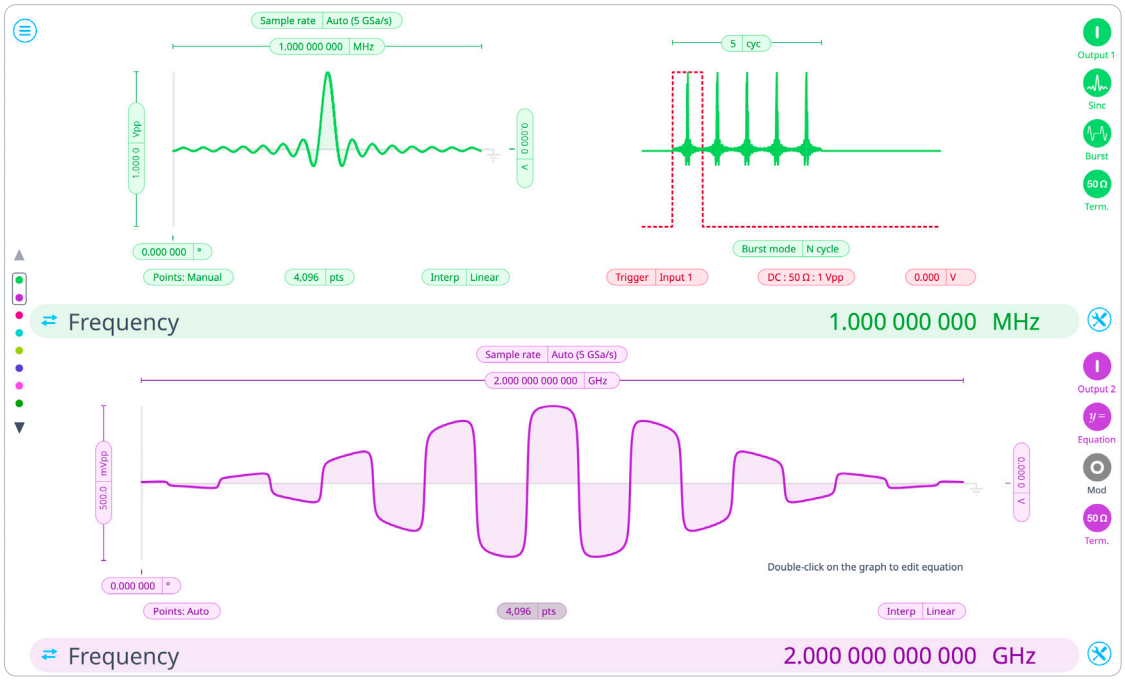
Moku:Delta Instrument Datasheet

Arbitrary Waveform Generator

The Moku:Delta Arbitrary Waveform Generator offers eight independent analog outputs with 14-bit resolution and supports sample rates up to 5 GSa/s with waveform lengths of up to 65,536 points. Users can define waveforms via file import or as up to 32-segment piecewise equations, with fine-grain control over amplitude, phase (0.001° resolution), and DC offset (100 µV resolution). Burst mode enables triggered waveform generation and channel synchronization, while pulsed mode supports precise dead time insertion between pulses for advanced timing control.



Maximum Sample Rate	Output Bandwidth	DAC Resolution	Independent Triggering	Supported Waveforms
5 GSa/s	**Up to 2 GHz**	**14-bits**	**Burst/Pulsed**	**5 predefined, segmented equations (up to 32), or custom**

Features

- Eight independent AWG channels with up to 2 GHz bandwidth
- Choose between preset waveforms, load points from a file, or input an equation directly
- Phase synchronization output between the eight channels
- Configure pulsed output with over 250,000 cycles of dead time between pulses
- Trigger output from TTL trigger port or any of the input channels
- Ultra-stable clock of 1 ppb with selectable 10 MHz or 100 MHz external reference

Specifications

- Supported waveforms: Sine, Gaussian, Exponential fall, Exponential rise, Sinc, equation editor, and custom (from file)
- Output amplitude (50 Ω):
  - 10 Vpp @ 312.5 MSa/s
  - 1 Vpp above 312.5 MSa/s
- DC offset: ± 5 V with 100 µV 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
  - 2.5 GSa/s with 8,192 points
  - 5 GSa/s with 4,096 points

Applications

- Random pattern scanning
- Sensor excitation and system identification
- Biomedical signal emulation
- Quantum optics and cold atom experiments
- Quantum control and qubit manipulation
- Multi-channel RF signal emulation
- Photonic modulation and pulse shaping
- Mixed-signal system co-simulation

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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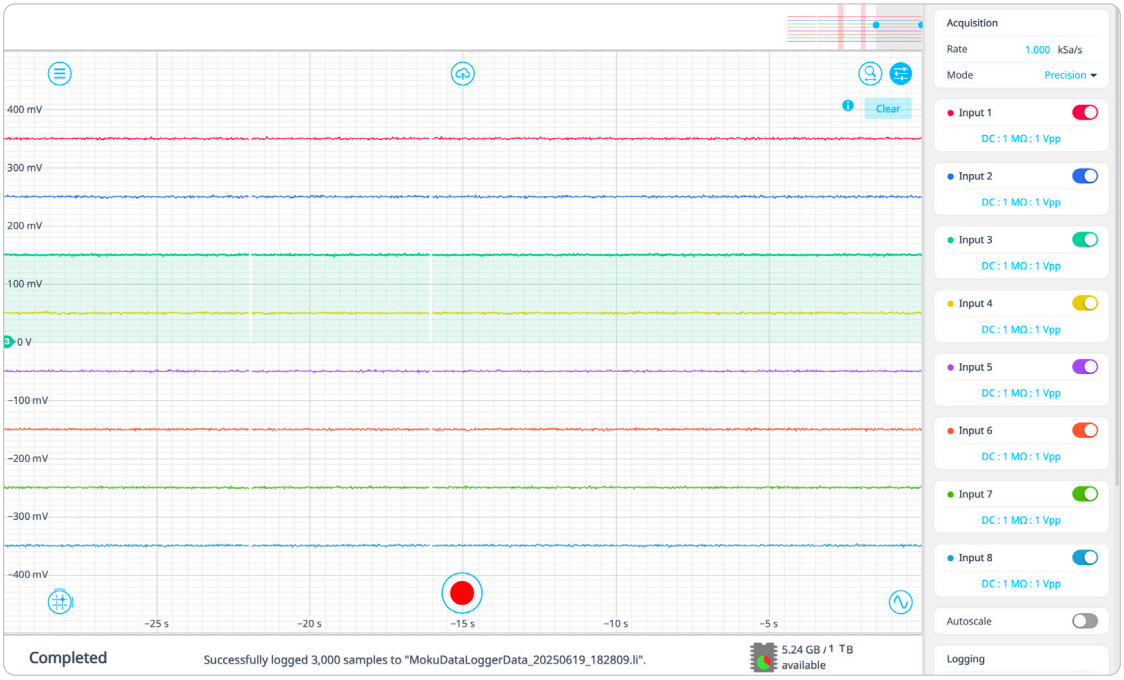
Data Logger

The Moku:Delta Data Logger features eight analog input channels with ultra-low noise performance (< 10 nV/√Hz). Data can be logged directly to the integrated 1 TB SSD or streamed to network storage via API at a rate of up to 10 MSa/s, making it ideal for high-speed, long-duration measurements. With GPS-disciplined timing and support for external 10 MHz and 100 MHz clock references, Moku:Delta delivers a flexible and precise solution for applications such as multi-channel sensor monitoring, quantum optics, and real-time experimental control.



Number of Inputs	Acquisition Rate	Input Range	Onboard storage	External Clock Reference Options	Sine Wave Generator
8	**10 MSa/s to SSD**	**Up to 40 Vpp**	**1 TB SSD**	**10 MHz, 100 MHz, GPS**	**4 Channels Integrated**

Features

- Log voltage data on eight independent channels to the internal 1 TB SSD
- Built-in four-channel signal generator, up to 2 GHz
- Onboard GPS receiver for GPS-disciplined oscillator capability
- Easily export data to computer, Dropbox, and other cloud-based services
- Schedule the log to start with a delay of up to 10 days, or by external triggered start
- Stream data directly to your computer using Moku APIs, including Python and MATLAB

Specifications

- Input ranges: 100 mVpp, 1 Vpp 10 Vpp, or 40 Vpp
- Input Impedance: 50 Ω / 1 MΩ
- Input coupling: AC / DC
- Maximum acquisition rate:
  - 10 MSa/s for 1 channel
  - 5 MSa/s for 2 channels
  - 2.5 MSa/s for 4 channels
  - 1.25 MSa/s for 8 channels
- Minimum acquisition rate: 10 Sa/s
- Acquisition mode:
  - Normal: direct downsampling
  - Precision: improves resolution by averaging
  - Peak detect: capture high and low amplitude samples

Applications

- Quantum optics
- Vibration analysis
- Environment monitoring
- Time-Correlated Single-Photon Counting (TCSPC)
- High-Frequency RF Signal Logging

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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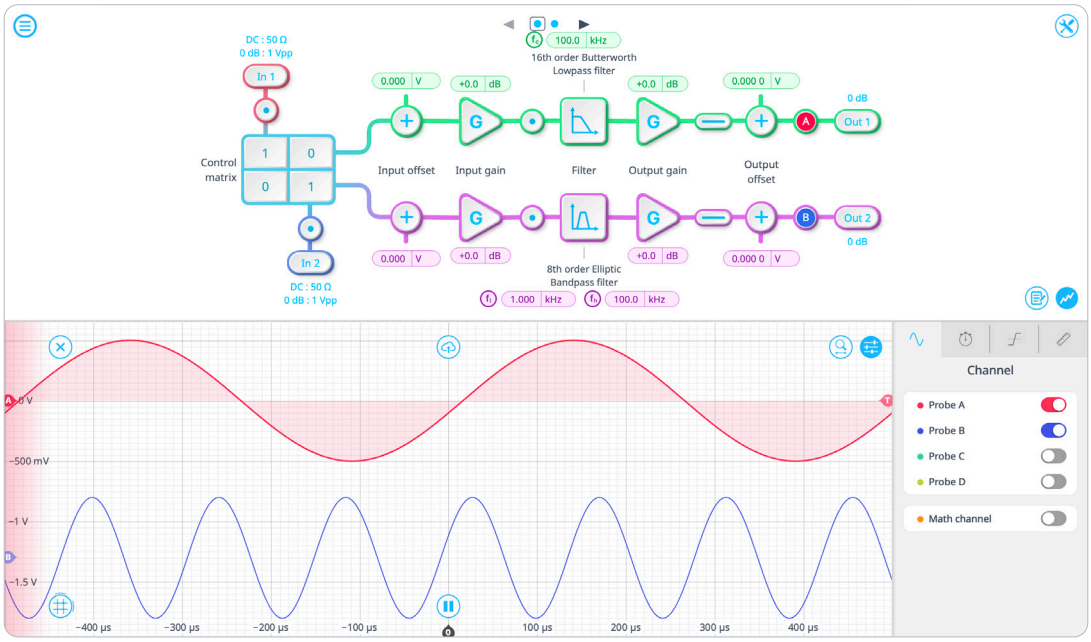
Moku:Delta Instrument Datasheet

Digital Filter Box

The Moku:Delta Digital Filter Box enables real-time design and deployment of IIR filters. It supports lowpass, highpass, bandpass, bandstop, and custom filter shapes, with selectable types including Butterworth, Chebyshev I/II, Elliptic, Bessel, Gaussian, Cascaded, and Legendre. Key parameters such as passband ripple (0.1–10 dB), stopband attenuation (10–100 dB), and filter order are fully configurable. Users can visualize the frequency response using an interactive Bode plot and monitor signal paths with built-in probe points. With sub-microsecond latency, the Digital Filter Box is optimized for closed-loop control, signal conditioning, and advanced system integration.



Sampling Rate	Filter Order	Input Range	Output Voltage Range	Filter Shapes
305.18 kHz, 4.8828 MHz, or 39.063 MHz	**2 to 16**	**up to 40 Vpp**	**10 Vpp 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: 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
- Input and output gain: -40 dB to 40 dB

Applications

- System design
- Closed-loop control
- Multi-channel noise suppression
- Signal amplification
- Filter design and evaluation
- Custom signal conditioning pipelines
- Adaptive RF filter emulation
- MIMO system prototyping

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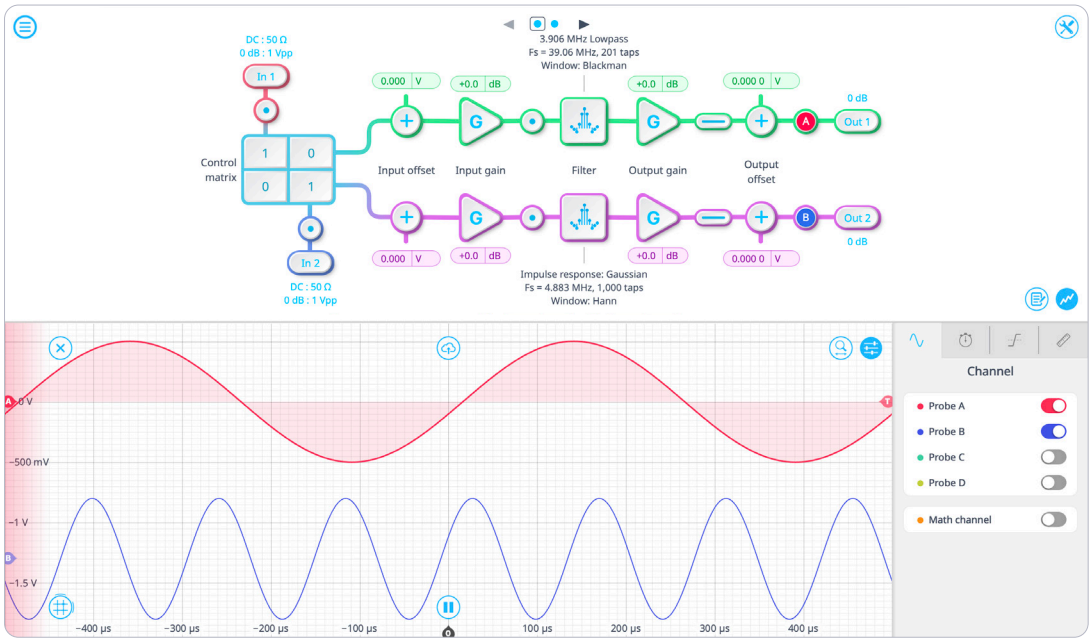
Moku:Delta Instrument Datasheet

FIR Filter Builder

The Moku:Delta FIR Filter Builder enables precision design and real-time implementation of lowpass, highpass, bandpass, and bandstop finite impulse response (FIR) filters across four high-speed analog channels. Users can define filters in either the time or frequency domain, with support for up to 14,819 coefficients via custom uploads or equation-defined impulse responses. The intuitive interface provides dynamic visualization of transfer functions, group delay, and impulse responses. Integrated probe points enable real-time signal monitoring and seamless high-speed data logging to the onboard SSD.



Sampling Rate	Filter Coefficients	Input Range	Output Voltage Range	Integrated Oscilloscope
Up to 39.06 MHz	Up to 14,819	Up to 40 Vpp	Up to 10 Vpp (50 Ω)	313 MSa/s

Features

- Visualize your signal and configuration in real-time: design filters in the time domain or in the frequency domain
- Up to 14,819 coefficients, scalable with sampling rate, enabling highly selective and precise filter designs
- Visualize the filter's transfer function, impulse and step response, or group and phase delay
- Block diagram view of the digital signal processing chain with built-in probe points for signal monitoring and logging
- Load your own filter coefficients or enter an equation to create a customized impulse response

Specifications

- Independent channels: 4
- Coefficient count at various sampling rates:
  - 2 to 232 @ 39.06 MHz
  - 2 to 928 @ 9.766 MHz
  - 2 to 7,424 @ 1.221 MHz
  - 2 to 14,819 @ 610.4 kHz
  - 2 to 14,819 @ 305.2 kHz
- Design domains: time (impulse response), frequency (frequency response)
- Impulse response: rectangular, sinc, triangular, equation, custom
- Frequency response: lowpass, highpass, bandpass, bandstop
- Window functions: Blackman, Hamming, Bartlett, Hann, Nuttall, Turkey, Kaiser

Applications

- Impulse response simulation
- DSP system design
- Precision noise filtering in RF and microwave systems
- Signal amplification
- Real-time signal conditioning
- Fractional delay generation

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Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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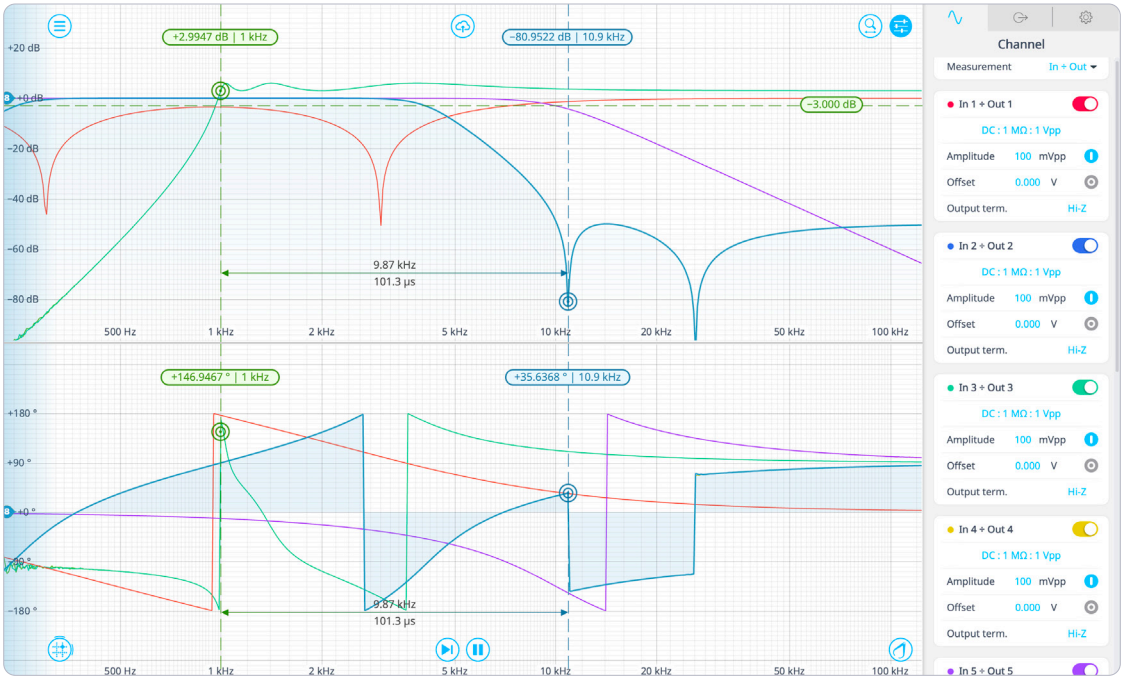
Frequency Response Analyzer

The Moku:Delta Frequency Response Analyzer enables frequency response measurements from DC to 2 GHz, leveraging eight input and output channels at 5 GSa/s to support simultaneous multi-point probing or parallel system testing. Combining 14-bit and 20-bit ADCs with frequency-dependent blending to deliver high dynamic range across the spectrum, while Dynamic Amplitude drive automatically adjusts excitation levels to optimize sensitivity. Up to 8192 sweep points can be measured with settling and averaging times between 1 µs and 10 s to balance measurement speed and resolution. The system also supports harmonic demodulation up to the 15th harmonic and includes a dedicated math channel for real-time computation.



Frequency range	Input impedance	Averaging time	Sweep	Output voltage range	Harmonics detection
Up to 2 GHz	**50 Ω or 1 MΩ**	**1 µs to 10 s**	**Linear / logarithmic**	**Up to 10 Vpp**	**Up to 15th**

Features

- Linear or logarithmic swept sine output
- Demodulate up to the 15th harmonic
- Measure entire system response with “In-put” or “In ÷ Out” modes, or components of the system with “In ÷ In 1”
- Math channel to add, subtract, multiply, divide, or apply an arbitrary calculation to response functions as they are acquired
- Saturation detection and avoidance with Dynamic Amplitude drive
- Configurable measurement averaging and settling times
- Measure key metrics with cursors and markers
- Remove constant phase shift with delay compensation
- Option to unwrap phase

Specifications

- Frequency range: 10 mHz to 2 GHz
- Averaging time: 1 µs to 10 s
- Settling time: 1 µs to 10 s
- Sweep points: 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192
- Input impedance: 50 Ω or 1 MΩ
- Output voltage range (into 50 Ω):
  - 1 Vpp
  - 10 Vpp (< 100 MHz)
- Input impedance: 50 Ω or 1 MΩ
- Input range: 100 mVpp, 1 Vpp, 10 Vpp, or 40 Vpp
- Measurement units: dB, dBm, dBVpp, dBVrms
- Noise floor: < 10 nV/√Hz

Applications

- RF filter and amplifier characterization
- Capacitance/inductance measurement
- EMI filter characterization
- Impedance spectroscopy
- Power supply analysis
- Stability analysis
- Sensor interface and conditioning circuit testing
- Control system validation
- Wide band device verification

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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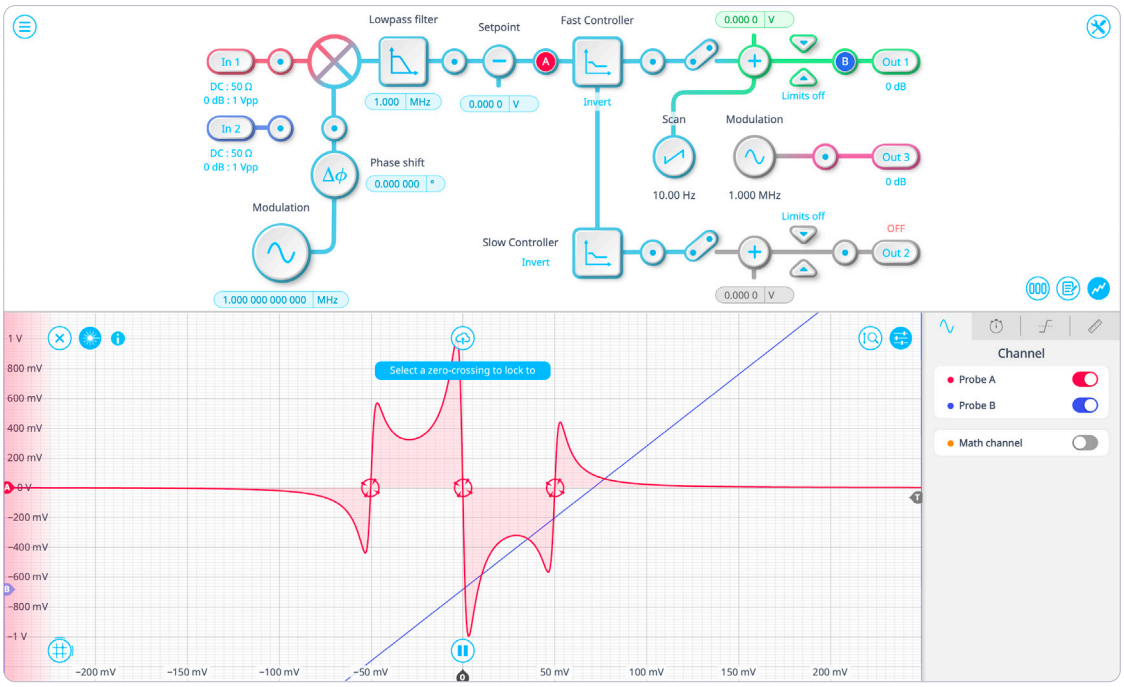
Laser Lock Box

Moku:Delta Laser Lock Box offers precision laser frequency stabilization with wideband performance up to 2 GHz and flexible scan waveforms. With support for up to eight simultaneous lock modules, it features dual PID controllers with independently tuned fast and slow feedback paths. Users can visualize and fine-tune locking behavior in real time using the integrated oscilloscope and leverage the “Lock Assist” function for locking to any zero-crossing in the error signal. Built on a high-speed and low-noise platform, the Laser Lock Box is a powerful tool for multi-laser stabilization, spectroscopy, and precision control experiments.



Demod. Frequency	Scan Frequency	Adjustable Filter	DAC Resolution	Built-in Controllers	Integrated Oscilloscope
1 mHz to 2 GHz	Up to 10 MHz	2.6 kHz to 35 MHz	14 bits	Dual PID	5 GSa/s

Features

- Stabilize a laser’s frequency to a reference cavity or atomic transition
- Virtually probe within signal processing chain with an integrated oscilloscope
- Quickly lock to any zero-crossing in the error signal using the “Lock Assist” 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
- Built-in IIR filter for custom filtering
- Stream or save traces from any point in the signal processing chain

Specifications

- Local oscillator frequency: 1 mHz to 2 GHz
- Input range: 100 mV, 1 Vpp, 10 Vpp, or 40 Vpp
- Scan waveforms: positive sawtooth, negative sawtooth, triangle
- Scan frequency: 1 mHz to 10 MHz
- Low-pass filter corner frequency: 2.601 kHz to 35.16 MHz (second or fourth order)
- Integrator crossover frequency:
  - Fast PID: 312.5 mHz to 3.125 MHz
  - Slow PID: 4.883 mHz to 48.83 kHz
- External PLL frequency multiplier: 0.125x to 250x
- Ultrafast data acquisition: snapshot mode up to 5 GSa/s, continuous mode up to 10 MS/s

Applications

- Custom phase-locked loop
- Gravitational wave detection
- Closed-loop control systems
- Pound-Drever-Hall technique
- Precision spectroscopy
- Atomic and optical clocks
- Quantum optics
- Nonlinear and ultrafast optics
- Cold atom experiments

Note: All Moku:Delta specifications are subject to change.

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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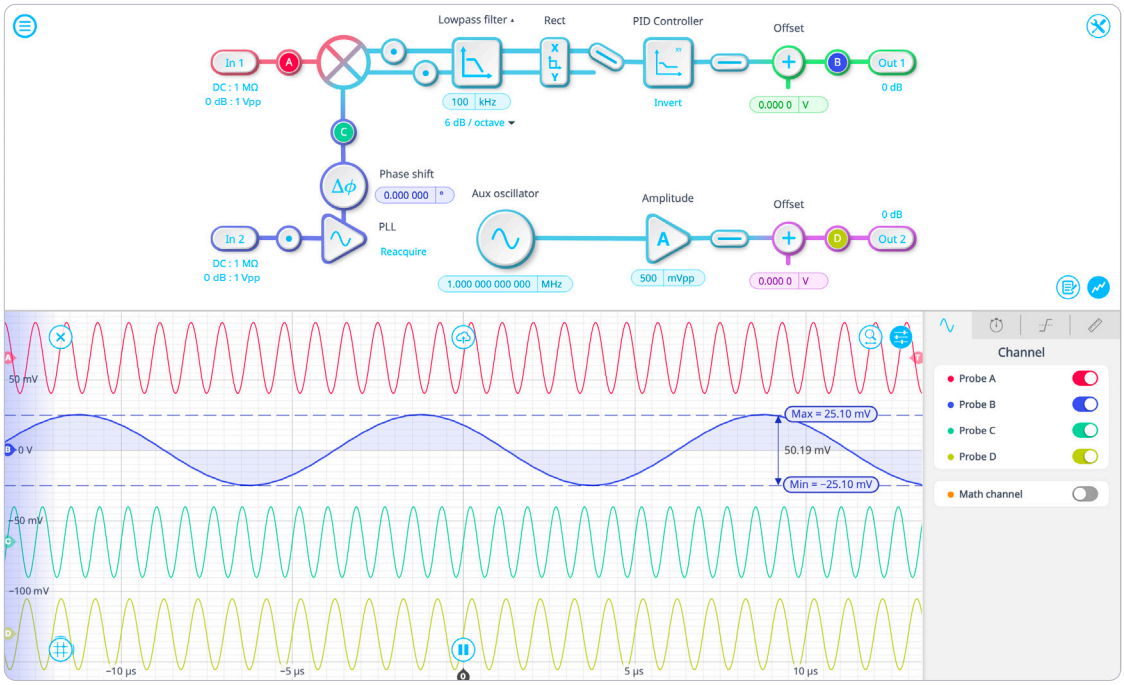
Lock-in Amplifier

The Moku:Delta Lock-in Amplifier delivers dual-phase demodulation from millihertz to 2 GHz with microhertz resolution and ultralow-noise floor of < 10 nV/√Hz. It supports external reference locking up to the 250th harmonic or down to the 1/8th subharmonic. A built-in PID controller enables real-time feedback and stabilization, and a 1 TB SSD supports high-throughput, long-duration data logging. With a GPS-disciplined oscillator for precise timing, Moku:Delta is ideal for signal recovery in quantum sensing, ultrafast optics, and advanced control systems.



Demod. Frequency	Dynamic Reserve	Time Constant	Filter Slopes	Input Noise	Built-in Feature
1 mHz to 2 GHz	**> 120 dB**	**From 12.8 ns**	**6, 12, 18, 24 dB/Oct**	**< 10 nV/√Hz**	**PID Controller Data Logger**

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 phase-locked loop (PLL)
- Demodulate at up to the 250th harmonic or down to 1/8th of the fundamental frequency
- Toggle between rectangular (X/Y mode) or polar coordinates (R/θ mode)
- Built-in PID Controller and Data Logger
- Supported external clock reference: 10 MHz, 100 MHz, GPS

Specifications

- Demodulate with frequencies ranging from 1 mHz to 2 GHz with µHz resolution
- External PLL frequency multiplier: 0.125x to 250x
- Phase shift precision of 0.000 001°
- Input impedance: 50 Ω / 1 MΩ
- Time constant : 12.8 ns to 0.215 s
- Low-pass filter corner frequency: 700 mHz to 12.4 MHz
- 6, 12, 18, or 24 dB/octave filter roll-off
- Output gain range: -80 to +160 dB
- LO output: up to 2 GHz with variable amplitude
- Ultrafast data acquisition:
  - snapshot mode up to 5 GSa/s
  - continuous mode up to 10 MSa/s

Applications

- Quantum sensing and control
- Ultrafast laser spectroscopy
- Laser frequency stabilization
- Laser scanning microscopy
- Multi-channel magnetometry (magneto-optical Kerr effect)
- Scanning probe and near-field microscopy

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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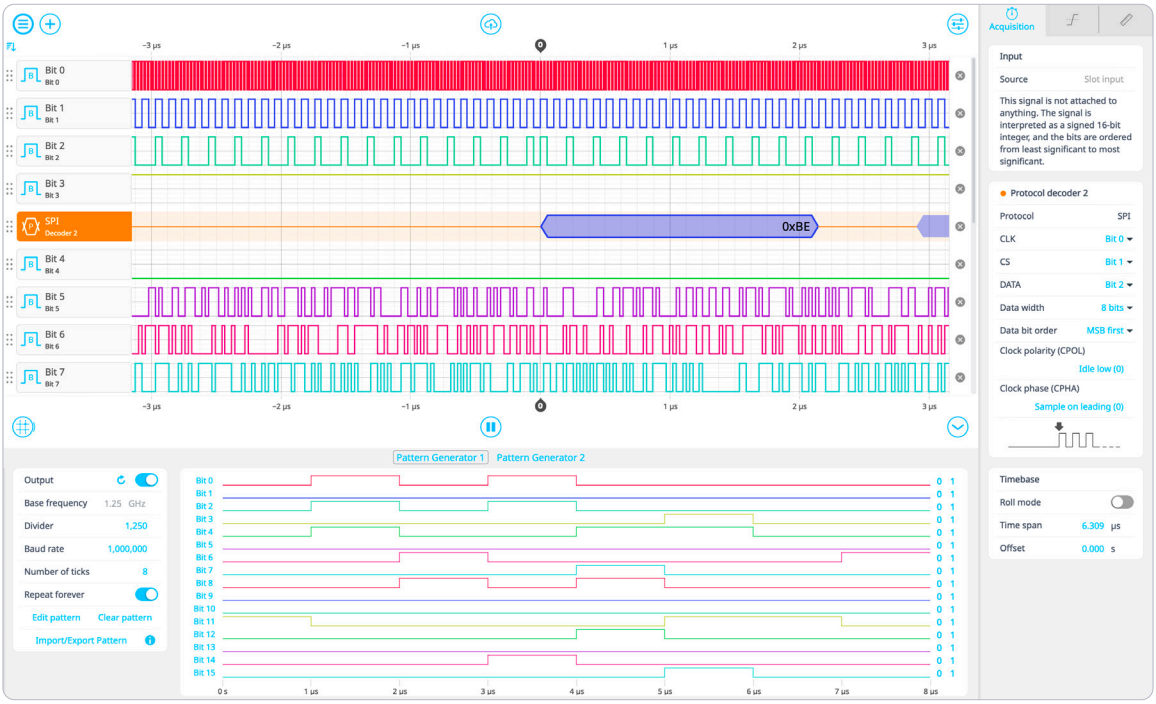
Logic Analyzer

Moku:Delta Logic Analyzer enables high-speed, multi-channel digital signal inspection and protocol decoding with seamless integration into your workflow. Featuring 32 bidirectional digital I/O channels and 8 analog channels with configurable threshold sampling rates at 312.5 MSa/s. Decode standard protocols including UART, SPI, I2C, CAN, I2S, USB, and parallel bus with ease, and leverage built-in Boolean logic operations (AND, OR, XOR, etc.) for complex signal analysis. With full API support across Python and MATLAB, and tight integration with Moku Cloud Compile, the Logic Analyzer accelerates custom hardware development from design to deployment.



Sample Memory Depth	Pattern Memory Depth	Input / Output Sampling Rate	Supported Protocols	Decoding Rate
250k × 16	32,764 × 16	312.5 MSa/s	UART, I2C, I2S, CAN, SPI, USB, and Parallel Bus	> 100 MHz

Features

- Two selectable 16-bit input buses and two 16-bit Pattern Generators
- Eight analog inputs with configurable threshold
- One auxiliary input channel from external trigger input
- Supported protocol: UART, I2C, I2S, SPI, CAN, USB, and parallel bus
- Supported math: AND, OR, XOR, NAND, NOR, XNOR
- Intuitive graphical user interface with Python and MATLAB API support

Specifications

- Sample memory depth: 250k × 16
- Pattern memory depth: 32,768 × 16
- Maximum clock frequency: 312.5 MHz

Logic Analyzer

- Logic level: 3.3 V, 5 V tolerant
- Impedance: 1 MΩ
- Sampling rate: up to 312.5 MSa/s

Pattern Generator

- Sampling rate: up to 312.5 MSa/s
- Logic level: LVCMOS (3.3 V)

Protocol Decoder

- Decode rate: > 100 MHz (protocol dependent)

Applications

- Custom design simulation, debugging, and monitoring
- IC testing and validation
- Digital circuit design
- Digital communication diagnosis
- Protocol decoding
- Signal simulation
- Embedded system development
- Mixed-signal system debugging

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
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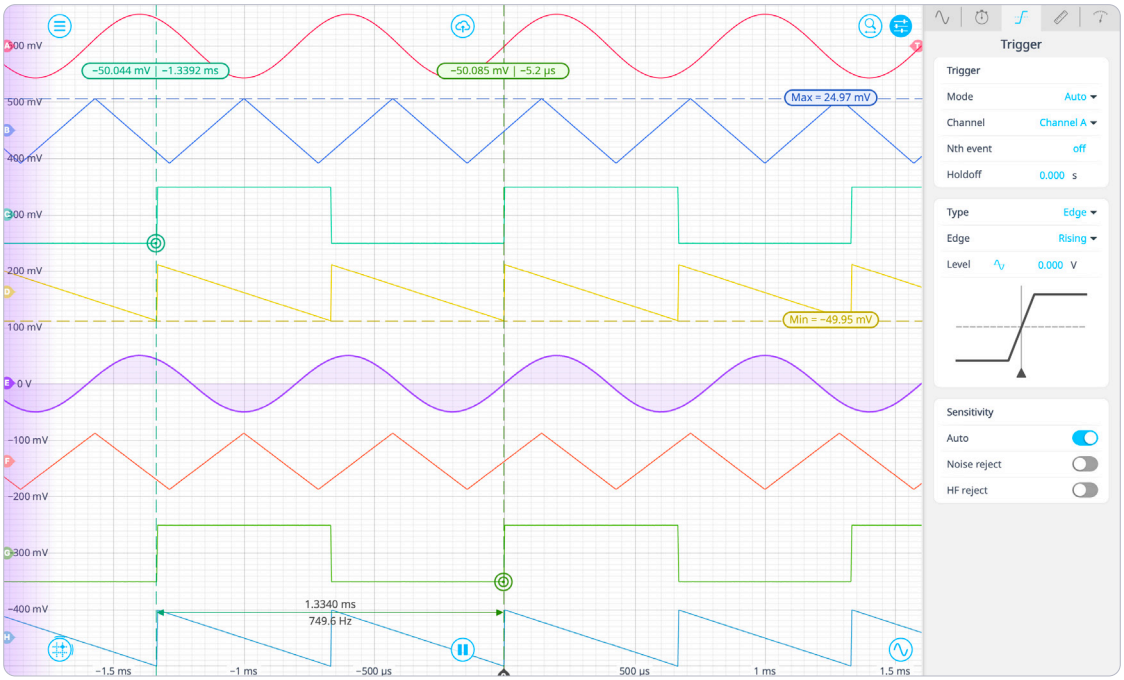
Oscilloscope

The Moku:Delta Oscilloscope features eight analog input channels with a 5 GSa/s sampling rate and 2 GHz bandwidth, utilizing a hybrid 14-bit and 20-bit ADC frontend to achieve a noise floor below 10 nV/√Hz. Built-in sine wave generator channels enable real-time stimulus-response and loopback measurements. Onboard clock with 1 ppb stability provides high-precision timebase, with support for external 10 MHz or 100 MHz reference inputs and a GPS-disciplined oscillator. Full API integration with Python and MATLAB facilitates automated test workflows.



Sampling Rate	Bandwidth	ADC Resolution	Input Impedance	Input Noise	Sine Wave Generator
Up to 5 GSa/s	**2 GHz**	**14-bits and 20-bits**	**50 Ω / 1 MΩ**	**< 10 nV/√Hz**	**4 Channels up to 2 GHz**

Features

- Eight analog inputs with 2 GHz bandwidth
- Exceptional low-frequency noise performance of < 10 nV/√Hz
- Dual-ADC design with blended ADC technology
- Ultra stable 1 ppb onboard oscillator with onboard GPS receiver for GPS-disciplined oscillator capability
- Integrated high-speed signal generator channels with analog bandwidths up to 2 GHz

Specifications

- Sampling rate: 5 GSa/s on 8 channels
- Input Impedance: 50 Ω or 1 MΩ
- Input noise: < 10 nV/√Hz
- Input coupling: AC or DC
- Input bandwidth:
  - 50 Ω: 2 GHz
  - 1 MΩ: 1 MHz
- Input range:
  - 50 Ω: 100 mVpp, 1 Vpp, or 10 Vpp
  - 1 MΩ: 1 Vpp, or 40 Vpp
- Output bandwidth:
  - 1 Vpp: 2 GHz
  - 10 Vpp: 100 MHz
- Math channel: Add, subtract, multiply, divide, XY mode, integrate, differentiate, FFT, min hold, max hold, and equation editor

Applications

- Automated system test
- Circuit design and characterization
- Jitter/clock analysis
- Photo detector alignment
- Signal monitoring and analysis
- Quantum optics
- RF and microwave signal characterization
- Time-domain reflectometry (TDR)
- Semiconductor test

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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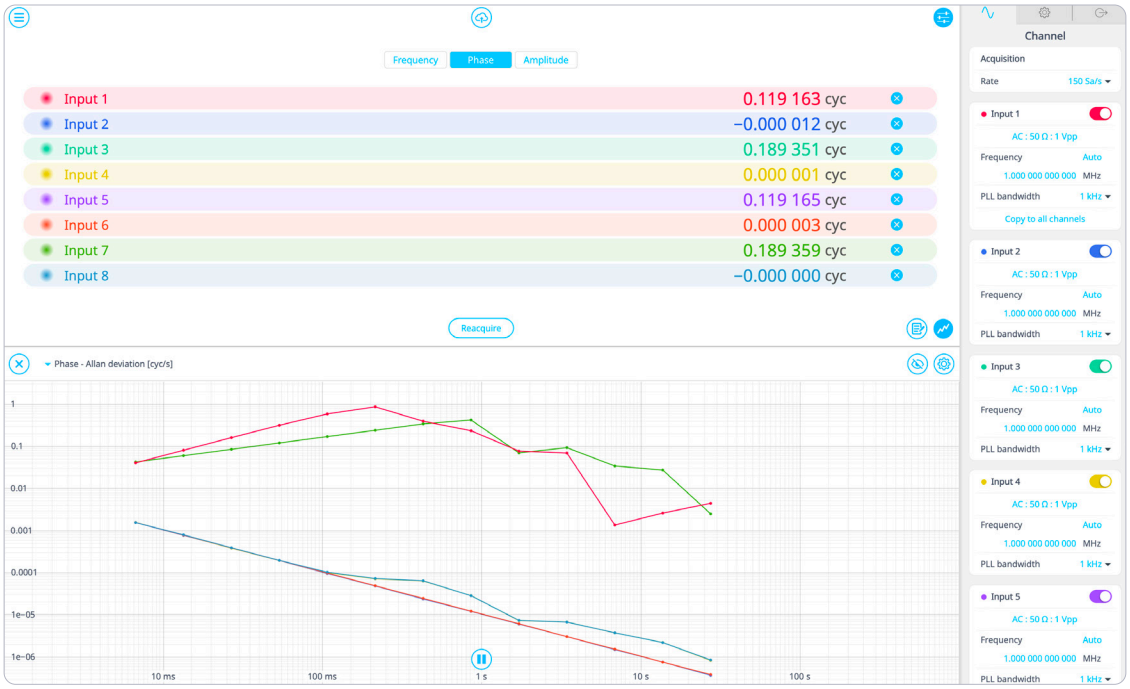
Phasemeter

The Moku:Delta Phasemeter provides ultra-precise phase, frequency, and amplitude tracking across eight analog input channels with up to 2 GHz frequency range. Built on a digitally implemented phase-locked loop (PLL) architecture, it delivers real-time measurements with zero dead time, < 10 nV/√Hz input noise, and sub-µrad phase precision. Ideal for advanced research, it includes built-in tools for Allan deviation, power spectral density, and frequency stability analysis. With phase-locked sine wave generation, frequency multipliers up to 250x, microhertz-level resolution, and full API support, it's a powerful solution for time/frequency metrology, optics, and quantum systems.



Frequency range	Tracking bandwidth	Input noise	Built-in analysis	Data capturing rates	Clock reference options
1 kHz to 2 GHz	**Up to 1 MHz**	**< 10 nV/√Hz**	**Allan deviation**	**37 Hz to 152 kHz**	**10 MHz, 100 MHz, GPS**

Features

- Eight independent Phasemeter channels that track and record phase, frequency, and amplitude in real time
- Phase-locked output option enables you to generate sine waves that are phase-locked to the inputs at the fundamental frequency or harmonics
- Output measured amplitude, phase, or frequency offset for closed-loop control systems, or stream to a computer using Moku APIs
- Real-time spectral analysis to display and save power spectral densities, Allan deviation, and more
- Ultra-stable onboard clock (± 1 ppb) with option for GPS clock reference

Specifications

- Input frequency range: 1 kHz to 2 GHz
- Input voltage range: 100 mVpp, 1 Vpp, 10 Vpp, or 40 Vpp
- Tracking bandwidth: 1 Hz, 10 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz
- Data acquisition rates: 37 Hz, 150 Hz, 596 Hz, 2.4 kHz, 19.1 kHz, 152 kHz
- Sine wave generators: eight-channel 2 GHz (manual or input-locked)
- Output frequency multiplier: 0.125x to 250x (phase-locked to input)
- Phase output wrap: off, ± π, ± 2π, ± 4π
- Built-in measurements: time series, power spectral density, amplitude spectral density, Rayleigh spectrum, coherence, Allan deviation

Applications

- Precision oscillator characterization
- Optical / ultrasound ranging
- Gravitational wave detection
- Optical and RF interferometry
- Time and frequency metrology
- Quantum optics and photonic systems
- Advanced control systems and feedback loops

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
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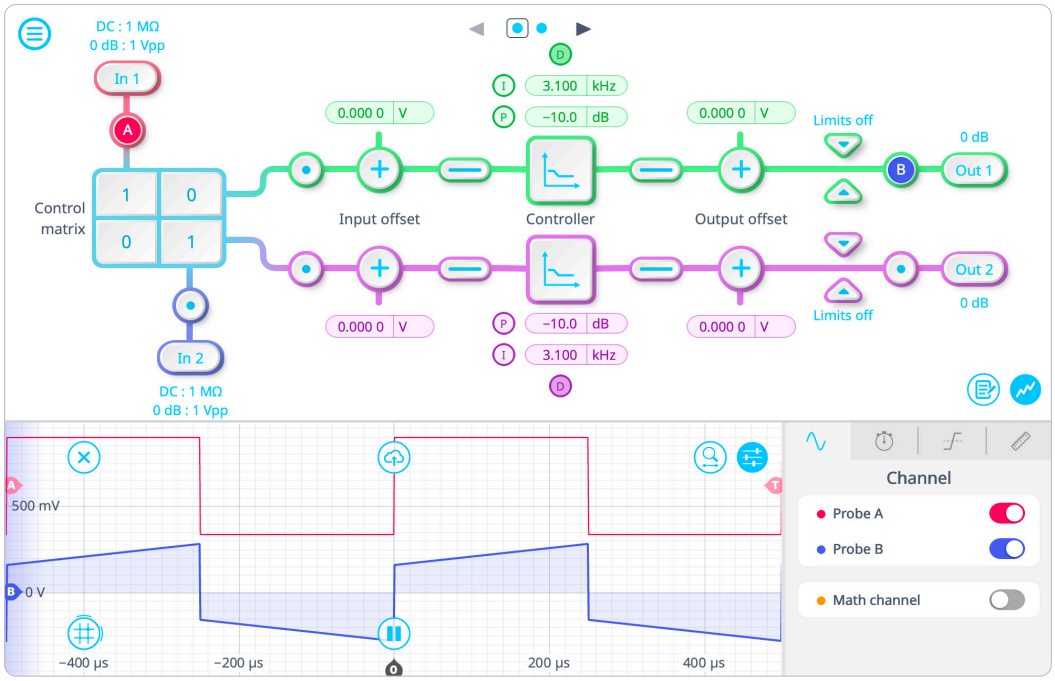
PID Controller

The Moku:Delta PID Controller features four fully configurable PID controllers with MIMO support, sub-microsecond latency, and real-time control loop shaping. Each channel operates at 5 GSa/s with input-to-output latency under 1 µs and an ultra-low noise floor below 10 nV/√Hz. Designed for precision and performance, Moku:Delta enables advanced multi-loop feedback control for applications such as laser stabilization, active alignment, and dynamic system regulation.



Versatile input	Proportional gain	DAC resolution	Input-output latency	Gain configuration	Advanced mode
4 inputs with MIMO	**-60 dB to 60 dB**	**14-bits**	**< 1 µs**	**Real time**	**Multi-section builder**

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 real time
- Block diagram view of the digital signal processing chain with built-in Oscilloscope probe points for real-time 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: 100 mVpp, 1 Vpp, 10 Vpp, or 40 Vpp
- Control matrix linear gain: ± 0.1 to ± 20
- Input offset range: ± 500 mV
- Output offset range: ± 500 mV
- Offset precision: 100 µV
- Voltage limiter range: -500 mV to 500 mV
- 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: 3.125 mHz to 3.125 MHz
- Differentiator crossover frequency: 3.125 Hz to 31.25 MHz

Applications

- Feedback and control systems design
- Laser frequency stabilization
- Cryogenic and quantum device control
- Magnetic/current control in plasma or fusion systems
- Scan heads/sample stage positioning
- Pressure, force, flow rate, and other controls

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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Moku:Delta Instrument Datasheet

Spectrum Analyzer

The Moku:Delta Spectrum Analyzer provides precision spectral analysis from DC to 2 GHz with a noise floor below 10 nV/√Hz across eight independent analog input channels. Hybrid 14-bit and 20-bit ADC blending enables high-fidelity acquisition with wide dynamic range across the full bandwidth. Real-time analysis and advanced digital windowing support detailed spectral inspection, making it well suited for RF diagnostics, quantum systems, and advanced research applications.

Frequency Range	Minimum RBW	Input Noise	Sine Wave Generator	Output Frequency	Advanced
DC to 2 GHz	**618.5 mHz**	**< 10 nV√Hz**	**4 channels**	**Up to 2 GHz**	**Real-time cross-correlation**

Features

- Display and record power spectra or power spectral densities in the frequency domain from DC to 2 GHz
- Real-time cross-correlation measurement to enhance signal detection amid noise
- Integrated high-speed signal generator channels with analog bandwidths up to 2 GHz
- Supported external clock reference: 10 MHz, 100 MHz, GPS
- Independent cursors for active peak tracking
- Live measurement functions: peak level, peak frequency, noise level, peak SNR, and occupied bandwidth

Specifications

- Frequency range:
  - 50 Ω: 2 GHz
  - 1 MΩ: 1 MHz
- Frequency span: 100 Hz to 2 GHz
- Number of input channels: 8
- Minimum resolution bandwidth (RBW): 618.5 mHz (span dependent)
- Input range:
  - 50 Ω: 100 mVpp, 1 Vpp, or 10 Vpp
  - 1 MΩ: 1 Vpp, or 40 Vpp
- Input impedance: 50 Ω / 1 MΩ
- Number of output channels: 4
- Output range: up to 2 GHz (1 Vpp)
  up to 100 MHz (10 Vpp)
- Video filter bandwidth: 580 mHz to 24 MHz

Applications

- Multi-channel spectrum monitoring
- System response characterization
- Noise spectra analysis
- Satellite communications
- RF system design and characterization
- Spurious signal identification
- Electromagnetic Interference (EMI) testing

Note: All Moku:Delta specifications are subject to change.

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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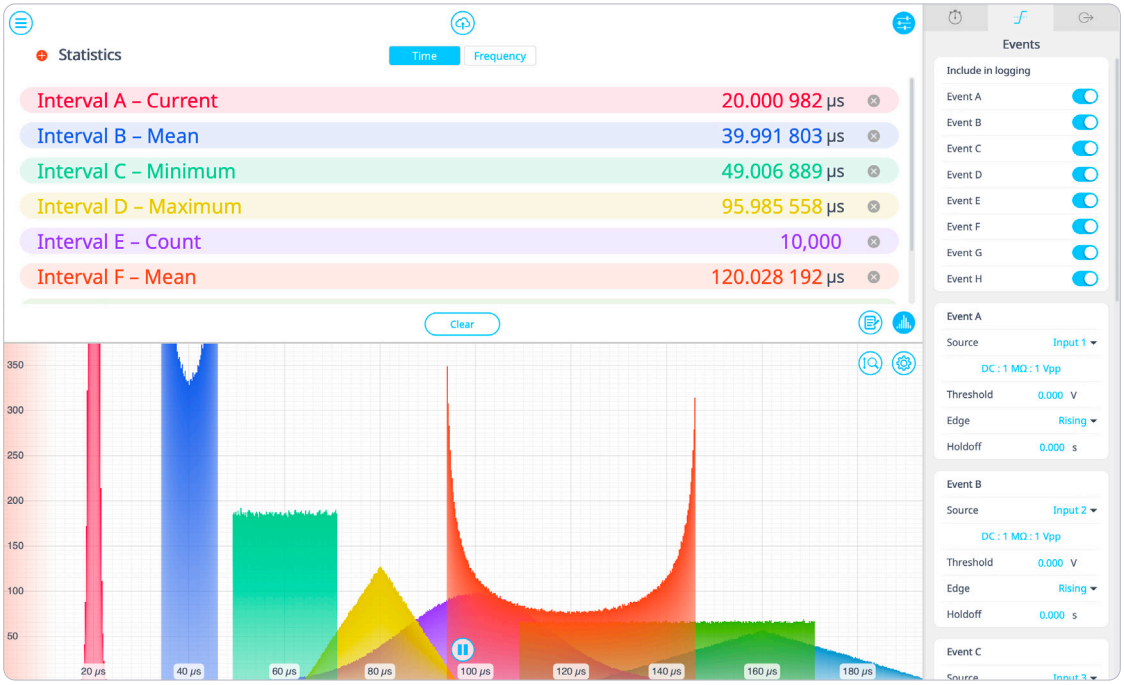
Moku:Delta Instrument Datasheet

Time & Frequency Analyzer

The Moku:Delta Time & Frequency Analyzer delivers high-resolution interval measurements between user-defined start and stop events, with a 5 GSa/s sampling rate and 0.2 ps digital resolution. It supports continuous, windowed, or gated acquisition modes, real-time and lossless histograms with statistics, and high-resolution timestamp logging to on-board storage. Optimized for precision timing applications, it is ideal for photon counting, pulsed laser characterization, and synchronized multi-detector systems.



No. of independent interval analyzers	Clock stability	Digital resolution	Max interval rate	Histogram
8	1 ppb	0.2 ps	312.5 MHz	Real-time and lossless

Features

- Up to eight independent event detectors with configurable thresholds on rising edge, falling edge, or both edges
- Lossless, real-time histograms with a minimum bin width of 0.2 ps
- Output interval count or current interval with adjustable scaling factor
- High-resolution raw event timestamp logging to on-board storage for post processing
- Combine with up to seven other instruments in Multi-Instrument Mode for system level characterization and feedback control

Specifications

- No. of independent interval analyzers: 8
- Digital resolution: 0.2 ps
- Input frequency range: DC to 2 GHz
- Input trigger threshold range: 100 mVpp, 1 Vpp, 10 Vpp, or 40 Vpp
- Maximum interval rate: 312.5 MHz
- Acquisition mode: continuous, windowed, or gated
- Interpolation mode: none or linear
- Output range: 1 Vpp or 10 Vpp
- Output mode: interval count or current interval

Applications

- Oscillator analysis
- Photon counting
- Jitter and phase noise analysis
- Linear optical quantum computing
- Pulsed laser stabilization
- Time-of-flight and LiDAR systems
- Particle or neutron detection
- Quantum computing and quantum sensing

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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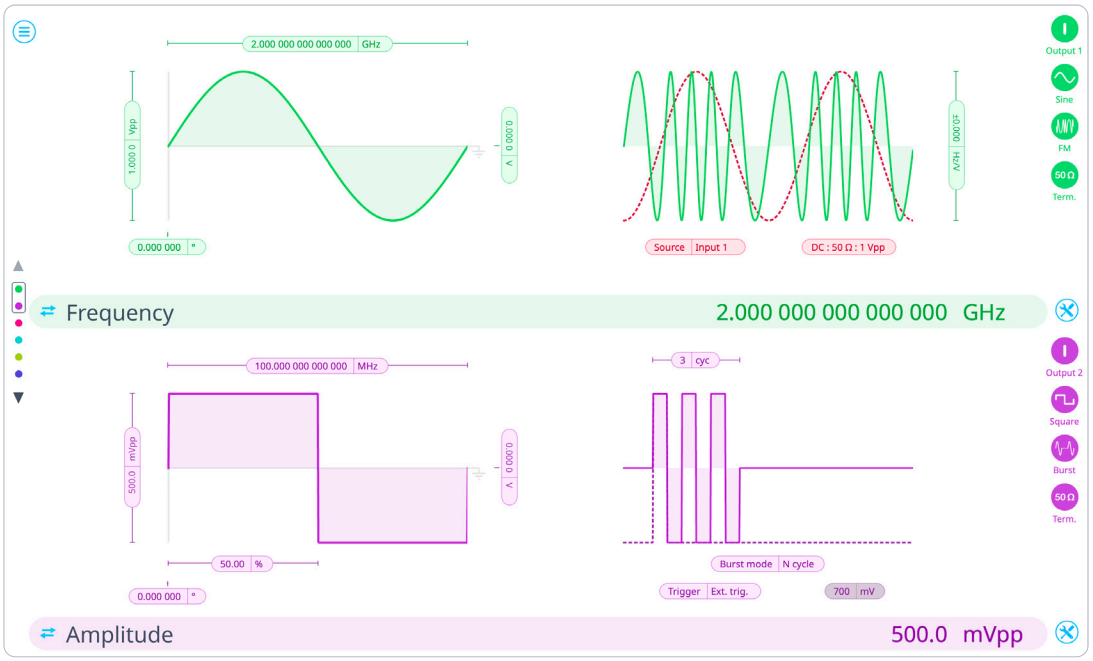
Moku:Delta Instrument Datasheet

Waveform Generator

The Moku:Delta Waveform Generator provides six independent analog outputs at 10 GSa/s with up to 2 GHz bandwidth. It supports sine, square, ramp, pulse, noise, and DC waveforms with configurable frequency, amplitude, phase, and offset. Modulation options include AM, FM, PM, and PWM. Advanced triggering from internal or external sources, multi-channel synchronization, and a GPS-disciplined clock enable precise waveform delivery in RF, quantum control, and timing-critical applications.



Frequency Range	Output Voltage Range	Modulation	Other Modes	Timebase Accuracy
1 mHz to 2 GHz	**Up to 10 Vpp (50 Ω)**	**FM, AM, PM, PWM**	**Burst, Sweep**	**1 ppb**

Features

- Generate six independent phase coherent waveforms from DC to 2 GHz
- Six built-in waveforms: sine, square, ramp, pulse, noise, and DC
- Broadband FM, AM, PM, and PWM modulation with internal waveform (cross-channel modulation) or external input
- Versatile trigger options: from input, dedicated TTL trigger port, or another channel
- Supported external clock reference: 10 MHz, 100 MHz, GPS

Specifications

- Output bandwidth:
  - 2 GHz (1 Vpp)
  - 100 MHz (10 Vpp)
- Frequency range (1 Vpp):
  - Sine: 1 mHz to 2 GHz
  - Square: 1 mHz to 600 MHz
  - Ramp: 1 mHz to 600 MHz
  - Pulse 1 mHz to 600 MHz
- Pulse width: 500 ps to period
- Modulation bandwidth: 156 MHz
- Timebase accuracy: 1 ppb
- Burst mode: start, N-cycle, gated
- Sweep time: 1 ms to 1 ks

Applications

- Quantum control and readout
- RF system prototyping and testing
- Signal simulation
- Laser scanning microscopy
- Circuit design and characterization
- System synchronization
- Clock source
- Microwave photonics and electro-optic modulation
- Modulation scheme evaluation

Note: All Moku:Delta specifications are subject to change.

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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Multi-Instrument Mode

Combine instruments to build a customized test system

Multi-instrument Mode on Moku allows you to run up to four instruments simultaneously to create custom test sequences. Each instrument has full access to the analog inputs and outputs along with adjacent instrument slots. The slots are connected by low-latency signal paths so instruments can run independently or be connected together to build sophisticated signal processing pipelines. Dynamically swap instruments in and out without interrupting those running in tandem. For advanced applications, deploy custom algorithms in Multi-instrument Mode using Moku Cloud Compile.

Moku:Pro

- Up to four instrument slots
- 300 ppb stability onboard clock
- < 650 ns input-to-output latency
- 10-bit and 18-bit ADCs with frequency-dependent blending
- 1.25 GSa/s sampling rate

Moku:Go / Moku:Lab

- Up to two instrument slots
- < 1 µs input-to-output latency
- Moku:Go: 12-bit, 125 MSa/s ADCs, 25 ppm stability onboard clock
- Moku:Lab: 12-bit, 500 MSa/s ADCs, 500 ppb stability onboard clock

Deployable Instruments

- Arbitrary Waveform Generator
- Data Logger
- Digital Filter Box
- FIR Filter Builder
- Frequency Response Analyzer
- Laser Lock Box*
- Lock-in Amplifier
- Logic Analyzer
- Moku Cloud Compile
- Neural Network*
- Oscilloscope
- Phasemeter
- PID Controller
- Spectrum Analyzer
- Time & Frequency Analyzer
- Waveform Generator

Applications

- Automated test sequences
- System prototyping and simulation
- Closed-loop control design
- Optical metrology and spectroscopy
- Control hub for optics, imaging, and other custom-made systems
- Quantum computing
- Signal processing modelling
- Deploying Simulink models to Moku hardware
- Signal classification and denoising with user-defined neural networks

*Not available in Multi-instrument Mode for Moku:Lab and Moku:Go

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
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info@si-gmbh.de
www.si-gmbh.de
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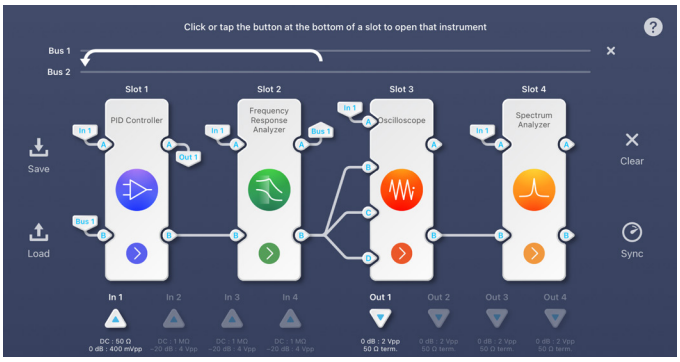
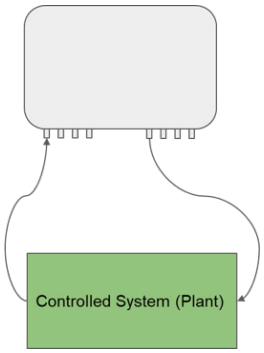
Application Highlights

Low-latency closed-loop control design and characterization

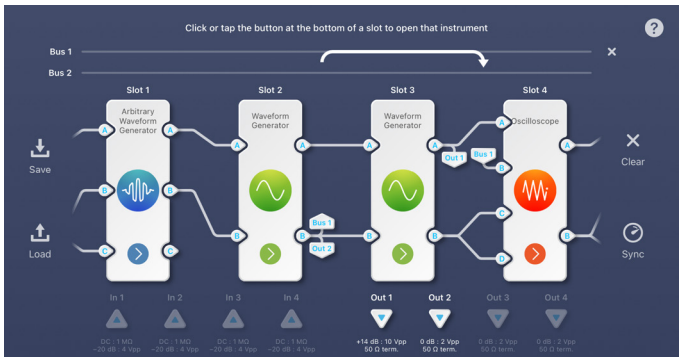
The Moku PID Controller provides a sub-µs input-to-output delay, ideal for high-speed closed-loop controller applications. The controller's transfer function and impulse response can be observed and measured in real-time by adding a Frequency Response Analyzer using Multi-instrument Mode. Measure the system's response in both time and frequency domains using the Oscilloscope and Spectrum Analyzer. Any adjustments in the controller are reflected in real-time in the monitoring instruments.

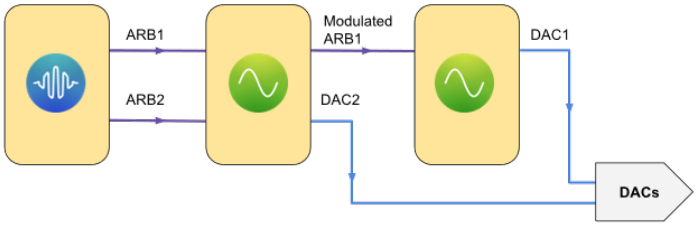




Generate signals with arbitrary modulation

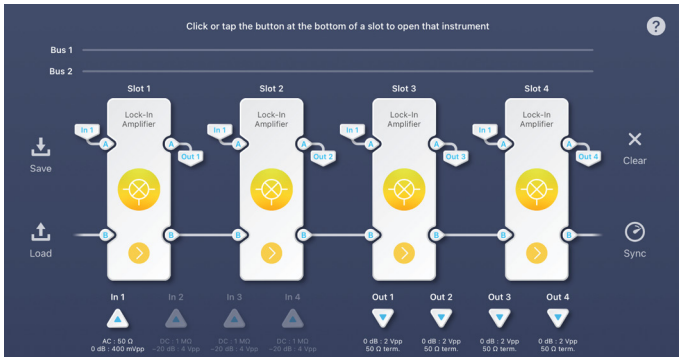
Combine the Arbitrary Waveform Generator with multiple Waveform Generators to output high-stability complex signals. Connect Arbitrary waveforms to the input of the Waveform Generators as the modulation source. Frequency, phase, and amplitude modulation can also be added to the signal. This removes look-up table calculations and provides better control over the modulation and output signal. Add an Oscilloscope or Spectrum Analyzer to one of the slots to measure the signals in the time and frequency domains.

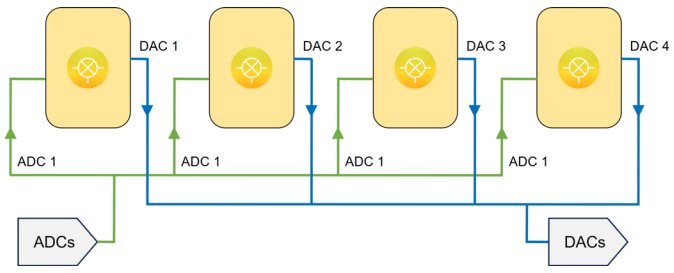




Multi-demodulator Lock-in Amplifier

Moku:Pro Multi-instrument Mode allows up to four Lock-in Amplifiers to run simultaneously. Each of the Lock-in Amplifiers can demodulate the signal at the fundamental, higher harmonics, or frequency divisions using an internal or external reference signal. With Moku's multi-window feature, the measured R/θ or X/Y components from each Lock-in Amplifier can be viewed in parallel on the embedded oscilloscope. Additionally, all four Lock-in Amplifiers can be triggered via a common external trigger.





SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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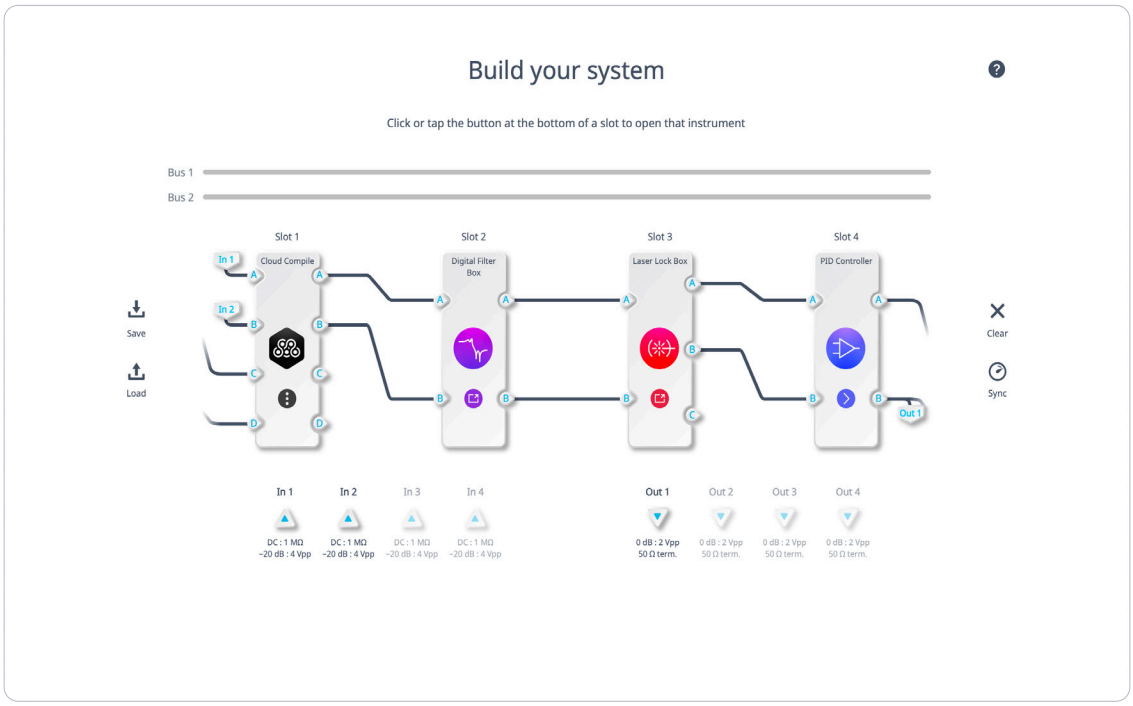
Moku Cloud Compile

Deploy custom VHDL code to Moku

Moku Cloud Compile (MCC) enables users to deploy custom code directly on Moku hardware, allowing for unprecedented customization capabilities with minimal development time. A custom wrapper is available to ensure Moku Cloud Compile creations can interface directly with the front end of any Moku. Run custom designs alongside any supported instrument in the Moku suite in Multi-instrument Mode. By opening access to the FPGA that enables Moku hardware, new features or functions can be deployed in minutes. The cloud-based workflow greatly simplifies setup and deployment.



Example use cases

- Create custom math functions, gain, or offset and create more complex signal processing flows
- Design and deploy a custom instrument like a boxcar averager, specific DC sequencing, or more advanced cross correlation functions
- Create custom pulse or function sequences
- Digitally sum, subtract, divide or otherwise combine signals, or create and add Gaussian noise for testing
- Combine with MathWorks® Simulink and MATLAB HDL Coder to produce noise generators, random sequences, or square root functions
- Find more extensive code examples on GitLab

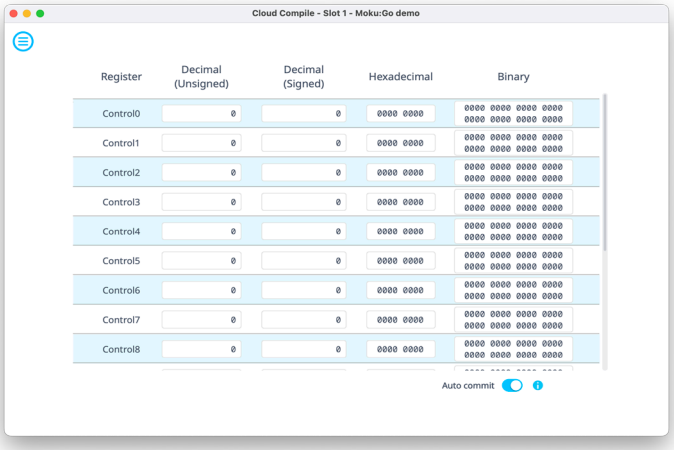
```
1  library IEEE;
2  use IEEE.Numeric_Std.all;
3
4  architecture Behavioural of CustomWrapper is
5  begin
6      -- interpret 16 bits of each of the first two control
7      -- registers as a (signed) DC voltage to output from
8      -- the MCC instrument
9      OutputA <= signed(Control1(15 downto 0));
10     OutputB <= signed(Control2(15 downto 0));
11 end architecture;
12
```

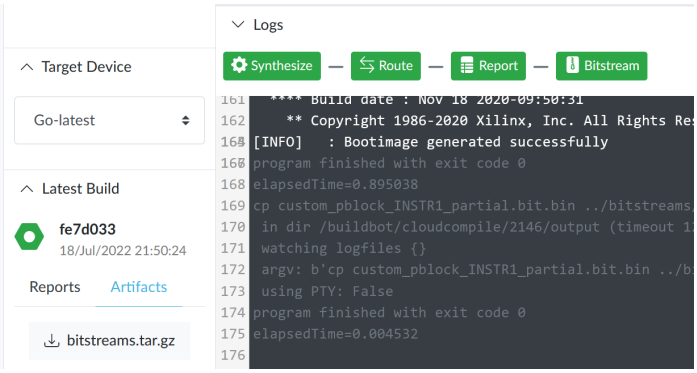
Learn more or get started on your custom instuments at https://compile.liquidinstruments.com/

Powerful customization made easy

Multi-instrument Mode allows Moku Cloud Compile to interact with the Moku suite of standard instruments. For example, the Oscilloscope can be used to observe the custom code outputs, or use the custom code to drive modulation onto a Waveform Generator signal. By harnessing the power of the existing instrument suite, users can create, compile, and validate their designs on one hardware platform.

Control custom code via web app-based registers to adjust gains or change operating modes in real time. Register changes are reflected immediately in the running VHDL for quick adjustment of design parameters.





Learn, explore, deploy

Compile, synthesize, and route entirely in the cloud. Users can code in VDHL or use third-party code generators like HDL Coder from Mathworks.

The synthesized design forms a bitstream file that is hardware deployable via Moku: Apps. Cloud-based synthesis allows users to avoid the need to install, debug, and maintain complex local tools.

Choose your hardware device

Moku:Pro

Customize advanced test setups by deploying custom DSP alongside up to three additional instruments in a 4-slot Multi-instrument Mode configuration, enabling you to tailor your test equipment to your requirements.

Moku:Lab

Run two instruments simultaneously to build custom test systems. Deploy custom code through Moku Cloud Compile in one slot, then test your design with any Moku instrument in the other.

Moku:Go

Quickly iterate on VHDL programs without complex software installations. Deploy Moku Cloud Compile creations alongside another instrument in Multi-instrument Mode to test designs in realtime.

	Moku:Pro	Moku:Lab	Moku:Go
FPGA	Ultrascale+	Zynq 7020	Zynq 7020
Core clock	312.5 MHz	125 MHz	31.25 MHz
Look-up tables	48,400	19,600	20,000
Flip-flops	96,800	39,200	40,000
Block RAM (36k)	154	60	50
DSP	432	100	100

All specifications are per slot

SI Scientific Instruments GmbH
Roemerstr. 67 | 82205 Gilching
+49 8105 77940
info@si-gmbh.de
www.si-gmbh.de
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