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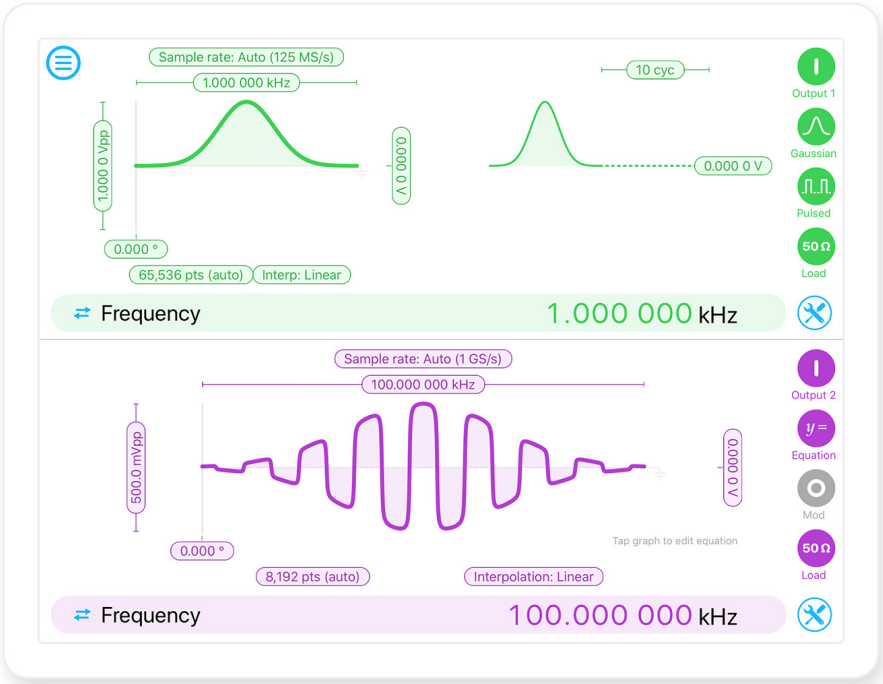
Moku:Lab Instrument Datasheet

# 300 MHz Arbitrary Waveform Generator

Moku:Lab's Arbitrary Waveform Generator can generate custom waveforms with up to 65,536 points at sample rates of up to 1 GSa/s. Waveforms can be loaded from a file, or input as a piece-wise mathematical function with up to 32 segments, enabling you to generate truly arbitrary waveforms. In pulsed mode, waveforms can be output with more than 250,000 cycles of dead time between pulses, allowing you to excite your system with an arbitrary waveform at regular intervals over extended periods of time.




| Maximum Sample rate | Output Bandwidth | DAC Resolution | Independent triggering | Supported Waveforms |
|---|---|---|---|---|
| **1 GSa/s** | **300 MHz** | **16-bits** | **Burst/Pulsed** | **5 predefined, segmented equations (up to 32) or custom** |

## Features

- Two independent AWG channels with 300 MHz bandwidth
- Choose between one of the preset waveforms, load points from a file or input an equation directly
- Phase synchronization output between the two channels
- Configure pulsed output with up to 250,000 cycles of dead time between pulses

## Specifications

- Supported waveforms: sine, Gaussian, exponential fall, exponential rise, sinc, equation editor, custom (from file)
- Output bandwidth (-3 dB): 300 MHz
- Output voltage: 2 Vpp into 50 Ω
- DC offset: ± 1 V with 100 µV resolution
- Phase offset: 0° to 360° with 0.001° resolution
- Maximum output rate:
  125 MSa/s with 65,536 points
  250 MSa/s with 32,758 points
  500 MSa/s with 16,384 points
  1 GSa/s with 8192 points

## Applications

- Random pattern scanning
- System response simulation
- Additive manufacturing
- Quantum optics

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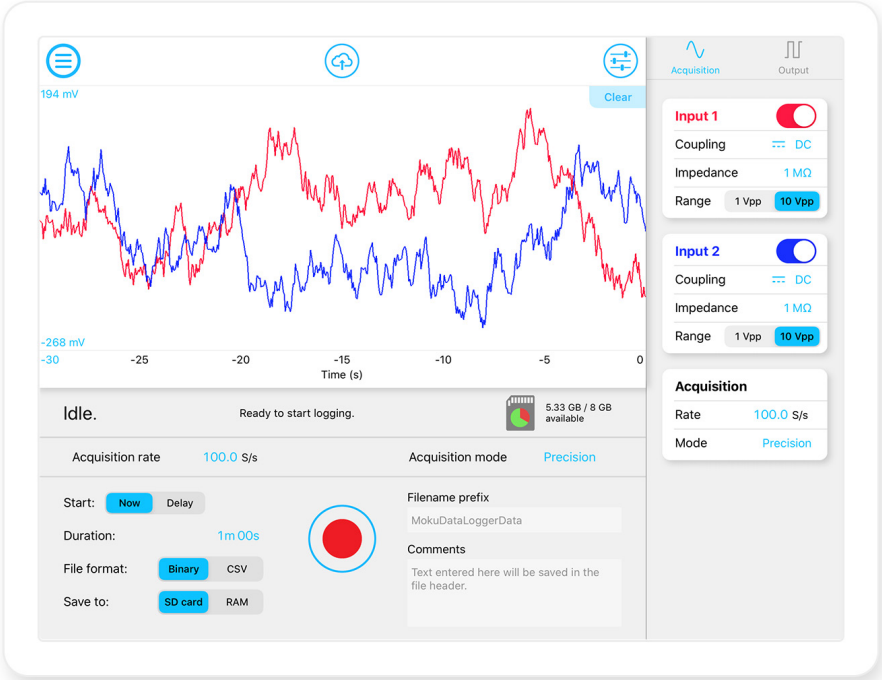
Moku:Lab Instrument Datasheet

# 1 MSa/s Data Logger

Moku:Lab's Data Logger enables you to log data directly to an SD card for long-term measurements at rates of up to 100 kSa/s, where the duration is limited only by the capacity of the SD card. Data can also be acquired at up to 1 MSa/s by saving directly to Moku:Lab's internal memory. Data saved to Moku:Lab's internal memory can be uploaded to the cloud for analysis once the measurement is complete.




| Number of Inputs | Acquisition rate | Input Range | Input Coupling | Input Impedance | Waveform Generator |
|---|---|---|---|---|---|
| **2** | **Up to 1 MSa/s** | **- 5 V to 5 V** | **AC or DC** | **50 Ω/1 MΩ** | **Integrated** |

## Features

- Log voltage data on two independent channels to an SD card for long-term measurements, or directly to Moku:Lab's internal RAM for short, high-speed bursts
- Built-in two-channel 250 MHz waveform generators
- Plain text (CSV) or binary, depending on data acquisition rate
- Easy export to SD card, Dropbox, Email, iCloud, or the iPad "My Files" folder
- Schedule a log to start after a delay of up to 10 days

## Specifications

- Input range: 1 Vpp or 10 Vpp
- Input Impedance: 50 Ω/1 MΩ
- Input coupling: AC/DC
- Maximum sampling rate:
  Into RAM:
  1 MSa/s with one channel enabled
  500 kSa/s with both channels enabled
  Into SD card:
  100 kSa/s one/both channel enabled
- Minimal sampling rate: 10 Sa/s
- Acquisition mode:
  Normal: Direct digitization at the acquisition rate
  Precision mode: Downsampling from 500 MSa/s by averaging

## Applications

- Temperature monitoring
- Vibration analysis
- Environment monitoring
- Other sensor data recording

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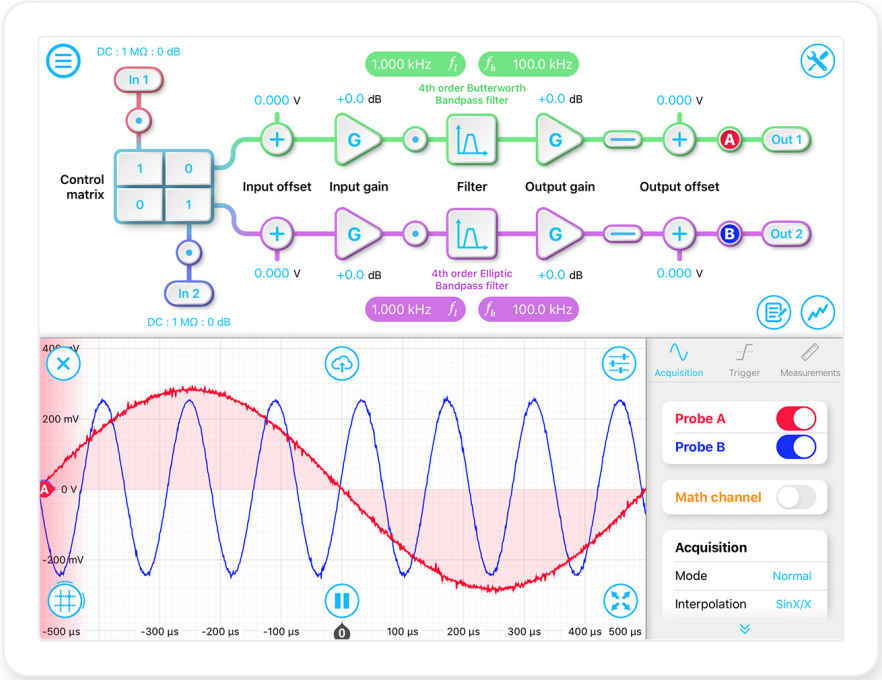
Moku:Lab Instrument Datasheet

# Digital Filter Box

With Moku:Lab's Digital Filter Box, you can interactively design and generate different types of infinite impulse response filters with sampling rates of 122 kHz and 15.625 MHz. Select between lowpass, highpass, bandpass, and bandstop filter shapes with up to seven fully configurable types including Butterworth, Chebyshev, and Elliptical.




| Sampling Rate | Filter Order | Input Range | Output Voltage Range | Filter Shapes |
|---|---|---|---|---|
| **122 kHz or 15.625 MHz** | **2, 4, 6, 8** | **± 0.5 V or ± 5 V** | **± 1 V into 50 Ω** | **Lowpass, Highpass, Bandpass, Bandstop, Custom** |

## Features

- Visualize your signal and configuration in real-time: design your filter's frequency response using the interactive Bode plot
- Block diagram view of the digital signal processing with built-in probe points for signal monitoring
- Versatile input and output options: 2 input channels, 2 output channels with optional blending for MIMO systems
- Supports custom filter designs

## Specifications

- Filter shapes: lowpass, highpass, bandpass, bandstop
- Filter types: Butterworth, Chebyshev I, Chebyshev II, Elliptic, Bessel, Gaussian, and Legendre
- Corner frequencies: 1 Hz - 6 MHz
- Input-output latency: sub-microsecond
- Passband ripple: configurable 0.1 – 10 dB
- Stopband attenuation: configurable 10 – 100 dB
- Adjustability: independently adjustable input and output offsets and gain

## Applications

- System design
- Closed-loop control
- Noise filtering
- Signal amplification

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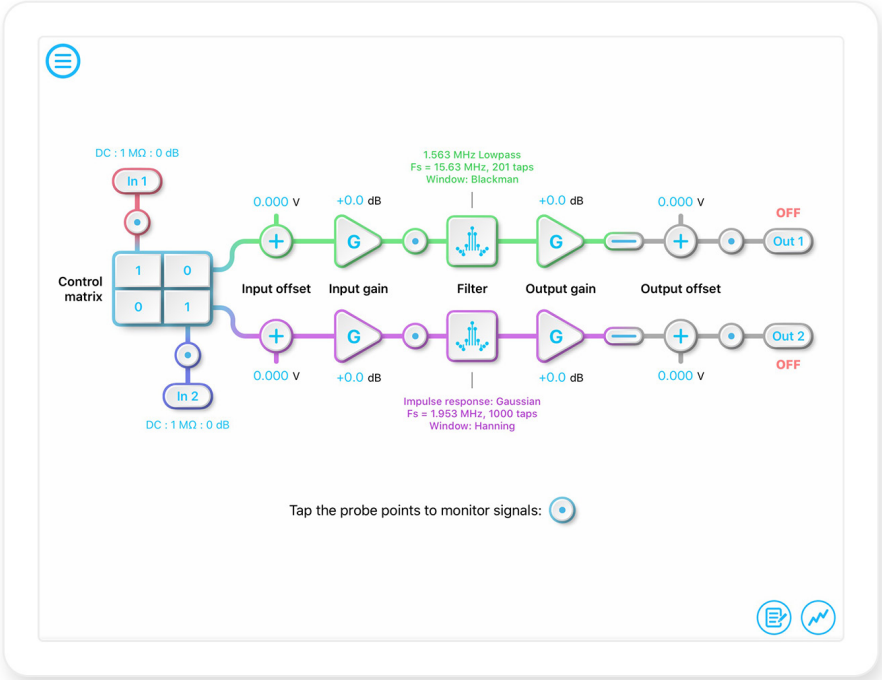
Moku:Lab Instrument Datasheet

# FIR Filter Builder

With Moku:Lab's FIR Filter Builder, you can design and implement lowpass, highpass, bandpass, and bandstop finite impulse response (FIR) filters with up to 14,819 coefficients. Moku:Lab's iPad interface allows you to fine-tune your filter's response in the frequency and time domains to suit your specific application. Select between four frequency response shapes, five common impulse responses, and up to eight window functions.




| Sampling Rate | Filter Coefficients | Input Range | Output Voltage Range | Integrated Oscilloscope |
|---|---|---|---|---|
| **Up to 15.625 MHz** | **Up to 14,819** | **± 0.5 V or ± 5 V** | **± 1 V into 50 Ω** | **500 MSa/s** |

## Features

- Visualize your signal and configuration in real-time: design filters in the time domain or in the frequency domain
- Visualize the filter's transfer function, impulse and step response, or group and phase delay
- Block diagram view of the digital signal processing with built-in probe points for signal monitoring
- Load your own filter coefficients or enter an equation to create a customized impulse response

## Specifications

- Independent channels: 2
- Coefficient count at various sampling rates:
  - 2 to 232 @ 15.63 MHz
  - 2 to 928 @ 3.906 MHz
  - 2 to 3712 @ 976.6 kHz
  - 2 to 14819 @ 244.1 kHz
- Filter coefficient precision: up to 24 bits
- Design domains: time (impulse response), frequency (frequency response)
- Impulse response: rectangular, sinc, equation input, custom, etc
- Frequency response: lowpass, highpass, bandpass, bandstop

## Applications

- Impulse response simulation
- DSP system design
- Noise filtering
- Signal amplification

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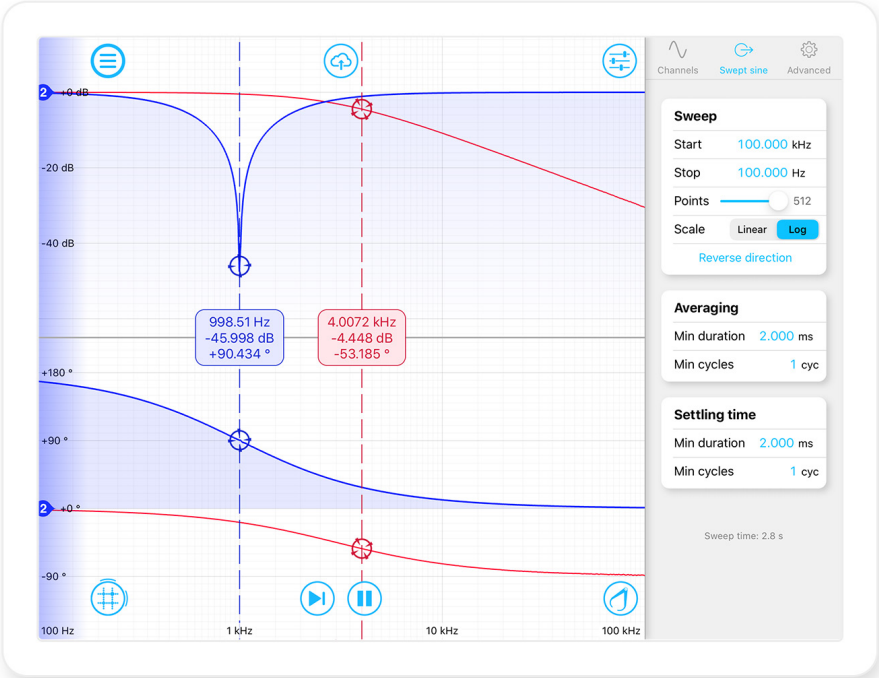
Moku:Lab Instrument Datasheet

# 120 MHz Frequency Response Analyzer

Moku:Lab's Frequency Response Analyzer enables you to measure the frequency response of a system in both magnitude and phase using a swept sine output from 10 mHz to 120 MHz. Select from between 32 and 512 points per sweep and configure settling and averaging times to balance total sweep duration and signal-to-noise ratio.




| Frequency Range | Input Impedance | Averaging time | Sweep | Output Voltage Range | Harmonics Detection |
|---|---|---|---|---|---|
| **Up to 120 MHz** | **50 Ω or 1 MΩ** | **1 µs to 10 s** | **Linear/Logarithmic** | **2 Vpp into 50 Ω** | **Up to 15th** |

## Features

- Linear or logarithmic swept sine output
- Math channel to add, subtract, multiply or divide response functions as they are acquired
- Use cursors and markers to measure exact values on the plots
- Measurement averaging and settling times are highly configurable
- Easily save data and upload to the cloud or Dropbox in common formats
- Probe two systems simultaneously, or one system at two points
- Demodulate up to 15th harmonic

## Specifications

- Frequency range: 10 mHz to 120 MHz
- Averaging time: 1 µs to 10 s
- Settling time: 1 µs to 10 s
- Sweep points: 32, 64, 128, 256, 512
- Source impedance: 50 Ω
- Output Voltage Range: 2 Vpp
- Input Impedance: 50 Ω or 1 MΩ
- Input voltage range: 1 Vpp or 10 Vpp
- Noise-floor: 10 mHz to 100 kHz: -100 dB
  100 kHz to 1 MHz: -125 dB
  1 MHz to 50 MHz: -130 dB
  50 MHz to 120 MHz: -120 dB

## Applications

- Impedance measurement
- Capacitance/inductance measurement
- Stability analysis
- Power supply analysis
- EMI filter characterization

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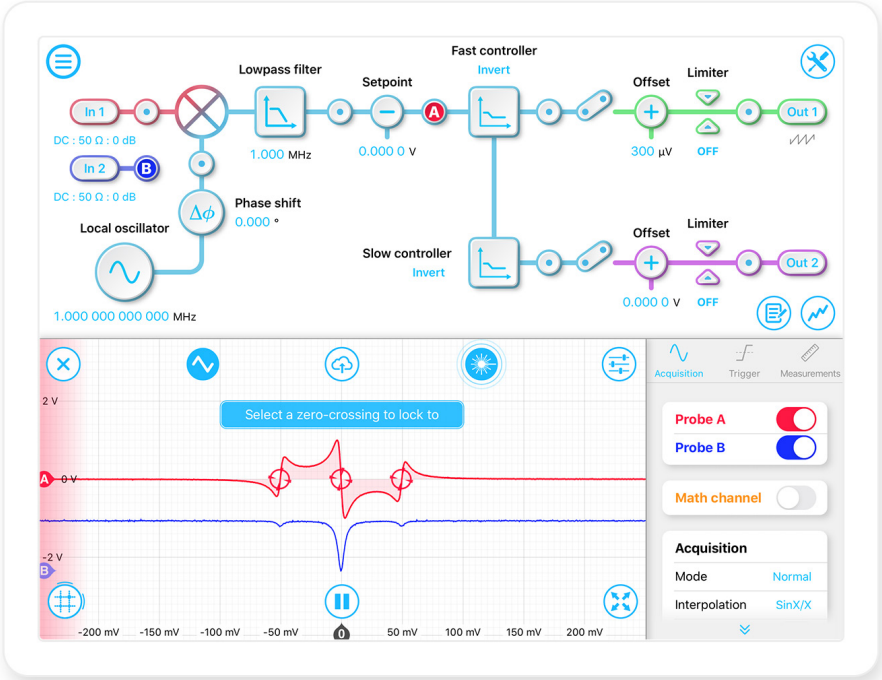
Moku:Lab Instrument Datasheet

# Laser Lock Box for PDH Technique

Moku:Lab's Laser Lock Box enables you to lock a laser's frequency to a reference cavity or atomic transition using high-performance modulation locking techniques. The Laser Lock Box includes a 'Tap-to-Lock' feature, enabling you to quickly lock to any zero-crossing on the demodulated error signal.




| Demod. Frequency | Scan Frequency | Adjustable Filter | DAC Resolution | Built-in Controllers | Integrated Oscilloscope |
|---|---|---|---|---|---|
| 1 mHz to 200 MHz | up to 10 MHz | 1 kHz to 14 MHz | 16 Bits | Dual PID | 500 MSa/s |

## Features

- Stabilize a laser's frequency to a reference cavity or atomic transition
- Virtually probe within signal processing chain to observe signals using an integrated oscilloscope
- Quickly lock to any zero-crossing in the error signal using the 'Tap-to-Lock' feature
- Individually configure high- and low-bandwidth PID controllers for fast and slow feedback
- Quickly access the controls you need with a customizable control palette view

## Specifications

- Local oscillator frequency: 1 mHz to 200 MHz (3.55 µHz resolution)
- Scan waveforms: positive sawtooth, negative sawtooth, triangle
- Scan frequency: 1 mHz to 10 MHz
- Infinite impulse response low-pass filter corner frequency: 1 kHz to 14 MHz (second or fourth order)
- Integrator crossover frequency: 1.25 Hz to 125 kHz (fast PID), 19.53 mHz to 1.953 kHz (slow PID)
- Ultra-fast data acquisition: snapshot mode up to 500 MS/s, continuous mode up to 1 MS/s

## Applications

- Pound-Drever-Hall technique
- Precision spectroscopy
- Gravitational wave detection
- Custom phase-locked loop
- Other closed-loop control systems

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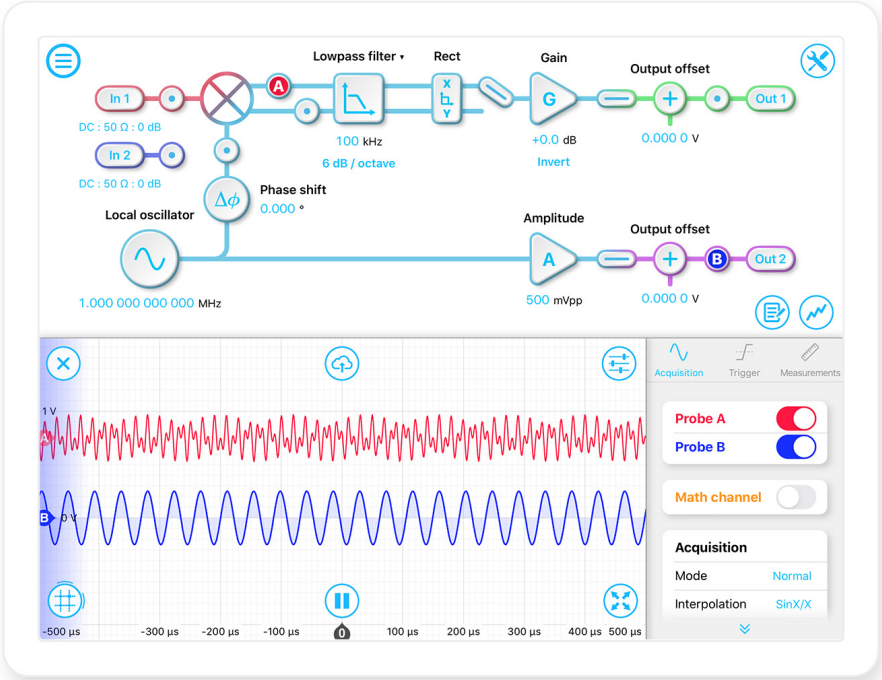
Moku:Lab Instrument Datasheet

# 200 MHz Lock-in Amplifier

Moku:Lab's digital Lock-in Amplifier supports dual-phase demodulation (XY/Rθ) from DC to 200 MHz with more than 120 dB of dynamic reserve. It also features an integrated 2-channel oscilloscope and data logger, enabling you to observe signals at up to 500 MSa/s and log data at up to 1 MSa/s.




| Demod. Frequency | Dynamic Reserve | Time Constant | Filter Slopes | Dual-phase Demod. | Built-in Feature |
|---|---|---|---|---|---|
| **1 mHz to 200 MHz** | **>120 dB** | **From 32 ns** | **6, 12, 18, 24 dB/Oct** | **X-Y or R-θ** | **PID Controller** |

## Features

- Measure signals obscured by noise with more than 120 dB dynamic reserve
- Block diagram view of the digital signal processing chain
- Built-in probe points for signal monitoring and data logging
- Internal or external demodulation modes including a PLL (phase-locked loop)
- Dual-phase demodulation
- Toggle between rectangular (X/Y mode) or polar coordinates (R/Theta mode)
- Built-in PID Controller

## Specifications

- Demodulate with frequencies ranging from 1 mHz to 200 MHz with 3.55 µHz resolution
- Phase shift precision of 0.001°
- 50 Ω / 1 MΩ input impedance
- Adjustable time constant from 32 ns to 0.537 s
- 6, 12, 18, or 32 dB/octave filter roll-off
- Output gain range: -80 to +160 dB
- LO output up to 200 MHz with variable amplitude
- Ultra-fast data acquisition: snapshot mode up to 500 MSa/s, continuous mode up to 1 MSa/s

## Applications

- Pump probe / ultrafast spectroscopy
- Laser scanning microscopy (SRS, TA, etc)
- Magnetic sensing (magneto-optical Kerr effect)
- Laser frequency stabilization

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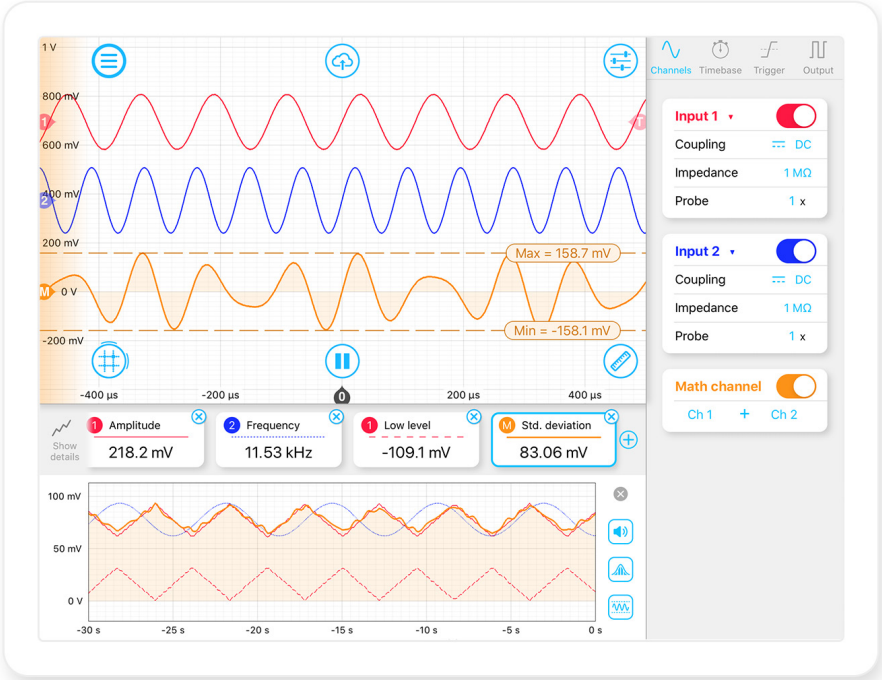
Moku:Lab Instrument Datasheet

# 200 MHz Oscilloscope

Moku:Lab's Oscilloscope features two 500 MSa/s analog input channels with 200 MHz analog bandwidth, 10 Vpp input voltage range, and user-configurable AC/DC coupling and 50 Ω/1 MΩ impedance. The oscilloscope also features two integrated waveform generators capable of producing sine waves at up to 250 MHz and square, sawtooth, and triangle waves at up to 100 MHz.




| Sampling Rate | Bandwidth | Input Range | Input Coupling | Input Impedance | Waveform Generator |
|---|---|---|---|---|---|
| **500 MSa/s** | **200 MHz** | **- 5 V to 5 V** | **AC or DC** | **50 Ω/1 MΩ** | **Integrated** |

## Features

- Two analog inputs with 200 MHz bandwidth; built-in two-channel 250 MHz waveform generator
- TTL-compatible external trigger
- Onboard signal analysis toolbox: visualization tools including measurement trends and histograms
- Math channel with support for arbitrary functions
- Single tap data uploading to the Cloud, email or SD card
- Python, MATLAB, and LabVIEW APIs support

## Specifications

- Vertical resolution: 12 bits at 500 MSa/s, up to 22 bits at 1 kSa/s
- Input noise: <30 nV/√Hz above 100 kHz
- Sampling rate: 500 MSa/s
- Input bandwidth: 200 MHz
- Input coupling: AD or DC
- Input Impedance: 50 Ω or 1 MΩ
- Output bandwidth: 300 MHz
- Output waveforms: sine, square, ramp, pulse, DC
- Math channel: Add, subtract, multiply, divide, XY mode, FFT, arbitrary equation mode, and many more

## Applications

- Signal monitoring and analysis
- Circuit design and characterization
- Jitter/clock analysis
- Photo detector alignment
- Automated system test
- System test and debug

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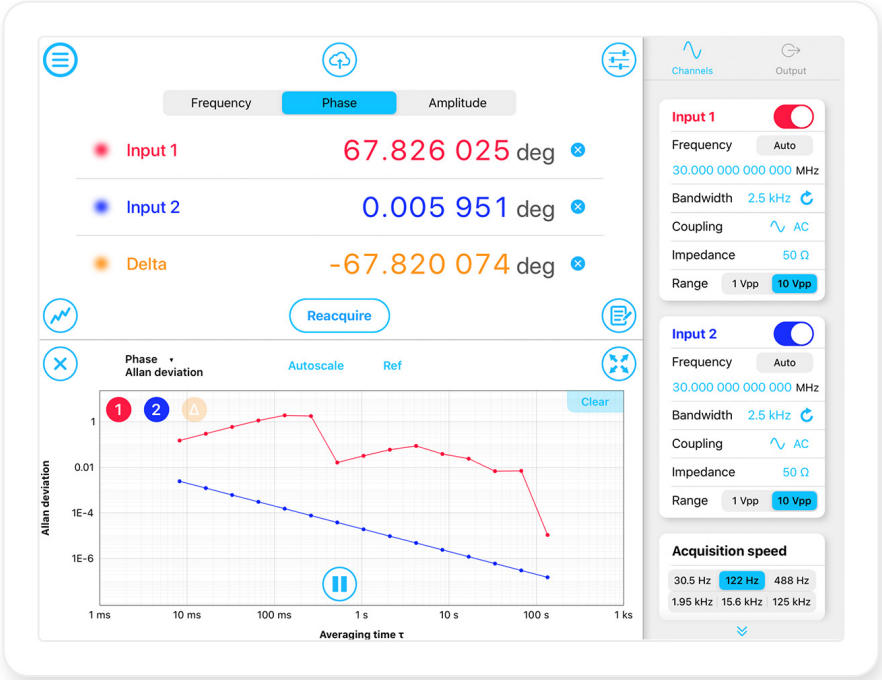
Moku:Lab Instrument Datasheet

# 200 MHz Phasemeter

Moku:Lab's Phasemeter measures phase of up to two input signals with better than 6 µradian precision from 1 kHz up to 200 MHz. Based on a digitally implemented phase-locked loop architecture, Moku:Lab's Phasemeter provides exceptional dynamic range, zero dead-time and measurement precision that exceeds the performance of conventional lock-in amplifiers and frequency counters.




| Frequency Range | Tracking Bandwidth | Phase precision | Frequency precision | Data Logging rates | Built-in Analysis |
|---|---|---|---|---|---|
| 1 kHz to 200 MHz | Up to 10 kHz | 6 µrad/√Hz | 10 µHz/√Hz | 30.5 Hz to 125 kHz | Allan Deviation |

## Features

- Two independent phasemeter channels with output options that track and record the phase, frequency, and amplitude of two independent signals
- Phase-locked output option enables you to generate sine waves that are phase-locked to the inputs
- Real-time spectral analysis to display and save Power Spectral Densities, Allan Deviation, and more
- Phase-locked loop tracking bandwidths from 10 Hz up to 10 kHz

## Specifications

- Input frequency range: 1 kHz - 200 MHz
- Input voltage range: 1 Vpp or 10 Vpp
- Frequency set-point precision: 3.55 µHz
- Tracking bandwidth: 10 Hz, 40, Hz, 150 Hz, 600 Hz, 2.5 kHz, 10 kHz
- Phase precision: up to 6 µrad/√Hz
- Frequency precision: up to 10 µHz/√Hz
- Data logging rates: 30.5 Hz, 122 Hz, 488 Hz, 1.95 kHz, 15.6 kHz, 125 kHz
- Sine wave generators: Dual channel 250 MHz (manual or input-locked)

## Applications

- Oscillator analysis
- Optical/ultrasound ranging
- Gravitational wave detection
- Interferometry
- Phase-locked loop

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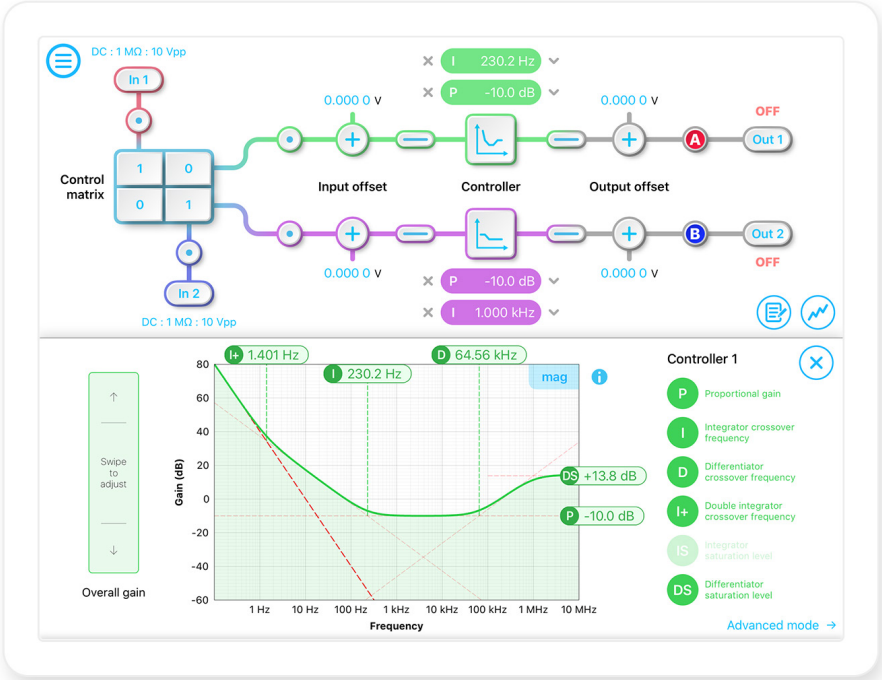
Moku:Lab Instrument Datasheet

# PID Controller

Moku:Lab's PID Controller features two fully 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 laser temperature and current stabilization. The PID Controller can also be used as a lead-lag compensator by saturating the integral and differential controllers with independent gain settings.




| Versatile input | Output sampling rate | DAC resolution | Phase lag | Gain configuration | Advanced mode |
|---|---|---|---|---|---|
| **2 inputs with optional blending** | **10 MSa/s** | **16-bits** | **30° at 100 kHz** | **Real-time** | **Multi-section builder** |

## Features

- 2 input channels, 2 output channels, 2 independent PID controllers with control matrix for optional blending
- Design your control system's frequency response using the interactive Bode plot in real-time
- Block diagram view of the digital signal processing with built-in probe points for signal monitoring
- Advanced multi-section PID builder with single or double integrators and differentiators with low- and high-frequency gain saturation

## Specifications

- Input voltage range: 1 Vpp or 10 Vpp
- Control matrix linear gain: -20 to +20
- Input/output offset range: -1 to +1 V
- Offset precision: 100 µV
- Gain profiles: Proportional (P), integral (I), differential (D), double-integral (I+), integral saturation (IS), differential saturation (DS)
- Proportional gain: -60 dB to 60 dB
- Integrator crossover frequency: 1 Hz to 100 kHz
- Differentiator crossover frequency: 10 Hz to 1 MHz

## Applications

- Feedback and control systems design
- Laser frequency stabilization
- Temperature regulation
- Scan heads/sample stage positioning
- Pressure, force, flow rate, and other controls

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Moku:Lab Instrument Datasheet

# 250 MHz Spectrum Analyzer

Moku:Lab's Spectrum Analyzer allows you to observe input signals in the frequency domain between DC and 250 MHz. View two channels of data simultaneously with a resolution bandwidth as low as 1 Hz over a minimum span of 100 Hz. The Spectrum Analyzer also features two integrated waveform generators capable of producing sine waves at up to 250 MHz.


| Frequency Range | Frequency Span | Minimum RBW | Video Filter Bandwidth | Singal Generator | Output Frequency |
|---|---|---|---|---|---|
| **DC to 250 MHz** | **100 Hz to 250 MHz** | **1 Hz** | **10 Hz to 2.4 MHz** | **Integrated** | **up to 250 MHz** |

## Features

- High bandwidth input and output options: display and record power spectra or power spectral densities in the frequency domain from DC to 250 MHz
- Generate two sine waves up to 250 MHz using Moku:Lab's built-in analog outputs
- Quickly measure key metrics by dragging measurement cursors onto features of interest using the iPad's multi-touch interface
- Python, MATLAB, and LabVIEW APIs for advanced programming support

## Specifications

- Frequency range: DC to 250 MHz
- Frequency span: 100 Hz to 250 MHz
- Resolution bandwidth (RBW): span dependent, minimal RBW is 1 Hz
- Number of inputs: 2
- Input range: 1 Vpp or 10 Vpp
- Input impedance: 50 Ω / 1 MΩ
- Noise floor: -130 dBm with 1 Vpp input range, 1 Hz RBW
- Number of outputs: 2
- Output frequency range: 1 mHz to 250 MHz
- Output voltage: 2 Vpp into 50 Ω

## Applications

- Frequency domain analysis
- System response characterization
- Noise measurement
- RF system design
- Spurious signal identification

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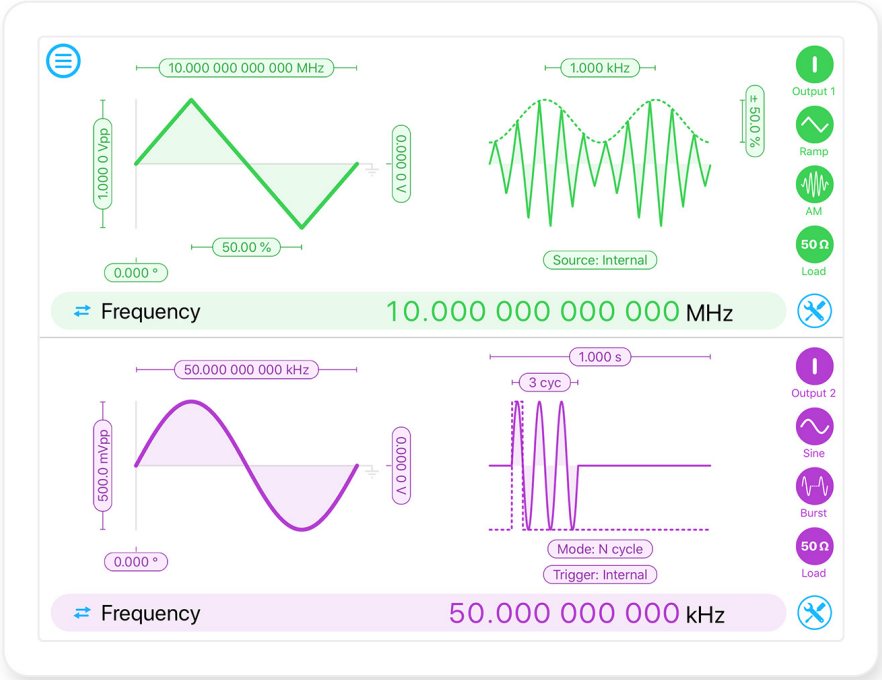
Moku:Lab Instrument Datasheet

# 250 MHz Waveform Generator

Moku:Lab's Waveform Generator enables users to generate two independent waveforms with a sampling rate of 1 GSa/s, a maximum frequency of 250 MHz and an output voltage range of ± 1 V into 50 Ω. Select between sine, square, ramp, pulsed or DC waveform shapes. Modulate the phase, frequency or amplitude, or generate triggered bursts or sweeps from an internal or external source.




| Frequency Range | Sampling Rate | Resolution | Output Voltage Range | Modulation | Other Modes |
|---|---|---|---|---|---|
| DC to 250 MHz | 1 GSa/s | 16 bit | ± 1 V into 50 Ω | FM, AM, PM | Burst, Sweep |

## Features

- Generate 2 independent waveforms from DC to 250 MHz
- 5 built-in waveforms: sine, square, ramp, pulse, and DC
- Intuitive graphical user interface with Python, MATLAB, and LabVIEW API support
- FM, AM, and PM modulation with internal waveform (cross-channel modulation) or external input
- Versatile trigger options: from input, dedicated TTL trigger port, or the other output channel

## Specifications

- Output bandwidth: 300 MHz
- Frequency range:
  - Sine: 1 mHz to 250 MHz
  - Square: 1 mHz to 100 MHz
  - Ramp: 1 mHz to 100 MHz
  - Pulse 1 mHz to 100 MHz
- Pulse width: 4 ns to period
- Modulation bandwidth: 62.5 MHz
- Burst mode: start, N-cycle, gated
- Sweep time: 1 ms to 1 ks
- SFDR: >50 dBc below 20 MHz
- THD: 0.5% (1.5 MHz, 5 harmonics)

## Applications

- Signal simulation
- Laser scanning microscopy
- Circuit design and characterization
- System synchronization
- Clock source
- DAC/Op-amp characterization

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