both passband and stopband, but also have the sharpest possible transition. Elliptical filters are useful in applications requiring extremely aggressive stopband attenuation.
Bessel	Bessel filters have maximally flat group and phase delay in the passband, thus preserving the wave shape of passband signals.
Gaussian	Gaussian filters have the minimum possible group delay, and a step response with no overshoot and minimum rise and fall time.
Legendre	Legendre (Optimum L) filters have the sharpest possible transition while maintaining a monotonic frequency response.

FIR Filter Builder

Description

Design and create advanced filters, all from an intuitive iPad interface, or with Python and MATLAB (LabVIEW coming soon).

Features

- Design filters in the time domain or in the frequency domain, choosing from common impulse responses and window functions
- Load your own filter coefficients or enter an equation to create a customized impulse response
- Visualize the filter's transfer function, impulse and step response, or group and phase delay
- Easily save data and upload to the cloud

Specifications

Inputs

Input characteristics

Channels	2
Input control matrix coefficients	-20 to +20
Input impedance	50 Ω / 1 MΩ
Input coupling	AC / DC
Input attenuation	0 dB / 20 dB
Input voltage range	± 0.5 V into 50 Ω with 0 dB attenuation

Filter characteristics

Pre-filter

Input offset range	± 1 V
Input offset resolution	100 µV
Input gain range	-40 dB to +40 dB
Input gain resolution	0.1 dB

Post-filter

Output offset range	± 2 V
Output offset resolution	100 µV
Output gain range	-40 dB to +40 dB
Output gain resolution	0.1 dB

General filter characteristics

Sampling rates	122.1 kHz, 244.1 kHz, 488.3 kHz, 976.6 kHz, 1.953 MHz, 3.906 MHz, 7.813 MHz, 15.63 MHz
Number of coefficients	2 to 232 @ 15.63 MHz
	2 to 464 @ 7.813 MHz
	2 to 928 @ 3.906 MHz
	2 to 1856 @ 1.953 MHz
	2 to 3712 @ 976.6 kHz
	2 to 7424 @ 488.3 kHz
	2 to 14819 @ 244.1 kHz and 122.1 kHz
Design domains	Time (impulse response) Frequency (frequency response)

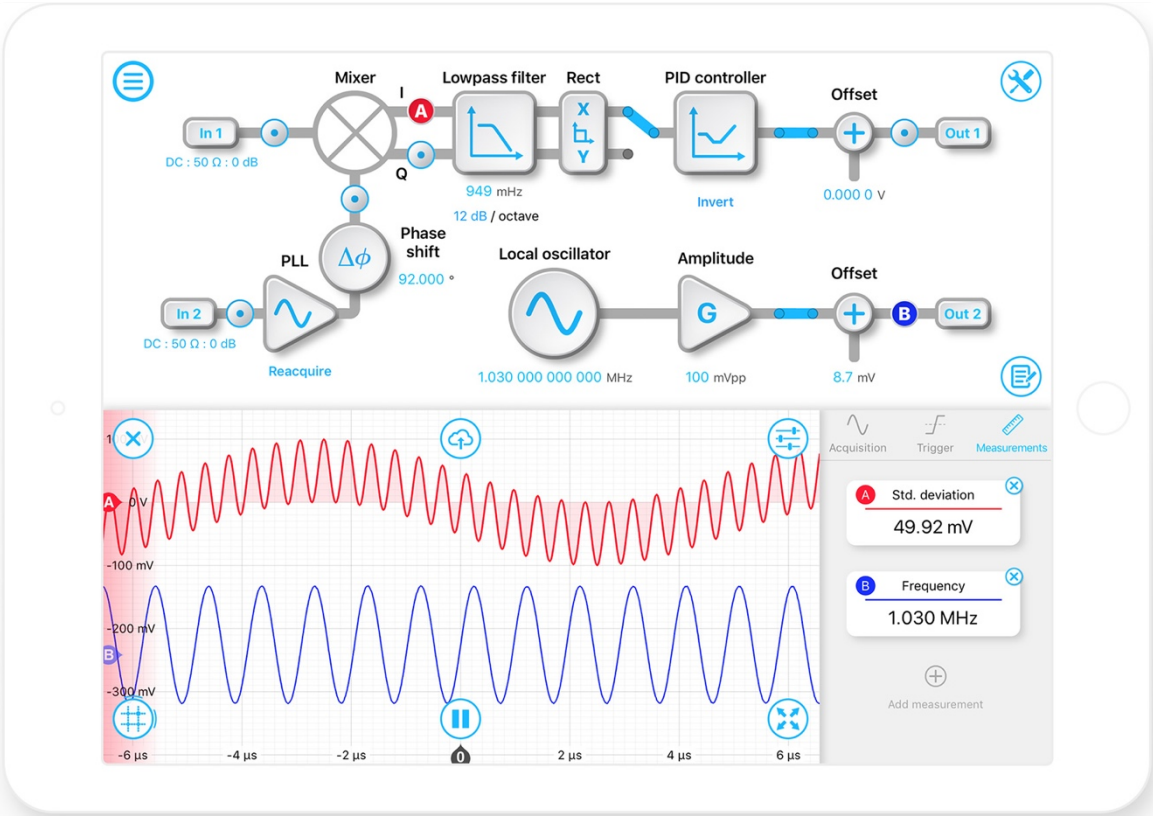
Filter design / configuration

Display options	Magnitude / Phase Impulse / Step Response Group / Phase Delay
Frequency response	Lowpass, highpass. bandpass, bandstop
Impulse response	Rectangular, Sinc, Triangular, Gaussian, Equation, Custom
Window	None, Bartlett, Hanning, Hamming, Blackman, Nuttall, Tukey, Kaiser
Minimum filter cut-off frequency	Sampling rate / 10,000 • e.g., f_{min} = 12.21 Hz @ 122.1 kHz
Maximum filter cut-off frequency	Sampling rate / 2 (approximately) • e.g., f_{max} = 59.81 kHz @ 122.1 kHz

Lock-In Amplifier

Description

The Moku:Lab's Lock-In Amplifier can be used to detect small oscillating signals that are obscured by noise. The intuitive user interface allows users to precisely configure the system and monitor its performance using probe points throughout the block diagram.



Features

- Block diagram view of the digital signal processing with built-in probe points for signal monitoring
- Demodulate signals at frequencies of up to 200 MHz
- Measure signals obscured by noise with more than 80 dB dynamic reserve

Specifications

Signal channel

Input characteristics

Input coupling	AC / DC
AC coupling corner (-3 dB)	100 Hz into 50 Ω 30 Hz into 1 MΩ
Input impedance	50 Ω / 1 MΩ
Input voltage range	± 5 V
Input noise	30 nV/√Hz above 100 kHz

Demodulator

Sources	Internal Reference oscillator, Internal Auxiliary oscillator, External direct, External with phase-locked loop
Types	Internal, External with PLL: Sine (In-phase) / Cosine (Quadrature) External direct: Sine (In-phase)
Input gain[2]	-20 dB / 0 dB / + 24 dB / + 48 dB
Filter mode	Low-pass filter
Filter cut-off frequency range	237 mHz to 3.98 MHz
Filter time-constant	251 nanoseconds to 4.219 seconds
Filter slope	6 dB or 12 dB per octave
Phase shift precision	0.001°
Gain accuracy	± 1%
Dynamic reserve	Better than 80 dB
PLL frequency range	2 MHz to 200 MHz
PLL bandwidth	10 kHz

Reference oscillator

Reference and Auxiliary oscillators

Waveform	Sine
Frequency range	1 mHz to 200 MHz
Frequency resolution	3.55 µHz
Distortion	< -70 dBc for frequencies lower than 10 kHz < -60 dBc for frequencies greater than 10 kHz

[2] +24 dB and +48 dB input gains are applied digitally and can be used to maximise the Lock-In Amplifier's dynamic range for weak input signals.

Signal output

Output routing

Output sources	X, Y (cartesian mode); R, Θ (polar mode); Auxiliary Oscillator
Output processing	Direct, PID[3]
Number of output channels	2
Polar-mode	0.8 V per cycle
Gain profiles	Proportional (P), integral (I), differential (D), integral saturation (IS), differential saturation (DS)
Controller frequency range	100 mHz to 10 MHz
Proportional gain	± 60 dB
Integrator crossover frequency	1.00 Hz to 100 kHz
Differentiator crossover frequency	10 Hz to 1 MHz

Signal output

Output voltage range (peak AC + DC)	±0.5 mV to ±1 V into 50 Ω
Gain range	-80 dB to +80 dB

Saving Data

Saving data

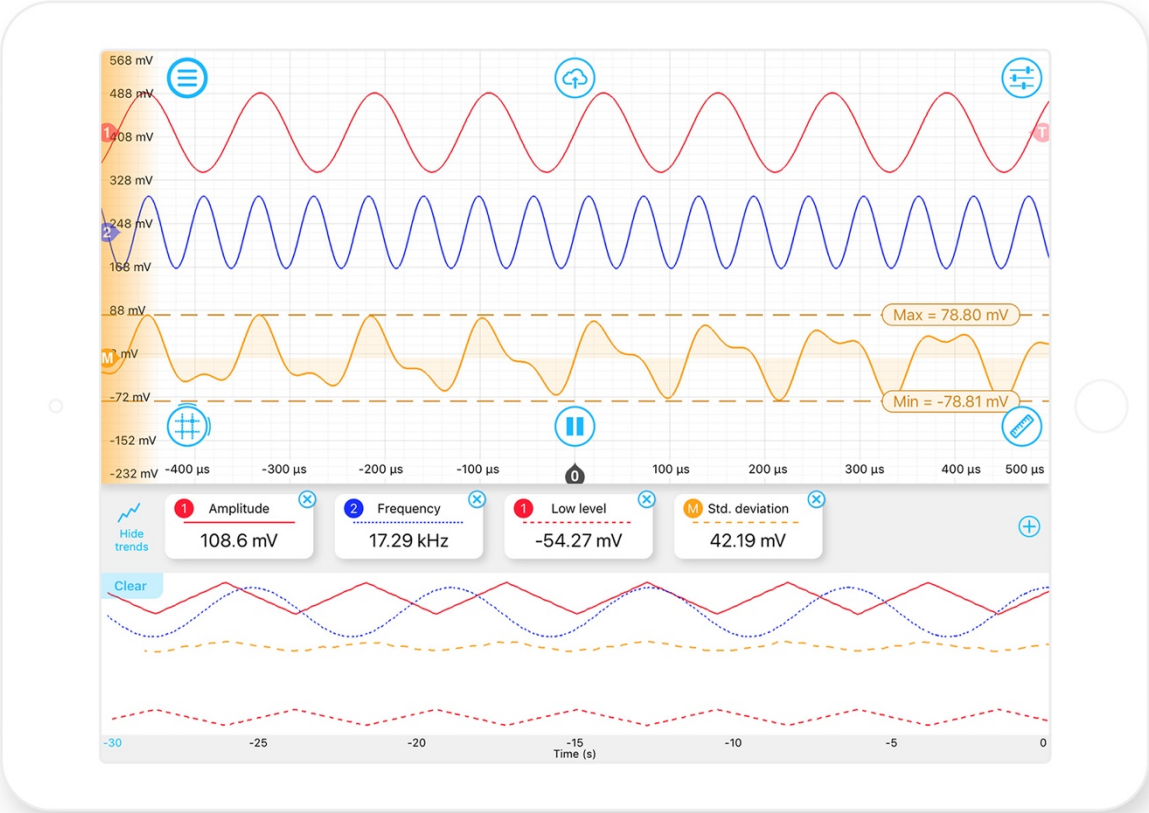
File formats	Plain text: records data using a standard CSV format
	Binary: records data using a proprietary LI format for high-speed data logging. **Note:** data saved using the LI format must be converted to plain text using the LI file converter available here: https://github.com/liquidinstruments/lireader
Maximum sampling rate	1 MS/s into RAM (format: *.li binary) (single channel) 500 kS/s into RAM (format: *.li binary) (two channels) 100 kS/s into SD card (format: *.li binary) 20 kS/s into RAM / SD card (format: *.csv) **Note:** data saved to the Moku:Lab's on-board RAM will be lost when the device is rebooted.
Export modes	SD Card, Dropbox, E-mail and iCloud, My Files (iOS 11)
Delayed log start time	Up to 240 hours
Log duration	1 second up to 240 hours

[3] Only one output may have a PID controller routing at a time

Oscilloscope

Description

The Moku:Lab's Oscilloscope features two analog input channels with 200 MHz bandwidth and independent control of AC/DC coupling and 50 Ω / 1 MΩ input impedance. The instrument's multi-touch interface allows you to intuitively adjust timescales and voltage levels.



Features

- Analyse two voltage channels with a vertical range of ±5 Volts and maximum sampling rate of 500 MS/s
- Input analog bandwidth of 200 MHz
- Synthesize sine, square, ramp, pulse, and DC waveforms
- Analyse signals in XY mode
- Quickly measure various waveform characteristics, trends and statistics

Specifications

Vertical characteristics

Voltage

Channels	2
Input coupling	AC, DC
Input bandwidth (-3 dB)	> 200 MHz into 50 Ω
Input impedance	50 Ω, 1 MΩ
Input voltage range	± 5 V
Vertical resolution[4]	12 bits at 500 MS/s (ADC resolution) 13 bits at 125 MS/s 22 bits at 1 kS/s
Channel-to-channel isolation	> 40 dB

Horizontal characteristics

Time

Time mode	Normal, Roll	
Horizontal range	1 ns/div to 10 s/div	
Delay range	Pre-trigger:	16 kSamples Greater of 32.768 µs or screen width
	Post-trigger:	2^{30} samples 2.147 s to 1 Ms

Acquisition

Acquisition mode	Normal, Precision[5]
Maximum sampling rate	500 MS/s
Memory depth	16,384 Samples per channel 32.7 µs at 2 ns/div
Averaging (linear)	Off, 2 to 100 waveforms
Persistence	Off, 100 ms to 10 s, infinite
Interpolation	Linear, SinX/X, Gaussian

[4] Higher effective number of bits (ENOB) above the physical ADC specification is only available in precision mode.

[5] Precision mode samples the waveform at the full rate and applies a finite impulse response (FIR) low-pass filter to attenuate noise above the usable bandwidth of the measurement sampling rate and prevent aliasing.

Trigger

Trigger

Trigger modes	Auto:	Triggers automatically after timeout (1 second if previously triggered, 0.05 seconds otherwise)
	Normal:	Triggers only on trigger event
	Single:	Triggers once on a trigger event. Press the 'play' button to re-trigger
Trigger sources	Input 1, Input 2, Output 1, Output 2, External	
Nth event	Trigger on the 1st to 65,535th event	
Holdoff	1 nanosecond to 10 seconds	
Trigger types	Edge: Rising edge, falling edge, both edges Pulse: Positive / negative polarity • 10.0 seconds > **pulse width** > 816.0 nanoseconds	

Trigger sensitivity

Sensitivity modes	Auto:	Automatically configures trigger sensitivity based on horizontal and vertical scales Select *Noise Reject* or high-frequency *HF Reject* options
	Manual:	Manually configure trigger sensitivity
Manual modes	Relative, Absolute	
Hysteresis	Relative: 0.01 div to 5.00 div Absolute: 100 µV to 5.00 V	

Measurements

Measurements

Time measurements	Frequency, period, duty cycle, positive pulse width, negative pulse width, rise time, fall time, rise rate, fall rate
Amplitude measurements	Peak-to-peak, amplitude, maximum, minimum, mean, cycle mean, RMS, cycle RMS, standard deviation, high-level, low-level, overshoot, undershoot
Math	Add, subtract, multiply, divide, XY mode, integrate, differentiate, FFT, min hold, max hold, arbitrary equation mode (using equation editor)
Visualisations	Histogram, time trend

Cursors

Maximum voltage cursors	5 per channel
Maximum time cursors	5 per channel
Voltage cursor options	Manual, track mean, track maximum, track minimum, maximum hold, minimum hold
User defined reference	A single cursor can be set as a reference for differential measurements using all other active cursors

Synthesizer

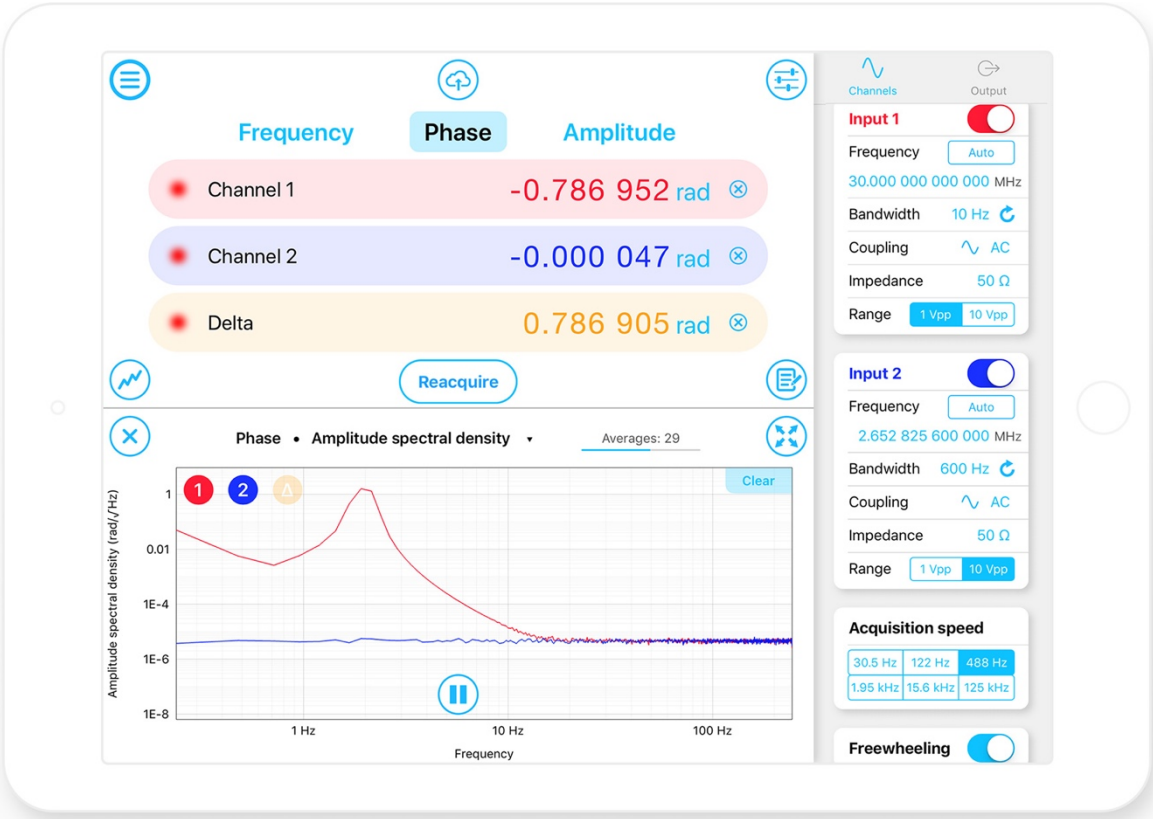
Channels	2
Output impedance	50 Ω
Waveforms[6]	Sine, Square, Ramp, Pulse, DC
Output frequency range	1 mHz to 250 MHz
Output voltage range	± 1 V into 50 Ω

[6] Modulation not available for waveforms synthesized using the oscilloscope instrument.

Phasemeter

Description

The Moku:Lab's Phasemeter can be used to measure the phase of oscillating input signals between 1 kHz and 200 MHz with 1 µcycle precision.



Features

- Measure the phase difference between two input signals with better than 1 µcycle precision
- Select between measuring phase, frequency and amplitude
- Acquire data at up to 125 kS/s
- Track frequency and phase disturbances at up to 10 kHz

Specifications

Inputs

Input characteristics

Input frequency range	1 kHz to 200 MHz
Input voltage range	± 0.5 V into 50 Ω
Input impedance	50 Ω / 1 MΩ
Input coupling	AC / DC

Measurement

Measurement characteristics

Freq. set-point precision	3.55 µHz	
Modes of operation	Auto-acquire:	Automatically determines input frequency
	Manual:	Initializes the phasemeter to a user-defined frequency
Tracking bandwidth	10 Hz / 40 Hz / 150 Hz / 600 Hz / 2.5 kHz / 10 kHz (user selectable)	
Frequency precision	**Input Frequency**	**Precision (f = Fourier frequency)**
	1 kHz to 10 MHz	*f* x 10 µHz/√Hz from 1 mHz to 1 kHz
	10 MHz to 100 MHz	*f* x 20 µHz/√Hz from 1 mHz to 1 kHz
	> 100 MHz	20 µHz/√Hz below 1 Hz *f* x 20 µHz/√Hz from 1 Hz to 1 kHz
Phase precision[7]	1 kHz to 10 MHz	100 nCycles/√Hz above 1 Hz RMS
	10 MHz to 100 MHz	2 µCycles/√Hz above 1 Hz
	> 100 MHz	20 µCycles/√Hz above 1 Hz

[7] Frequency and phase measurement precision is limited by sampling jitter at low Fourier frequencies.

Saving Data

Saving data	
Logging rates	30 S/s, 120 S/s, 490 S/s, 1.95 kS/s, 15.6 kS/s, 125 kS/s
File formats	Plain text: records data using a standard CSV format
	Binary: records data using a proprietary LI format for high-speed data logging. **Note:** data saved using the LI format must be converted to plain text using the LI file converter available here: https://github.com/liquidinstruments/lireader
Maximum sampling rate	1 MS/s into RAM (format: *.li binary) 100 kS/s into SD card (format: *.li binary) 20 kS/s into RAM / SD card (format: *.csv) **Note:** data saved to the Moku:Lab's on-board RAM will be lost when the device is rebooted.
Export modes	SD Card, Dropbox, E-mail and iCloud, My Files (iOS 11)
Delayed log start time	Up to 240 hours
Log duration	1 second up to 240 hours

Synthesizer

Synthesizer[8]	
Channels	2
Output impedance	50 Ω
Waveforms	Sine
Output modes	Manual, input-locked
Sampling rate	1 GS/s per channel
Voltage range	± 1 V into 50 Ω

[8] Where not stated, Phasemeter Synthesizer specifications match those of the Moku:WaveformGenerator instrument.

PID Controller

Description

The Moku:Lab's PID controller enables users to design and deploy a control system for a wide range of applications including temperature stabilization and laser frequency control.

Features

- Design your control system's frequency response using the interactive Bode plot
- Block diagram view of the digital signal processing with built-in probe points for signal monitoring
- Two input channels and two output channels with control matrix for blending inputs
- Includes single or double integrators and differentiators with low- and high-frequency gain saturation
- Configure controller parameters in basic or advanced editing modes

Specifications

Inputs

Input characteristics

Channels	2
Input control matrix coefficients (linear gain)	-20 to +20
Input impedance	50 Ω / 1 MΩ
Input coupling	AC / DC
Input attenuation	0 dB / 20 dB
Input voltage range	± 0.5 V into 50 Ω with 0 dB attenuation

Controller

General characteristics

Gain profiles	Proportional (P), integral (I), differential (D), double-integral (I+), integral saturation (IS), differential saturation (DS)
Maximum bandwidth	100 kHz with a phase delay of 30°
Input / output offset range	± 1 V
Offset precision	100 µV

Gain characteristics

Gain profiles	Proportional (P), integral (I), differential (D), double-integral (I+), integral saturation (IS), differential saturation (DS)
Controller frequency range	100 mHz to 10 MHz
Input / output offset range	± 1 V
Offset precision	100 µV
Proportional gain	± 60 dB
Integrator crossover frequency	1.00 Hz to 100 kHz
Double integrator crossover frequency	1.00 Hz to integrator crossover frequency
Integral saturation level	Between proportional gain and +60 dB The integrator saturation crossover frequency cannot be lower than 10 Hz
Differentiator crossover frequency	10.0 Hz to 1.00 MHz
Differentiator saturation level	Between proportional gain and +60 dB The differentiator saturation crossover frequency cannot be higher than 1 MHz

Spectrum Analyzer

Description

The Moku:Lab's spectrum analyzer enables users to analyze dynamic signals in the frequency domain from DC to 250 MHz.

Features

- DC to 250 MHz frequency range
- 1 kHz to 250 MHz frequency span
- Quickly measure key metrics by dragging measurement cursors onto features of interest using the iPad's multi-touch interface

Specifications

Frequency

Frequency

Range	DC to 250 MHz
Span	1 kHz to 250 MHz

Resolution bandwidth (RBW)

Modes	Auto	Automatically sets the RBW based on the current span and window function
	Manual	Allows the user to manually set the RBW within the limits tolerated by the span and window function
	Min	Sets the RBW at the minimum possible value for the current span and window function The minimum RBW is 1 Hz
Windows	None (uniform), Hanning, Flat Top, Blackman-Harris	

Amplitude

Voltage

Channels	2
Input coupling	AC / DC
Input impedance	50 Ω / 1 MΩ
Input attenuation	0 dB / 20 dB
Input bandwidth (-3 dB)	> 200 MHz into 50 Ω > 180 MHz into 1 MΩ
Input voltage range	± 0.5 V into 50 Ω with 0 dB attenuation
	± 5 V into 50 Ω with 20 dB attenuation
Input voltage sensitivity	-130 dBm with 0 dB attenuation at minimum RBW

Display

Scales	Volts, dBm
Display modes	Power, Power Spectral Density (PSD)
Video bandwidth (VBW)	10 Hz to 2.4 MHz depending on span
Averages	1 to 100
Persistence	100 ms to 10 s, infinite, off

Synthesizer

Synthesizer

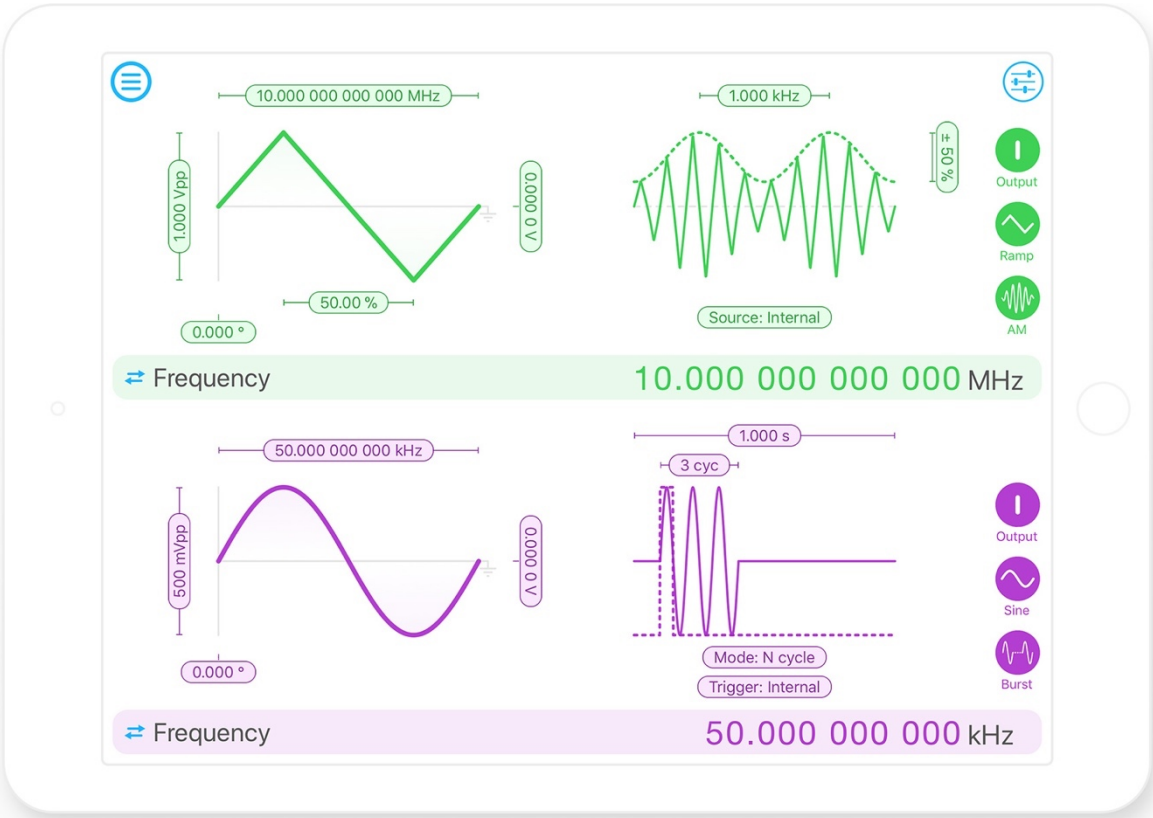
Channels	2
Output impedance	50 Ω
Waveforms[9]	Sine
Output frequency range	1 mHz to 250 MHz
Sweep mode	Sweeps the output frequency across the current span with a fixed sweep period of 5 seconds
Output voltage range	± 1 V into 50 Ω

[9] Modulation not available for waveforms synthesized using the oscilloscope instrument.

Waveform Generator

Description

The Moku:Lab's waveform generator can be used to generate two independent waveforms at up to 200 MHz with a voltage range of 2 V_{pp} into a 50 Ω load. Waveforms can be modulated in amplitude, frequency and phase at frequencies of up to 62.5 MHz.



Features

- Generate sine waves from 1 mHz to 250 MHz
- Generate square and ramp waves from 1 mHz up to 100 MHz
- Generate pulsed waveforms with a minimum pulse width of 10 ns at up to 100 MHz
- Modulate waveforms in amplitude, frequency and phase at up to 62.5 MHz using both internal and external sources

Specifications

Common characteristics

Overview

Channels	2
Bandwidth (-3 dB)	300 MHz into 50 Ω
Sampling rate	1 GS/s per channel
Output impedance	50 Ω
Waveforms	Sine, Square, Ramp, Pulse, DC

Amplitude

Range	1 mV_{pp} to 2 V_{pp} into 50 Ω
Offset error	< 500 µV into 50 Ω
Resolution	100 µV
Channel isolation	> 40 dB from DC to 200 MHz
Units	V_{pp}, dBm

DC offset

Range (peak AC + DC)	± 1 V into 50 Ω
Resolution	100 µV

Phase offset

Range	0° to 360°
Resolution	0.001°

Waveform characteristics

Sine

Frequency range	1 mHz to 250 MHz	
Amplitude flatness (into 50 Ω)	< 100 kHz	< 0.03 dB
	100 kHz to 10 MHz	< 0.08 dB
	10 MHz to 250 MHz	< 0.12 dB
Total harmonic distortion	< 0.1% (1.5 MHz, 5 harmonics)	
SFDR	> 50 dBc for frequencies less than 20 MHz	

Square

Frequency range	1 mHz to 100 MHz
Edge time[10]	< 2.3 ns into 50 Ω < 2.6 ns into 1 MΩ
Overshoot	≤ 10% for edge times between 2 ns and 8 ns ≤ 2% for edge times greater than 8 ns
Jitter (cycle-to-cycle)	< 1 ns

Ramp

Frequency range	1 mHz to 100 MHz	
Symmetry[11]	20% to 80% at 100 MHz 4% to 96% at 20 MHz 0% to 100% at 5 MHz	
Linearity	Below 1 MHz	> 99%
	Between 1 MHz and 50 MHz	> 98%
	Above 50 MHz	> 95%

Pulse

Frequency range	1 mHz to 100 MHz
Period range	1000 s to 10 ns
Pulse width	2 ns to period
Edge time	2 ns to half the pulse width
Edge time resolution	1 ns
Overshoot	< 2% for rise times greater than 8 ns < 15% for rise times between 2 ns and 8 ns
Jitter	Same as square wave

Modulation

Amplitude

Carrier waveforms	Sine, Square, Ramp, Pulse
Source	Internal, External
Internal modulation	Sine
Frequency	1 mHz to 62.5 MHz
Depth	0% to 100%

Frequency

Carrier waveforms	Sine, Square, Pulse

[10] Measured for a 2 V_{pp} square wave at 10 kHz.

[11] Symmetry is limited by the minimum rise time of 2 ns and number of harmonics required to maintain a linearity of more than 99%.

Frequency

Source	Internal, External
Internal modulation	Sine
Frequency	DC to 62.5 MHz
Deviation (carrier + deviation)	DC to 250 MHz

Phase

Carrier waveforms	Sine, Square, Pulse
Source	Internal, External
Internal modulation	Sine
Frequency	DC to 62.5 MHz
Phase shift	0.0° to 360.0°

External

Carrier waveforms	Sine, Square, Ramp, Pulse
Source	Ch1: Input 1, Output 2 Ch2: Input 2, Output 1
Voltage range	± 1 V into 50 Ω
Frequency	DC to 62.5 MHz
Variable deviation	AM: %/V FM: Hz/V PM: °/V

Burst

Modes of Operation	Start, N-Cycle, Gated
N-Cycle range	1 to 1,000,000
Trigger Sources	Ch1: Input 1, Output 2, External Ch2: Input 2, Output 1, External
Nominal Trigger Level	Input Channel: 1.8 V Output Channel: 0.5 V External: 1.2 V

Sweep

Sweep Frequency Start/End	Sine: 1 mHz to 250 MHz Square, Ramp, Pulse: 1 mHz to 100 MHz
Sweep Time	1 ms to 1 ks
Trigger Sources	Ch1: Input 1, Output 2, External Ch2: Input 2, Output 1, External
Nominal Trigger Level	Input Channel: 1.8 V Output Channel: 0.5 V External: 1.2 V

Revision History

2018.2

Introduced FIR Filter Builder specifications	Added instrument specifications for the FIR filter builder
Reorganised order of specifications	Order in which instrument specifications appear is now consistent with other material
Updated specifications	Updated specifications in line with feature upgrades in Moku:Lab release version 1.7

2018.1

Updated specification	Updated spurious free dynamic range specification for frequencies lower than 20 MHz (old value was > 70 dBc, new value is > 50 dBc)

2017.2

Reformatted document	Added table of contents Included hardware specifications

2017.1

Waveform Generator	Added Burst, Sweep modulation specifications
	Corrected frequency range text in instrument description
Oscilloscope	Updated description of auto-mode triggering timeouts
Phasemeter	Added new output/logging rates
	Added synthesizer phase-locked functionality
Lock-in Amplifier	Added new demodulation source specifications
	Added new output routing and processing options

2017.0

Initial Revision