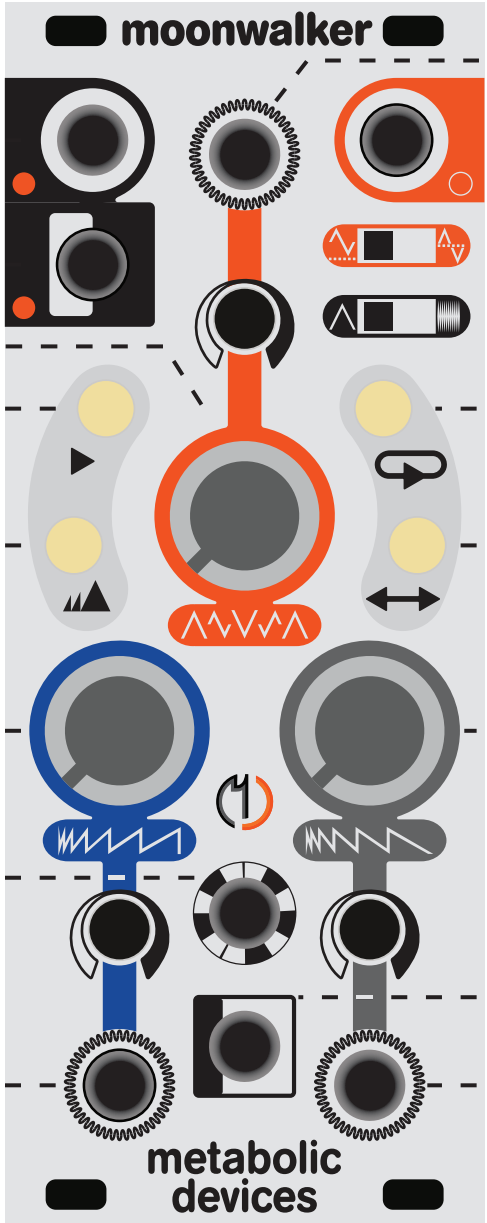
metabolic devices



reference waveform out

not decay out

360° phase offset

manual trigger

hard sync / retrigger

attack time

v/oct input

attack cv input w/ attenuverter

cv input with attenuverter / skew control

phase offset waveform out

phase offset bias mode

low / mid / audio

cycle

reverse / alternate attack & decay

decay time

trigger / hard sync / inhibit input

decay cv input w/ attenuverter

phase variable attack / decay generator

Figure 1a shows how phase offset affects the phase offset output in unipolar and bipolar modes, as well as the reference waveform output

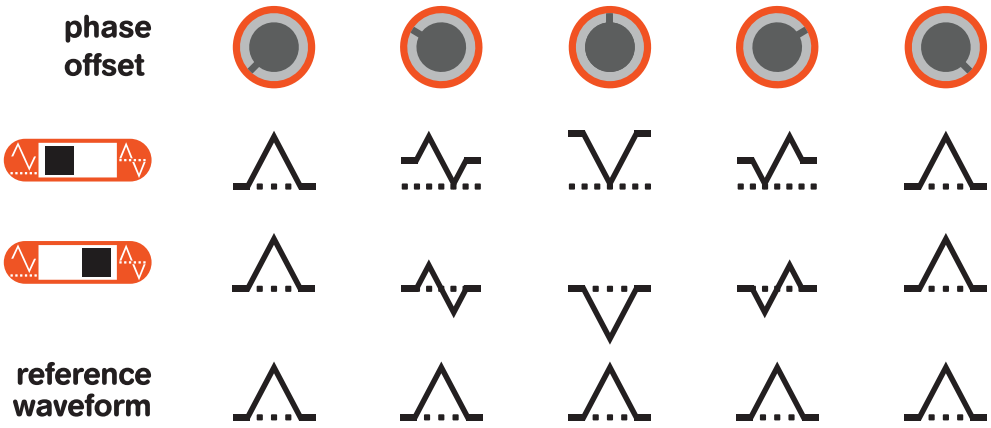


Figure 1b shows how phase offset affects the outputs when attack and decay rates are not equal.

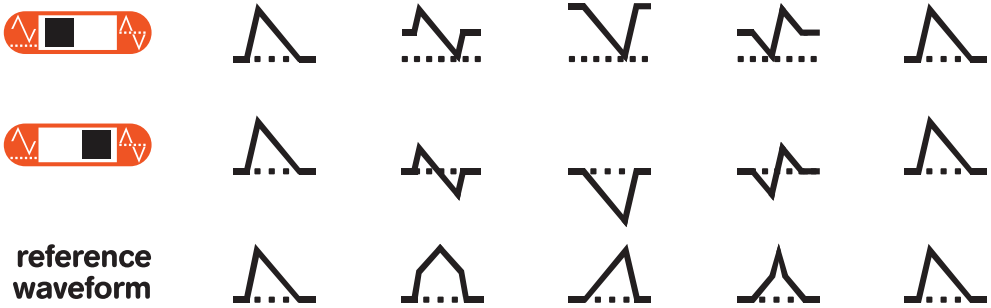


Figure 2 shows how inhibit affects the output

metabolic devices

Moonwalker is an extremely flexible signal generator that can act as an envelope generator, LFO, or audio oscillator. Perhaps the most uniquely defining characteristic of Moonwalker is the Phase Offset parameter which moves the start and end of the waveform to any point in the cycle. There are however a number of other unique features that set it apart.

This manual starts by covering the basics of how to use Moonwalker in the 3 most common configurations. We'll then dive in to Phase Offset, explaining what it does and how to use it. Finally we'll discuss some advanced use cases that really exploit the feature set.

For the purposes of these sections Phase Offset will not be discussed and as such the output can be taken from either the Phase Offset or the Reference outputs without any notable difference. Be aware that once phase offset has been adjusted to anything other than null, the outputs are not the same. The differences will be discussed in detail later in the section on phase offset.

Moonwalker as an envelope:

When Moonwalker is first turned on it is in one-shot mode as used when generating envelopes, so let's start here. For envelopes, set mid or low frequency range active, Phase Offset output mode to unipolar, and plug a trigger source into the trigger input. Start with the phase offset at minimum and it's cv attenuverter to 12:00, patch the phase offset output to the destination of choice, and set attack and decay times to taste.

NOTE: it is very important to null the phase offset cv attenuverter even if nothing is plugged into it! There is a powerful feature here that can lead to confusing behavior during the learning process. When in doubt, plug a cable into the cv input jack with the other end floating or grounded (0v). We'll discuss this feature in detail later.

Use the Attack knob to set how long it takes to go from 0v to 10v. A positive voltage at the Attack cv input will increase the attack time, while a negative voltage will decrease it. The amount of modulation can be attenuated or attenuated & inverted using the cv attenuverter.

Use the **Decay** knob to set how long it takes to go from 10v to 0v. A positive voltage at the Decay cv input will increase the decay time, while a negative voltage will decrease it. The amount of modulation can be attenuated or attenuated & inverted using the cv attenuverter.

Plug a trigger source into the **Trigger Input** on Moonwalker, or if you don't have a trigger source ready you can use the Manual button on Moonwalker to trigger it. Once it has been triggered, Moonwalker will ignore additional triggers until it completes it's cycle. This can be very handy for deriving slow moving events from a master clock and works like a clock divider based on absolute time rather than number of clock pulses.

If the **Retrigger** button is enabled Moonwalker will react to all incoming triggers, resetting the envelope to the starting amplitude each time a trigger is received. Enable this when you want Moonwalker to be more active, and to cut off longer notes when a new note happens before the old one is finished.

The **Volt Per Octave** input can be used to modulate both attack and decay at the same time and change the overall frequency. A typical patch would take the v/oct that drives the vco here, so that higher pitches have shorter envelopes while lower notes are longer.

The **Reverse / Alternate Attack & Decay** button provides a handy way to audition how an envelope would sound with the attack and decay times swapped. When the led is on, the Attack controls are now assigned to Decay, and the Decay controls are now assigned to Attack. When alternating, Moonwalker will generate the envelope with Attack & Decay rates as normal, and then swap them when the next trigger is received. They are returned to normal on the next trigger, and the pattern continues to alternate between normal and swapped as long as this mode is enabled. A short button press enables reverse, and a long press enables the alternating mode. Button presses take effect on the next trigger so as not to interrupt playback.

The **Not Decay** output goes to +5v when Moonwalker is not in the decay segment of the Reference Output. This includes the time when Moon-

walker is inactive, so it goes high after decay is finished and stays high during steady state and until attack is finished. It is at 0v during decay. It can be used as a logic source to enable effects or routing during only a portion of the event. It can also be used to chain multiple Moonwalkers to create very complex envelopes.

Moonwalker as an LFO:

Tap the Cycle button to use Moonwalker as a low frequency oscillator.

Use the Attack knob to set how long it takes to go from 0v to 10v. A positive voltage at the Attack cv input will increase the attack time, while a negative voltage will decrease it. The amount of modulation can be attenuated or attenuated & inverted using the cv attenuverter.

Use the Decay knob to set how long it takes to go from 10v to 0v. A positive voltage at the Decay cv input will increase the decay time, while a negative voltage will decrease it. The amount of modulation can be attenuated or attenuated & inverted using the cv attenuverter.

The Volt Per Octave input can be used to modulate both attack and decay at the same time and change the overall frequency. The response here is inverted to that of the attack and decay inputs, meaning that a positive voltage will increase the frequency while a negative voltage will decrease it.

Just as in envelope mode, a trigger in the Trigger input with Retrigger enabled will reset Moonwalker to the beginning amplitude. This allows Moonwalker to be synchronized with an external clock regardless of the frequency it's running at. A slower clock that syncs Moonwalker every bar or two can be a cool way to give some form to an LFO that is at a different tempo than the clock. Synchronizing it every bar or two creates a recognizable pattern out of what would otherwise be an unrelated free running LFO.

Without Retrigger enabled, the Trigger Input now pays attention to how long the input is held high. A gate in the trigger input will Inhibit the LFO as long as the pulse is high. Inhibit drives the waveform in a direction and at a rate determined by the attack / decay rates.

The **Manual Trigger** button can be used to activate **Inhibit** when a trigger source is not available.

In the top part of the Attack / Decay range, the **Inhibit** rate is relatively fast and moves towards 0v where it will hold until the inhibit pulse goes low. In the middle of the range it will move very slowly in either direction and will look like plateaus in the waveform. In the lower part of the range it will move towards 10v and the effect is lessened because we are already at the end of the range.

Activating **Inhibit** is a great way to add complexity and interest to a repeating LFO. To get stepped waveforms, drive inhibit with the pulse out from another LFO and set it's width to very wide. Set the Moonwalker frequency fairly fast, but set the other LFO 3 or 4 times faster. Sync the other LFO using the Not Decay out from Moonwalker to get a consistent number of steps for every cycle and start them at the same time. If you modulate the frequency of both LFO's using their v/oct inputs, the number of pulses per cycle stays consistent.

The **Reverse / Alternate Attack & Decay** button provides a handy way to audition how an LFO would sound with the attack and decay times swapped. When the led is on, the Attack controls are now assigned to Decay, and the Decay controls are now assigned to Attack. When alternating, Moonwalker will generate the envelope with Attack & Decay times as normal, and then swap them on the next cycle. They are returned to normal on the next cycle, and the pattern continues to alternate between normal and swapped as long as this mode is enabled. As a free running LFO, alternating mode effectively makes Attack & Decay frequency controls for two consecutive waveforms. A short button press enables reverse, and a long press enables the alternating mode. Button presses take effect on the next trigger so as not to interrupt playback.

The **Not Decay Output** is the pulse wave output of Moonwalker so it provides a hard edge switching LFO signal rather than the sloped LFO available at the Reference and Phase Offset outputs. It goes to +5v when Moonwalker is in the attack segment of the Reference Output and to 0v during decay.

Moonwalker as an Audio VCO:

If we now switch our frequency range to audio, Moonwalker is ready to be used as an audio source.

The Attack and Decay knob range is limited from about 750Hz to 20Hz to provide increased resolution for tuning, in light of the absence of a fine tune control. Moonwalker can still generate frequencies across the entire audio range, however it must be driven through the volt per octave input.

Set the frequency and shape of the waveform using the Attack and Decay controls. Modulation of Attack and Decay work just like in the other modes, however modulation of the Volt Per Octave input should be used by those concerned with staying in tune. A positive voltage at the volt per octave input will increase the frequency while a negative voltage will decrease it.

Moonwalker tracks pitch accurately from roughly 5kHz to 15Hz.

A trigger in the Trigger Input with Hard Sync enabled will reset Moonwalker to the beginning amplitude. Syncing Moonwalker to another VCO in this way can create additional harmonics for a brighter sound. Be sure and patch the volt per octave to both modules if you want to keep the shape and amplitude the same for different frequencies.

With Hard Sync disabled, the Trigger Input now becomes a gate input that carves into the waveform for added harmonic complexity. A pulse in the Trigger Input will Inhibit Moonwalker as long as the pulse is high. Inhibit will drive the waveform in a direction and at a rate determined by Moonwalker's frequency.

In the top part of the frequency range, the inhibit rate is relatively fast and moves towards 0v like a reversal in direction. In the middle of the frequency range it will move very slow in either direction and will look like plateaus in the waveform. In the lower part of the range it will move towards 10v and the effect is lessened because we are already at the end of the range. Experimentation with the relative frequency and pulse width of the pulse source is encouraged.

To get stepped waveforms, drive inhibit with the pulse out from another VCO. Set it's width to very wide and the frequency several times faster than Moonwalker. Plug the pulse out from Moonwalker to the sync input on the other VCO to get a consistent number of steps for every cycle and start them at the same time. Be sure to patch the volt per octave control signal to both modules in order to keep a consistent tone.

The **Reverse Attack & Decay** button won't have much of an effect at audio rate, but enabling the **Alternating mode** will drop the frequency by an octave, so long as Attack and Decay are not equal.

A short button press enables reverse, and a long press enables the alternating mode. At audio rate it is unfortunately difficult to visually detect which mode we are in. The only way to know for sure is to press the button. Button presses are quantized to the reset of the waveform so switching octaves will not generate any unpleasant transients, and can be used in a performative way.

The **Not Decay Output** is the pulse wave output of Moonwalker so it provides a pulse wave audio signal rather than the sloped signal available at the Reference and Phase Offset outputs. It goes to +5v when Moonwalker is in the attack segment of the Reference Output and to 0v during decay. Pulse width modulation inherently changes the frequency, but PWM without changing the frequency is possible using Phase Offset and is discussed in a later section.

Phase Offset:

Now that we're familar with how to set up Moonwalker in the most common ways, let's take a closer look at the Phase Offset parameter. Phase defines where in the cycle the envelope / oscillator starts and ends, or more specifically it defines the start / end amplitude and direction of travel.

Imagine our waveform is sitting on a table exactly it's size. We are going to push the waveform over the edge of the table and as soon as any molecule passes the edge of the table, it is instantly transported to the beginning of the table.

Moonwalker can invert the polarity of the modulation in this fashion, but also offers the ability to invert the shape while keeping the voltage range the same.

When driving a VCA, Moonwalker can transform from a normal VCA response to a ducking VCA response. When driving a Panner, Moonwalker maintains the full range of panning modulation regardless of the initial pan position which can change at any time. These are just two of the countless applications where adjusting the Phase Offset opens up new avenues of exploration.

In the sections that follow, we'll discuss in detail how the Phase Offset works, philosophy on how to apply it effectively, as well as some patch ideas and advanced techniques.

Moonwalker has two sloped outputs. The Phase Offset Output generates a signal whose phase can be continuously offset from 0° to 360° and this is where the action is most of the time. The Reference Output doesn't change phase but provides a "normal" signal to which the phase offset signal can be compared. Well, almost normal. We want our reference signal to always move at the same rate as our offset signal, so it changes from attack to decay rate at the same time as the phase offset signal. This brings it's own unique action which we'll cover later.

Below are descriptions of Moonwalker's outputs at a few different settings. A visual depiction of this can be seen in Figure 1a/1b.

The Phase Offset Output in Unipolar Mode always outputs a signal between 0v and 10v but the start / end amplitude, and direction change.

> **If we set phase to 0° (7:00) or 360° (5:00) the phase offset output will be sitting at 0v. When triggered, the phase offset envelope will rise to 10v at attack rate, and fall to 0v at decay rate just like a normal envelope.**
>
> **If we set phase to 90° (9:30) the phase offset output will now be sitting at 5v. When triggered, the phase offset envelope will rise to 10v at attack rate, fall to 0v at decay rate, and go back up to 5v at attack rate.**

If we set phase to 180° (12:00) the phase offset output will now be sitting at 10v. When triggered, the phase offset envelope will fall to 0v at decay rate, and go back up to 10v at attack rate.

If we set phase to 270° (2:30) the phase offset output will now be sitting at 5v. When triggered, the phase offset envelope will fall to 0v at decay rate, rise to 10v at attack rate, and go back down to 5v at decay rate.

The Phase Offset Output in Bipolar Mode outputs a 10v peak to peak signal between -10v and +10v. The phase is offset just like in unipolar mode but the start / end- amplitude changes that come with phase changes are nulled so we always start and end at 0v.

If we set phase to 0° (7:00) or 360° (5:00) the phase offset output will be sitting at 0v. When triggered, the phase offset envelope will rise to 10v at attack rate and fall to 0v at decay rate just like a normal envelope.

If we set phase to 90° (9:30) the phase offset output will rise from 0v to 5v at attack rate, then fall from 5v to -5v at decay rate, then back up to 0v at attack rate.

If we set phase to 180° (12:00) tthe phase offset output will fall from 0v to -10v at the decay rate, and rise from -10v to 0v at the attack rate.

If we set phase to 270° (2:30) the phase offset output will fall from 0v to -5v at the decay rate, then from -5v to +5v at attack rate, and back down to 0v at decay rate.

The Reference Output always starts at 0v, rises to 10v, and falls back to 0v, but it follows the Attack / Decay rate changes of the Phase Offset Output to ensure it's modulation is perfectly synchronous with the Phase Offset Output.

If we set phase to 0° (7:00) or 360° (5:00) the reference output will rise from 0v to 10v at the attack rate, and fall from 10v to 0v at the decay rate, just like a normal envelope.

If we set phase to 90° (9:30) the reference output will rise from 0v to 5v at the attack rate, then from 5v to 10v and back down to 5v at decay rate, and 5v to 0v at attack rate.

If we set phase to 180° (12:00) the reference output will rise from 0v to 10v at the decay rate, and fall from 10v to 0v at the attack rate.

If we set phase to 270° (2:30) the reference output will rise from 0v to 5v at the decay rate, then from 5v to 10v and back down to 5v at attack rate, and 5v to 0v at decay rate.

Working with Phase Offset

Moonwalker has two different modes for the Phase Offset output. The Unipolar Mode is designed to offset the phase while maintaining the same voltage range on the output. The Bipolar Mode is the opposite where any phase offset brings with it an offset of the voltage range, however we always start from 0v.

A fun way to use Bipolar Mode is with a normal, fully off VCA. We start with the Phase Offset at 180° so the envelope is outputting from 0v to -10v to 0v and our VCA stays fully closed. With a sequence triggering Moonwalker, we slowly decrease the phase offset towards 0° and we get little hints of each note as the peak of our waveform starts to peek above 0v, briefly opening the VCA a little. As the Phase shifts towards 0°, more of the note is revealed until the entire envelope is above 0v giving us a normal full note.

This transform is somewhat similar to adjusting the bias of our envelope, except that when only changing the bias, the peak of the waveform is always at the same point in time. As it first peeks above 0v it is delayed from the beginning of the note. For example if we are generating a triangle envelope, we will first start to hear the note in the middle of the note as opposed to the beginning.

With Moonwalker, the note reveal will always start with the trigger…unless we offset the phase in the other direction. If we restart our example above with 180° phase offset but this time we move towards 360°, the note begins to reveal itself from the end of the envelope.

There is a lot of fun subtlety and rhythmic interplay that can occur with these kinds of reveals!

Phase is a relative attribute, so it is a good idea to establish a reference to which the offset signal can be compared, especially in Unipolar Mode. Adjusting the phase of our signal is like rotating a loop to set where the start / end point is. If we repeatedly play the loop with a brief pause between each playback, we can clearly hear how it changes. If it is infinitely looped and we adjust the loop point without syncing it to something, the adjusted loop point can't be heard.

Establishing a reference for an envelope

When using Moonwalker as an envelope, leaving off-time in between modulation events (notes) establishes the reference point from which the modulation begins. After each envelope you can hear the starting amplitude as a static value for a moment. The starting amplitude and (eventually) initial direction change as the phase is offset.

Adjusting the phase offset can really change the dynamics of a sequence without changing the overall timing of the event.

> **Create a bass sound with some nice harmonics and run that through a nice low pass filter without using a VCA.**
>
> **Set the cutoff frequency of the filter low enough that we can't hear anything.**
>
> **Now use Moonwalker to modulate the filter cutoff frequency, setting the envelope shape and triggering it so that we have off-time in between some notes.**
>
> **As the sequence plays back adjust the Phase Offset and you can hear how the dynamics change. If we start at 360° and adjust to 20° our filter is now normally open a little bit creating a subtle bed of sound that briefly cuts off when the envelope is triggered, then a still mostly normal envelope plays back.**
>
> **Continue adjusting the phase across the full range or leave it alone when you find the sweet spot.**

Establishing a reference for an LFO

When using Moonwalker as an LFO we cannot establish a reference using off-time between events because we are generating constant signal. So let's look at another method using the Reference output

waveform to separately modulate a second parameter where the phase does not change.

By establishing a modulation pattern that is synchronous with the phase offset pattern, the listener will more easily be able to recognize the effect of the phase offset as it changes.

A good example is to use Moonwalker to modulate the pan position of two sounds, or two layers of one sound over the course of a phrase:

Plug a sound source with both low frequency and high frequency content into a filter that has both low pass and high pass outputs, and set the cutoff frequency to separate the harmonic content. A crossover filter is ideal for this.

Plug the low pass and high pass outputs into separate channels on a stereo mixer and pan both channels hard left.

Plug the Reference output to the pan cv input on channel one, and the Phase Offset output to the pan cv input on channel two.

Adjust the frequency so that one cycle modulates the pan position over the course of one phrase.

Start with the Phase Offset at 0° so both channels are panning in unison, and over several repetitions of the phrase, modulate the Phase Offset from 0° to 360°. As the Phase is offset, the start position of one sound will be further right from the other so that at 180° they will be starting on opposite sides of the sound field. As we continue on towards 360° the start points begin to get closer again, however the initial direction of movement is opposite. Once we reach 360° the sounds will be moving in unison again.

Establishing a reference with external cues

A reference can also be established using a rhythmic pattern or singular event at the beginning of each cycle.

Play a drum pattern that triggers a slow moonwalker envelope that modulates a filter on the drums.

Set Attack so the modulation peaks at beat 2 of bar 2 and decays until the end of bar 2.

Adjusting the phase offset allows the user to time align the peak and trough of the envelope to any point in the loop, emphasizing different elements of the drum loop while de-emphasizing others…without changing the rate or overall time of the envelope.

The envelope is varied while maintaining a constant amount of change. Other methods of variation typically adjust the overall amplitude resulting in more or less change in the same amount of time, or the length of an envelope segment resulting in a longer event.

Since the Not Decay output goes high at the end of a Moonwalker envelope / cycle, it can be used to trigger an event and establish a reference in this manner.

Skew

The Phase Offset Output is half-normalled to the cv input of the phase offset and the feedback will change the waveshape, so nulling the attenuverter is important for normal operation. Patching a cable into the cv jack will break the normalization and allow normal operation of the cv input.

For LFO's, this normailzation is designed to offer a skew control that can move the peak of the waveform so that it smoothly transforms from a downward ramp to a triangle to an upward ramp without changing the frequency:

Set the Phase Offset to 180°, Phase Offset Output to unipolar mode, and tune the attack and decay times to be equal

Monitor the Phase Offset Output as the reference output is unaffected by Skew.

Adjust the attenuverter for positive modulation to skew from triangle to falling ramp or for negative modulation to skew from triangle to rising ramp.

If the attack and decay times are not equal, frequency will change along with the skew. Skewing the waveform provides the ability to set your envelope time and then easily change the ratio of attack vs decay without changing the notelength.

The Skew feature in the audio context is best suited for morphing only between triangle and ramp of either direction. This provides a lovely sounding transform that gradually incrreases the amplitude of the individual harmonics one at a time, sounding much like a low pass filter opening up:

Set the Phase Offset to 0º, Phase Offset Output to unipolar mode, and tune the attack and decay times to be equal

Monitor the Phase Offset Output as the reference output is unaffected by Skew.

Adjust the attenuverter for positive modulation to skew from triangle to falling ramp.

Tip: the fastest way to get equal attack and decay times is to set them both to minimum. Tuning must then be accomplished externally using the volt per octave input.

Tip: to automate skew, patch the Phase Offset output through a VCA and back into the Phase Offset cv input. Modulating the VCA amount will modulate the skew.

How Phase Offset affects the Reference Output

So far we have been mostly focusing on the Phase Offset Output as our main signal source, but another powerful avenue to explore is using the Reference Output as our main signal source.

Attack and Decay rate changes are tied to the Phase Offset waveform, which means they are decoupled from the Reference waveform attack and decay segments. So as phase is offset, the Attack and Decay rate breakpoints are also offset. If phase is offset to 90°, the reference output will go from 0 to 5v at the attack rate, from 5v to 10v and back down to 5v at the decay rate, and from 5v to 0v at attack rate.

Offsetting Curves on the Reference Output

A common technique to get curved slopes from a linear slope generator is to feed the output back into the cv input of Attack or Decay. Negative polarity feedback will yield a concave curve while positive polarity feedback yields a convex one.

With Moonwalker we can patch the feedback from the Phase Offset output so the curves created can be offset from the attack and decay segments of the Reference Output.

Try feeding the Phase Offset Output back to the Decay cv input with positive polarity gain. Set the phase to 90° and monitor the Reference Output. The top half of the envelope will be curved and the bottom half linear. Adjusting the phase moves the peaks and troughs of the feedback across the waveform creating some very unusual shapes!

Even more waveshapes can be had by tweaking the Phase Offset cv attenuverter that feeds the Phase Offset output to it by normalization. See the skew function for more on how that works.

It should be noted that patching feedback to the Atack and Decay cv inputs will also affect the frequency, so adjustments to attack/decay times may need to be made. Once the adjustments are made, phase offset adjustments will not affect the frequency when the Phase Offset Output is in unipolar mode. Additional waveforms can be achieved using bipolar mode but adjustments to the phase offset will cause significant frequency changes.

Moonwalker Audio Envelopes:

An audio rate envelope might sound strange at first but there are some cases when this configuration is very useful.

Transient Articulation

The first case for an audio rate envelope is taken from the famous 808 kick drum. This uses a one-shot envelope one octave higher than the fundamental frequency, to modulate the pitch of the drum and simulate a drumstick hitting the head of a drum.

In a modular synthesizer this technique can be applied to any percussive patch and need not be limited to modulating pitch, but also the amount of distortion or waveshaping or?

Working with Formants

Another concept is to take a Master VCO and have it drive Moonwalker to create richer tones using complex waveforms or formants.

With Moonwalker in one-shot mode at audio rate, patch a pulse output from the Master VCO into the trigger input on Moonwalker and set the frequency of Moonwalker to taste. Monitoring the Reference output on Moonwalker is recommended.

Drive the Master VCO with pitch CV as normal and Moonwalker will track it. This establishes a **constant formant** due to Moonwalkers static frequency. If the pitch CV is also patched into Moonwalker's v/oct input, Moonwalkers envelope will scale with ptich changes and provide a **constant waveform**.

Tip: since the knob range in audio mode is limited, you may want to use an external DC source to control the overall frequency of Moonwalker using the volt per octave input to more easily access the entire audio range.

If Moonwalker's frequency is greater than or equal to the Master VCO frequency, a Moonwalker envelope is triggered every time the pulse goes high.

The higher the frequency of Moonwalker is relative to the Master VCO, the shorter the spike is and the more off-time there is between spikes. Modulating the pitch of Moonwalker above the pitch of the Master VCO sounds similar to pulse width modulation.

If Moonwalker is at a lower frequency than the Master VCO it locks into certain pitches as it divides the pulses down incrementally by 2,3,4 and so on. This is a great way to add some body to a sound and even simple melodies can be played using continuous modulation rather than discreet quantized pitches.

Mixing the Master VCO pulse (or other) output with Moonwalker's output can yield some beautiful deep tones.

It is highly recommended to patch feedback from the phase offset output to Attack or Decay cv inputs to get non-linear curves. Tweak the Phase Offset and Skew for even more variations! See "Offsetting Curves on the Reference Output" for details on how to set this up.

Pulse Width Modulation

The Not Decay Output will generate a 0 to +5v pulse wave where the pulse width is inherently defined by the ratio of attack to decay time. A short attack time with a long decay time will yield a thin pulse at the beginning of the cycle. The obvious way to widen the pulse is to increase the attack time, but this also changes the frequency.

We can however modulate the pulse width without affecting the frequency by modulating the phase offset.

The ratio of attack to decay establishes the minimum and maximum pulse width possible.

Frequency must then be set using the v/oct input.

Adjusting the Phase Offset will now sweep the pulse width, and this can of course be modulated using the Phase Offset cv input.

This works because the Reference output attack / decay breakpoints follow the phase offset output. So as the phase is offset, we are shifting the phase offset output decay rate onto the reference output attack. When phase is at 180º the attack segment of the Reference output will be at the decay rate and the decay will be at attack rate.

If you are still hearing a pitch deviation as phase is modulated, try plugging a cable into the Phase Offset cv input to disable the normal.

Retrigger / Hard Sync

All characteristics of oscillator or envelope modes apply to all frequency ranges except for the retrigger / hard sync function. Retrigger slows the reset function for low / mid frequency ranges to avoid unwanted transients. A fast reset is critical for audio rate VCO performance so that has been implemented for audio rate. Switching between these types of reset is automatic.