



Waveform Generator

Moku:Pro User Manual

Moku:Pro's Waveform Generator is designed to generate common signals with high accuracy and configurability across four 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.





Table of Contents

User Interface.....	4
Main Menu	5
Preferences.....	6
Settings	7
Output Configuration	8
Enable / Disable Outputs	8
Impedance	8
Waveform types	8
Sine Wave	9
Square Wave	10
Ramp Wave	11
Pulse Wave	12
DC wave	12
Modulation types	13
Amplitude modulation	13
Frequency modulation	14
Phase modulation	15
Triggered modulation modes	16
Instrument Reference.....	18
Waveform Types	18
Sine Wave	18
Square Wave	18
Ramp Wave	18
Pulse Wave	18
DC	18
Waveform Parameters	18
Amplitude	18
Frequency	19
Offset	19
Phase	19
Symmetry	19
Pulse Width	19
Edge Time	19
DC Level	20
Modulation Types and Trigger Modes	20
Modulation Sources	20
Trigger Sources	20
Amplitude Modulation	21
Frequency Modulation	21
Phase Modulation	21
Burst Mode	21
Sweep Mode	21



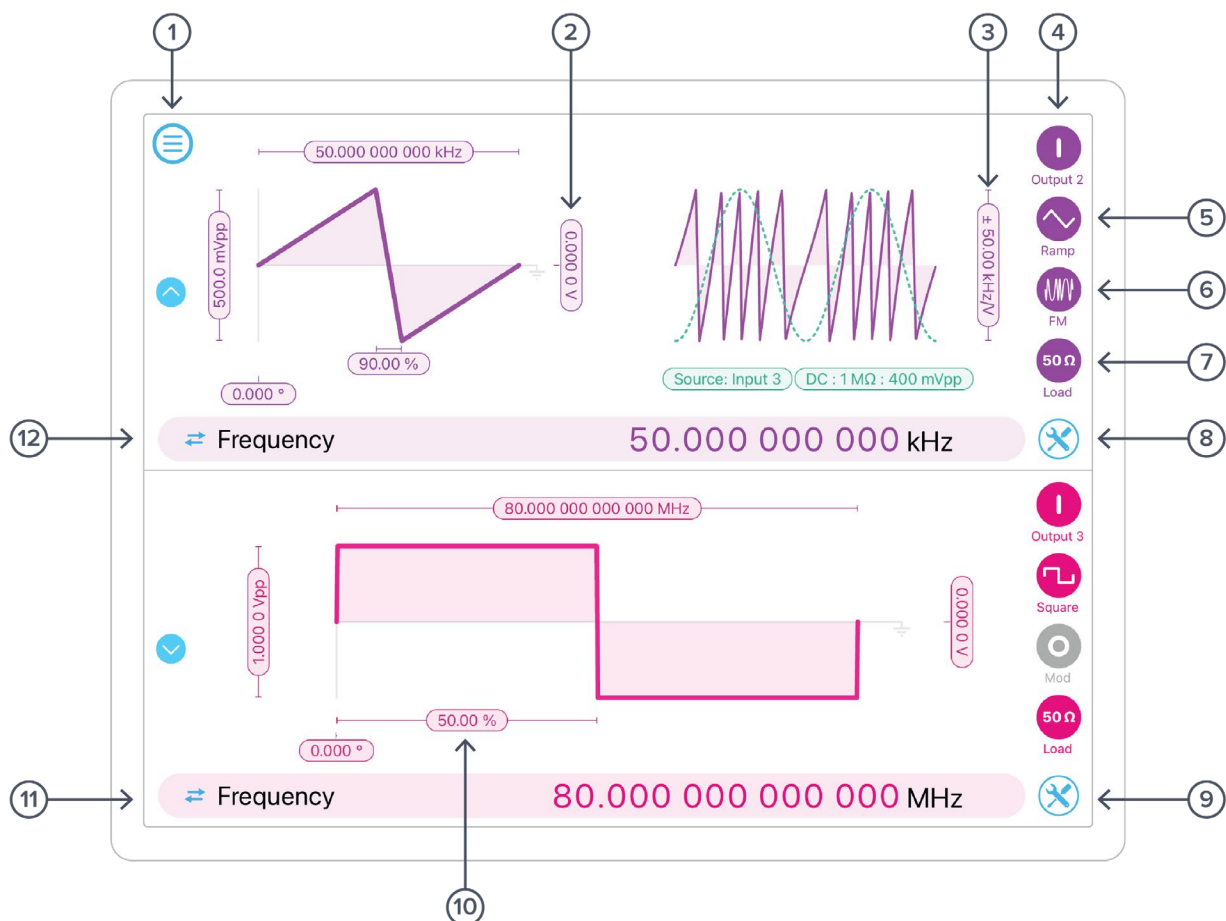
Ensure Moku:Pro is fully updated. For the latest information:

www.liquidinstruments.com



User Interface

Moku:Pro is equipped with four outputs channels. You can tap the or icons to navigate between channels.



ID	Description	ID	Description
1	Main menu	7	Configure output load (50 Ω or 1 MΩ)
2	Configure offset	8	Settings (Ch 2)
3	Configure modulation depth	9	Settings (Ch 3)
4	Enable / disable output	10	Configure square duty cycle
5	Waveform shape	11	Switch between frequency and period
6	Configure modulation	12	Switch between frequency and period



Main Menu

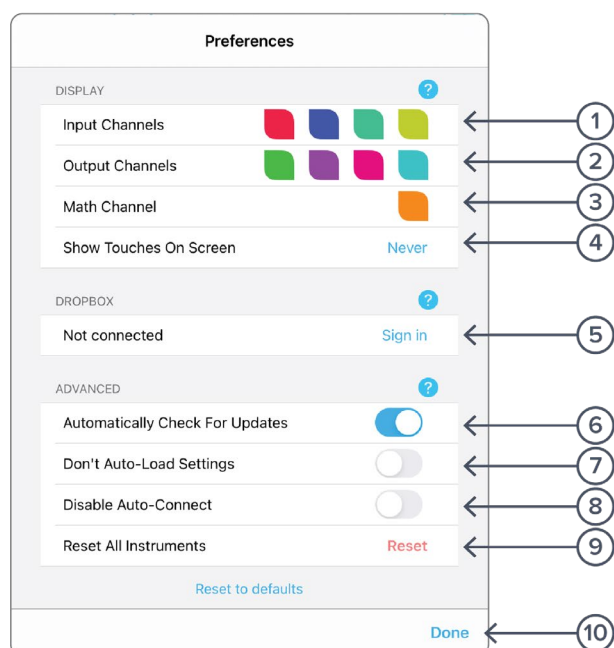
The main menu can be accessed by pressing the  icon, allowing you to:





Preferences

The preferences pane can be accessed via the main menu. In here, you can reassign the color representations for each channel, connect to Dropbox, etc. Throughout the manual, the default colors (shown in the figure below) are used to present instrument features.




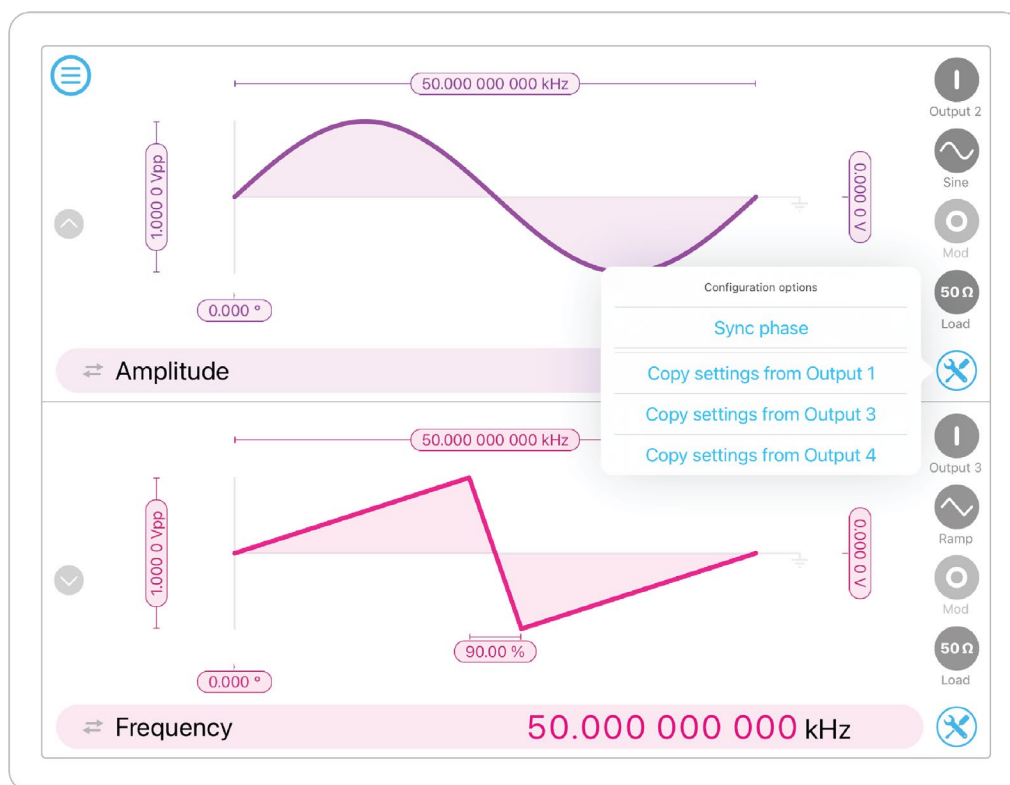
ID Description

1	Tap to change the color associated with input channels.
2	Tap to change the color associated with output channels.
3	Tap to change the color associated with math channel.
4	Indicate touch points on the screen with circles. This can be useful for demonstrations.
5	Change the currently linked Dropbox account to which data can be uploaded.
6	Notify when a new version of the app is available.
7	Moku:Pro automatically saves instrument settings when exiting the app, and restores them again at launch. When disabled, all settings will be reset to defaults on launch.
8	Moku:Pro can remember the last used instrument and automatically reconnect to it at launch. When disabled, you will need to manually connect every time.
9	Reset all instruments to their default state.
10	Save and apply settings.



Settings

The settings menu can be accessed by tapping the  icon, allowing the settings on other channels to be instantly applied to channel this channel. The output phase can be synced by tapping [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

Impedance

Moku:Pro's outputs have an impedance of $50\ \Omega$. As such, voltages supplied to a $50\ \Omega$ load will be reduced by a factor of two due to the voltage divider formed by the closed circuit. Changing the load impedance on the user interface does not affect the actual output voltage. Instead, it scales the voltage displayed on the screen corresponding to the output load.

Waveform types

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



Sine



Square



Ramp



Pulse



DC

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

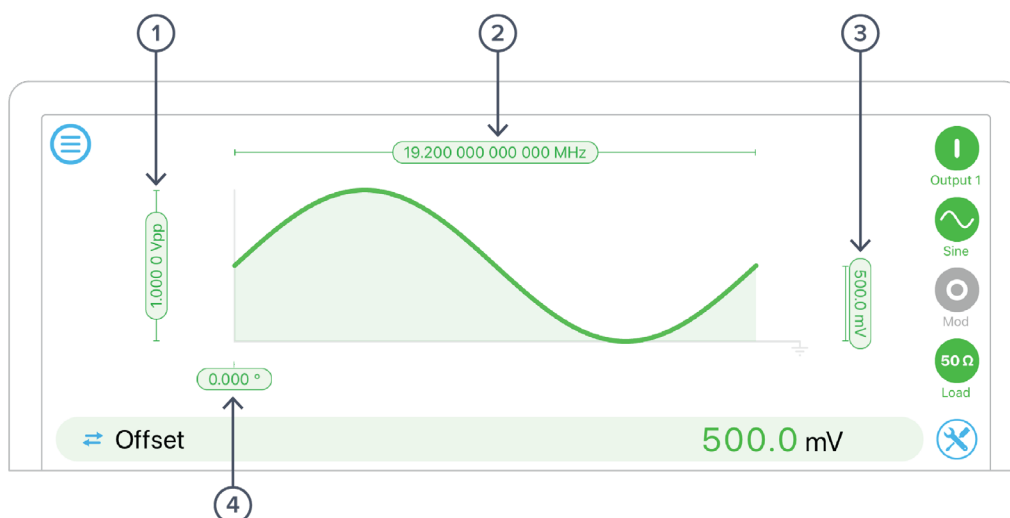
The Square wave is low jitter and symmetric (50% duty cycle by default)

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

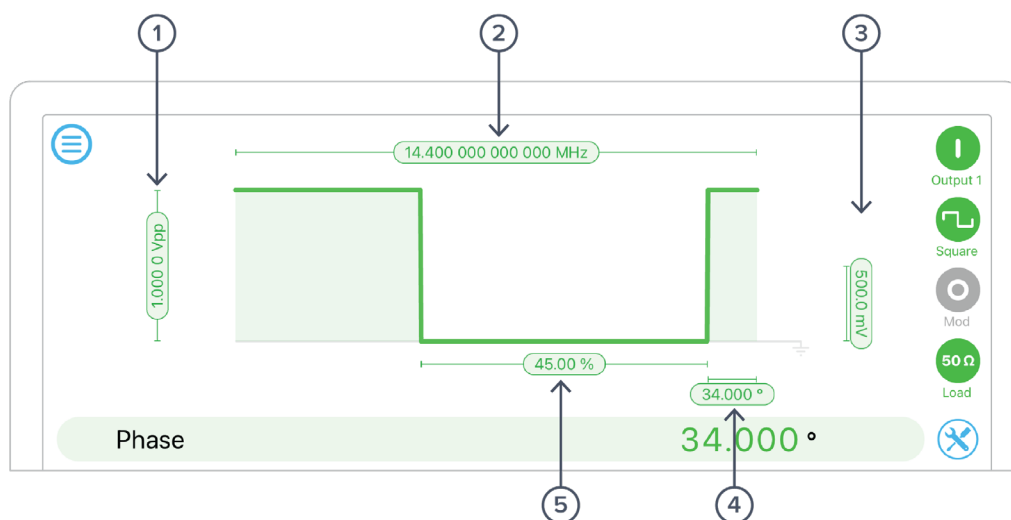


ID	Description	ID	Description
1	Amplitude (High Level)	3	Offset (Low Level)
2	Signal Frequency (Period)	4	Phase

Tap Parameter Settings pill or bar to change. Parameter bar can show different representations of many parameters; these alternative representations are shown in brackets and revealed in the UI by tapping the 'left right' icon.



Square Wave

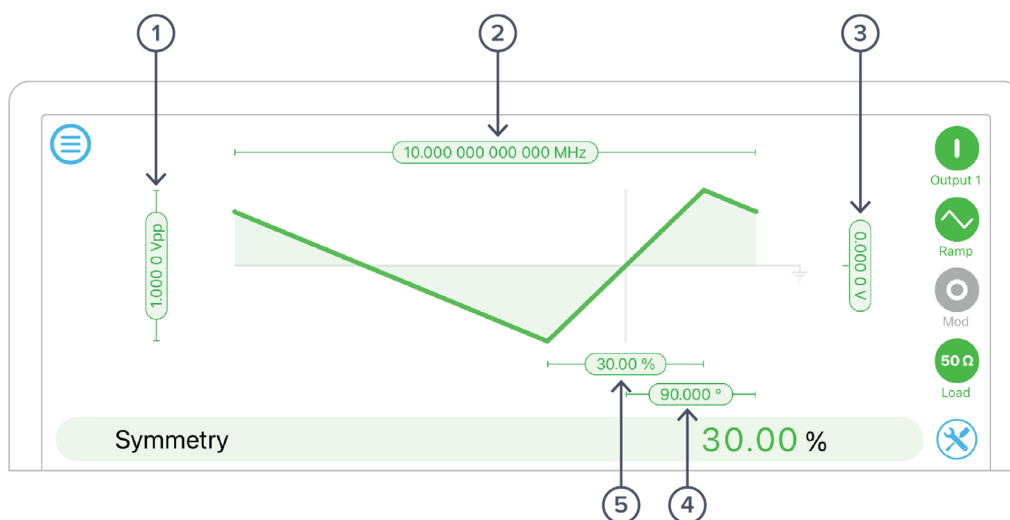


ID	Description	ID	Description
1	Amplitude (High Level)	4	Phase
2	Signal Frequency (Period)	5	Duty Cycle
3	Offset (Low Level)		

Tap Parameter Settings pill or bar to change. Parameter bar can show different representations of many parameters; these alternative representations are shown in brackets and revealed in the UI by tapping the 'left right' icon.



Ramp Wave

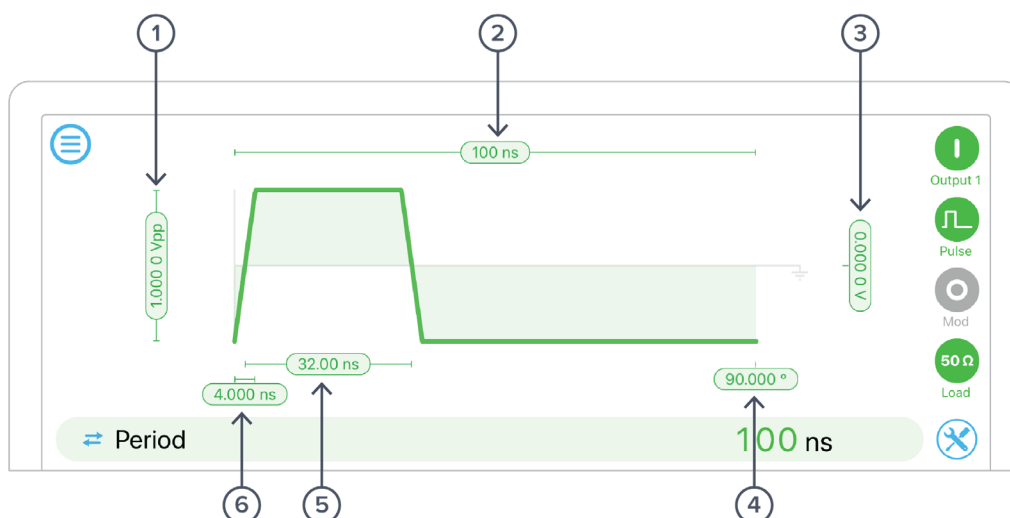


ID	Description	ID	Description
1	Amplitude (High Level)	4	Phase
2	Signal Frequency (Period)	5	Symmetry
3	Offset (Low Level)		

Tap Parameter Settings pill or bar to change. Parameter bar can show different representations of many parameters; these alternative representations are shown in brackets and revealed in the UI by tapping the 'left right' icon.



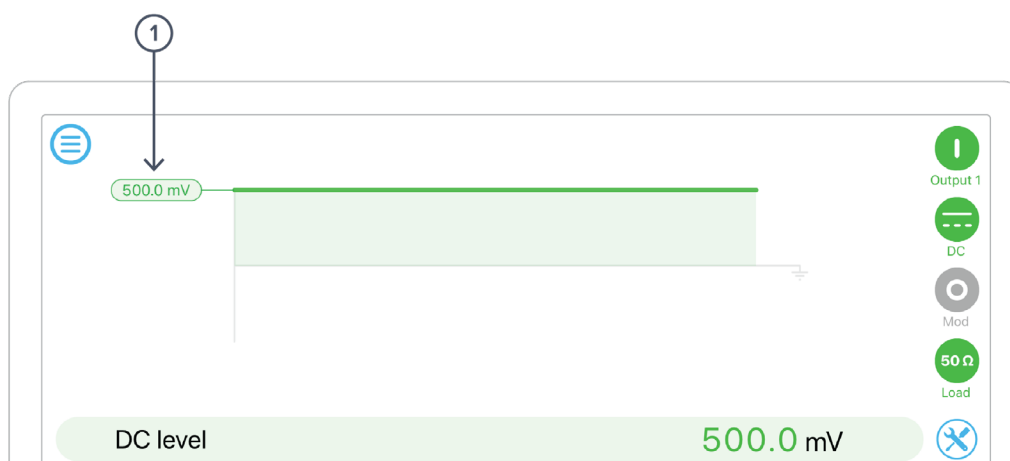
Pulse Wave



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 and revealed in the UI by tapping the 'left right' icon.

DC wave



ID	Description
1	DC level

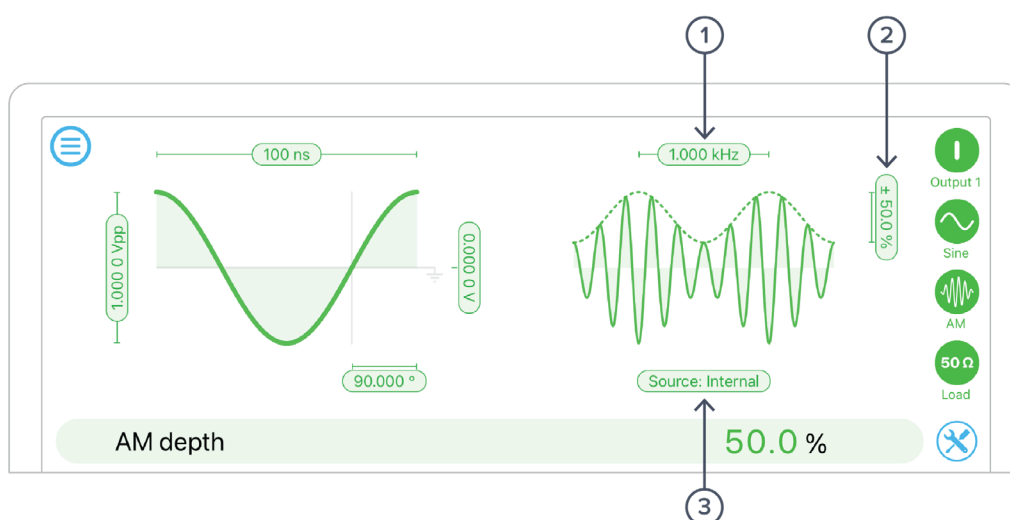
Tap Parameter Settings pill or bar to change.



Modulation types

Moku:Pro'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.

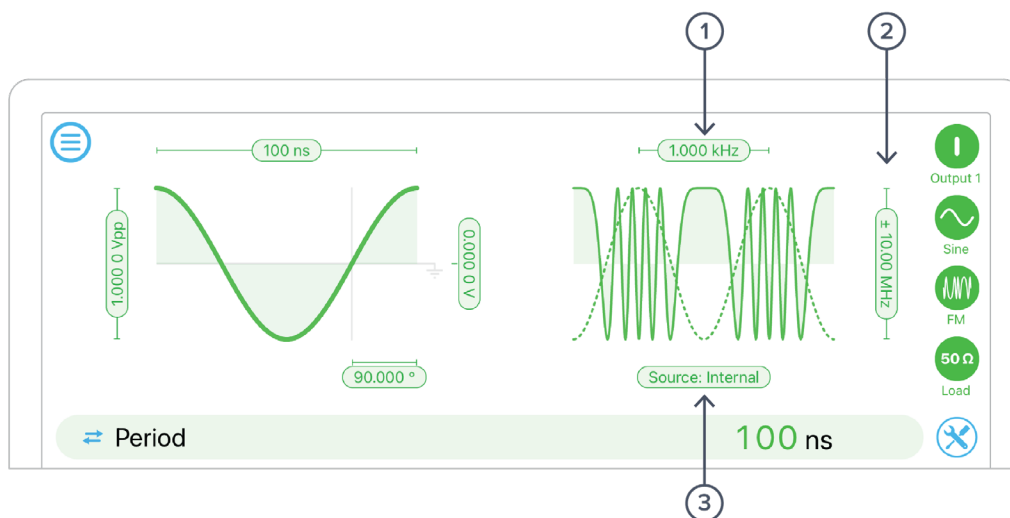
Amplitude modulation



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:Pro input; the another Moku:Pro output or “internal”, an internally-generated sinewave.



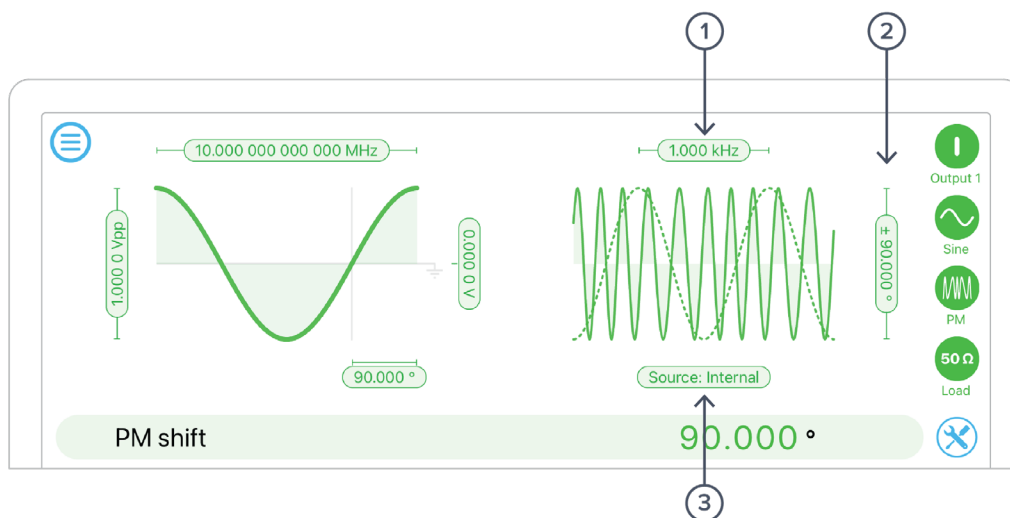
Frequency modulation



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:Pro input; the another Moku:Pro output or “internal”, an internally-generated sinewave.



Phase modulation



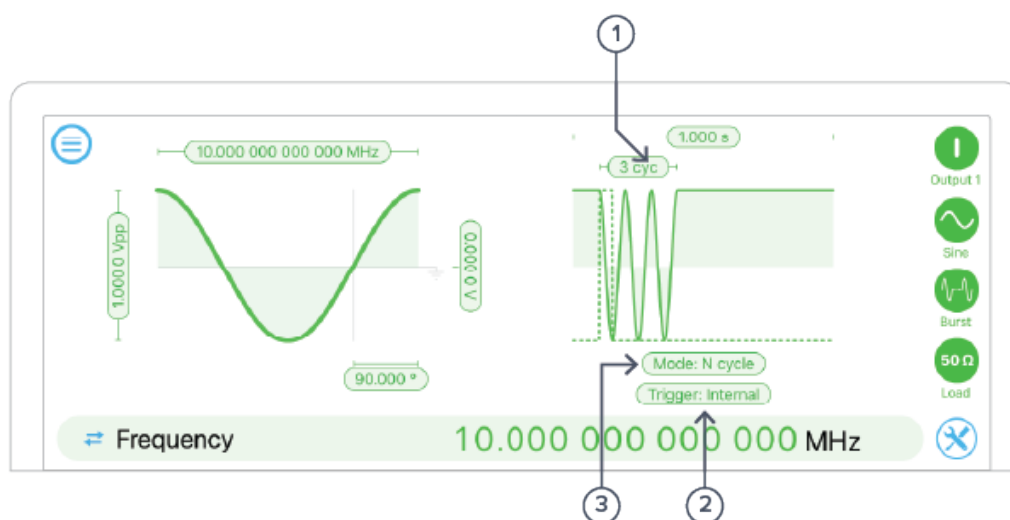
ID	Parameter	Description
1	Frequency	Only for “Internal” modulation; the frequency of the sine wave being used for modulation.
2	Depth	Full-range phase deviation. A full-range input signal will vary the output phase by this amount.
3	Modulation Source	The modulation source can be a Moku:Pro input; the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

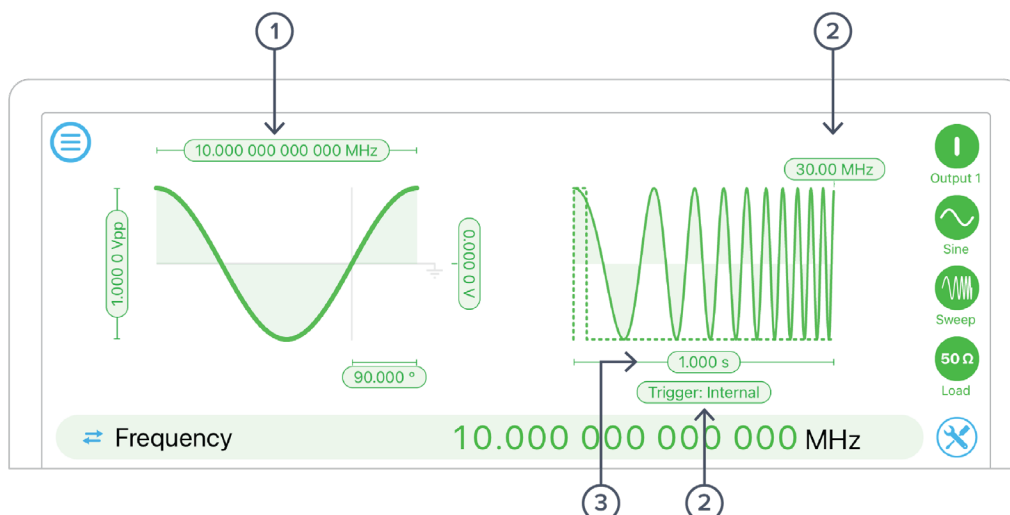
Burst



ID	Parameter	Description
1	Cycle count	N - Cycle mode only. The number of cycles to generate.
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 another 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 another output channel, at given voltage
4	Sweep Time	Time between sweep start and end



Instrument Reference

Waveform Types

The Moku:Pro'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:Pro. 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 any channel of the Moku:Pro 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:Pro 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 50 Ω 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:Pro's internal reference. By tapping the "Sync Phase" button in the Settings Drawer, this phase also becomes relative to another 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 (zero¹ 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:Pro 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, Output 3 from Input 3, Output 4 from Input 4). The depth is specified *per volt* on the input.

Output

Modulation for a given channel is driven by the another analog output (i.e. Output 1 is modulated by the waveform on Output 3). 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:Pro Technical Specifications available at www.liquidinstruments.com.

Input

The corresponding analog 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 3 from Input 3, Output 4 from Input 4.



Output

The other analog outputs are 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 it 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.



Ensure Moku:Pro is fully updated. For the latest information:

www.liquidinstruments.com