Waveform Generator

Moku:Lab User Manual

Moku:Lab's Waveform Generator is designed to generate common signals with high accuracy and configurability across two independent output channels. The outputs are precisely adjustable for frequency, phase and amplitude. Further, the outputs may be modulated with a variety of internally generated or external signals and there are flexible, programmable triggers.

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Introduction

The waveform generator is an essential item of equipment in almost all engineering laboratories. The Moku:Lab implements a waveform generator as one of 12 high quality instruments.

The Moku waveform generator is a precision yet versatile instrument with a modern, touch based and intuitive interface. The tablet based interface operates wirelessly and this enables the engineer or technician to operate the Moku fully while free to move about the working environment.

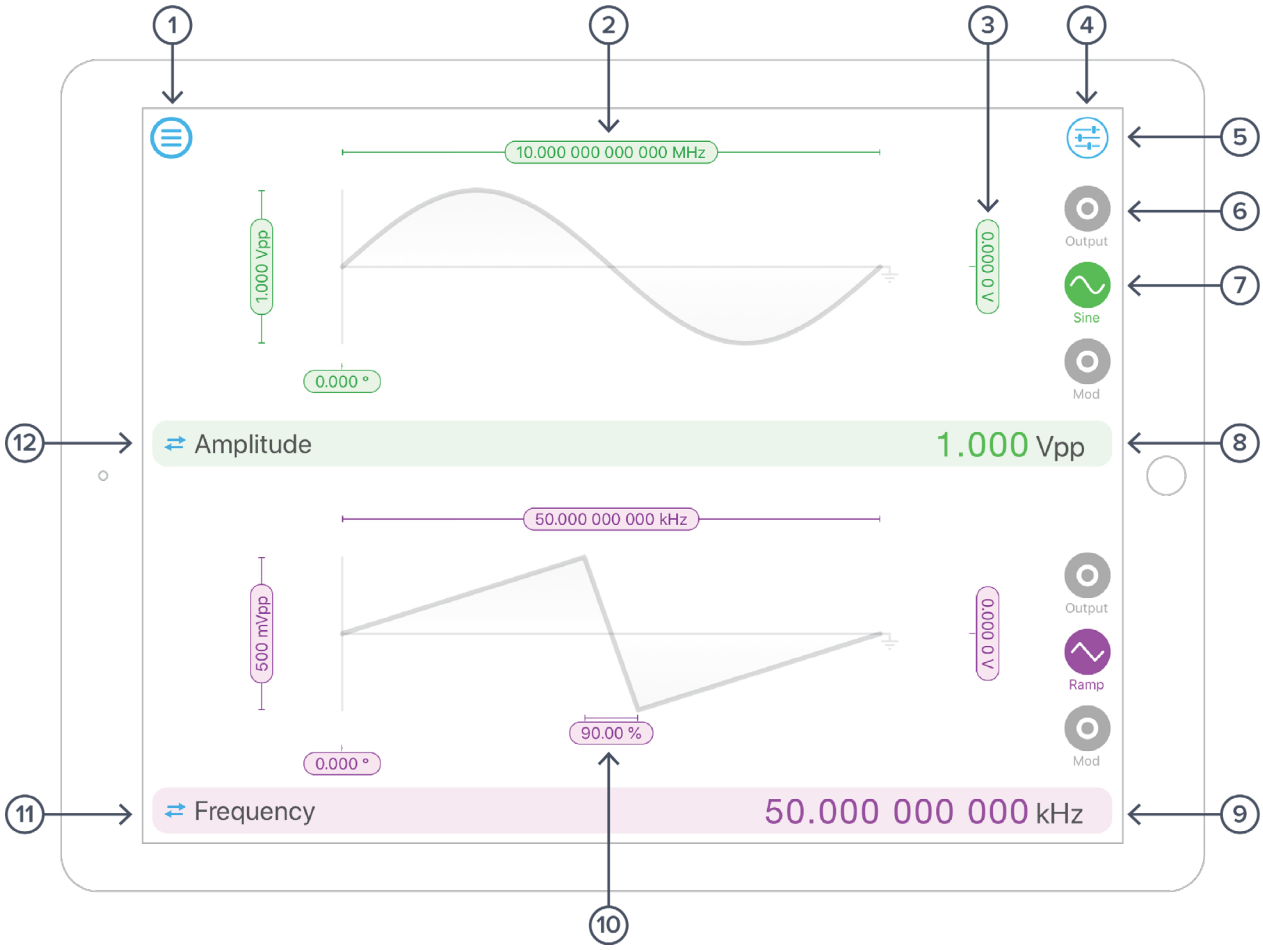
Extensive configurations are readily available from the touch interface while the Moku can provide a precision timing reference or synchronize to an external time base.

Moku also has Python, LabView and MATLAB interfacing capabilities.

The Moku waveform generator can be reconfigured nearly instantaneously to be one of:

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

Quick start: User Interface



ID	Description	ID	Description
1	Main menu	7	Configure modulation
2	Configure frequency / period	8	Configure displayed parameter (ch 1)
3	Configure waveform offset	9	Configure displayed parameter (ch 2)
4	Settings menu	10	Configure ramp symmetry
5	Enable / disable output	11	Switch between frequency and period
6	Waveform shape	12	Switch between frequency and period

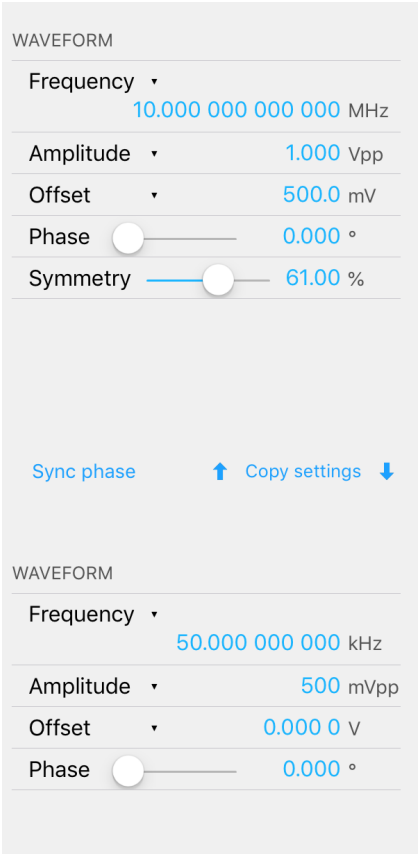
Main Menu

The main menu can be accessed by pressing the icon, allowing you to:

Settings

The settings menu can be accessed by tapping the icon, allowing detailed waveform configurations on a per channel basis. Frequency, Amplitude, Phase and other waveform specific parameters can be entered manually

The settings on channel 1 can be instantly applied to channel two with Copy Settings and the two channels phase aligned with Sync Phase.



Output Configuration

Enable / Disable Outputs

shows the output channel is disabled, tap to enable

shows the output channel is enabled, tap to disable

Note on impedance

Moku's outputs have an impedance of 50 Ω. As such, voltages supplied to a 50 Ω load will be reduced by a factor of two due to the voltage divider formed by the closed circuit. A consequence of this is that the voltage measured across a high-impedance load will be *twice* the value displayed on the interface since the voltage division of the high-impedance circuit is comparably small.

Waveform types

Each channel can be set to generate one of five predefined waveforms.

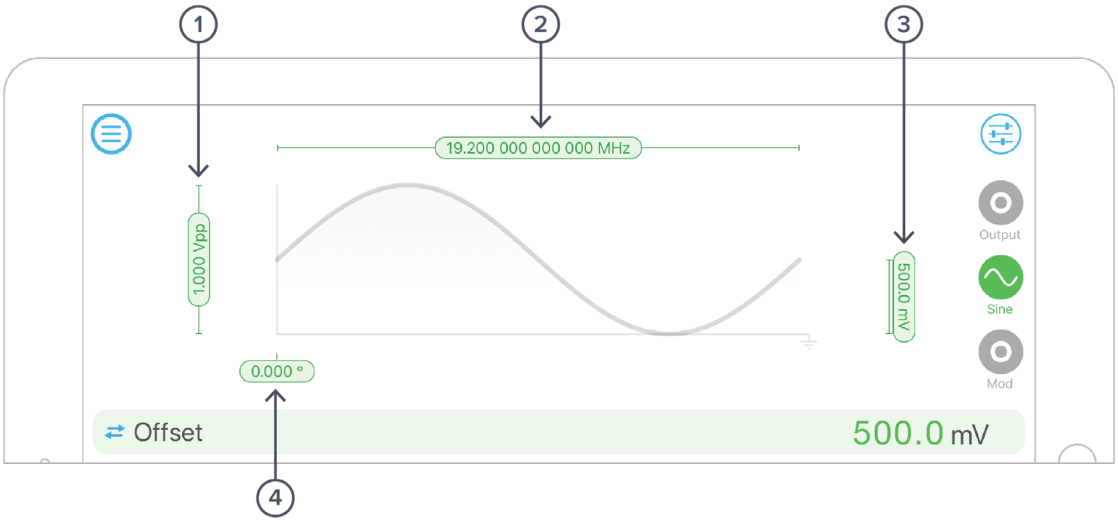
Each of Sine, Square and Ramp can be configured for Frequency, Amplitude, Offset and Phase.

The Square wave is low jitter and symmetric (50% duty cycle)

The Ramp type has a variable symmetry setting, while the Pulse provides a highly configurable square wave with variable duty and slew rate.

The DC setting provides an accurate and stable voltage reference.

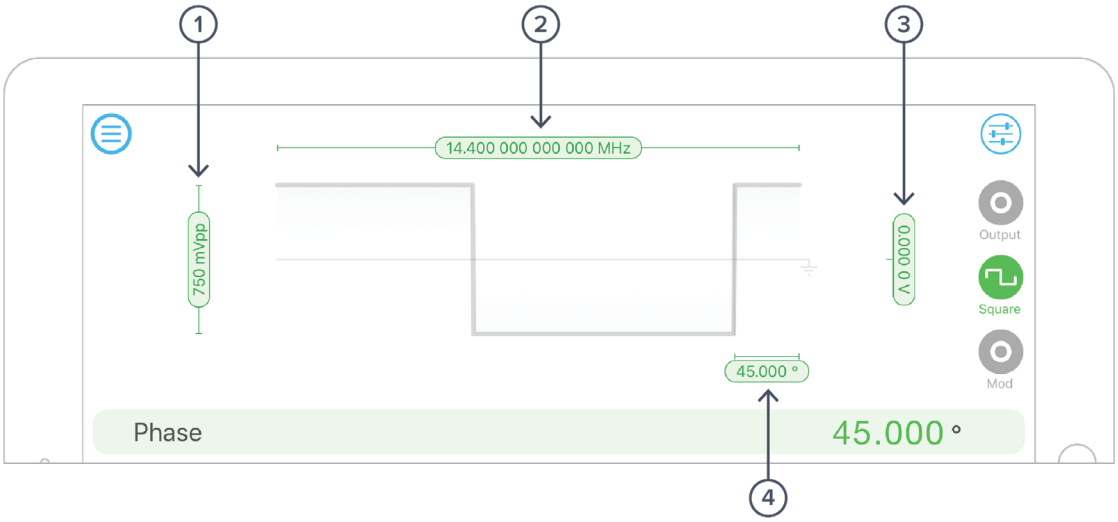
Sine Wave



ID	Description	ID	Description
1	Amplitude (High Level)	3	Offset (Low Level)
2	Signal Frequency (Period)	4	Phase

Tap Parameter Settings pill or bar to change. Parameter bar can show different representations of many parameters; these alternative representations are shown in brackets.

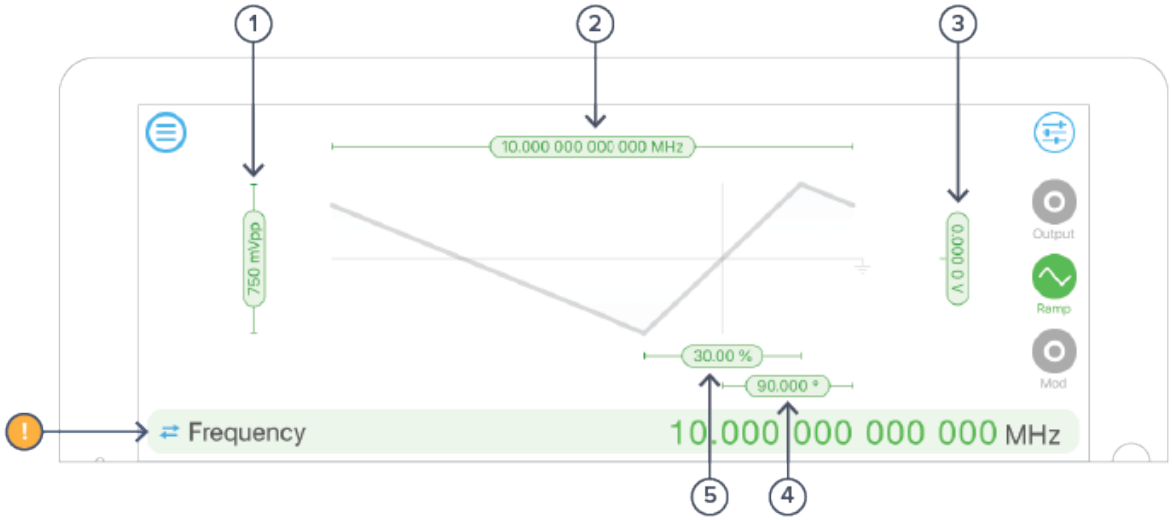
Square Wave



ID	Description	ID	Description
1	Amplitude (High Level)	3	Offset (Low Level)
2	Signal Frequency (Period)	4	Phase

Tap Parameter Settings pill or bar to change. Parameter bar can show different representations of many parameters; these alternative representations are shown in brackets.

Ramp Wave

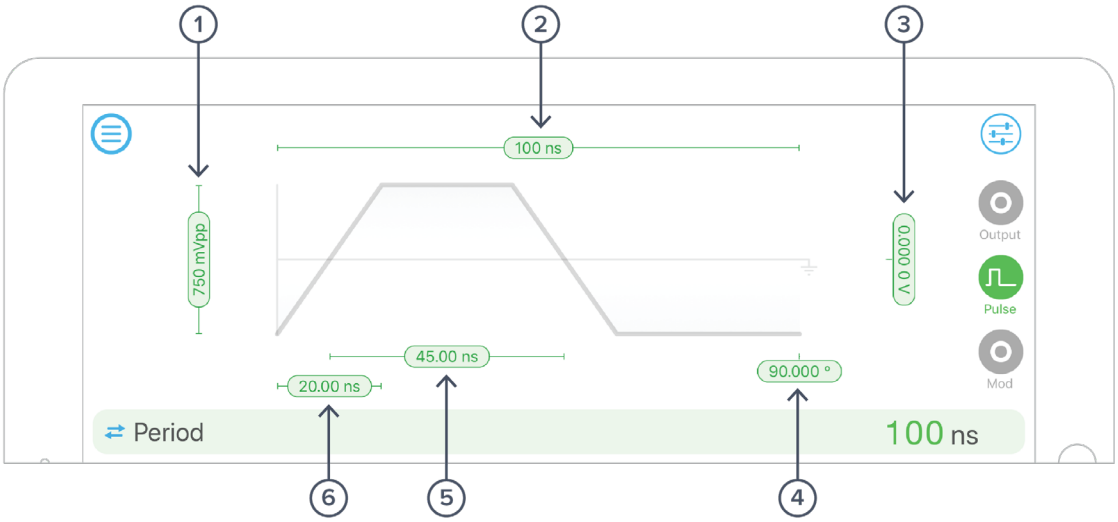


ID	Description	ID	Description
1	Amplitude (High Level)	4	Phase
2	Signal Frequency (Period)	5	Symmetry
3	Offset (Low Level)		

HOT TIP: Tap ‘Frequency’ to change to ‘Period’ and vice versa

Tap Parameter Settings pill or bar to change. Parameter bar can show different representations of many parameters; these alternative representations are shown in brackets.

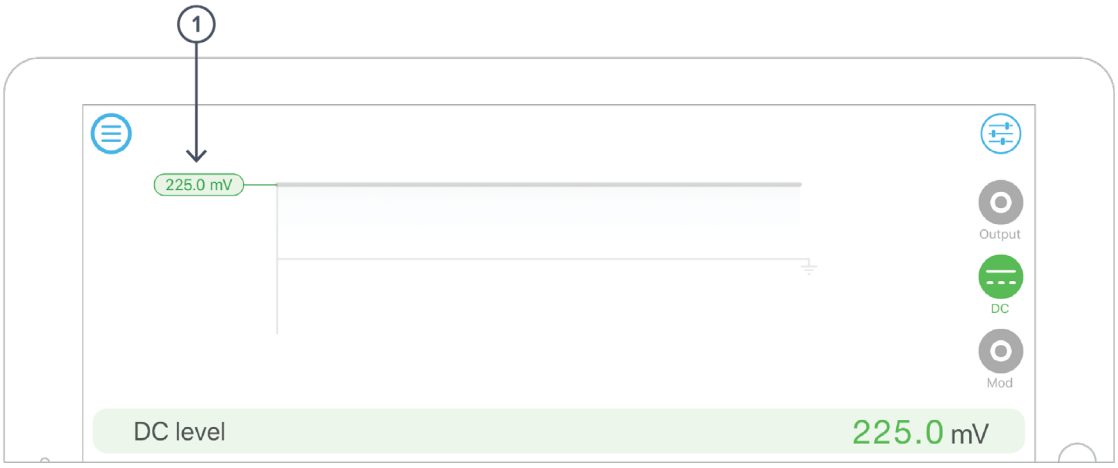
Pulse Wave



ID	Description	ID	Description
1	Amplitude (High Level)	4	Phase
2	Signal Frequency (Period)	5	Pulse Width
3	Offset (Low Level)	6	Edge time

Tap Parameter Settings pill or bar to change. Parameter bar can show different representations of many parameters; these alternative representations are shown in brackets.

DC wave



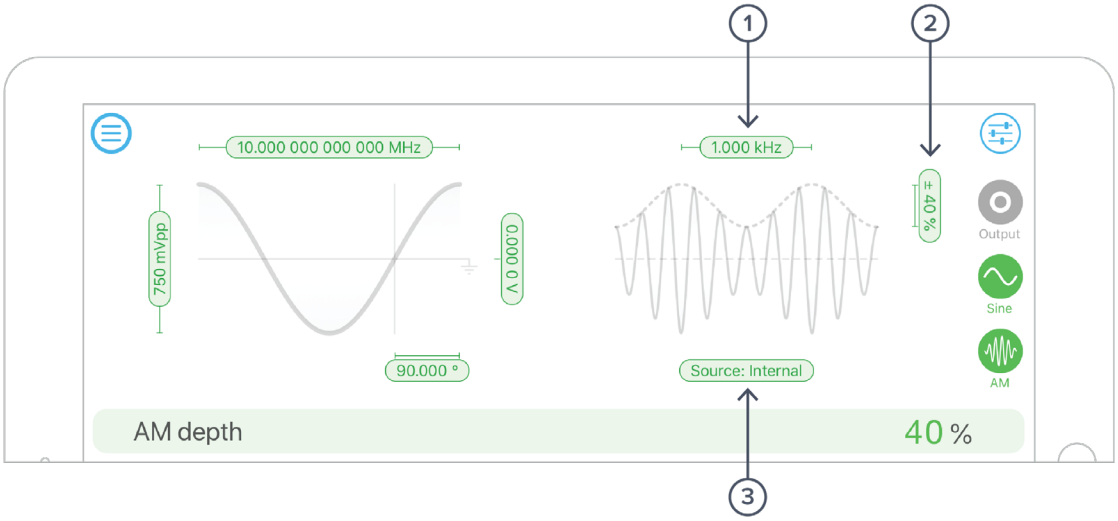
ID	Description
1	DC level

Tap Parameter Settings pill or bar to change. Parameter bar can show different representations of many parameters; these alternative representations are shown in brackets.

Modulation types

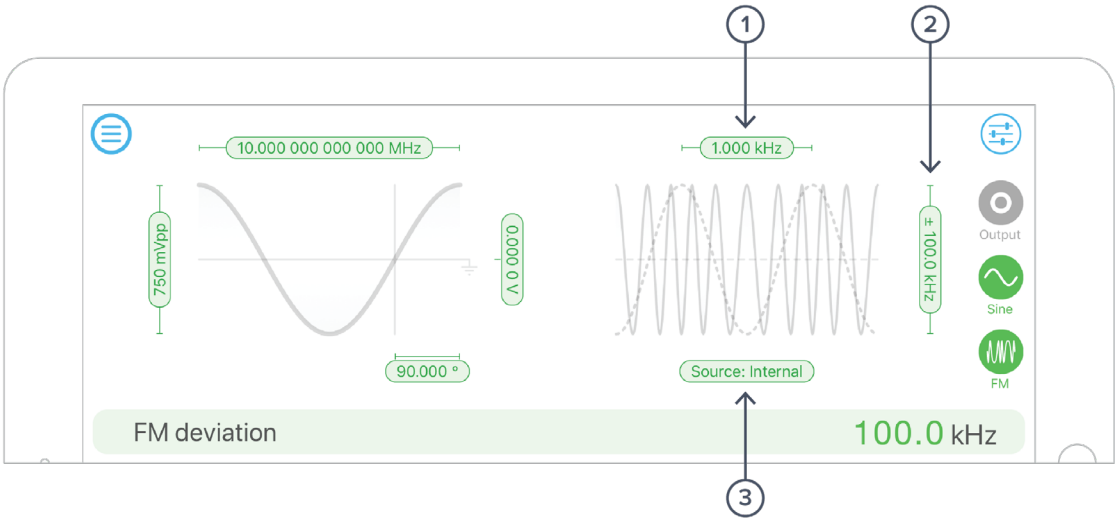
Moku's Waveform Generator supports a variety of modulations. Modulation is available on all waveforms except DC. Ramp waveforms can only be amplitude modulated; but all other waveforms can be Amplitude, Frequency or Phase modulated and can be continuous or triggered in burst or sweep modes.

Amplitude modulation



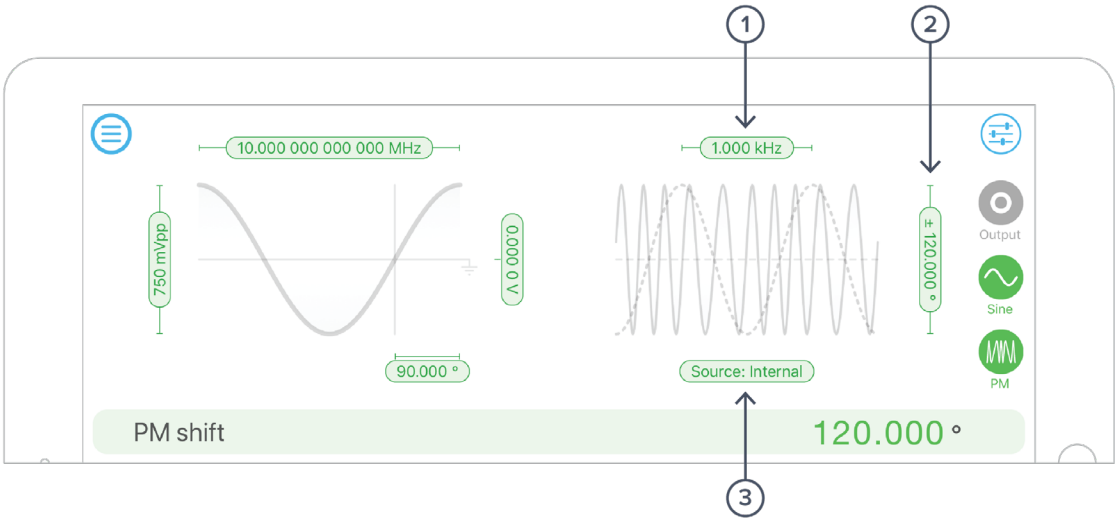
ID	Parameter	Description
1	Frequency	Only for "Internal" modulation; the frequency of the sine wave being used for modulation.
2	AM Depth	Fractional depth of modulation. 100% depth will reduce the signal amplitude to zero for a full-range negative modulation signal
3	Modulation Source	The modulation source can be a Moku input; the other Moku output or a "internal", an internally-generated sinewave.

Frequency modulation



ID	Parameter	Description
1	Frequency	Only for “Internal” modulation; the frequency of the sine wave being used for modulation.
2	FM Deviation	Full-range frequency deviation. A full-range input signal will vary the output frequency by this amount.
3	Modulation Source	The modulation source can be a Moku input; the other Moku output or a “internal”, an internally-generated sinewave.

Phase modulation

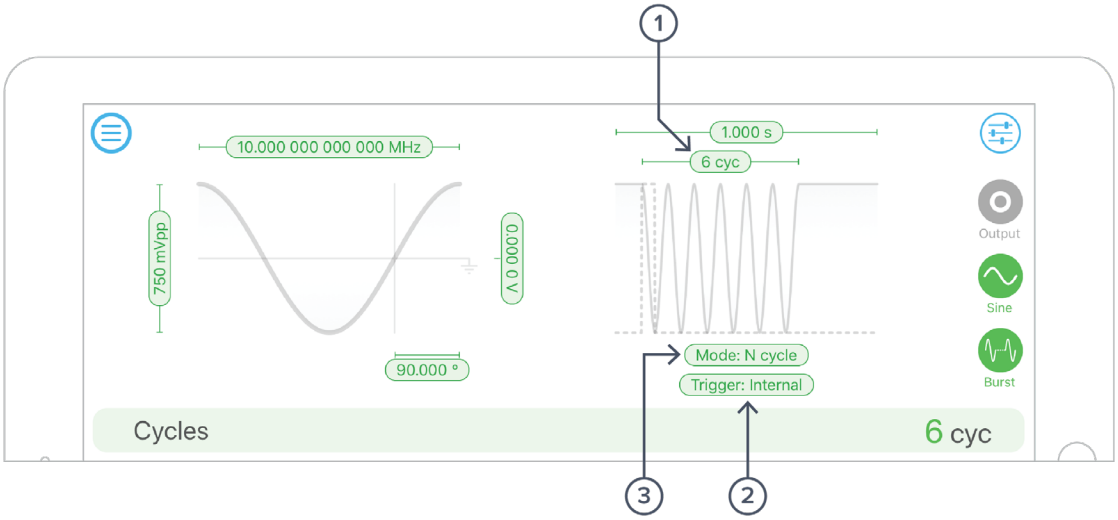


ID	Parameter	Description
1	Frequency	Only for “Internal” modulation; the frequency of the sine wave being used for modulation.
2	Depth	Full-range phase deviation. A full-range input signal will vary the output phase by this amount.
3	Modulation Source	The modulation source can be a Moku input; the other Moku output or a “internal”, an internally-generated sinewave.

Triggered modulation modes

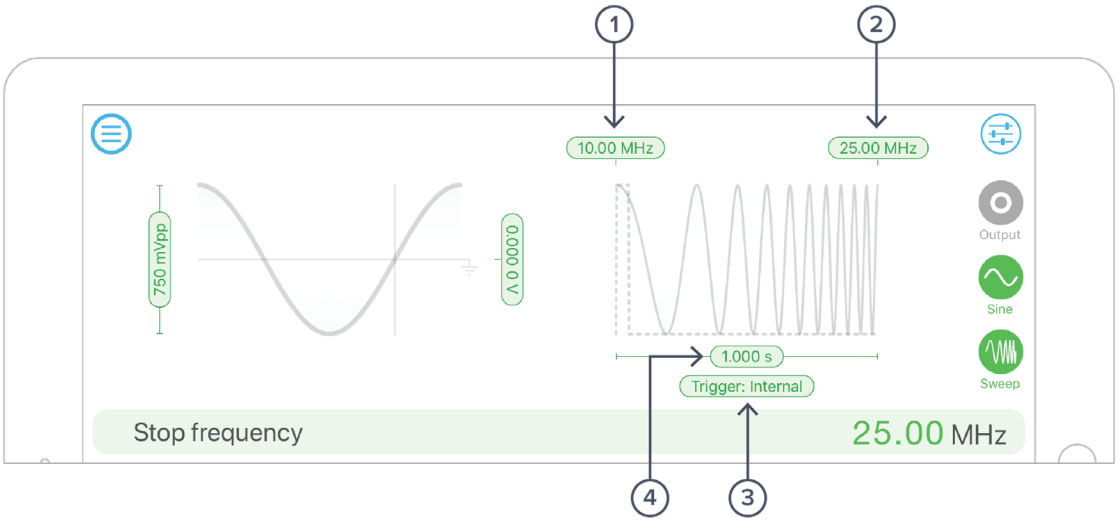
Sine, Square and Pulse waves can be triggered from an external source. The behaviour upon receipt of the trigger signal varies according to mode.

Burst



ID	Parameter	Description
1	Cycle count	N - Cycle mode only. The number of cycles to generate before re-arming.
2	Trigger source	One of: **Internal:** Trigger automatically at the defined rate **External**: Trigger event on from rear-panel external trigger input **Input**: Trigger from associated input channel, at given voltage **Output**: Trigger from opposite output channel, at given voltage
3	Mode	One of: **Gated**: Continue to generate the output signal while ever the trigger event is asserted (level-triggered) **Start**: Begin generation of the waveform on trigger, continue indefinitely. **N Cycle**: Upon receipt of trigger signal, generate this many cycles of the waveform then re-arm.

Sweep



Sweep modulation acts like frequency modulation with a sawtooth, where the sawtooth starts on the trigger event.

ID	Parameter	Description
1	Start Frequency	Waveform frequency at the trigger event (sweep start)
2	End Frequency	Waveform frequency at the sweep end
3	Trigger Source	One of: **Internal:** Trigger automatically at the defined rate **External:** Trigger event on from rear-panel external trigger input **Input:** Trigger from associated input channel, at given voltage **Output:** Trigger from opposite output channel, at given voltage
4	Sweep Time	Time between sweep start and end

Instrument Reference

Waveform Types

The Moku:Lab's waveform generator is programmed to generate one of five different signals, each with optional modulation.

Sine Wave

The Sine wave is the simplest dynamic signal in the Moku. It features extremely low harmonic distortion; it's very close to a pure single frequency.

The Sine wave can be modulated by all available modulation types. Moreover, it forms the basis of the "Internal" selectable modulation source, providing a modulating waveform regardless of whether either channel of the Moku is currently outputting a Sine wave.

Square Wave

The Square wave is a low-jitter waveform with fixed 50% duty cycle and high slew rates. The high analogue bandwidth of the Moku gives very sharp rise and fall times, highly desirable in many applications. If you require slew-rate limits or variable duty cycle in your application, see Pulse Wave below.

Ramp Wave

The Ramp wave consists of linear ramps from low level to high and back again. The ratio between the time spent rising and the overall period is referred to as the symmetry. If you require configurable dwell times at the high or low levels but common rise and fall times, you may use the Pulse Wave with large edge times.

Pulse Wave

The Pulse wave is like the Square wave but has configurable duty cycle and edge times (rise and fall time). The trade-off is that at high frequency, Pulse has slightly worse edge jitter behaviour compared to the Square wave.

DC

Provides a high precision, fixed reference voltage at the output. Note that the outputs are always 50Ω terminated.

Waveform Parameters

Amplitude

Applicable To: Sine, Square, Ramp, Pulse

Amplitude is specified as a Peak-to-Peak value; that is, the high level minus the low level. If you wish to specify the high and low levels explicitly, tap the Amplitude pill then the Toggle Arrows in the parameter bar; or just tap the Amplitude label in the Settings Drawer to toggle between the two representations.

Frequency

Applicable To: Sine, Square, Ramp, Pulse

Specified in Hertz. Can also be represented as period in seconds by tapping the Frequency label in the Settings Drawer, or the Toggle Arrows in the parameter bar.

Offset

Applicable To: Sine, Square, Ramp, Pulse

Average value of the Sine wave over time. The alternative representation of this parameter is Low Level, which combined with High Level also specifies Amplitude.

Phase

Applicable To: Sine, Square, Ramp, Pulse

Defines the phase of the waveform with respect to the Moku's internal reference. By tapping the "Sync Phase" button in the Settings Drawer, this phase also becomes relative to the other output channel.

Symmetry

Applicable To: Ramp

Ratio, in percent, between the time spent on the rising edge and the overall period. In the limit of 0% and 100% symmetry, the ramp wave becomes a sawtooth (zero[1] rise and fall times respectively).

Pulse Width

Applicable To: Pulse

Positive width of the pulse. Any specified Edge Time is split equally between the Pulse Width and the rest of the cycle; that is, duty cycle is preserved when altering Edge Time.

Edge Time

Applicable To: Pulse

Time taken to transition from low level to high and vice-versa. This limits the slew rate of the signal which can be advantageous in some applications. Edge Time is split between high and low time equally, preserving duty cycle.

[1] The minimum rise and fall time of the Moku:Lab is actually 2ns not zero, which means in practice that the output can never achieve exactly 0% or 100% symmetry, even if specified.

DC Level

Applicable To: DC

Fixed voltage to output.

Modulation Types and Trigger Modes

Modulation Sources

Each modulation type can be driven by one of three sources.

Internal

Modulation is driven by an internally-generated sine wave of configurable frequency. The amplitude of this wave is “full range”, in that it will modulate to the depth specified when configuring the modulation type.

Input

Modulation for a given channel is driven by the corresponding analogue input (i.e. Output 1 can only be modulated from Input 1, Output 2 from Input 2). The depth is specified *per volt* on the input.

Output

Modulation for a given channel is driven by the opposite analogue output (i.e. Output 1 is modulated by the waveform on Output 2 and vice-versa). This allows the user to doubly-modulate a signal by modulating a signal on one channel, then using that signal to modulate the opposite channel. This can be useful for example when you wish to generate an “ideal” modulated signal on one channel, but then perturb the phase, frequency or amplitude in order to test a system’s response.

Trigger Sources

Burst and Sweep modes depend on the detection of a trigger event. There are three possible sources for this event.

Internal

The trigger event is generated automatically at a given rate (specified period).

External

A rising edge on the back-panel External Trigger Input is used as the trigger source. For trigger level and precision characteristics, refer to the Moku:Lab Technical Specifications available at www.liquidinstruments.com.

Input

The corresponding Analogue input is monitored for a rising edge past the specified voltage. Output 1 can only be triggered from Input 1; Output 2 from Input 2.

Output

The opposite Analogue output is monitored for a rising edge past the specified voltage. Combined with the fact that that opposite output can in turn be modulated from a variety of sources, this provides extremely flexible control of the trigger period (included for example changing period based on an external voltage).

Amplitude Modulation

Applicable To: Sine, Square, Ramp, Pulse

Amplitude modulation will change the amplitude of the generated signal proportionally to the modulation input. The actual proportion changed is called the modulation depth, the units of which depend on the modulation source (see discussion of sources above).

Frequency Modulation

Applicable To: Sine, Square, Pulse

Frequency modulation will change the frequency of the generated signal proportionally to the modulation input. The change in frequency caused by a given input is called the modulation depth and has units of Hertz or Hertz per Volt depending on the modulation source used.

Phase Modulation

Applicable To: Sine, Square, Pulse

Phase modulation will change the phase of the generated signal proportionally to the modulation input. The change in frequency caused by a given input is called the modulation depth and has units of Degrees or Degrees per Volt depending on the modulation source used.

Burst Mode

Applicable To: Sine, Square, Pulse

In burst mode, a trigger event causes the given output to begin generating its configured waveform. Burst requires you to specify a sub-mode that defines if or when the generation ends.

N-Cycle: The waveform will stop being generated after the specified number of cycles, at which time is will re-arm and become ready to receive a new trigger.

Gated: The waveform will continue to be generated while-ever the trigger signal is high (level-triggered).

Start: The waveform generation begins on a trigger signal but will continue indefinitely.

Sweep Mode

Applicable To: Sine, Square, Pulse

Sweep mode provides a frequency modulation of the input waveform, where the modulation waveform is a ramp wave that begins generation on the detection of a trigger signal. That is, when a trigger is detected, waveform generation will begin at the Start frequency and sweep (or “chirp”) to the End frequency over a given duration.

Sweep mode has three configurable parameters:

Start Frequency: Initial frequency of the output waveform, immediately on detection of a trigger. Note that in sweep mode, the waveform itself cannot have a frequency set independently; its frequency parameters are completely defined by the sweep.

End Frequency: Final frequency of the output waveform, *duration* sections after the trigger has been detected.

Duration: The time taken to sweep from Start to End frequency. Upon completion of the sweep, the sweep circuit will re-arm and be ready to receive a new trigger input.

For further information and latest updates visit

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