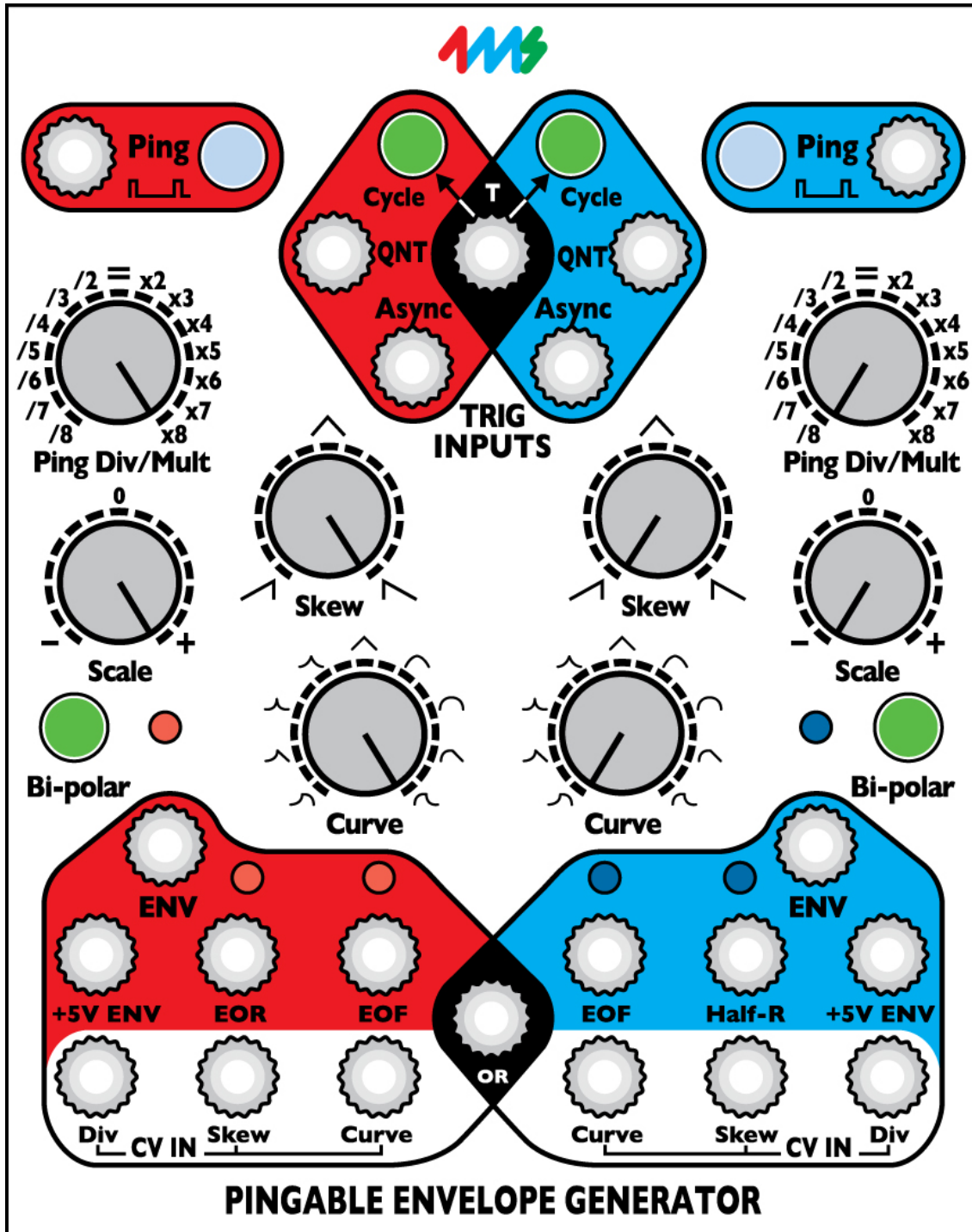


4ms Pingable Envelope Generator
Eurorack Module User Manual v2011-11-25



The Pingable Envelope Generator (PEG) from 4ms is a dual envelope generator whose envelope lengths are set by incoming clocks or “pings”. The PEG has full CV control of envelope shape, skew, and ping (clock) division/multiplication, as well as a plethora of triggering and cycling options (AD, AR, quantization, cycle, cycle toggle), and a tap tempo button for each channel.

DOWNLOAD UPDATED MANUAL AT:
<http://4mspedals.com/peg.php>

Features

- **Basics:**
 - Dual “pingable” envelope generator – total envelope time is set by a minimum of two pulses (“ping”)
 - Tap tempo button or external clock/triggers sets the ping time
 - Two taps will set the tempo. If a third tap is given close to the tempo to the first two taps, the two timing periods will be averaged
 - Envelope time is a multiple or division of the ping clock (from /8 to x8) set by Ping Div/Mult knob and CV
 - Curve knob and CV control the shape of the output envelope – various combinations of exponential, linear, logarithmic, and interpolated curves are available separately for rise and fall portions
 - Skew knob and CV control the ratio between rise and fall times without changing total envelope time
 - Envelope is triggered by Quantized trigger jack, Asynchronous trigger jack, and/or Cycle mode
- **Outputs and scaling/shifting:**
 - Scale knob is an attenuating inverter for main envelope output (Maximum 0V to +10V non-inverted, and Minimum -10V to 0V inverted).
 - Bi-polar button centers main envelope output around 0V (-5V to +5V output)
 - “+5V ENV” jack is a non-scaling output that always produces a 0V to +5V envelope, regardless of Scale and Bi-polar settings
 - “OR” jack outputs an analog OR of the two channels' scaled envelope curves. This outputs the highest value from either envelope at any given moment, taking into account the Scale and Bi-polar controls.
- **Gate outputs:**
 - End-of-Rise (EOR) gate output goes high when envelope finishes a rise portion, and goes low when envelope begins a rise portion
 - End-of-Fall (EOF) gate output goes high when envelope finishes a fall portion, and goes low when envelope begins a fall portion
 - Half-R (Half-Rise) gate goes high when 50% of the **time** of the rise portion has elapsed, and goes low after 50% of the **time** of the fall portion (this is different than a voltage comparator-based design). Jumper for each channel changes EOR output to a Half-Rise gate output. Factory setting is EOR for red channel, Half-Rise for blue channel. This jack provides a 90-degree-out-of-phase gate output useful for quadrature effects, clock phase shifting, and trigger delay effects.
- **Triggering/cycling:**
 - Cycle button for each channel forces envelope to self-cycle (LFO mode) in sync to the ping clock. Button lights up when in cycle mode.
 - “T” jack toggles the state of both channels' Cycle buttons while a gate is applied
 - “QNT” jack for each channel triggers an envelope to start at the next quantized beat, with respect to the divided/multiplied ping clock. Holding a gate high on this jack causes the envelope to repeat.
 - “Async” jack for each channel causes an envelope to output immediately (asynchronously). Holding a gate high results in an AR envelope (rise-sustain-fall). If cycle mode is enabled, the envelope will continue to cycle at this new phase with respect to the ping clock. Phase can be reset to being in sync with the ping clock by pressing the cycle button or applying a pulse to the QNT jack.
- **CV input jacks:**
 - CV control of each channel's Ping Div/Mult, Skew, and Curve using the CV jacks.
 - Respective knobs set the center offset for the applied CV
 - CV of 0-10V will modulate the parameter's full range – however, a 0-5V CV will modulate the parameter within a useful range.

Dimensions

- 20 HP Eurorack format module
- 1.6” (40mm) deep

Your first P.E.G. Patch: a Basic Walkthrough

Step 1: Prepare the PEG

- Unplug all cables from the PEG, turn the Div/Mult, Skew, and Curve knobs to center (12 o'clock), turn Scale all the way up, and make sure the Cycle and Bi-polar are off (not lit up).
- Plug the "ENV" jack on the red channel into something you want to modulate — perhaps a filter, or the pitch of an oscillator. Choose something simple so you can hear what's going on while you're learning about the PEG.

Step 2: Set your Ping time

Before the PEG can generate an envelope, you need to supply a Ping time. The Ping time is the basic reference that determines the timing of the envelope.

- Tap the red channel Ping button two or three times, about a second between taps. It's easier to see what's going on with a slow envelope. The white Ping button should be flashing at the tempo you tapped. If you gave a third tap, the time between the taps will be averaged (unless the third tap occurs more than 50% different than the timing period of the first two taps)
- You also could run an external clock into the red Ping jack (when a gate is received on the Ping jack, the internal tap tempo clock is stopped).

Step 3: Provide a trigger source

Like any envelope module, the PEG will produce an envelope when it receives a trigger. Also, like many envelope modules, it can be set to self-trigger so that it'll cycle without any external trigger.

- Press the red channel Cycle button (it will light up green). Notice the white LED above the ENV jack starts flashing. The envelope is now running freely, in time with the ping clock. Adjust the other module(s) you are running the PEG into so you can hear the modulation.
- You also could turn Cycle off and run a manual trigger into the QNT or Async jack (e.g. try the Gate output from a Pressure Points, or perhaps a clock output from an RCD/SCM)

Step 4: Adjust your output level

- Adjust the Scale knob and/or play with the Bi-polar button to get a good voltage range that works well with whatever you're modulating with the PEG.

That's the basic PEG patch: Ping, Trigger, and Output. Now we can play with the parameters of the envelope.

Step 5: Set up your Division/Multiplication amount

- Turn the Ping Div/Mult knob to various settings and watch the Ping button flash faster and slower. Notice how the tempo doesn't change gradually, but instead jumps from speed to speed. This is because each speed is an integer multiple or division of the original tempo (e.g. three times as fast, or half as slow).
- You also can modulate this parameter with the Div CV jack at the bottom.

Step 6: Adjust Skew and Curve

- Fiddle with the Skew and Curve knobs to get an envelope shape you like. Notice the curve shapes in the center section of the knob are all symmetrical (same rise and fall shape), while the shapes at the start and end of the knob's range are asymmetrical (different curves for rise and fall). Of course, you can modulate these parameters with the CV jacks at the bottom.

Step 7: Trigger the blue channel with the red channel

- Now plug the red EOF (end-of-fall) jack into the blue Ping jack.
- Turn the blue channel Cycle button On.
- Run the blue channel "ENV" jack output to modulate something else. Set Scale and Bi-polar as desired.

Step 8: Modulate the blue channel with the red channel

- Make sure the blue Ping Div/Mult knob is set to "=", and patch the red "+5V ENV" jack into the blue channel's Div CV jack. Set the red channel Div/Mult knob to something slow. The blue channel should speed up/slow down in time with the red channel's envelope.

Keep going, play with the "T" jack, try clocking both channels the same and hitting different triggers into the QNT jacks... play with off-time triggers into the Async jack while the channel is in Cycle mode... modulate each channel with the other, or themselves... etc etc! Have fun!

Ping and Tap Tempo

"Ping" is the core of the PEG: every aspect of the envelope relates back to the timing established by the ping time. There are two ways to set the ping time:



- 1. Tap tempo button** — tap the white "Ping" button at least twice to set the timing.
 - **It's easiest to tap a tempo with Ping Div/Mult set to "="**. This is because the tap tempo clock can be divided/multiplied just like the external Ping clock. For example, if you tap a tempo with the Ping Div/Mult knob set to "x4", the Ping light will flash four times as fast as you tapped.
 - **Three taps will average**. Two taps set the ping timing period. If you give a third tap, it will be averaged with the first two taps, unless the timing period set by the third tap is widely different than the first two taps (specifically, it must be more than half, and less than twice the timing period set by the first two taps).
 - **When a gate is received on the Ping jack, the tap tempo clock is disabled**. Try tapping a fast tempo while you have a slow clock going into the Ping jack — the fast tempo will take effect immediately, but will revert back to the slow tempo when a gate is received
 - **Hold the Ping button down for 2 seconds to clear the tempo**. The light will go off and the envelope will stop. You also can clear an externally generated ping if the external unit has stopped sending pulses.
- 2. External Clock** — plug a clock or manual trigger module into the Ping jack.
 - **Only the timing between the last two pulses is used** to set the ping clock timing (no averaging). Therefore you can plug in a manual trigger/gate module (such as the Pressure Points) and just tap in two pulses: the ping clock will continue to run at that tempo even though you're not providing any more trigger pulses.
 - **Tip**: A quick way to keep both channels in sync is to mult/stack an incoming clock in both Ping jacks. Alternatively, you can use a clock module with multiple outputs, such as the Rotating Clock Divider or Shuffling Clock Multiplier. Or you can patch the EOF of one into the other.
 - The Ping jack has no roll-off, but the main chip can process incoming clocks up to about 10kHz. However it can only output cleanly up to about 1kHz (depending on your requirements for "cleanly"). So you can divide a 10kHz clock down to 1.25kHz, but it will be dirty. When outputting frequencies higher than 1kHz, the output will be unstable, noisy and glitchy, but responsive to the input frequency. See Self-oscillation sample patch. Below the 1kHz threshold, the PEG can be used as a rudimentary harmonizer (e.g. sub-octave generator). See Audio Harmonizer patch.

The maximum time of either envelope curve (rise or fall) is about 15 minutes, so the total envelope time can be up to about 30 minutes.

Ping Divider/Multiplier

Once a ping time has been established, you can then divide or multiply it from 1/8th the speed to 8 times the speed, in whole number increments. The resulting clock is called the "Divided/Multiplied Ping Clock", or just "Ping Clock" for short.

- The Ping button flashes to the rate of the Divided/Multiplied Ping Clock
- The Ping Div/Mult knob sets the amount of multiplication or division of the incoming ping time, along with any CV that's applied to the Div jack (the knob sets the offset for the CV)
- Changing the Div/Mult amount in the middle of an envelope will have no effect until a ping clock is received, or the divided ping clock timing period renews, or the envelope starts a new rise/fall segment. See Figure 1A.
- Giving a pulse to the QNT jack will force an update of the div/mult amount immediately (in the middle of a curve if necessary). If you hold a gate high on the QNT jack, the div/mult amount will track the CV (glitchy envelope shapes can be obtained this way!) See Figure 1B.
- When the Div/Mult amount changes, the PEG has to compensate the envelope in order to maintain timing. A partial envelope may be generated after the div/mult amount changes in order to insure that subsequent envelopes are synced to the ping clock. See Figure 2.

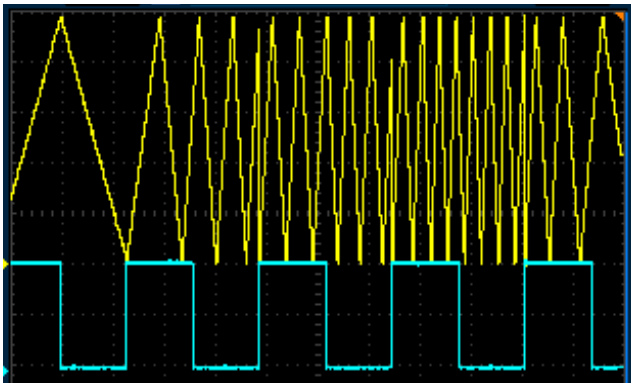


Figure 1A: Changing Div/Mult (with no gate on QNT) Notice the envelopes always start on the ping clock's rising edge

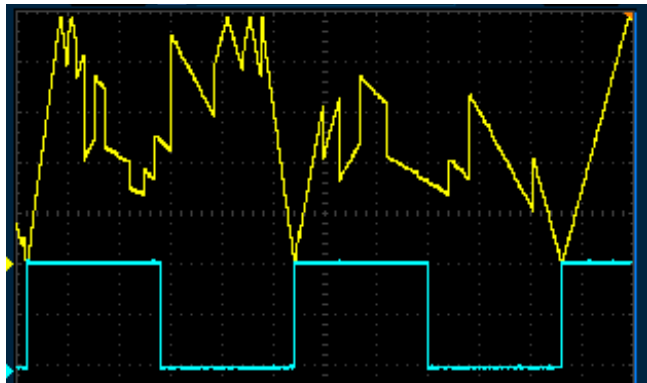


Figure 1B: Changing Div/Mult while holding a gate high on QNT Slope of envelope changes each time the Div/Mult CV/knob moves to a new div amount

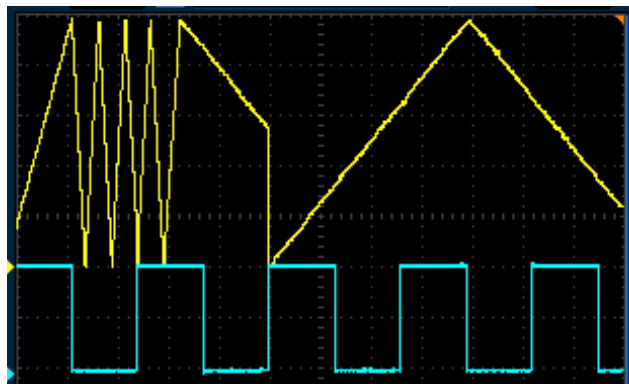


Figure 2: Changing Div/Mult causes "catchup" partial envelope. Change occurred from x4 to /4, in the middle of second "high" portion of the ping clock. New envelope re-syncs abruptly on the following ping clock.

Triggering/Cycling the Envelope

1. **Cycle Button** — Press the button to toggle Cycle mode on/off. When this button is lit up, the envelope will be free-running. In Cycle mode, the envelope will start on the ping clock (unless you gave an Async trigger, see below... Pressing this button after an Async pulse will make the envelope re-sync.) As soon as the button is pressed, the PEG calculates where in its cycle the envelope should be so that it ends on the next ping clock, and starts outputting the envelope from this point. See Figure 3.
2. **QNT jack (Quantized)** — Apply a trigger/gate to this jack to cause an envelope to start **on the next ping clock**. The PEG will wait for the next ping clock and then start the envelope. Holding a gate high on this jack causes the envelope to repeat. See Figure 4. The rising edge of a trigger on this jack will cause the envelope to re-sync if an Async pulse has previously been applied. The envelope will complete at least one entire cycle even if the QNT jack goes low mid-way through the envelope.
3. **Async jack (Asynchronous)** — Apply a trigger/gate to this jack to cause an envelope to start **immediately**. Holding a gate high will cause the envelope to sustain as long as the gate is high, and then start the fall curve once the gate is released (A-S-R envelope). See Figure 5
4. **"T" jack (Cycle Toggle)** — When a gate is applied to this jack, both channel's Cycle buttons will toggle state (on->off and off->on). When the gate is released they will revert to their previous state. The "T" jack is useful for toggling between the two channels: set one channel in Cycle mode and the other channel to non-cycling, and take the output from the OR jack (see Outputs section below). The "T" jack is also useful for turning both channels on/off at the same time. *Note: applying a gate to the "T" jack is the same as pressing both Cycle buttons at the same time (whether pressing the button turns it on or off). Thus, all features that apply to starting Cycle mode also apply to turning the Cycle button on using the "T" jack.*

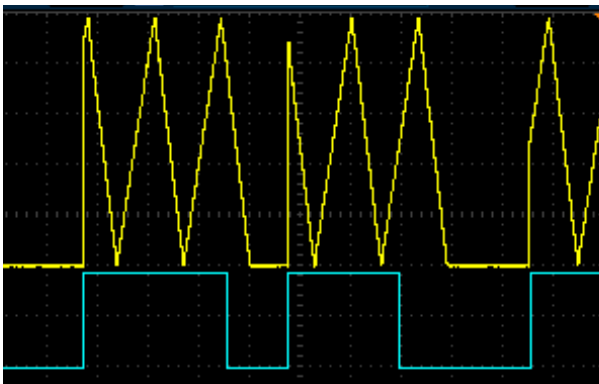


Figure 3: Pressing Cycle button
When button is pressed, envelope starts outputting instantly, from a point in its cycle such that it's in sync with the divided ping clock. (Blue trace is cycle button)

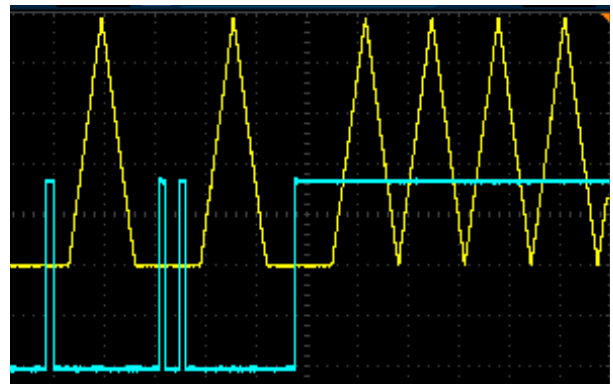


Figure 4: Quantized QNT trigger
Applying a QNT trigger causes an envelope to output at the next ping clock (ping clock not shown in figure). Holding a gate high causes the envelope to repeat.

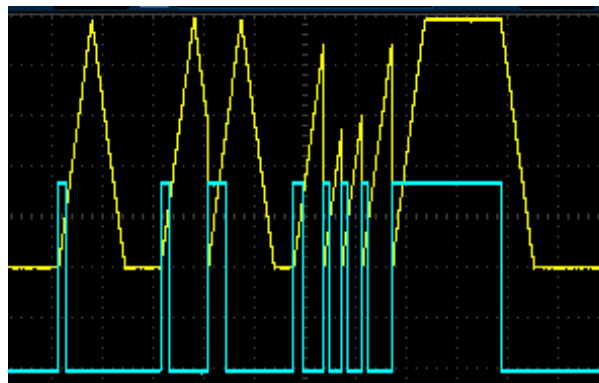


Figure 5: Asynchronous trigger
Trigger causes an envelope to output immediately (rising edge of trigger). Holding a high gate causes a sustain period, and a fall period to begin after gate goes low (ASR envelope). Envelope is re-triggerable.

Skew

Skew is the ratio between the rise and fall times. Unlike most envelope generators, in the PEG the total envelope length is held constant when the skew is changed, thus allowing you to change between ramp-up, ramp-down, triangle, and everything in-between, without altering the timing.

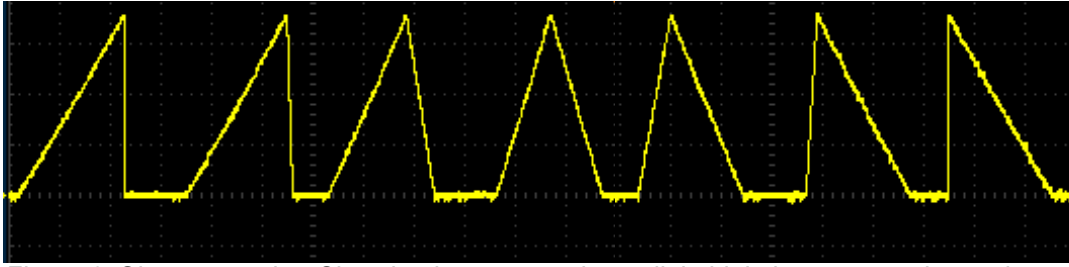


Figure 6: Skew examples. Skew knob was turned up a little bit in between each envelope.

If Skew is changed while an envelope is running, the curve will update immediately. Some funky outputs can result from this, see figure for examples.

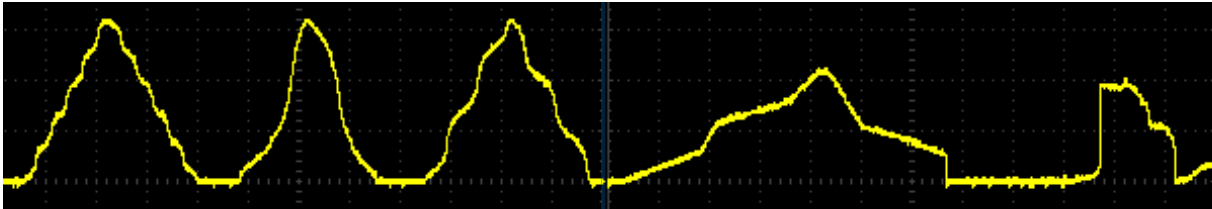


Figure 7: Funky envelopes made by twiddling the skew parameter while envelope is running

Curve

The envelope shapes available in the PEG are formed by combinations of exponential, linear, and logarithmic waveforms. In between each fully expo/lin/log waveform, there are three interpolated waveforms formed from weighted combinations of each (e.g. 25% log, 75% linear). The waveforms can be symmetrical (e.g. linear rise & linear fall), or asymmetrical (e.g. exp rise & log fall). See figures 8a-8d.

The curve is selected from one of 17 using the Curve knob and CV jack (the knob sets the offset for any applied CV). As you turn the knob clockwise, the first 4 curves are asymmetrical with exponential attacks and varying decays. The last 4 curves are asymmetrical with logarithmic attacks and varying decays. The middle 9 curves are symmetrical, ranging from exponential to linear to logarithmic. Look closely at the artwork around the Curve knob on your PEG to see how the curves are laid out.

Once a rise or fall segment has begun, the shape will not change until the segment ends. However, applying a pulse on the QNT jack or turning the cycle button on will force an update of the curve shape. As opposed to the Div/Mult parameter, holding the QNT jack high will **not** force the Curve shape to track the CV.

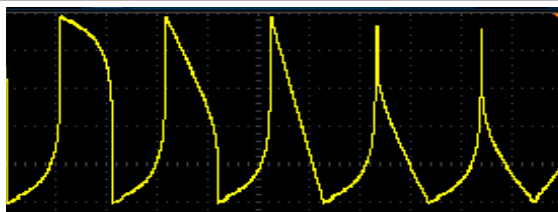


Figure 8a: Curves 1-5
Asymmetrical curves with expo attacks

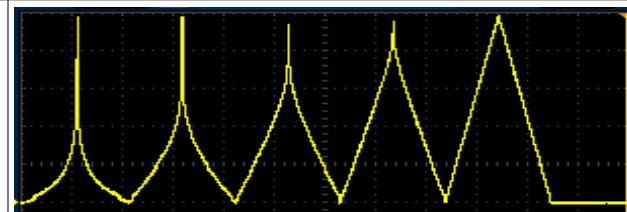


Figure 8b: Curves 5-9
Symmetrical curves (expo to linear)

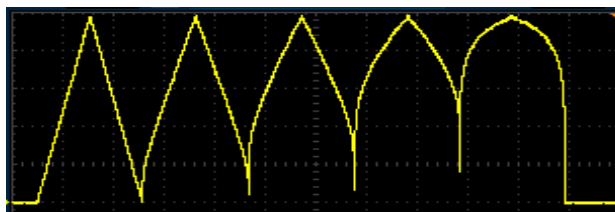


Figure 8c: Curves 9-13
Symmetrical curves (linear to log)

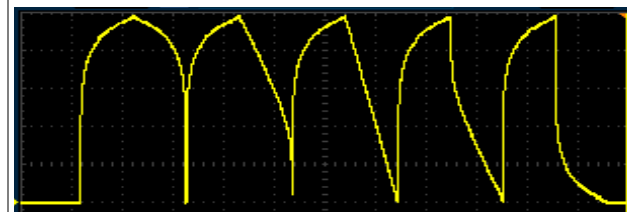


Figure 8d: Curves 13-17
Asymmetrical curves with log attacks

Envelope Outputs (Main ENV, +5V ENV, OR)

Each side of the PEG has two outputs: a scaled output labeled "ENV" and an unscaled output labeled "+5V ENV". Additionally, there is a shared output that's the arithmetic "OR" of the scaled outputs.

- The Scale knob and Bi-polar button only effect the ENV output jack:
 - With Bi-polar off: If the scale knob is right of center, the output will be positive-only, from 0V to a maximum of +10V. Left of center, the envelope inverts and is negative-only, from 0V to a minimum of -10V.
 - With Bi-polar on: Scale knob right of center, the output will rise from negative to positive, then fall back to negative voltage (maximum range -5V to +5V). Scale knob left of center, the output starts positive and "rises" to negative voltage, then "falls" back to positive voltage.
 - In any setting, Scale knob in the center will produce no output.
 - The Bi-Polar button is a level-shifter (before the scale inversion/attenuation in the circuit). The amount of level-shifting is controlled by a trim pot on the back of the module. Factory setting is a shift of -5V (thus 0V to +10V becomes -5V to +5V), but other levels may be obtained by turning this trim pot. One common use would be to set this to about -10V of level shift, so that the output when Scale is inverting would be positive voltages, but with an inverted waveshape. This is useful because now the +5V ENV jack and main ENV jacks will produce inverted copies of the same waveshape, but in the same voltage range.
- The main output is the ENV output and its amplitude is controlled by the Scale knob and Bi-polar button
- The +5V ENV jack always outputs a waveform that goes from 0V to +5V. The scale and bi-polar controls have no effect on this. This jack is useful as an auxiliary envelope output. It's often useful to patch into the other channel's CV jack(s) to modulate parameters.
- The OR jack will output the highest voltage value from either side's ENV jack at any given moment. One way to use this is to think of the OR jack as a mix out, and use the Scale knobs as level knobs and the Bi-Polar buttons to bring down the relative level of a channel (kind of like a mute button). See Fig 9c.

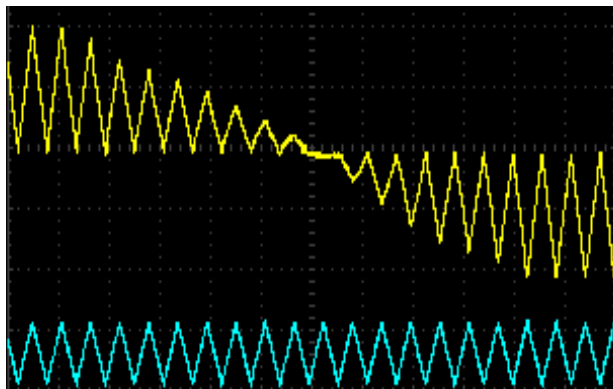


Figure 9a: Changing Scale (Bi-polar off)

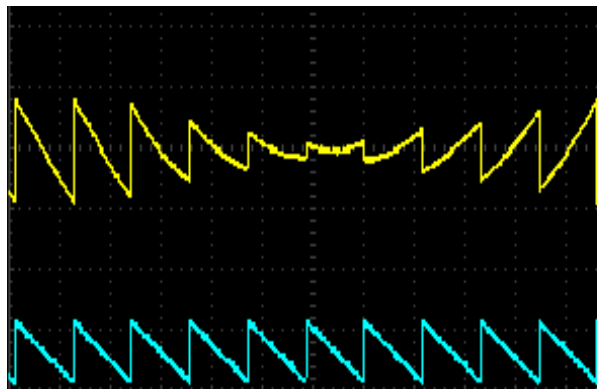


Figure 9b: Changing Scale (Bi-polar on)

Top traces are ENV as Scale is turned from max to min. Bottom traces are +5V ENV. Grid lines are 5V/division.

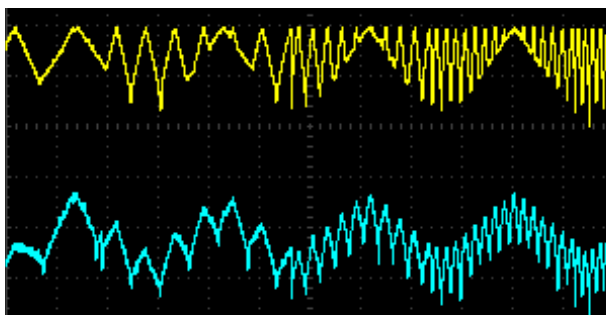
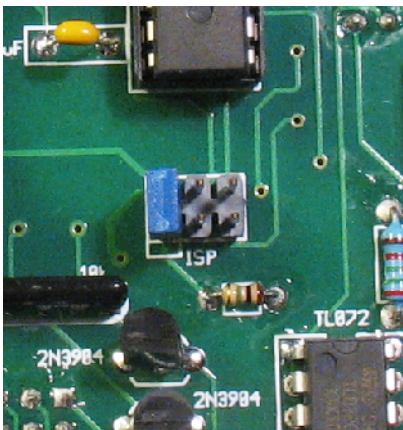


Figure 9c: OR jack vs. adding ENV outputs
Top trace is OR jack (one channel is being sped up).
Bottom trace is from mixing both channels using a passive mult

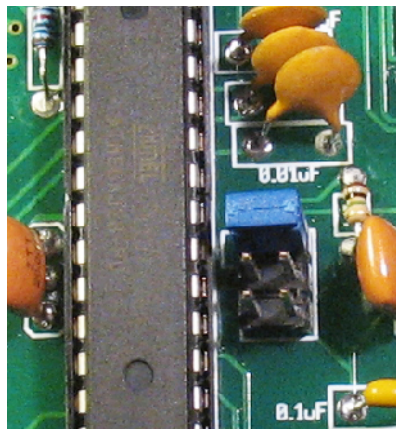
Gate Outputs (EOR/EOF/Half-Rise)

Each channel has a two gate outputs: End-of-Fall (EOF), and either End-of-Rise (EOR) or Half-Rise. A jumper selects the latter (see photos below for location of jumpers).

- End-of-Rise outputs a gate that goes high when the fall segment begins, and goes low when the envelope completes. It is low during a sustain segment. The jack will stay low when the envelope is not running. Another name for this jack might be "Envelope is Falling". See figure 10a.
- End-of-Fall outputs a gate that goes high when the fall segment ends and goes low when a rise segment ends. It is low during a sustain segment. It will stay high when the envelope is not running. Another name for this jack might be "Envelope is Rising or Resting". See figure 10b.
- Half-Rise outputs a gate that goes high when 50% of the envelope's rise time has elapsed. It goes low when 50% of the fall time has elapsed. It is high during a sustain segment, and stays low when the envelope is not running.
- While the Curve and Scale parameters have no effect on the gate outputs, Skew has a big effect:
 - Skew changes the pulse width of EOF and EOR. Turning Skew to the right (more CV) creates longer EOR pulses and shorter EOF pulses. To the left, we get shorter EOR and longer EOF pulses.
 - The width of the Half-R pulse is always 50% of the envelope time. Changing the Skew will change the phase of the Half-R output. See figure 10c.



Red channel Half-Rise jumper installed. Remove jumper for EOR.
Factory setting is removed.



Blue channel Half-Rise jumper installed. Remove jumper for EOR.
Factory setting is installed.

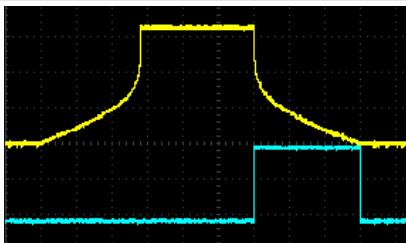


Figure 10a: End-of-Rise (EOR)
aka "Is Falling"

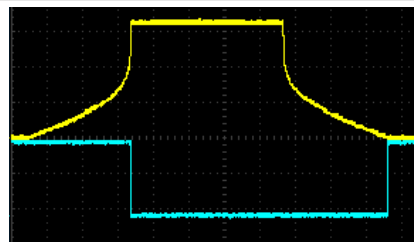


Figure 10b: End-of-Fall (EOF)
aka "Is Rising or Resting"

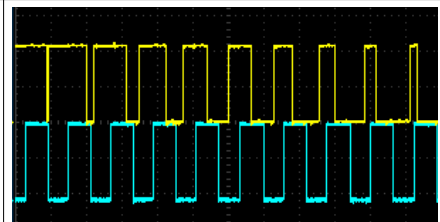


Figure 10c: Phase-shifting Half-R
Yellow trace is EOF, Blue is Half-R.
Skew knob being turned slowly.
Notice the phase shift from 180 to
almost 0 degrees, relative to the
rising edges.

Beyond Mere Envelopes... Advanced PEG Patching

Hopefully after reading this manual and playing with your PEG, you have a clear understanding of how to make a variety of timing-dependent envelopes. The following patches illustrate how the PEG's large assortment of inputs and output types can be used for a variety of purposes besides envelopes.

Complex pattern generator

Use the PEG's quantization features to create complicated repeating beat patterns. For this patch, it's helpful to have a "metronome" or "kick" in the background being triggered at the steady master clock rate or slow division of the master clock.

Run a Shuffling Clock Multiplier x8 output (or RCD /1 out) into Ping. Run another SCM output, say S5 or RCD /3, into QNT. Cycle Off. Div/Mult to "=". Run the ENV output to open a filter (try a 100% Skew, triangle Curve). If the beat pattern isn't goovy, use a different clock output into QNT (use the SCM's slip/shuffle!), and adjust Div/Mult.

To increase complexity, run EOF into the other channel's Ping. Turn that channel's Cycle on or run a different clock into QNT. Play with Div/Mult. Use the OR out, or run its ENV out to modulate another sound, or perhaps a second aspect of the same sound.

If you can, play with the pulse width of the module feeding QNT jacks (the SCM Breakout has a PW knob and jack, as do many VCOs and LFOs). Longer PW means more repeated notes.

"Ratcheted" quantized beats

Control the repeat rate of each note of a sequenced bassline.

Clock a sequencer and run the same clock into Ping. Presumably one CV output from the sequencer is controlling the pitch of your "bassline". Patch a different CV output of the sequencer into Div CV. Turn Cycle on (or run the sequencer's Gate output into the QNT jack). Set each step to a CV value that corresponds to the number of repeats you want for that particular step. For example, suppose you have an 8-step sequence and you want notes to be played once for every step until the last note, which you want to be repeated 8 times and played 8 times as fast... set the sequencer steps 1-7 to 0V output, and step 8 to 5V.

If you want to control the number of times the note repeats (e.g. 8 times as fast, but only hit 4 times), you can use a sequencer with variable pulse width for its gate output (patched into the QNT jack) or another module to change the pulse width (e.g. Seq Gate->SCM In and SCM x1 -> PEG QNT, playing with SCM's PW knob)

Self-oscillation (self-patched)

Very chaotic interesting noises. Needs a human to fine-tune the settings. Spend some time on this one!

Patch EOF to Ping. Patch ENV output to your audio mixer. Set Div/Mult to between = and x2 (adjust this very slowly throughout the patch). Cycle On. Scale will be your output volume. Skew and Curve effect the "timbre" (heh). Give PING a few taps to get it started.

More advanced: Do the basic patch to both channels, with both ENV outputs going to an audio mixer (or just listen to the OR output). Now patch Half-Rise into the "T" jack. Play with Cycle button settings. Keep patching each channel into itself and/or the other. Try running one channel's output to control a filter, the other controls a VCO running into the filter.

Clockable Trigger Delay

A trigger is fed in, and after a delay (which is determined by a clock), a trigger is outputted.

Patch a trigger (e.g. from Pressure Points gate output) to the Async jack. Patch a clock into the PING jack. Set Div/Mult to /2. Set Skew to center. EOR will be your delayed trigger output (actually is a gate as wide as the clock period). Changing Skew will fine-tune the delay time as well as output gate pulse width.

Audio Harmonizer

Sub-octave and harmonic series from an audio input

Run an oscillator into Ping input. Cycle On. Set your frequency shift amount with the Div/Mult (e.g. x2 will be an octave up, x3 will be an octave plus a fifth, /8 will be three octaves down, etc...). Audio output from the ENV jack. Scale sets your volume. Skew and Curve set your waveshape/timbre. Keying Async will mute the signal. Turning Cycle off and keying QNT will gate the signal.

Do this on both channels and use the T jack to toggle between harmonics, taking the output from the OR jack. Unplug one channel's Ping to let it slowly drift, creating phaser swooshing sounds.

Run into a LPF with roll-off at 10kHz for a less harsh sound!

Phase Shifting

Variable phase shift – two sets of events are repeatedly occurring at the same intervals, but the amount of stagger between them is variable.

Ping both sides with the same clock. Cycle on (both channels). Main envelope outputs to open two different filters or LPG's or somehow make sound.

Some options for setting the amount of phase difference:

- **Manual trigger into Async jack on one channel.** For example, to set the blue channel to lag by 25% (90° phase difference), hit the trigger a quarter of the way after a red channel pulse.
- **CV Skew.** Changing the skew will change the timing that the peak of the envelope occurs. Thus, sweeping the Skew of one channel while holding the other steady will cause the envelope peak to shift in phase with respect to the other envelope's peak.
- **Quantized phase selection.** Slow each channel down to /8. Speed your clock up if necessary. Turn blue channel cycle off. Listen to the red channel and at a moment right before you want the blue channel to come in, press the Cycle button on. The blue channel's phase will be quantized to one of 8 possible phases (0°, 45°, 90°, 135°, 180°, 225°, 270°, or 315°). It helps to set a sharp attack on the red channel (Skew at 100%) so you can hear the timing better. Cycle button can be turned off and back on to change phase again.

Use different Div settings for different possible phase shift amounts (e.g. /7 gives 0°, 51°, 102°. etc...)

Quadrature patch

First, you have to set up the phase difference between the two channels:

- **The easy way:** Clock both channels with the same clock and patch the blue channel Half-R into red channel Async. Turn blue Cycle on and red Cycle off. Adjusting the Skew of the blue channel will change the amount of phase shift from 0-180° (50% skew will be 90°). *Note: If you set red Skew to more than 50%, this technique will result in a trapezoidal waveform, which may not be desired. To overcome this, turn the red channel to Cycle mode, wait for one cycle, then unplug the Half-Rise->Async patch cable. Another way to overcome this is to run the Half-R output through a trigger to gate module before going into Async.*
- **Another way, just for kicks:** Clock both channels together and set both to /4. Using the same technique as described in the *Quantized phase selection* patch above, hit the Cycle button at the right moment so that one channel is 90 degrees out of phase as the other. Or, turn blue Skew one mark to the right of center, turn red Cycle off, wait for red envelope to finish, wait for the blue Half-R LED to go off, and immediately patch blue Half-R into red QNT. The two channels will be 90 degrees out of phase.

Now adjust the levels:

- Turn both Scale knobs to Invert (about 10:00) and both Bi-polar buttons on. Run the main ENV outputs into a Level Shifter (e.b. Bubblesound LvL+rm or Doepfer A-129/3) to add about 2.5V so that the inverted signals are at the same DC offset as the +5V ENV outputs. Your four phase shifted outputs will be Blue +5V ENV (0°), Red +5V ENV (90°), Blue level-shifted ENV (180°), Red level-shifted ENV (270°).

If you use this patch often and want to avoid using an external level shifter module, you can adjust the Bi-Polar trim pot as described in the Bi-Polar section above.

Power consumption

+12V rail:

60mA max with 5V Source jumper selecting external 5V

105mA max with 5V Source jumper selecting internal 5V

+5V rail:

40mA max with 5V Source jumper selecting external 5V

not used with 5V Source jumper selecting internal 5V

-12V rail:

35mA max