

# Moku:Pro

## Specifications

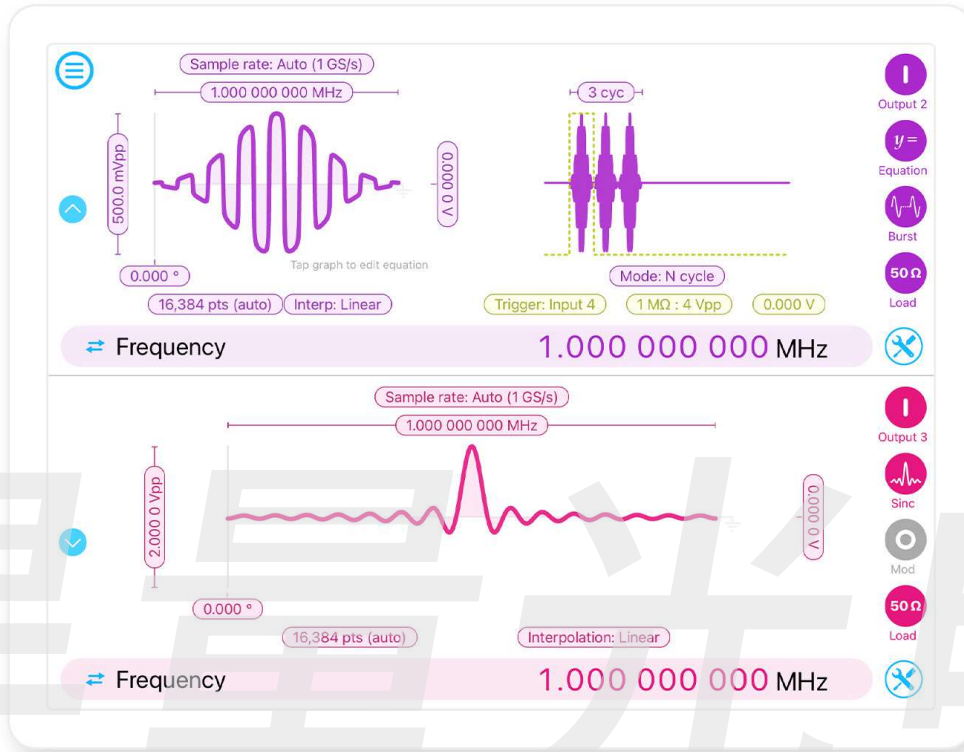
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# 4 Channel 500MHz Arbitrary Waveform Generator

Moku:Pro's 4 channel Arbitrary Waveform Generator can generate 4 custom waveforms with up to 65,536 points and sample rates ranging from 312.5 MSa/s to 1.25 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 burst mode, waveform generation can be triggered from input channels with start or n cycle modes. In pulsed mode, waveforms can be output with more than 250,000 cycles of dead time between pulses.



<b>Maximum Sample Rate</b> 1.25 GSa/s	<b>Output Bandwidth</b> Up to 500 MHz	<b>DAC Resolution</b> 16-bits	<b>Independent Triggering</b> Burst/Pulsed	<b>Supported Waveforms</b> 5 predefined, segmented equations (up to 32) or custom
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## Features

- Four independent AWG channels with up to 500 MHz bandwidth
- Choose between preset waveforms, load points from a file, or input an equation directly
- Phase synchronization output between the four 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, and custom (from file)
- Output bandwidth:
  - 10 Vpp @ 312.5 MSa/s
  - 2 Vpp @ 625 MSa/s and 1.25 GSa/s
- DC offset:  $\pm 5$  V with 100  $\mu$ V resolution
- Phase offset: 0° to 360° with 0.001° resolution
- Maximum output rate:
  - 312.5 MSa/s with 65,536 points
  - 625 MSa/s with 32,768 points
  - 1.25 GSa/s with 16,384 points

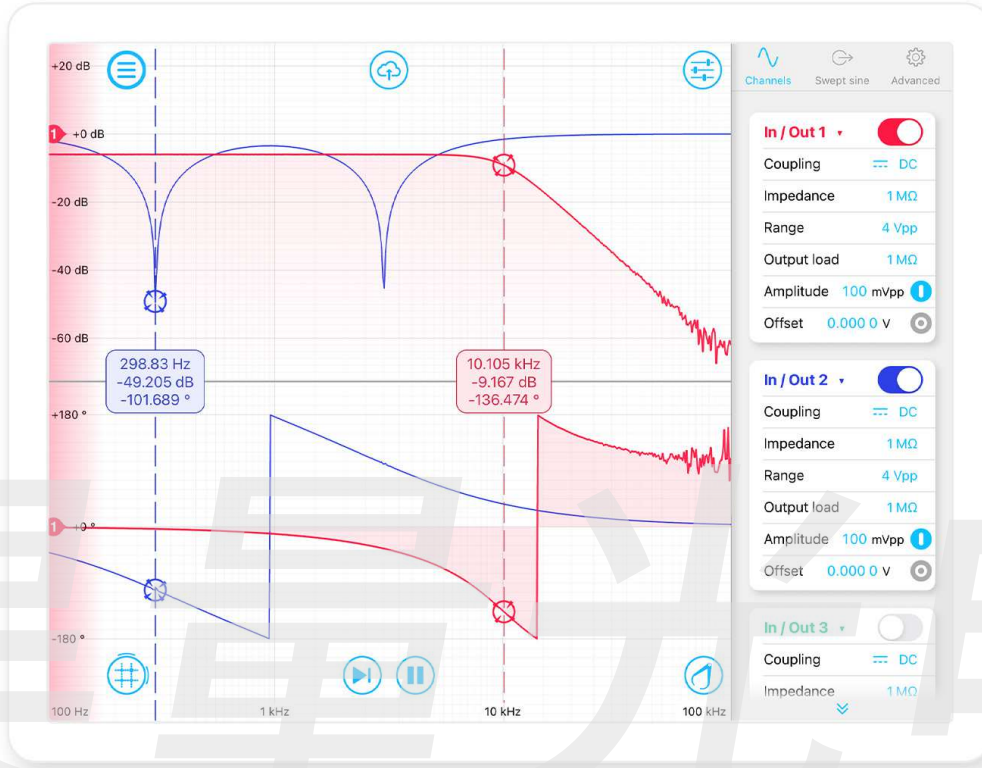
## Applications

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



# Ultra Low-noise Frequency Response Analyzer

Moku:Pro'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 300 MHz. It has a noise floor of -135 dBm across the entire frequency range. Moku:Pro is equipped with four inputs and outputs ports, enabling differential or ratiometric measurements. 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.



<b>Frequency Range</b> Up to 300 MHz	<b>Input Impedance</b> 50 Ω or 1 MΩ	<b>Averaging time</b> 1 μs to 10 s	<b>Sweep</b> Linear/Logarithmic	<b>Output Voltage Range</b> Up to 10 Vpp	<b>Harmonics Detection</b> Up to 15th
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## Features

- Linear or logarithmic swept sine output
- Math channel to add, subtract, multiply or divide response functions as they are acquired
- Measure key metrics with cursors and markers
- Configurable measurement averaging and settling times
- Easily save data and upload to the cloud or Dropbox in common formats
- Probe 4 systems simultaneously, or one system at multiple points
- Demodulate up to 15th harmonic

## Specifications

- Frequency range: 10 mHz to 300 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  
10 Vpp (< 100 MHz)
- Input Impedance: 50 Ω or 1 MΩ
- Input range: 400 mVpp, 4 Vpp, or 40 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 240 MHz: -120 dB

## Applications

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



# 4-Channel Ultra-Low-Noise Data Logger

Moku:Pro's Data Logger enables you to log data to its 120 GB internal solid-state drive with sampling rates of up to 10 MSa/s. Four inputs are equipped with dual 10-bit and 18-bit ADCs. With blended ADC technology, input noise is down to 30 nV/-Hz at 100 Hz, providing ultra-low noise data logging from acoustic to RF frequencies. Moku:Pro is also equipped with a 10 MHz clock synchronization I/O, and four 500 MHz outputs, allowing flexible integration with other electronics.



<b>Number of Inputs</b> 4	<b>Acquisition Rate</b> 10 MSa/s to SSD	<b>Input Range</b> Up to 40 Vpp	<b>Input Coupling</b> AC or DC	<b>Input Impedance</b> 50 Ω / 1 MΩ	<b>Waveform Generator</b> Integrated
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## Features

- Log voltage data on four independent channels to its 120 GB SSD.
- Built-in four-channel waveform generator, up to 500 MHz.
- 10 MHz clock synchronization ports.
- Easily export data to computer, Dropbox, and other cloud-based services.
- Schedule your log to start with a delay of up to 10 days

## Specifications

- Input ranges: 0.4 Vpp, 4 Vpp or 40 Vpp
- Input Impedance: 50 Ω / 1 MΩ
- Input coupling: AC/DC
- Maximum sampling rate:
  - 10 MSa/s for 1 channel
  - 5 MSa/s for 2 channels
  - 2.5 MSa/s for 4 channels
- Minimum sampling rate: 10 Sa/s
- Acquisition mode:
  - Normal: direct downsampling
  - Precision mode: improves resolution by averaging

## Applications

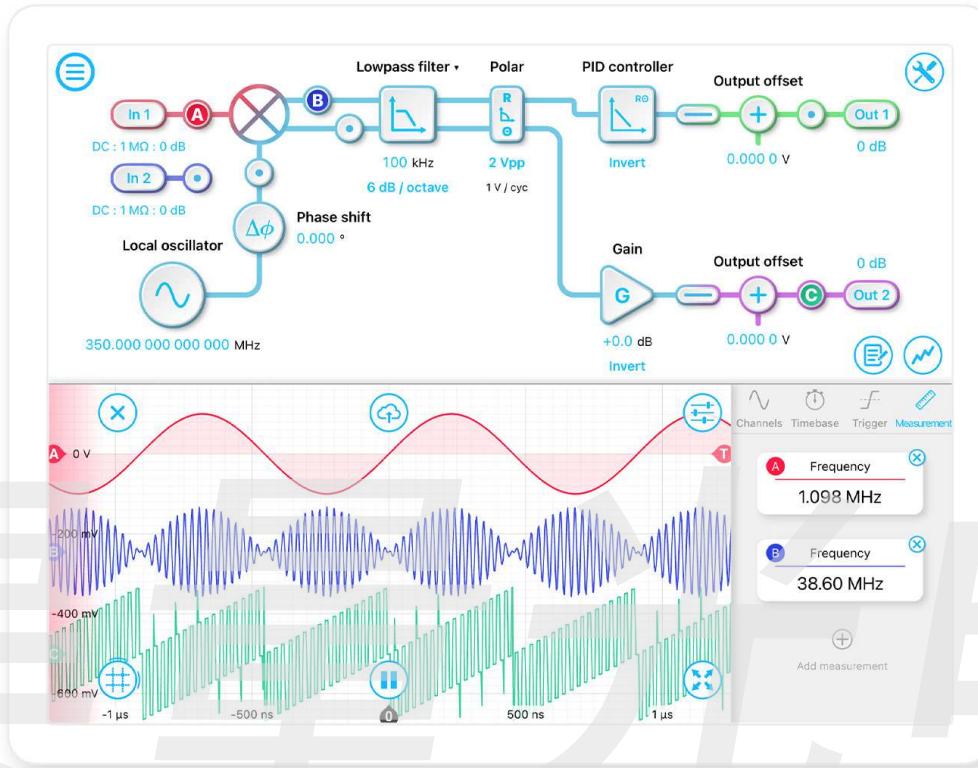
- Temperature monitoring
- Vibration analysis
- Environment monitoring
- Sensor logging



# 600 MHz Lock-in Amplifier



Moku:Pro's digital Lock-in Amplifier supports dual-phase demodulation (XY/R $\theta$ ) from 1 mHz to 600 MHz with more than 120 dB dynamic reserve. A PID controller can be placed after the demodulation stage for phase-locked loop applications. It also features an integrated 4-channel oscilloscope and data logger, enabling you to observe signals at up to 1.25 GSa/s and log data at up to 1 MSa/s.



<b>Demod. Frequency</b> 1 mHz to 600 MHz	<b>Dynamic Reserve</b> > 120 dB	<b>Time Constant</b> From 12.8 ns	<b>Filter Slopes</b> 6, 12, 18, 24 dB/Oct	<b>Input Noise</b> 30 nV/-Hz @ 100Hz	<b>Built-in Feature</b> PID Controller
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## 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)
- Toggle between rectangular (X/Y mode) or polar coordinates (R/Theta mode)
- Built-in PID Controller

## Specifications

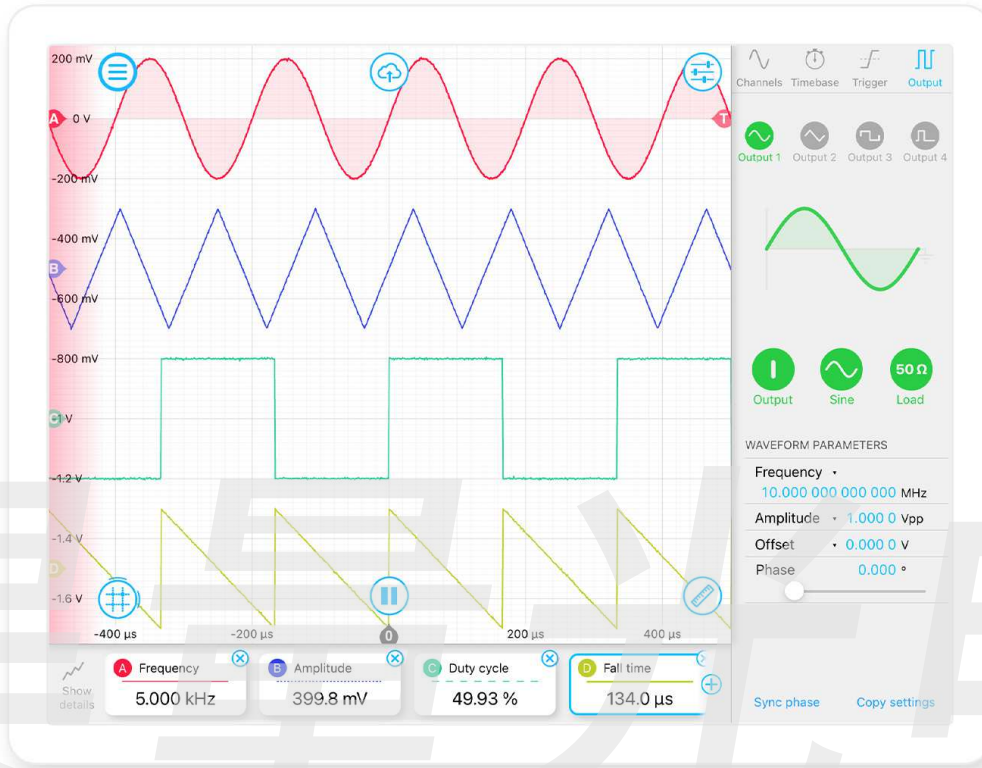
- Demodulate with frequencies ranging from 1 mHz to 600 MHz with  $\mu$ Hz resolution
- Phase shift precision of 0.001°
- 50  $\Omega$  / 1 M $\Omega$  input impedance
- Adjustable time constant from 12.8 ns to 0.215 s
- 6, 12, 18, or 24 dB/octave filter roll-off
- Output gain range: -80 to +160 dB
- LO output up to 500 MHz with variable amplitude
- Ultra-fast data acquisition: snapshot mode up to 1.25 GSa/s, continuous mode up to 1 MSa/s

## Applications

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



Moku:Pro's Oscilloscope features four highspeed, ultra-low noise input channels with 600 MHz analog bandwidth. An innovative blended ADC technology combines the information from 10 bit and 18 bit ADCs to cover a broad spectrum, providing class-leading input noise performance at 30nV/√Hz @ 100Hz with large dynamic range. The built-in four-channel waveform generators are capable of producing waveforms with a bandwidth of up to 500 MHz.



<b>Sampling Rate</b> Up to 5 GSa/s	<b>Bandwidth</b> 600 MHz	<b>ADC Resolution</b> 10 / 18 bits	<b>Input Impedance</b> 50 Ω / 1 MΩ	<b>Input Noise</b> 30 nV/√Hz @ 100Hz	<b>Waveform Generator</b> 4 Channels up to 500 MHz
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## Features

- Four analog inputs with 600 MHz bandwidth
- Exceptional low-frequency noise performance: 30 nV/√Hz @ 100 Hz
- Dual-ADC design with blended ADC technology
- Ultra stable 0.3 ppm onboard oscillator with 10 MHz synchronization in and out
- Integrated high-speed waveform generator channels with analog bandwidths up to 500 MHz

## Specifications

- Input range: 400 mVpp, 4 Vpp, or 40 Vpp
- Input noise: 30 nV/√Hz @ 100 Hz
- Sampling rate: 5 GSa/s on 1 channel  
1.25 GSa/s on 4 channels
- Input bandwidth: 300/600 MHz switchable
- Input coupling: AC or DC
- Input Impedance: 50 Ω or 1 MΩ
- Output bandwidth: 500 MHz (2 Vpp)  
100 MHz (10 Vpp)
- Output waveforms: sine, square, ramp, pulse, DC
- Math channel: Add, subtract, multiply, divide, XY mode, integrate, differentiate, FFT, min hold, max hold, and equation editor

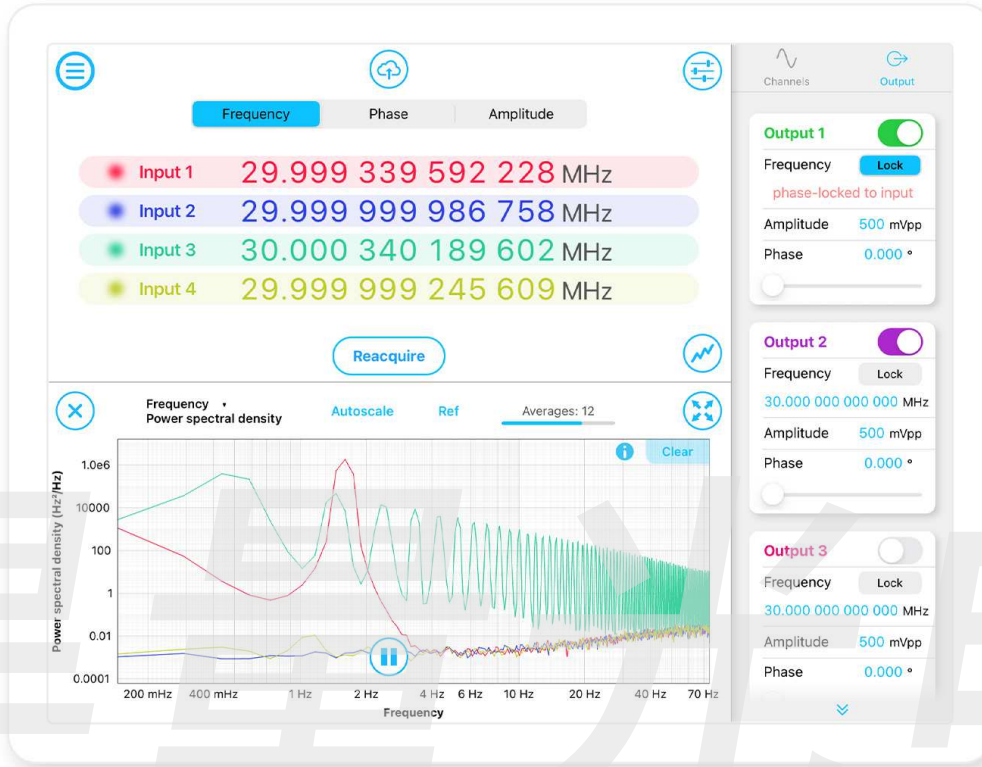
## Applications

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



# 300 MHz Phasemeter

Moku:Pro's Phasemeter measures phase (relative to a reference clock) of up to four input signals with better than 6  $\mu$ radian precision from 1 kHz up to 300 MHz. Based on a digitally implemented phase-locked loop architecture, Moku:Pro's Phasemeter provides exceptional dynamic range, zero dead-time, and measurement precision that exceeds the performance of conventional lock-in amplifiers and frequency counters.



<b>Frequency Range</b> 1 kHz to 300 MHz	<b>Tracking Bandwidth</b> Up to 10 kHz	<b>Phase precision</b> 6 $\mu$ rad/ $\sqrt{\text{Hz}}$	<b>Frequency precision</b> 10 $\mu$ Hz/ $\sqrt{\text{Hz}}$	<b>Data capturing rates</b> 30 Hz, 120 Hz, 477 Hz	<b>Built-in Analysis</b> Allan Deviation
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## Features

- Four 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

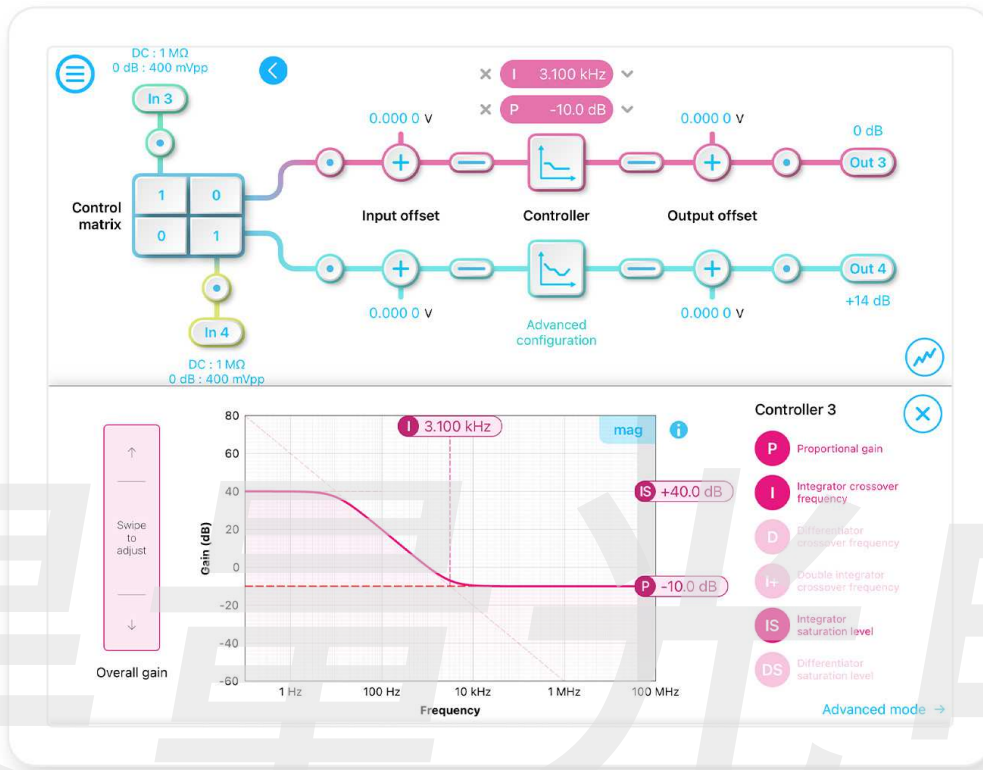
- Input frequency range: 1 kHz - 300 MHz
- Input voltage range: 400 mVpp, 4 Vpp, or 40 Vpp
- Frequency set-point precision: 1.4  $\mu$ Hz
- Tracking bandwidth: 10 Hz, 40 Hz, 150 Hz, 600 Hz, 2.5 kHz, 10 kHz
- Data acquisition rates: 30 Hz, 120 Hz, 477 Hz
- Phase precision: down to 6  $\mu$ rad/ $\sqrt{\text{Hz}}$
- Frequency precision: down to 10  $\mu$ Hz/ $\sqrt{\text{Hz}}$
- Sine wave generators: Four-channel 500 MHz (manual or input-locked)

## Applications

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



Moku:Pro's PID Controller features four fully configurable PID controllers with sub-microsecond latency. 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 4 inputs with MIMO	Proportional Gain - 60 dB to 60 dB	DAC resolution 16-bits	Input-output latency <1 $\mu$ s	Gain configuration Real-time	Advanced mode Multi-section builder
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## Features

- 4 input channels, 4 output channels, and 4 independent PID controllers with control matrix for MIMO
- Design your control system's frequency response using the interactive Bode plot in realtime
- Block diagram view of the digital signal processing with built-in probe points in signal processing chain
- Advanced multi-section PID builder with single or double integrators and differentiators with low- and high-frequency gain saturation
- Intergrated probe points for signal monitoring

## Specifications

- Control matrix linear gain:  $\pm 0.1$  to  $\pm 20$
- Input offset range:  $\pm 1$  V
- Output offset range:  $\pm 5$  V
- Offset precision: 100  $\mu$ V
- Gain profiles: Proportional (P), integral (I), differential (D), double-integral (+), integral saturation (IS), differential saturation (DS)
- Proportional gain: -60 dB to 60 dB
- Integrator crossover frequency: 3.125 Hz to 312.5 kHz
- Differentiator crossover frequency: 31.25 Hz to 31.25 MHz

## Applications

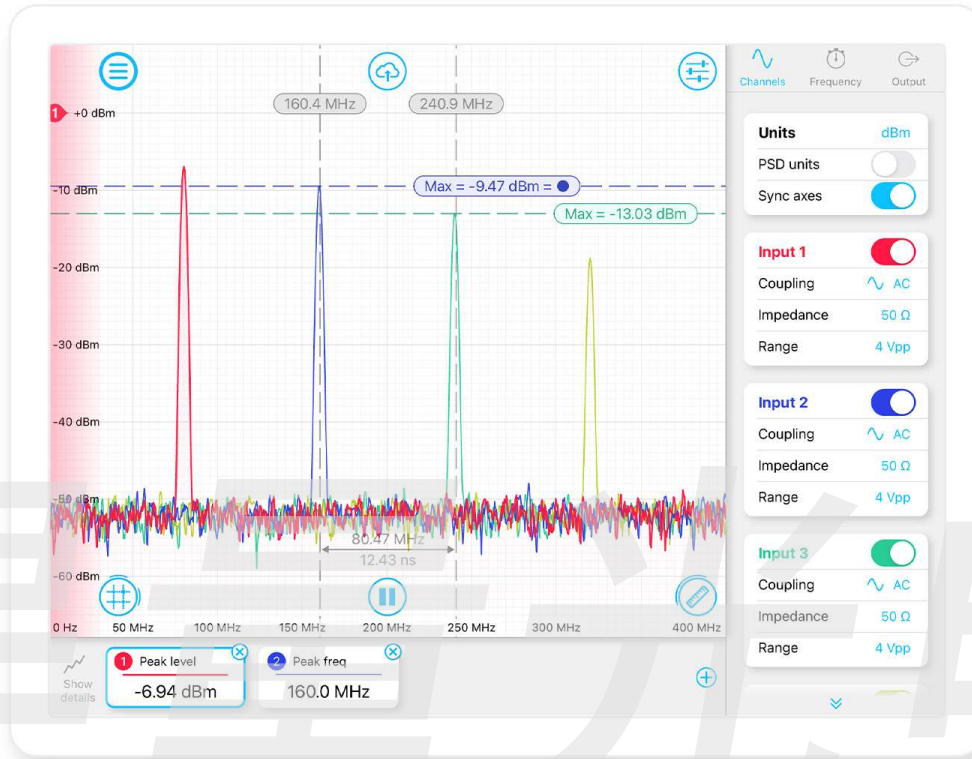
- Feedback and control systems design
- Laser frequency stabilization
- Temperature regulation
- Scan heads/sample stage positioning
- Pressure, force, flow rate, and other controls





# 4 Channel Spectrum Analyzer

Moku:Pro's Spectrum Analyzer allows you to observe input signals in the frequency domain between DC and 300 MHz with an ultra-low noise floor. View four channels simultaneously with a resolution bandwidth as low as 2.2 Hz and a minimum span of 100 Hz. The Spectrum Analyzer also features four 500 MHz sinewave generators.



Frequency Range DC to 300 MHz	Frequency Span 100 Hz to 300 MHz	Minimum RBW 2.2 Hz	Input Noise 30 nV $\sqrt{\text{Hz}}$ @ 100Hz	Signal Generator 4 channels	Output Frequency Up to 500 MHz
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## Features

- Display and record power spectra or power spectral densities in the frequency domain from DC to 300 MHz
- Generate four sine waves up to 500 MHz using Moku:Pro's built-in analog outputs
- Quickly measure key metrics by dragging measurement cursors onto features of interest using the multi-touch interface
- Live measurement functions: peak level, peak frequency, noise level, peak SNR, and occupied bandwidth

## Specifications

- Frequency range: DC to 300 MHz
- Frequency span: 100 Hz to 300 MHz
- Resolution bandwidth (RBW): span dependent, minimum RBW is 2.2 Hz
- Number of input channels: 4
- Input range: 400 mVpp, 4 Vpp, or 40 Vpp
- Input impedance: 50  $\Omega$  / 1 M $\Omega$
- Number of output channels: 4
- Output range: up to 500 MHz (2 Vpp) up to 100 MHz (10 Vpp)
- Video filter bandwidth: 2.3 Hz to 4.6 MHz

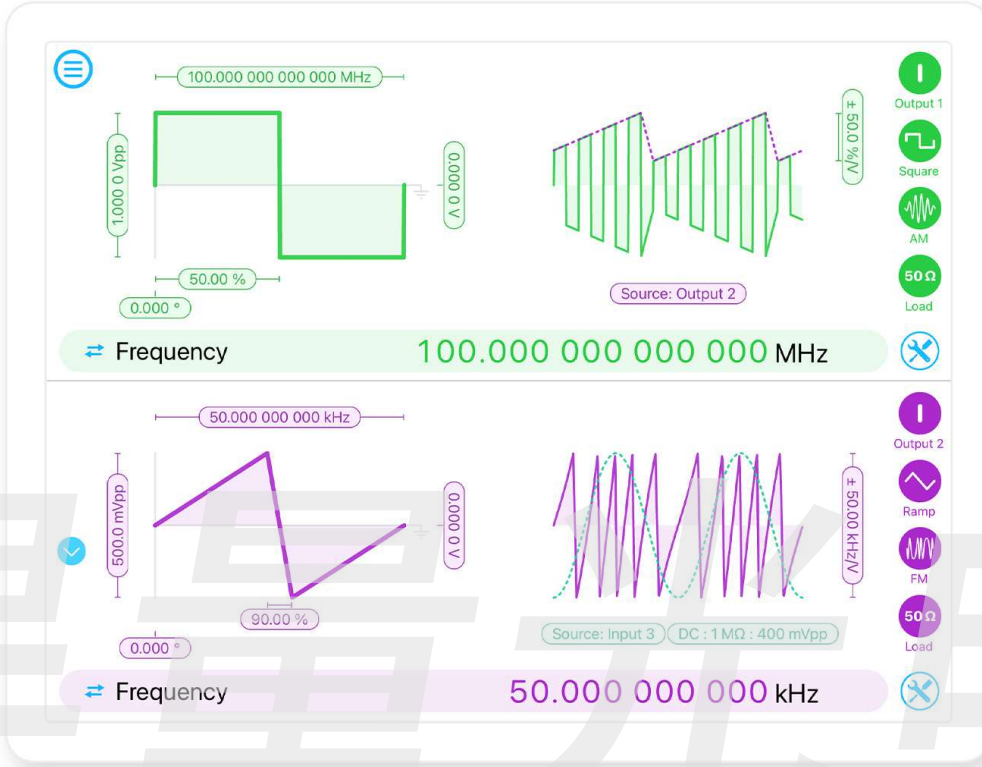
## Applications

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



# 4-Channel 500 MHz Waveform Generator

Moku:Pro's Waveform Generator enables you to generate four independent waveforms with a maximum bandwidth of 500 MHz. Select between sine, square, ramp, pulsed, or DC waveform shapes. High bandwidth modulation of phase, frequency, or amplitude, or generate triggered bursts or sweeps from an internal or external source.



<b>Frequency Range</b> 1 mHz to 500 MHz	<b>Output Voltage Range</b> Up to 10 Vpp (50 Ω)	<b>Modulation</b> FM, AM, PM	<b>Other Modes</b> Burst, Sweep	<b>Timebase Accuracy</b> < 500 ppb
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## Features

- Generate 4 independent phase coherent waveforms from DC to 500 MHz
- 5 built-in waveforms: sine, square, ramp, pulse, and DC
- Broadband FM, AM, and PM modulation with internal waveform (cross-channel modulation) or external input
- Versatile trigger options: from input, dedicated TTL trigger port, or another channel
- 10 MHz reference input and output

## Specifications

- Output bandwidth:
  - 500 MHz (2 Vpp)
  - 100 MHz (10 Vpp)
- Frequency range (2 Vpp):
  - Sine: 1 mHz to 500 MHz
  - Square: 1 mHz to 150 MHz
  - Ramp: 1 mHz to 150 MHz
  - Pulse 1 mHz to 150 MHz
- Pulse width: 4 ns to period
- Modulation bandwidth: 125 MHz
- Timebase accuracy: < 500 ppb
- Burst mode: start, N-cycle, gated
- Sweep time: 1 ms to 1 ks

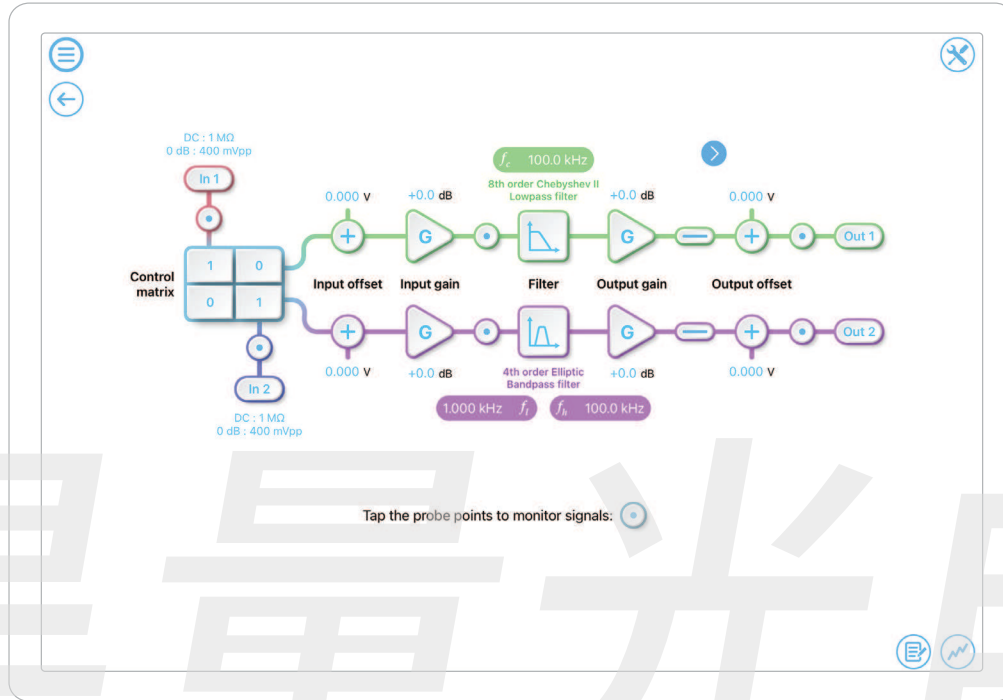
## Applications

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



# Digital Filter Box

With Moku:Pro's Digital Filter Box, you can interactively design and generate different types of infinite impulse response filters with sampling rates of 305.18 kHz or 39.063 MHz. Select between lowpass, highpass, bandpass, and bandstop filter shapes with up to eight fully configurable types including Butterworth, Chebyshev, and Elliptic. This instrument can be deployed independently or used as filter components in the multi-instrument mode.



<b>Sampling Rate</b> 305.18 kHz or 39.063 MHz	<b>Filter Order</b> 2, 4, 6, 8	<b>Input Range</b> up to 40 Vpp	<b>Output Voltage Range</b> 10 Vpp into 50 Ω	<b>Filter Shapes</b> Lowpass, Highpass, Bandpass, Bandstop, Custom
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## 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: 4 input channels, 4 output channels with optional blending for input signal mixing
- Supports custom filter designs
- Built-in Oscilloscope and Data Logger

## Specifications

- Filter shapes: lowpass, highpass, bandpass, bandstop
- Filter types: Butterworth, Chebyshev I, Chebyshev II, Elliptic, Cascaded, Bessel, Gaussian, and Legendre
- Corner frequencies: 58.63 mHz - 17.58 MHz
- Input-output latency: sub-microsecond
- Passband ripple: configurable 0.1 – 10 dB
- Stopband attenuation: configurable 10 – 100 dB
- Independently adjustable input and output offsets and gains

## Applications

- System design
- Closed-loop control
- Noise filtering
- Signal amplification
- Filter design and evaluation