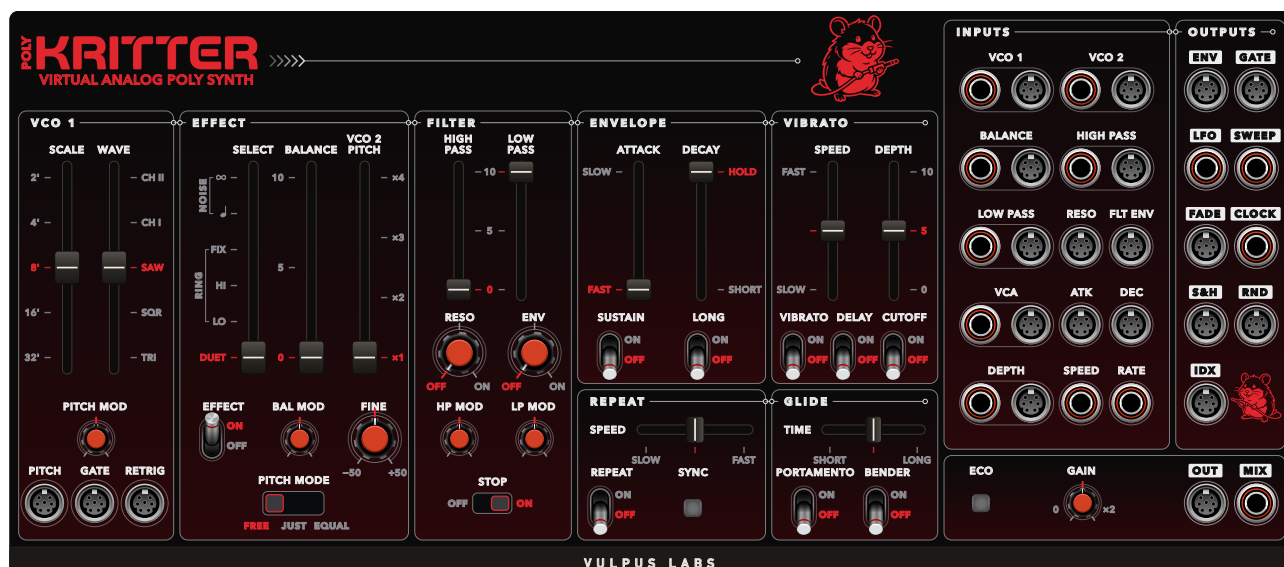


PolyKritter

Polyphonic synthesizer for Voltage Modular · up to sixteen voices



PolyKritter runs up to sixteen copies of Kritter's voice from one panel. Each voice has two oscillators, a ring modulator and noise, a high-pass and a low-pass filter in series, a two-slider envelope and a VCA. One poly cable carries the keys in and one carries the voices out, each voice on its own channel, and a mono output sums them.

This manual describes every control and jack, and gives measurements taken from the module's own DSP code: filter responses, envelope shapes, control ranges, spectra and aliasing.

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Overview

What it is

PolyKritter is a polyphonic version of Kritter, which models a monophonic synthesizer from 1974. Each voice is a complete Kritter voice, with its own copy of every stage. All the voices share one panel, and so one set of settings. Every control starts at the setting that matches the original instrument. The controls and jacks the original did not have start where they have no effect: CV amounts at their centre, VCO 2's tuning at FREE, STOP on, RESO and the filter's ENV at OFF.

Signal path

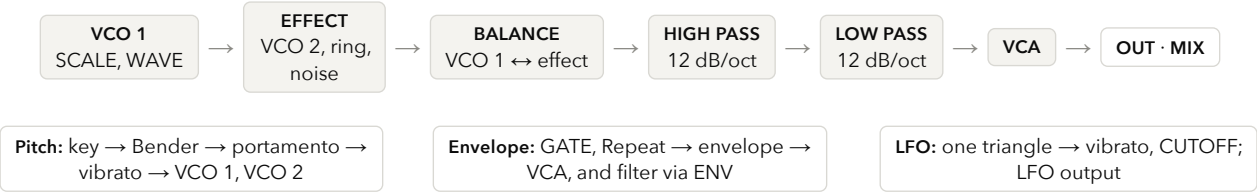


Figure 1. One voice. The oscillators, effect section and filter run at twice the host's sample rate (HI) and are brought down to it after the VCA. The pitch effects work in hertz, not in volts per octave; see Section 11.

Connecting it

Patch a poly pitch into **PITCH** and a poly gate into **GATE**, from a keyboard or a note allocator. Take **MIX** to a mixer, or **OUT** to process each voice separately.

Poly channel *n* is voice *n*. PolyKritter does not allocate notes to voices: whatever produces the poly pitch and gate has already done that. The number of voices that run is the cabinet's polyphony setting. Voices above it are not processed, and their outputs are 0 V.

A voice whose envelope has closed the VCA, and whose last output samples have left the output stage, stops processing until its next note. The cost of the module therefore rises with the number of voices sounding, not with the number available.

What each voice has, and what the voices share

Per voice	Shared by all voices
The key: pitch, gate and RETRIG	The panel's settings
Envelope, VCA, and the whole audio path	The vibrato LFO, and so CUTOFF vibrato
The Bender's swoop and portamento	Repeat's clock
Delay vibrato's fade-in	The chorus sweep of CH I and CH II
Every poly input lane, and every poly output	Every mono input and output

The shared LFO means that all voices' vibrato moves in step. Delay vibrato still fades in from each voice's own note. Repeat's clock starts with the first note of a phrase and runs steadily while any key is held; notes added during the phrase join its pulse rather than restarting it (Section 6).

The face

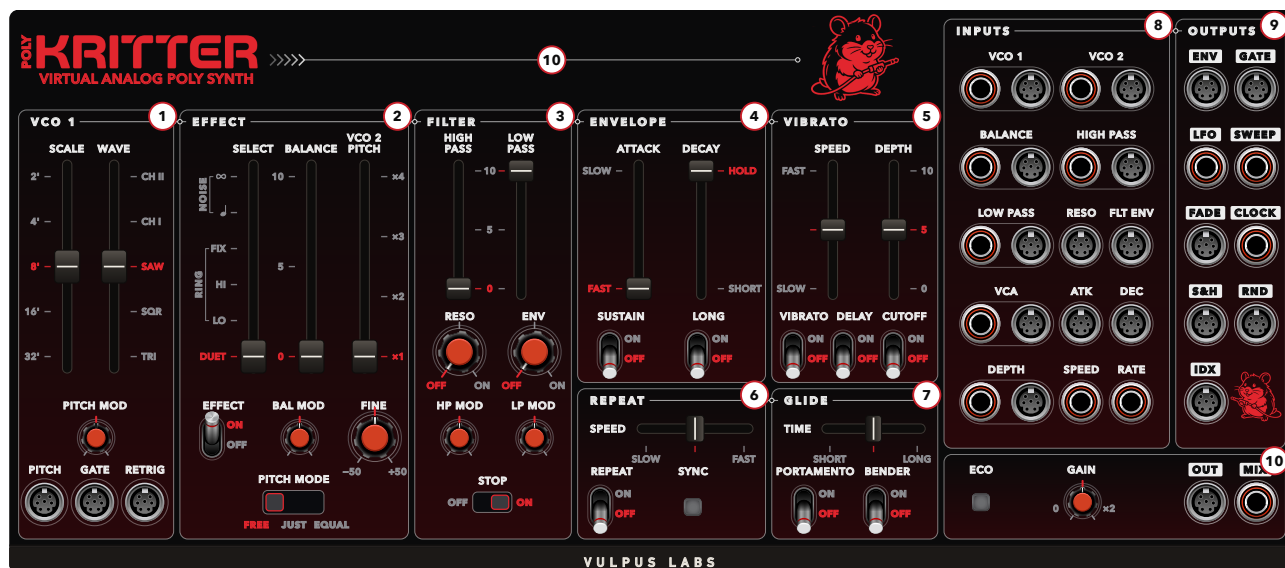


Figure 2. The face, by section. Each number is the section of this manual that describes it.

- | | | | |
|------------------|-------------------------------------|-----------------------|---------------------------------|
| ① VCO 1 | the oscillator, and the key's jacks | ② EFFECT | VCO 2, ring modulator and noise |
| ③ FILTER | high-pass and low-pass | ④ ENVELOPE | two sliders, two switches |
| ⑤ VIBRATO | the LFO and its three destinations | ⑥ REPEAT | re-strikes held notes |
| ⑦ GLIDE | portamento and the Bender | ⑧ INPUTS | CV inputs |
| ⑨ OUTPUTS | CV outputs | ⑩ Output plate | ECO, GAIN, OUT, MIX |
| ⑩ Display | MIX's waveform | | |

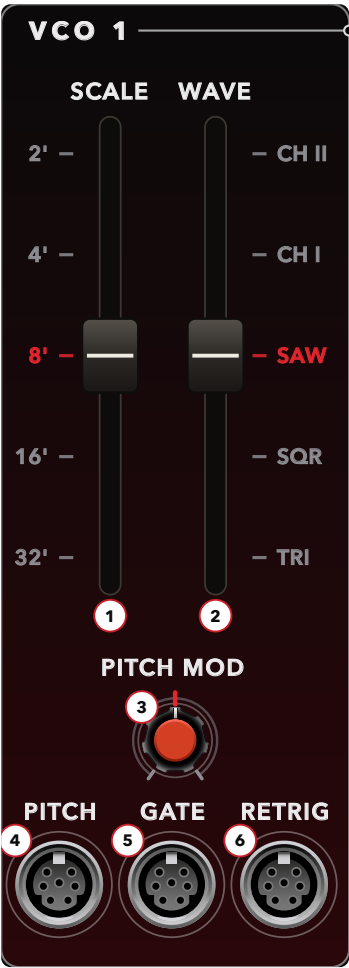
Faders read upwards, and switches have ON at the top or the right. The red tick beside each control marks its starting position.

Jacks

Poly jacks have pins. Mono jacks have a red ring. Voltage Modular does not allow a mono cable into a poly jack, so each CV input that is usually driven from a mono source has a mono jack beside its poly jack. The two sit in one outline under one name, mono on the left, and their voltages are added: each voice receives the mono voltage plus its own poly channel. A mono CV therefore moves every voice alike, and a poly CV moves each voice separately.

Every input reads 0 V when unpatched, and at 0 V each leaves the module as it would be without it. **GATE** and **RETRIG** are read every sample. Every other input is read once every 32 samples (0.67 ms at 48 kHz).

1 • VCO 1



- 1

SCALE
- octave: 32' to 2'
- 2

WAVE
- TRI, SQR, SAW, CH I, CH II
- 3

PITCH MOD
- amount for the VCO 1 input
- 4

PITCH
- poly, 1 V/oct, 0 V = C2 at 8'
- 5

GATE
- poly, high above 0 V
- 6

RETRIG
- poly, re-strikes a held note

VCO 1 is a single oscillator followed by a chain of frequency dividers. Each footage is a divider output, so the five footages are always exactly in tune with one another.

SCALE selects the footage in five steps: 32', 16', 8', 4', 2', with 2' at the top. At 8' the oscillator plays the pitch at **PITCH**; each step is one octave. It starts at 8'.

SCALE also moves both filters' cutoffs by one octave per step, so a filter setting keeps the same relation to the notes when the footage changes. The filters do not follow the key played, only this switch.

WAVE selects the waveform. It starts at SAW.

Position	Waveform
TRI	Triangle. Odd harmonics only, falling at 12 dB per octave ($1/n^2$).
SQR	Square. Odd harmonics only, falling at 6 dB per octave ($1/n$).
SAW	Sawtooth. Every harmonic, falling at 6 dB per octave ($1/n$).
CH I	Pulse, its width swept by a 0.8 Hz triangle between 15% and 85%.
CH II	Pulse, its width swept by a 5 Hz triangle between 40% and 60%.

The chorus sweep has its own oscillator, shared by every voice; the VIBRATO section does not affect it. It runs continuously, through notes and through changes between CH I and CH II, and is available at the **SWEEP** output. There is no sine wave.

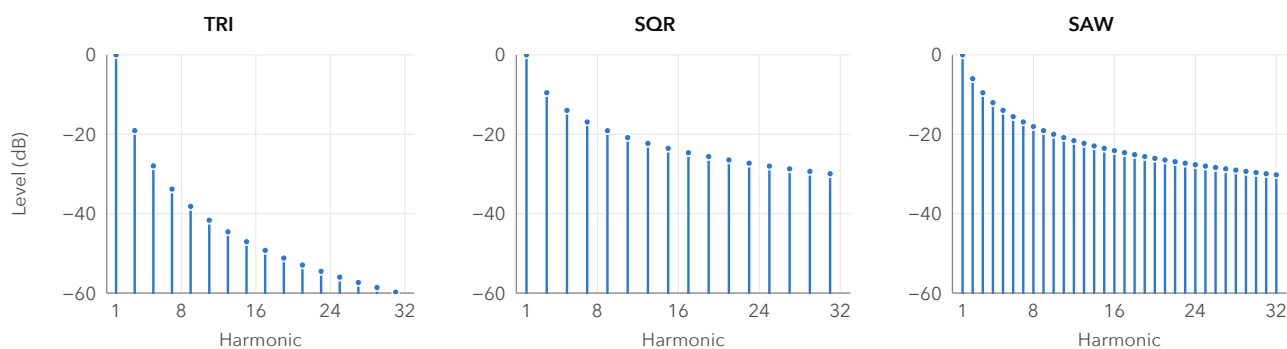


Figure 3. Harmonic levels against the fundamental, measured at OUT with the filter open, C3 (130.8 Hz), HI. Even harmonics of TRI and SQR are below -140 dB.

PITCH is the pitch input, 1 V/oct, 0 V at C2 (65.41 Hz) with SCALE at 8'. Tracking is exact.

GATE is the gate input. A voltage above 0 V is a held key. A rise starts a note: it strikes the envelope, and starts the Bender's swoop and delay vibrato's fade-in. The first note of a phrase also starts Repeat's clock (Section 6). A gate that stays high while the pitch changes is a legato note, and nothing restarts.

RETRIG re-strikes the envelope of a voice whose gate is held, from its current level. It is not a new note: the Bender's swoop and delay vibrato's fade carry on, and Repeat's clock is not restarted. A voltage above 0 V is high, and a high that persists strikes once. With the gate low it does nothing.

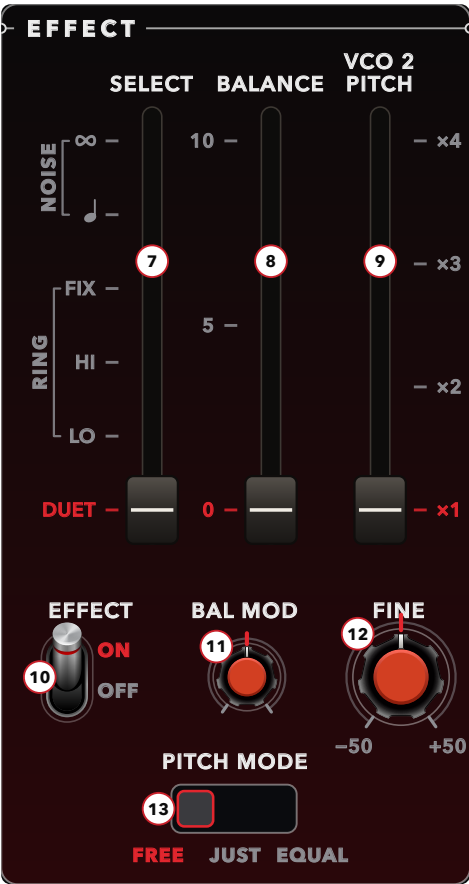
PITCH MOD sets how much the **VCO 1** input in the patchbay moves VCO 1's pitch. At its centre the input has no effect; at either end it is 1 V/oct, inverted to the left of centre. The amount is linear in the knob's rotation, and the tooltip shows it in octaves per volt. This input moves VCO 1 only. VCO 2, the ring modulator's fixed carrier and the filters are unaffected.

Output level

WAVE	RMS (V)	Peak (V)
TRI	2.885	4.875
SQR	4.988	8.639
SAW	2.874	8.032
CH I	4.593	11.204
CH II	4.956	9.564

Measured at one voice's **OUT**, C3, the filter open, GAIN at its centre. The waveforms are ± 5 V before the filters. The peaks are higher because the high-pass filter at its lowest setting (20 Hz) and the band-limiting shift the phases of the harmonics, which raises the peaks of waveforms with steep edges. The RMS level is the better guide to loudness.

2 • EFFECT



- 7

SELECT

the effect section's source
- 8

BALANCE

VCO 1 against the effect
- 9

VCO 2 PITCH

VCO 2's ratio to VCO 1, $\times 1$ to $\times 4$
- 10

EFFECT

the section on or off
- 11

BAL MOD

amount for the BALANCE input
- 12

FINE

VCO 2's fine tuning, ± 50 cents
- 13

PITCH MODE

FREE, JUST, EQUAL

The effect section contains a second oscillator, a ring modulator and a noise source. **SELECT** chooses what the section produces, and **BALANCE** mixes it with VCO 1.

With **BALANCE** at 0, where it starts, the effect section is not heard.

SELECT has six positions, **DUET** at the bottom. It starts at **DUET**.

Position	Output
DUET	VCO 2, sawtooth, following the key at the ratio set by VCO 2 PITCH.
RING LO	VCO 1 ring-modulated by VCO 2, VCO 2 following the key as at DUET.
RING HI	As RING LO, with VCO 2 two octaves higher.
RING FIX	VCO 1 ring-modulated by VCO 2 at a fixed frequency, not following the key.
NOISE ↓	Noise ring-modulated by VCO 2, VCO 2 following the key two octaves up: noise with a pitch.
NOISE ∞	White noise.

The selector switches without a crossfade; moving it during a note gives a click.

The ring modulator

The ring modulator switches the polarity of its input at VCO 2's frequency. VCO 2 is clipped into a square with rounded edges, and the input is multiplied by that square. The output contains the sums and differences of the input's frequencies and the square's odd harmonics; it contains neither the input's own frequencies nor the carrier's. Only VCO 2's zero crossings matter, so its waveform does not.

With VCO 2 following the key (RING LO, RING HI), the sidebands keep the same relation to every note, and the result plays in tune. At RING FIX, VCO 2 stays at one frequency while VCO 1 follows the key, so each note produces

a different, inharmonic set of sidebands. The fixed carrier is set by VCO 2 PITCH and FINE, from 110 Hz at $\times 1$ to 440 Hz at $\times 4$.

BALANCE (0 to 10) crossfades linearly between VCO 1 at 0 and the effect section at 10. At 5 the two are equal. In DUET it sets VCO 2's level against VCO 1; in the ring and noise positions it sets how much plain VCO 1 remains.

BAL MOD sets how much the **BALANCE** input in the patchbay moves **BALANCE**: none at the centre, and at either end ± 5 V moves **BALANCE** across its whole range, inverted to the left of centre. The CV is added to the fader's position, and the sum is held within 0 to 10. Each voice receives its own sum.

VCO 2 PITCH sets VCO 2's frequency as a ratio of VCO 1's 8' pitch, from $\times 1$ (unison) to $\times 4$ (two octaves up). The fader is linear in frequency: $\times 2$ is a third of the way up and $\times 3$ two thirds. VCO 2 counts from VCO 1's 8' whatever **SCALE** is set to, so at 16' the two are an octave apart with the fader at $\times 1$. It starts at $\times 1$.

PITCH MODE sets how the fader is read. **FREE** is continuous. **JUST** snaps it to the nearest whole-number ratio: unison, the thirds, fourth, fifth, sixths and sevenths ($5/4$, $3/2$, $5/3$...), the octave, the same intervals an octave higher, and $\times 4$. **EQUAL** snaps it to the nearest equal-tempered semitone. **FINE** detunes from wherever the fader lands, in all three modes. The fader's tooltip names the interval. It starts at **FREE**.

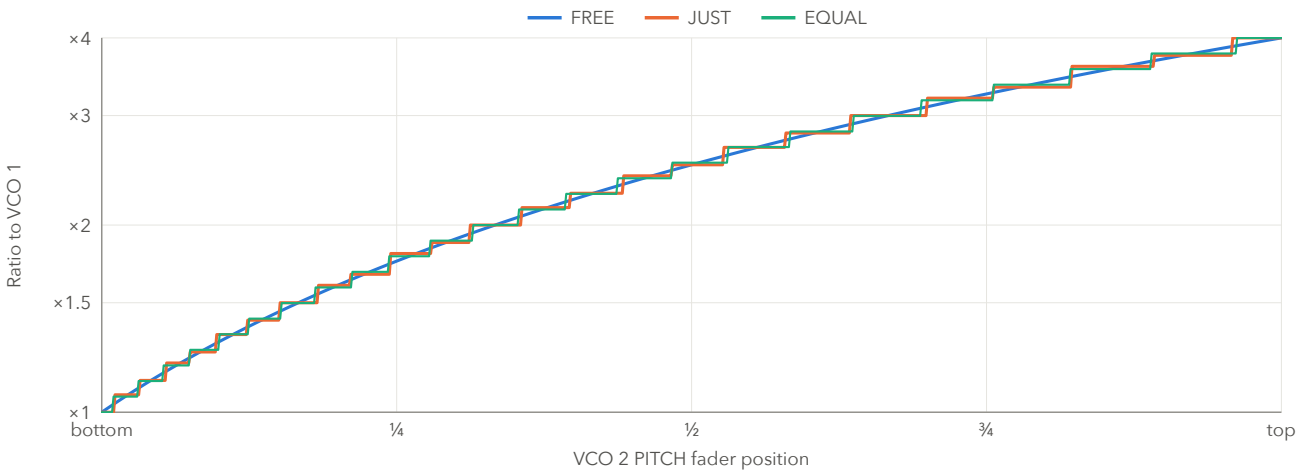


Figure 4. VCO 2's frequency ratio against fader position in the three PITCH MODEs, FINE centred. The vertical scale is logarithmic, so equal heights are equal musical intervals.

FINE (-50 to $+50$) is VCO 2's fine tuning in cents. It starts at its centre.

At $\times 1$ with **FINE** centred, VCO 1 and VCO 2 produce identical samples, so in DUET with VCO 1 on SAW the sound does not change as **BALANCE** moves. Detune **FINE** by a few cents to hear the two oscillators beat.

EFFECT switches the section on and off. Off, the voice plays VCO 1 alone whatever **BALANCE** is set to. It does not affect **LONG** or **CUTOFF**. It starts on.

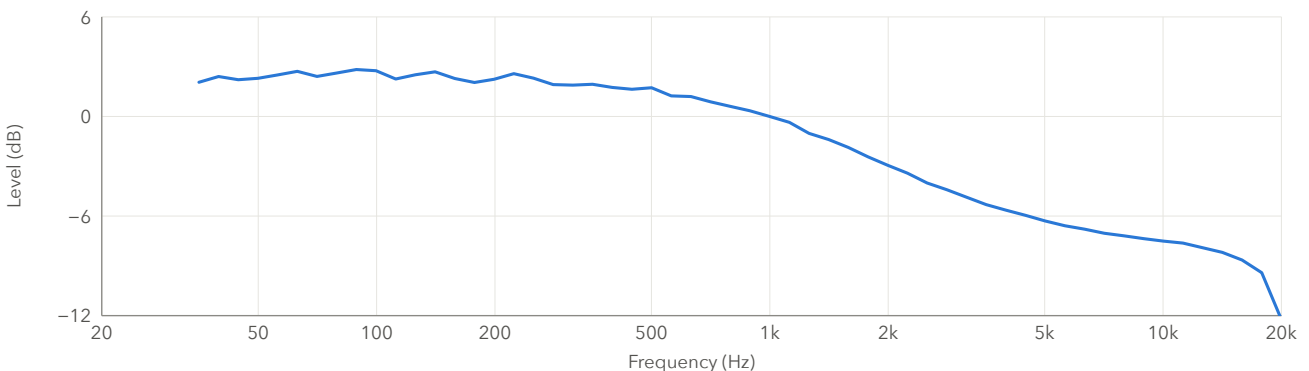


Figure 5. Spectrum of $\text{NOISE } \infty$ at OUT, in sixth-octave bands, relative to the band at 1 kHz. The noise source's own filtering tilts it down by about 10 dB between 50 Hz and 12 kHz.

3 • FILTER



- 14 HIGH PASS high-pass cutoff, 0 to 10
- 15 LOW PASS low-pass cutoff, 0 to 10
- 16 RESO resonance of both filters
- 17 ENV envelope amount on both cutoffs
- 18 HP MOD amount for the HIGH PASS input
- 19 LP MOD amount for the LOW PASS input
- 20 STOP keeps LOW PASS at or above HIGH PASS

The filter is a 12 dB/oct high-pass followed by a 12 dB/oct low-pass. Each is a two-pole diode-ring filter with its own slider. Together they pass a band: moving both sliders together moves the band, and moving them apart widens it.

HIGH PASS and LOW PASS (0 to 10) set the two cutoffs. Each mark is one octave:

Mark	0	1	2	3	4	5	6	7	8	9	10
Cutoff (Hz)	20	40	80	160	320	640	1280	2560	5120	10240	20480

The figures are for SCALE at 8'; each step of SCALE moves both cutoffs by one octave. The sliders start at HIGH PASS 0 and LOW PASS 10, which leaves the audio band open.

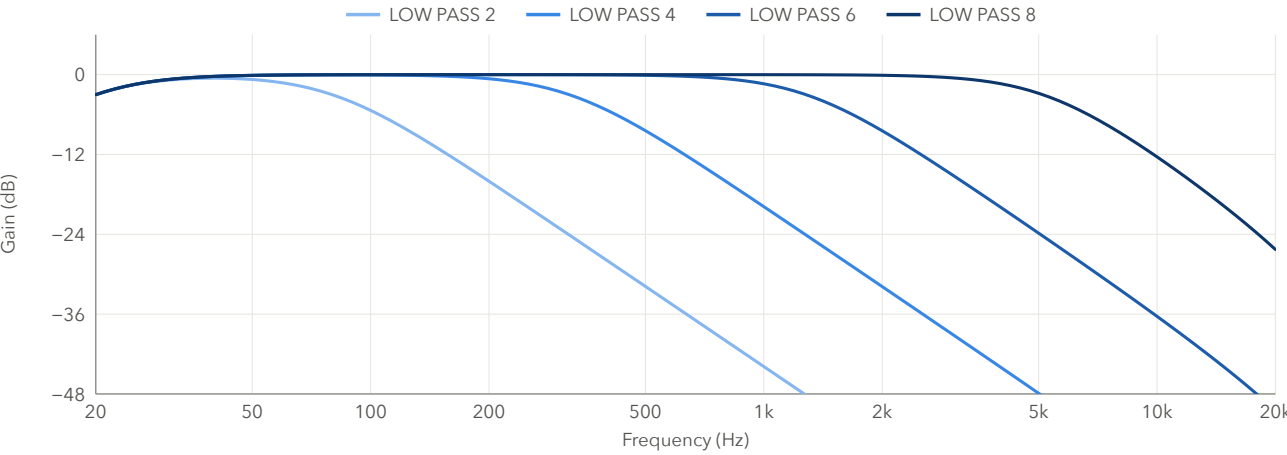


Figure 6. Low-pass response at four LOW PASS settings, HIGH PASS at 0, RESO off. At each cutoff the gain is -3 dB, and an octave above it -12 dB. The fall at 20 Hz is the high-pass at its lowest setting.

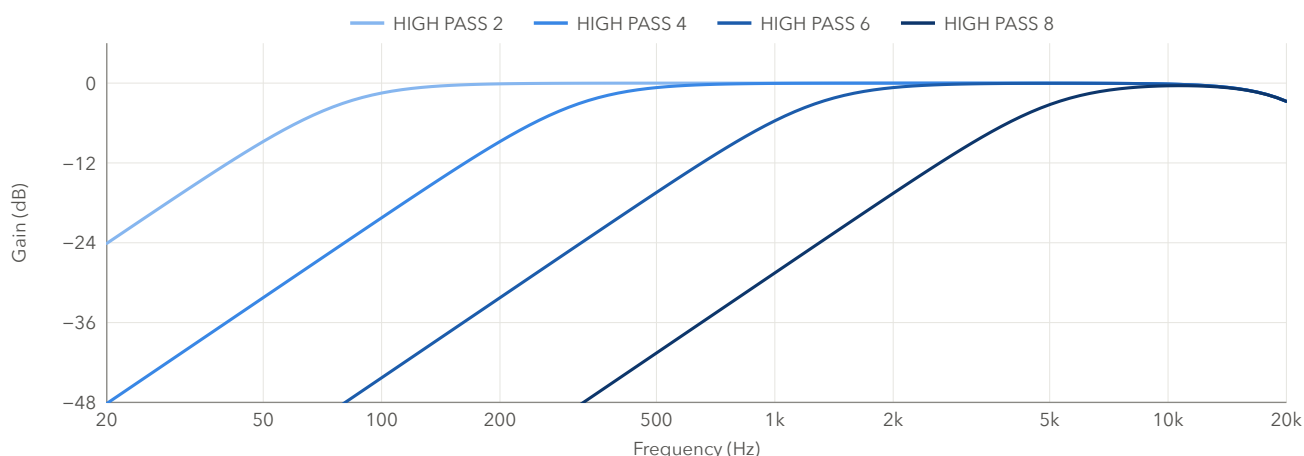


Figure 7. High-pass response at four HIGH PASS settings, LOW PASS at 10, RESO off.

The diode rings compress large signals smoothly rather than clipping them. Below full scale the effect is small with RESO off.

RESO (OFF to ON) sets the resonance of both filters together. At OFF each filter has a Q of 0.71, the flattest response without a peak. At ON the low-pass rings for about five cycles (Q 4.7) and the high-pass for about four (Q 3.7), the original instrument's factory setting. The passband level does not change; the response rises at each cutoff. Settings between OFF and ON give a resonance between the two. It starts at OFF.

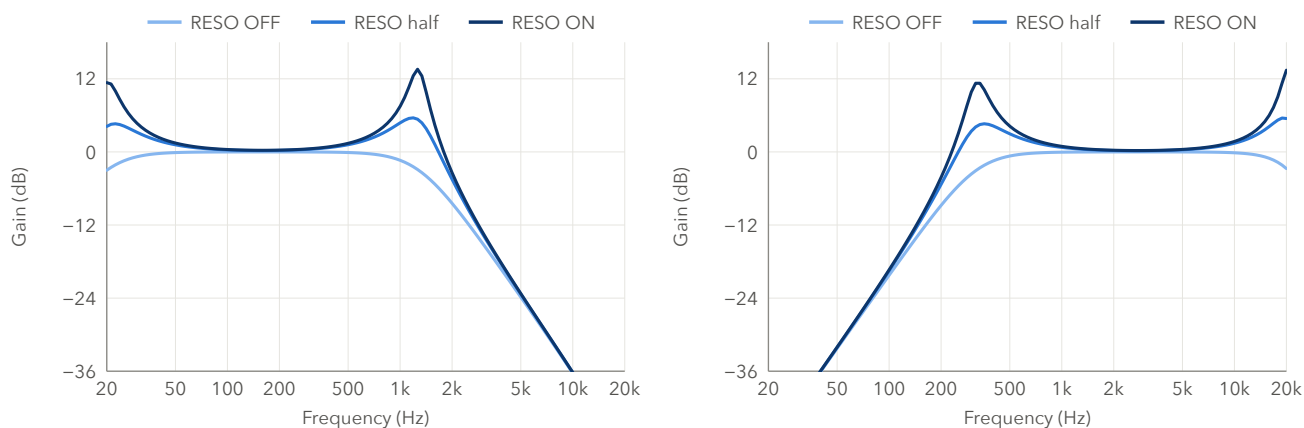


Figure 8. RESO at three settings. Left: LOW PASS at 6, HIGH PASS at 0. Right: HIGH PASS at 4, LOW PASS at 10. RESO acts on both filters, so each graph also shows the other filter's peak at the edge of the band: at 20 Hz on the left, near 20 kHz on the right. Small-signal measurement.

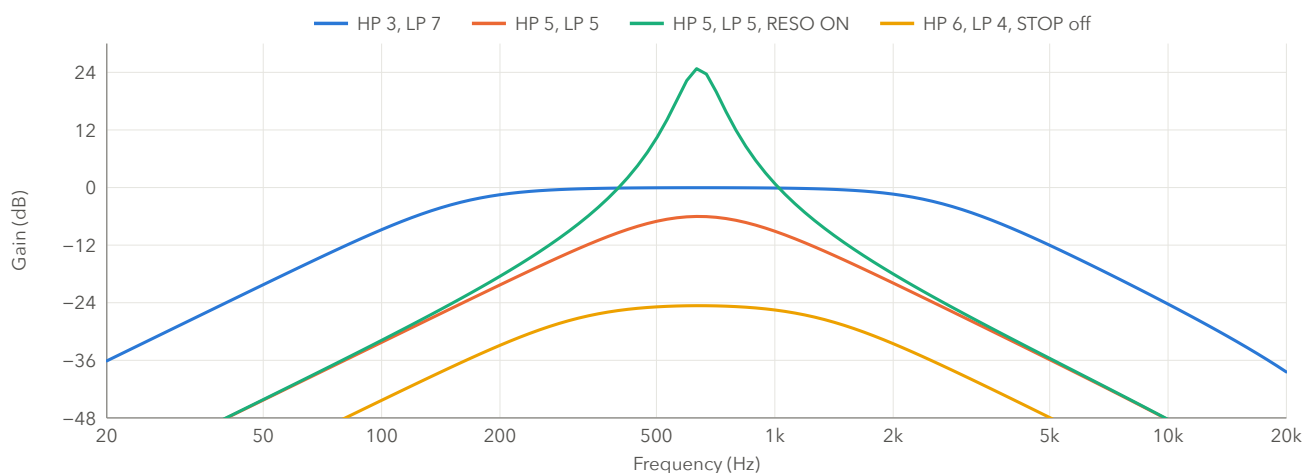


Figure 9. The two filters together. With both cutoffs at one setting the band narrows to a peak 6 dB down; with RESO on, the two resonances add to +25 dB. With STOP off and LOW PASS below HIGH PASS, the slopes overlap and the level falls by about 25 dB.

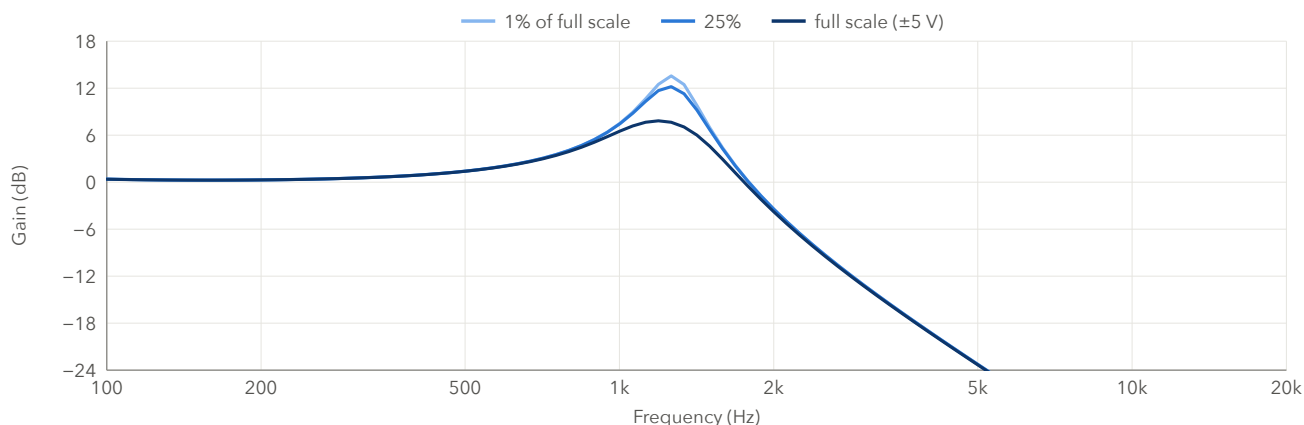


Figure 10. LOW PASS at 6 with RESO ON, measured with sine waves at three levels. The diodes and the output stage compress the resonant peak: +13.6 dB for small signals, +12.2 dB at a quarter of full scale, +7.8 dB at full scale.

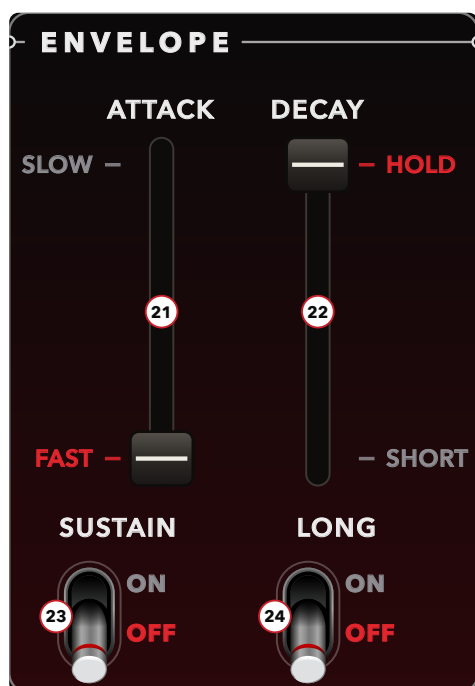
STOP reproduces the original's mechanical stop between the two knobs. On, the low-pass cutoff cannot go below the high-pass: if LOW PASS (with its CV) is set below HIGH PASS (with its CV), it is held at HIGH PASS. ENV, CUTOFF vibrato and SCALE move both cutoffs by the same amount, so they cannot break the rule. It starts on.

Off, the two are independent, and LOW PASS can be set below HIGH PASS. The pass band then closes: the slopes overlap, and the level drops (see the band figure).

ENV (OFF to ON) sets how far each note's envelope moves both cutoffs upwards. At ON both cutoffs rise by up to four octaves at the envelope's peak; between OFF and ON the movement is proportionally less. The same ATTACK and DECAY that shape the level therefore shape the tone. It starts at OFF. (This is not the **ENV** output jack.)

HP MOD and **LP MOD** set how much the **HIGH PASS** and **LOW PASS** inputs in the patchbay move each slider: none at the centre, and one mark (one octave) per volt at either end, inverted to the left of centre. The CV is added to the slider's position, and the sum is held within the slider's 0 to 10. **STOP** applies to the result. ENV and CUTOFF vibrato act on top. Slider and CV changes are smoothed over 5 ms. The CVs are meant for envelopes, LFOs and sequences, not audio-rate modulation.

4 • ENVELOPE



- 21 **ATTACK** rise time, FAST to SLOW
- 22 **DECAY** what a held note does, SHORT to HOLD
- 23 **SUSTAIN** a long release after the key
- 24 **LONG** attack, decay and SUSTAIN eleven times longer

The envelope has two sliders, not four, and it is not an ADSR. There is no sustain level. While the key is held, the envelope rises to its peak and then either holds there or decays towards silence. When the key is released it falls: quickly, or more slowly with **SUSTAIN** on. The envelope drives the VCA, and the filter through **ENV**.

Each segment is the charge or discharge of a capacitor: an exponential curve towards a target. A new note starts its attack from the envelope's current level, so a note played during another's release does not drop to zero first. A legato note does not restart the envelope.

ATTACK (FAST to SLOW) sets the rise from zero to the peak: 2 ms at FAST to 1 s at SLOW, exponentially along the slider. The rise aims at 1.5 times the peak and stops at the peak, so it is fast at first and slows into the top. It starts at FAST.

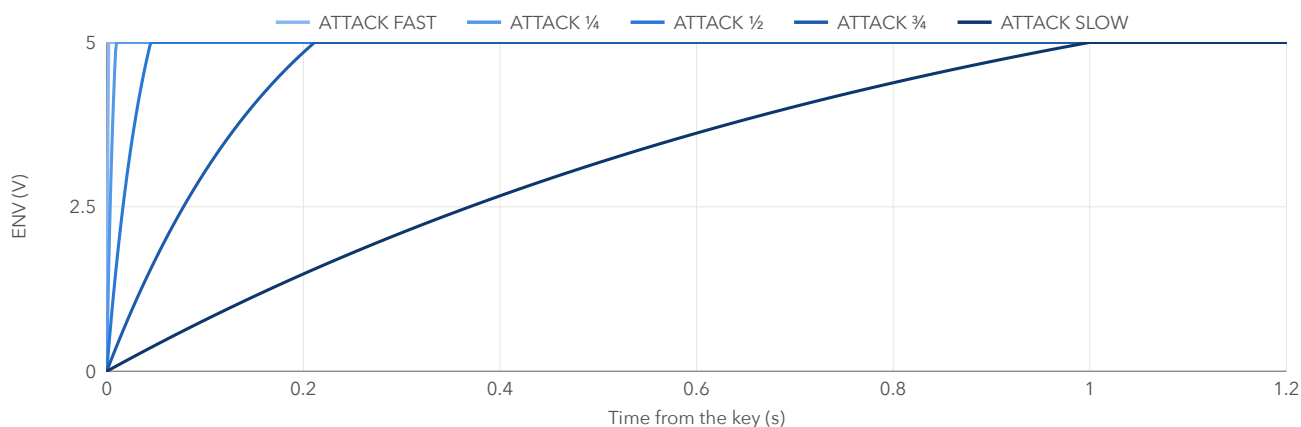


Figure 11. The attack at five ATTACK positions, DECAY at HOLD. Times to the peak: 2 ms, 9 ms, 45 ms, 0.21 s and 1 s.

DECAY (SHORT to HOLD) sets what a held note does after the attack. At HOLD the envelope stays at its peak while the key is held. Below HOLD it decays towards zero with a time constant of 0.15 s at SHORT, lengthening without limit towards HOLD. At SHORT a held note falls 40 dB in 0.7 s. It starts at HOLD.

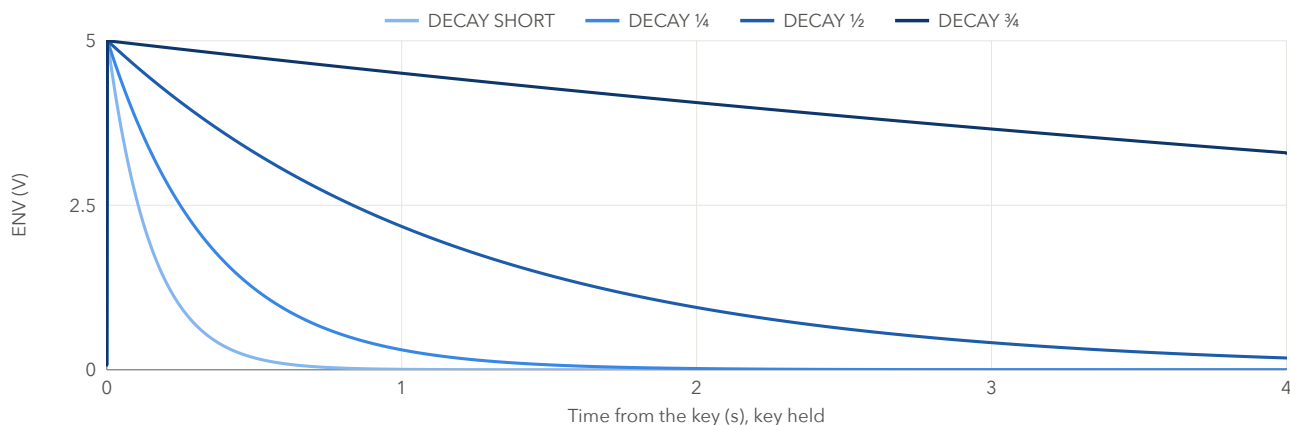


Figure 12. The held decay at four DECAY positions, ATTACK at FAST. Time constants: 0.15 s, 0.36 s, 1.2 s and 9.6 s.

SUSTAIN sets the release, and only the release. Off, the envelope falls with a 10 ms time constant when the key is released, and the VCA shuts 46 ms after the key: fast, but without a click. On, the time constant is 0.3 s, and the note is audible for about 1.4 s after the key. The release time is fixed. It starts off.

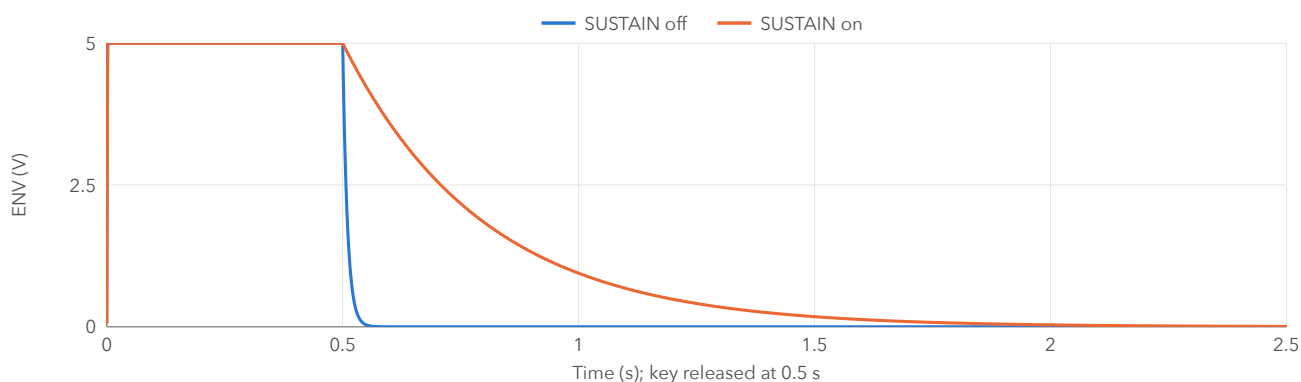


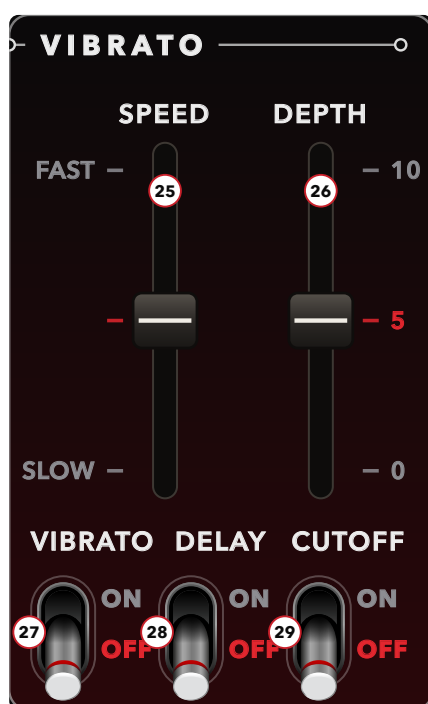
Figure 13. The release, ATTACK at FAST and DECAY at HOLD.

LONG multiplies the attack, the held decay and the SUSTAIN release by eleven. At **SLOW** the attack takes 11 s; with SUSTAIN on, the release is audible for about 15 s. It does not change the short release, so a note with SUSTAIN off still stops with the key. It starts off.

The VCA is linear in the envelope, and shuts completely when the envelope falls below 1% of its peak (−40 dB), so a released note ends in silence rather than a long low-level tail.

Sound	ATTACK	DECAY	SUSTAIN
Organ	FAST	HOLD	off
Plucked string, harpsichord	FAST	¼ up from SHORT	off
Struck bar	FAST	SHORT	on
Flute, bowed string	just under ½	HOLD	off
Bass with a ring after the key	FAST	¼ up from SHORT	on
Chime	FAST	most of the way to HOLD	on, with LONG

5 • VIBRATO



- 25 **SPEED** LFO rate, 2 to 15 Hz
- 26 **DEPTH** depth of vibrato and CUTOFF
- 27 **VIBRATO** vibrato from the start of each note
- 28 **DELAY** vibrato that fades in
- 29 **CUTOFF** the LFO on both filter cutoffs

One triangle LFO, shared by every voice, and three switches that send it to the pitch or the filter.

SPEED (SLOW to FAST) sets the rate, from 2 Hz to 15 Hz, exponentially along the slider. The centre is 5.5 Hz. It starts at the centre.

DEPTH (0 to 10) sets the depth of both the vibrato and CUTOFF. The slider has an audio taper: its centre is a tenth of full depth, so the lower half gives fine control of normal vibrato and the upper half gives large depths. It starts at the centre.

VIBRATO applies vibrato to the pitch from the start of each note. It starts off.

DELAY fades vibrato in over 0.6 s from each new note. The fade advances only while the key is held, and a legato note does not restart it. With VIBRATO and DELAY both on, VIBRATO takes precedence: full depth from the start. It starts off.

The vibrato is a fixed deviation in hertz, not in pitch, so it is wider in cents on low notes than on high ones. At the centre of DEPTH the deviation is ± 2.7 Hz: ± 71 cents at C2, ± 25 cents at F#3, ± 9 cents at C5. Section 11 explains why.

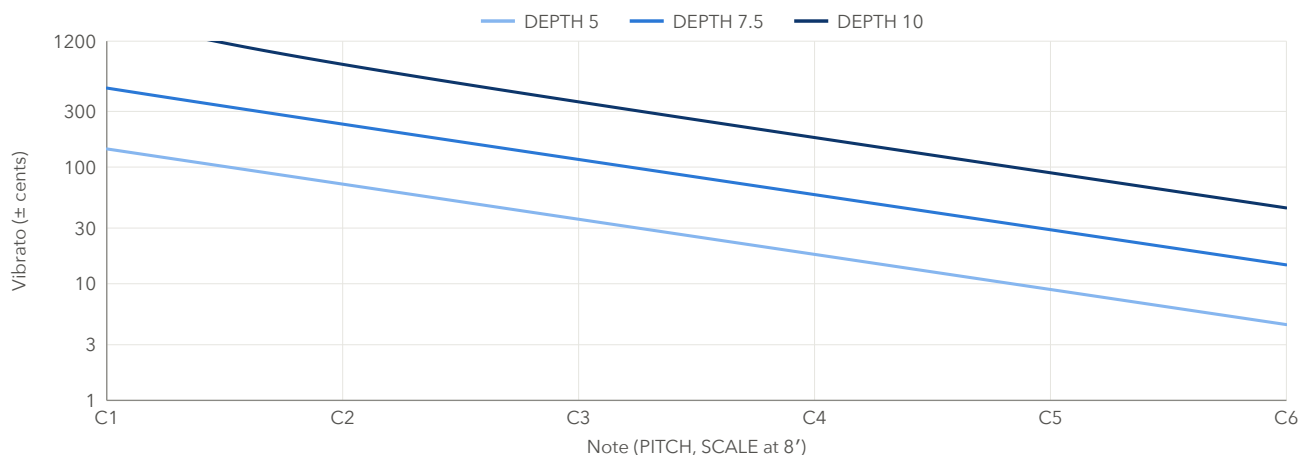
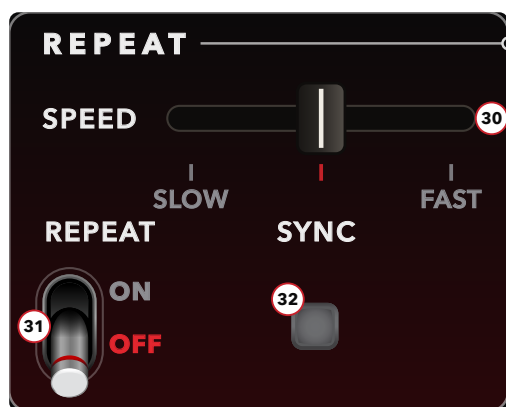


Figure 14. Vibrato depth across the keyboard at three DEPTH settings, measured on the voice's pitch. The depth halves with each octave up. At full DEPTH on the lowest notes the swing exceeds an octave.

CUTOFF applies the LFO to both filter cutoffs, so the band moves up and down at SPEED. At the centre of DEPTH it swings ± 0.4 octave; at full DEPTH, ± 4 octaves. It works without VIBRATO or DELAY, is never delayed, and is not switched off by EFFECT. It starts off.

The LFO's triangle, before DEPTH, is available at the LFO output, ± 5 V. It runs at SPEED whatever the switches are set to.

6 • REPEAT



- 30 **SPEED** clock rate, 2 to 25 Hz
- 31 **REPEAT** re-strikes held notes
- 32 **SYNC** SPEED as a division of the host's tempo

Repeat is a clock that re-strikes held notes at a steady rate. There is one clock for all the voices.

SPEED (SLOW to FAST) sets the clock's rate, from 2 to 25 Hz, exponentially along the slider. The centre is 7.1 Hz. It starts at the centre.

REPEAT turns re-striking on. While a key is held, the clock opens the envelope's gate for the first half of each period and closes it for the second half, so each period is a new attack and each gap a release. It starts off.

The clock is restarted by the first note of a phrase: a key that rises while every key is up. The first repeat comes one period after that key. While any key is held the phrase continues, and a note added to it, or a RETRIG, leaves the clock running. Such a note sounds from its key until the clock's next period begins, then follows the clock, so it joins the pulse of the notes already held. The phrase ends when every key is up.

Because Repeat works through the envelope, the envelope settings decide what it sounds like. With **ATTACK** at FAST and **SUSTAIN** off, each strike is sharp and each gap silent. With **SUSTAIN** on, the gaps fill in and the strikes become a pulse on a held note. With a slow attack and a fast **SPEED**, the envelope does not reach its peak before the next strike.

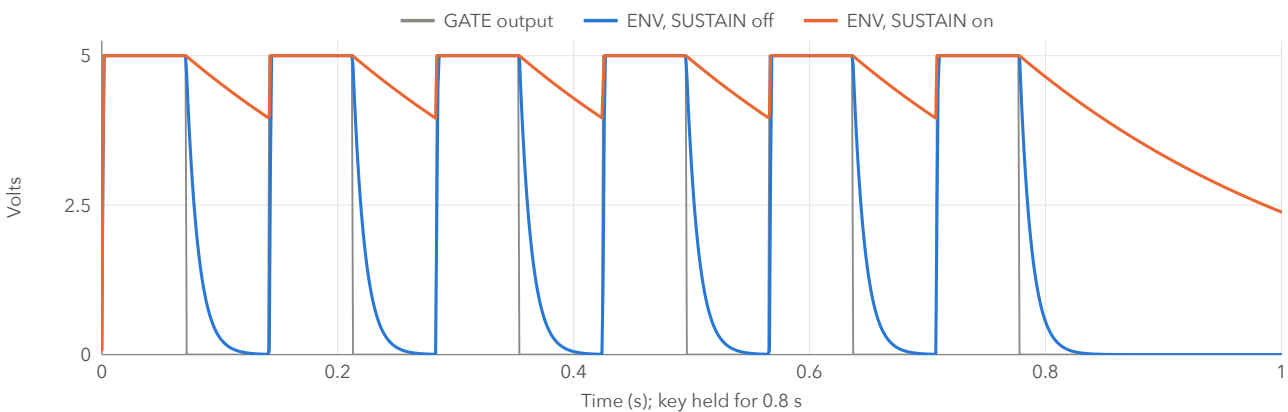


Figure 15. Repeat at **SPEED**'s centre (7.1 Hz), **ATTACK** at FAST, **DECAY** at HOLD.

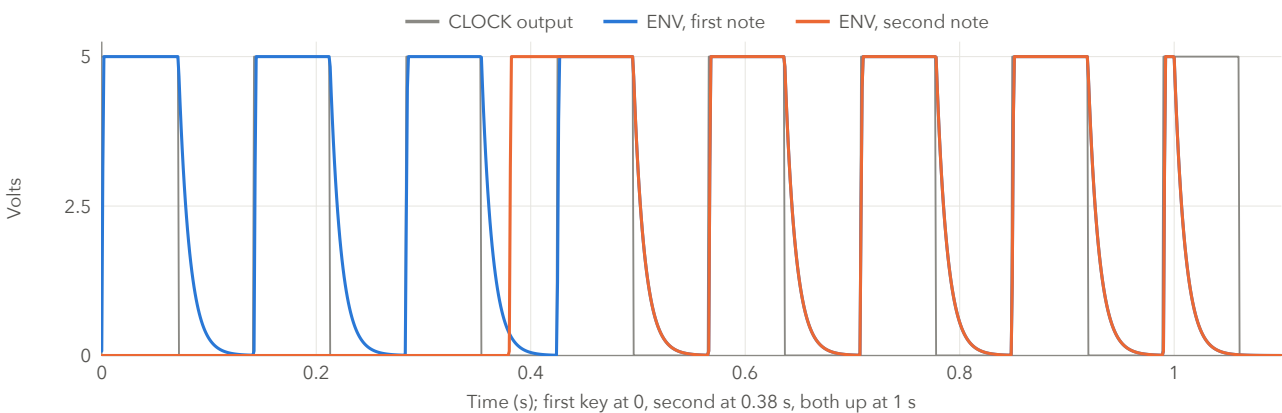


Figure 16. A phrase of two notes, Repeat at **SPEED**'s centre, **SUSTAIN** off. The second key falls in one of the clock's gaps: it sounds at once, holds until the next period begins, then repeats with the first. The clock is not restarted.

SYNC locks the clock to the host's tempo. With **SYNC** on, **SPEED** selects a note value, from four bars at the bottom to a thirty-second-note triplet at the top, and the clock runs at that value at the current tempo. The tooltip on **SPEED** shows the value and its rate. The first note of a phrase still restarts the clock, so the clock's phase follows the playing, not the host's beat. It starts off.

The **RATE** input moves the clock's rate at 1 V/oct, in both modes. **CLOCK** outputs the clock as a 0/5 V square wave; it runs whether **REPEAT** is on or off, and between phrases, and restarts with the first note of each phrase.

7 • GLIDE



- 33 TIME portamento time
- 34 PORTAMENTO glides between notes
- 35 BENDER a swoop up into each note

PORTAMENTO makes each voice glide from its previous pitch to each new one, at **TIME**. It starts off.

TIME (SHORT to LONG) sets the glide's time constant: none at the bottom, 0.2 s at the centre (where it starts), and 2 s at the top. A glide covers 95% of the distance in three time constants: 0.6 s at the centre and 6 s at the top. The slider has an audio taper, so most of its travel is given to short times.

The glide is exponential in frequency, not in pitch. It covers the same fraction of the distance in hertz in the same time, so a rising glide moves most of its pitch distance early, and a falling glide spreads it more evenly. Over an octave, a rising glide has covered seven semitones when a falling glide has covered five.

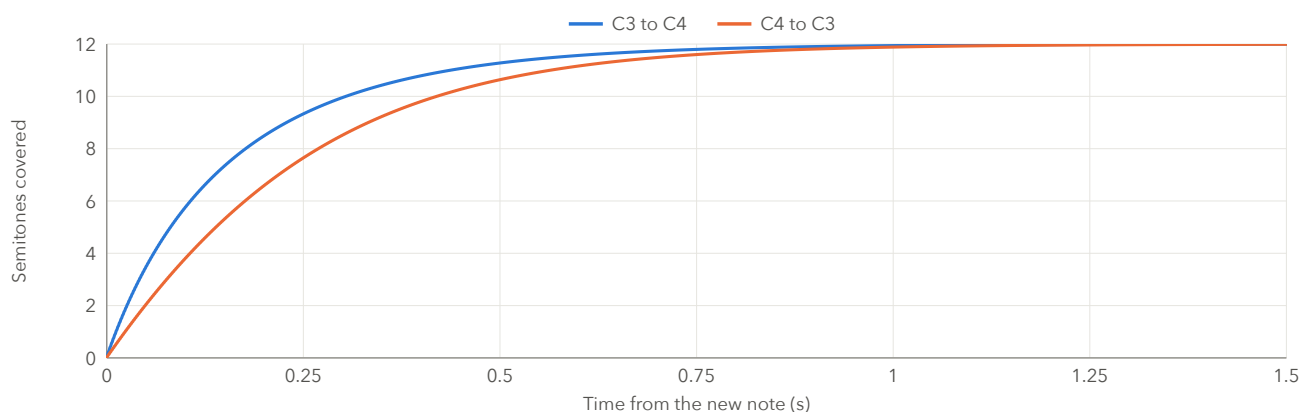


Figure 17. Portamento over an octave up and an octave down, TIME at its centre.

BENDER starts each new note 20 Hz below its pitch and lets it rise into the pitch, with a time constant of 80 ms: 95% of the way in 0.24 s. Like the vibrato, the depth is in hertz, so the swoop is about six semitones on C2, two on F#3 and under one from C5 up. Turning BENDER off ends a swoop at once. With PORTAMENTO on as well, the swoop is glided too. It starts off.

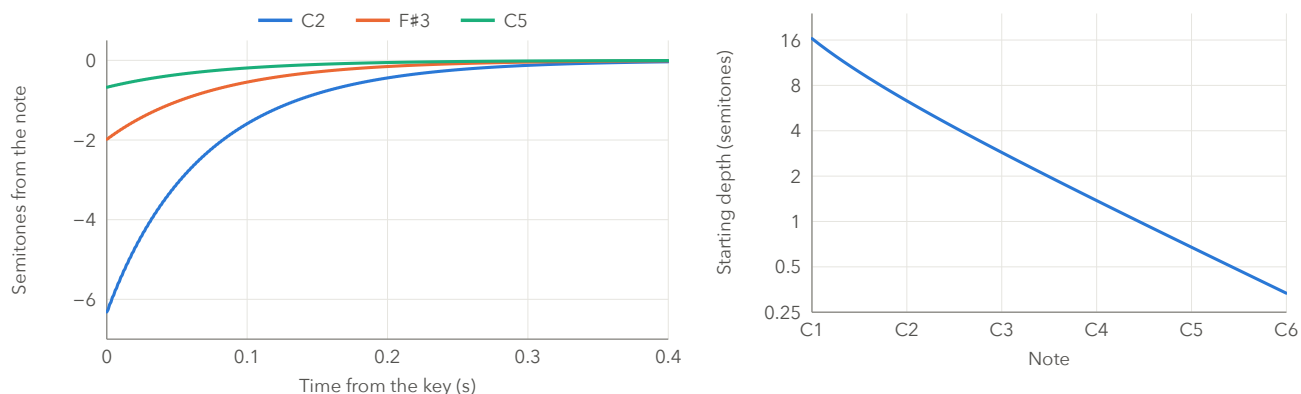
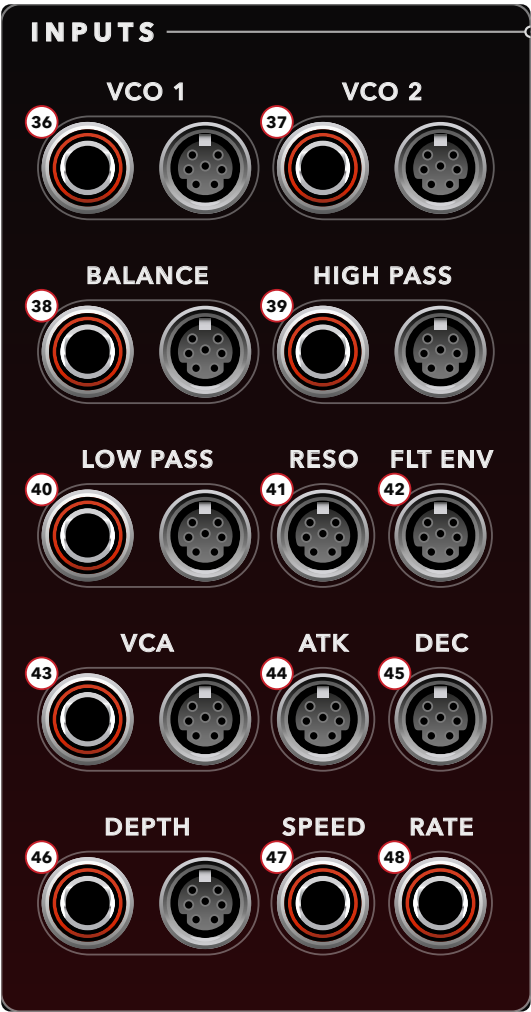


Figure 18. The Bender. Left: the swoop into three notes. Right: how far below the note each swoop starts, across the keyboard.

8 • INPUTS



- 36

VCO 1

mono + poly
- 37

VCO 2

mono + poly
- 38

BALANCE

mono + poly
- 39

HIGH PASS

mono + poly
- 40

LOW PASS

mono + poly
- 41

RESO

poly
- 42

FLT ENV

poly
- 43

VCA

mono + poly
- 44

ATK

poly
- 45

DEC

poly
- 46

DEPTH

mono + poly
- 47

SPEED

mono
- 48

RATE

mono

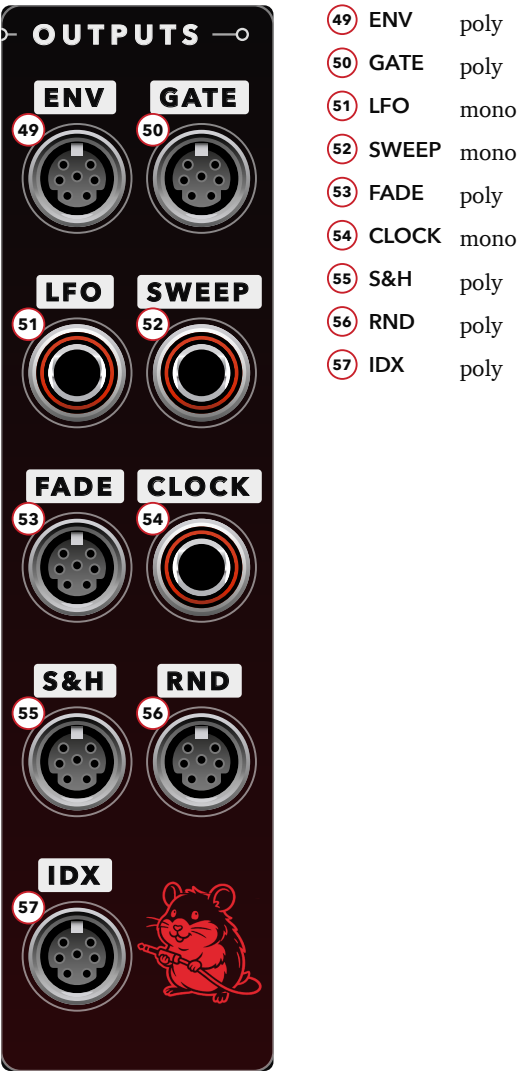
Input	What it does
VCO 1	VCO 1's pitch, through PITCH MOD: 1 V/oct at either end of the knob.
VCO 2	VCO 2's pitch, 1 V/oct, including RING FIX's fixed carrier.
BALANCE	BALANCE, through BAL MOD: at either end of the knob, ± 5 V moves it across its whole range.
HIGH PASS, LOW PASS	Each slider, through HP MOD or LP MOD: at either end of the knob, one mark (one octave) per volt.
RESO, FLT ENV	The filter's RESO and ENV knobs.
VCA	Opens the VCA, 0 V closed to 5 V fully open, in place of the envelope while either jack is patched.
ATK, DEC	ATTACK and DECAY.
DEPTH	Vibrato DEPTH, for each voice's own share of the vibrato and CUTOFF.
SPEED	Vibrato SPEED, for the one LFO.
RATE	Repeat's clock rate, 1 V/oct.

RESO, FLT ENV, ATK, DEC, DEPTH and SPEED have no amount knob. On each, +5 V moves the control from its bottom to its top, added to where the control is set; the sum is held within the control's range. DEPTH's CV is added before the slider's audio taper.

While a **VCA** jack is patched, the envelope no longer opens the VCA, but it still runs: **ENV** still carries it, so it can be processed elsewhere and patched back.

Each voice's CV is the mono jack plus its own channel of the poly jack. A mono LFO on LOW PASS sweeps every voice's filter together; velocity on LOW PASS's poly jack opens each note's filter by its own amount. **IDX** (Section 9) patched to **BALANCE** gives each voice a different balance, so a chord fades from VCO 1 to the effect section across its voices.

9 · OUTPUTS



Output	Range	What it carries
ENV	0 to 5 V	Each voice's envelope, including Repeat's re-strikes.
GATE	0 or 5 V	Each voice's gate as its envelope sees it: the key's gate, chopped by Repeat while REPEAT is on.
LFO	±5 V	The vibrato LFO's triangle, before DEPTH.
SWEEP	±5 V	VCO 1's chorus sweep, a triangle at CH I's rate or CH II's, as WAVE is set.
FADE	0 to 5 V	Each voice's delay-vibrato fade: a 0.6 s ramp from each new note, whether or not DELAY is on.
CLOCK	0 or 5 V	Repeat's clock, restarted by the first note of each phrase.

S&H	0 to 5 V	A random voltage per voice, drawn at each new note and, while REPEAT is on, at each of Repeat's periods.
RND	0 to 5 V	A random voltage per voice, drawn at each new note and held.
IDX	0 to 5 V	Each voice's position: 0 V for the first voice to 5 V for the last the cabinet runs, in equal steps.

None of these outputs passes through GAIN.

10 • Output, ECO and the display



- 58 ECO host-rate filter, lower cost
- 59 GAIN level of OUT and MIX, 0 to ×2
- 60 OUT poly: each voice on its own channel
- 61 MIX mono: the voices summed, at a quarter

OUT carries each voice on its own channel, at Kritter's level: about ±5 V for one oscillator (Section 1 gives measured levels).

MIX is the sum of the voices multiplied by 0.25. That gives a fixed headroom of four voices: a four-note chord peaks where one voice does on **OUT**, and a single note on **MIX** is 12 dB below **OUT**.

GAIN scales **OUT** and **MIX** together, linearly from silence at the left, through unity at the centre (where it starts), to ×2 (+6 dB) at the right. Its changes are smoothed over 5 ms. At ×2 a single note on **MIX** is 6 dB below **OUT**.

ECO

ECO runs the filter of every voice at the host's sample rate instead of twice it. It costs a little under half as much per sounding voice, so more voices fit on a slower computer. It starts off (HI).

Under **ECO**, the oscillators, the effect section and **BALANCE** still run at twice the host rate, and are brought down to it with a shorter filter than **HI** uses. The diode filter then runs at the host rate behind a low-pass at 16 kHz, which stops the diodes folding high frequencies back into the audible range. The cost is a slight loss at the top of the audio band.

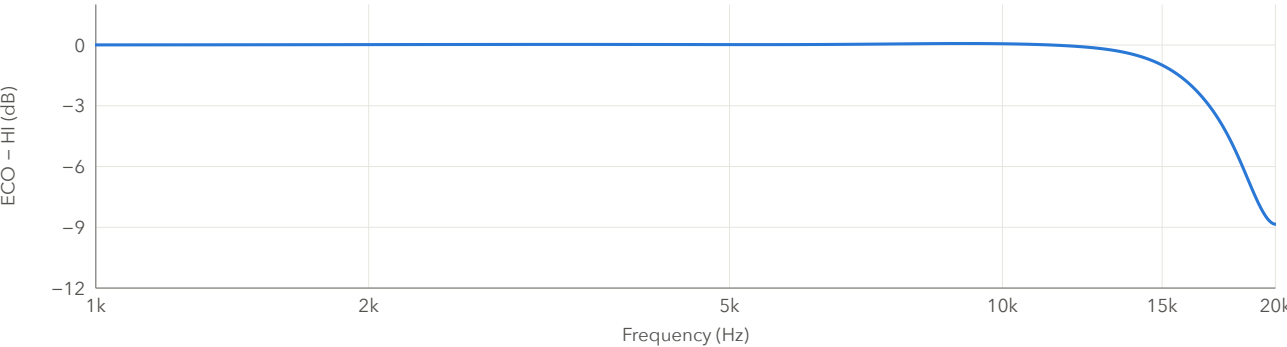


Figure 19. The level of the harmonics of a sawtooth at C2 under **ECO**, against **HI**. **ECO** is within 0.3 dB of **HI** to 13 kHz, -2.3 dB at 16 kHz and -8.7 dB at 19.7 kHz.

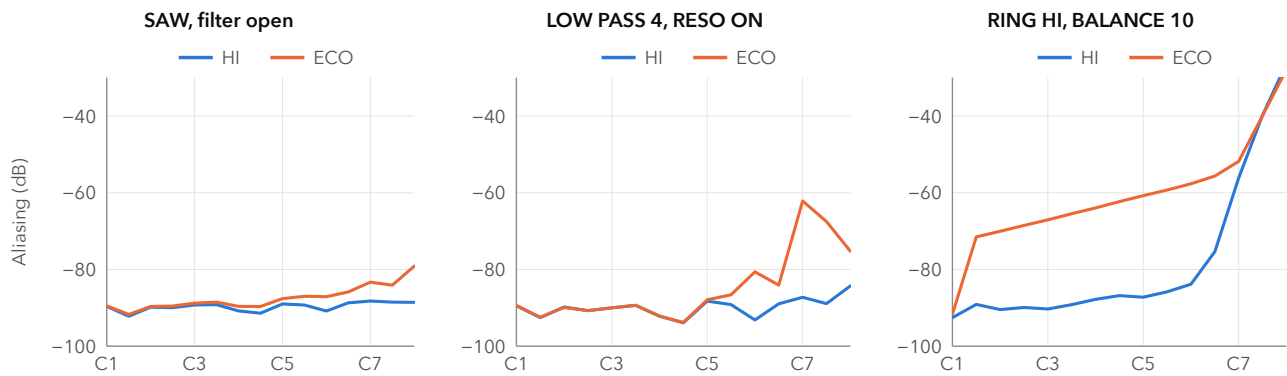


Figure 20. Alias energy below 15 kHz against the signal, across the keyboard, HI and ECO. On plain and filtered sounds the two are close; the ring modulator aliases more under ECO, by 20 dB or more from C2 to C6.

Changing ECO while notes sound fades the outputs out over 10 ms, switches, and fades back in over 10 ms, so the change does not click.

The display

The strip across the top of the face shows **MIX** as an oscilloscope trace: about 21 ms at 48 kHz, starting at a rising zero crossing, so a held note stands still. With no zero crossing (silence, or a very slow sweep) it shows the latest samples. Its vertical range is ± 7 V. It has no controls and does not affect the sound.

11 • Hertz, not pitch

The original instrument's oscillators were linear in frequency, and its keyboard voltage stood for hertz rather than octaves. Its vibrato, Bender and portamento acted on that voltage, so they acted in hertz. A fixed deviation in hertz is a large interval on a low note and a small one on a high note, and an exponential glide in hertz is not symmetrical in pitch.

PolyKritter takes 1 V/oct pitch, so that it works with the rest of the rack. Each voice converts its pitch to hertz, applies the Bender, then portamento, then vibrato, and converts the result back to 1 V/oct for the oscillators. With all three off, **PITCH** passes through exactly.

The effects:

- Vibrato at one DEPTH is deeper on low notes: it halves with each octave up.
- The Bender's swoop is wide on low notes and slight on high ones.
- Portamento covers more of its pitch distance early when rising than when falling.

There is no switch for a 1 V/oct behaviour. For vibrato that is equal in pitch across the keyboard, patch **LFO** through an attenuator into the **VCO 1** input; it moves VCO 1 only.

12 • Control ranges

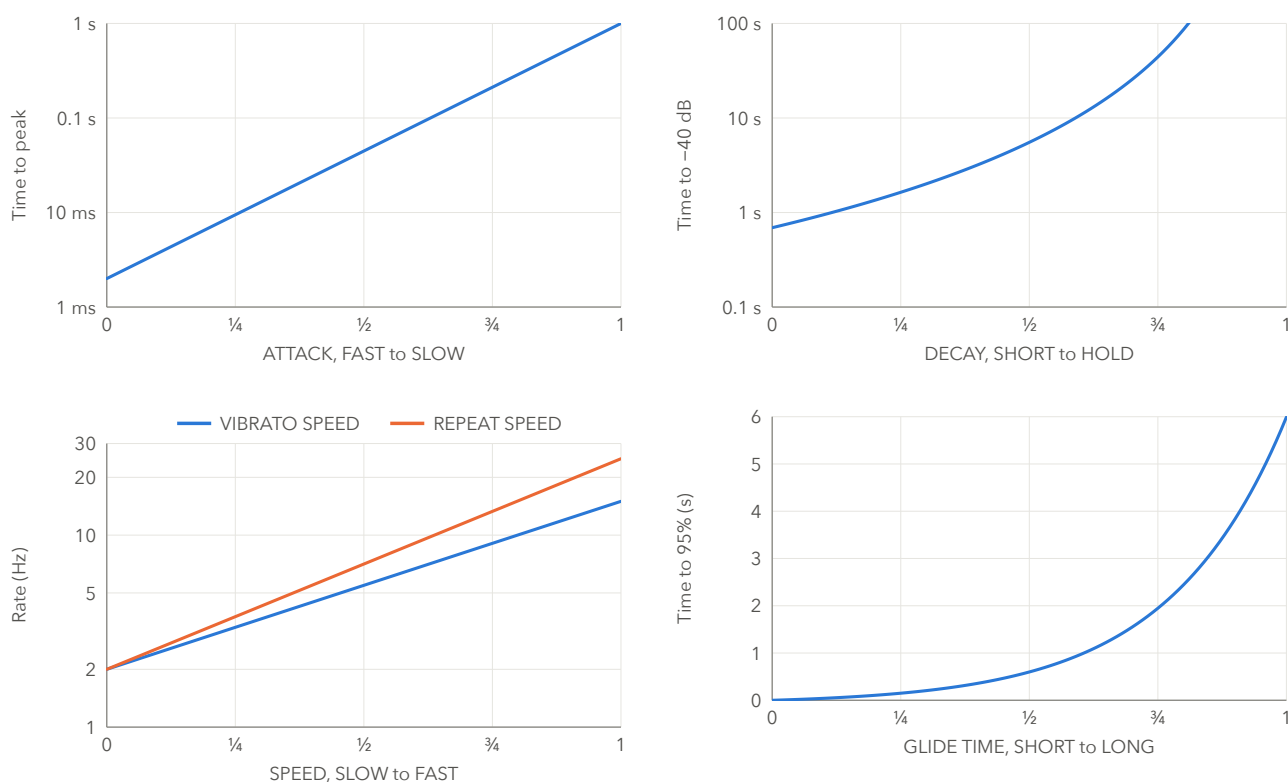


Figure 21. The slider laws. Each is the function the engine runs. DECAY's time is infinite at HOLD. LONG multiplies ATTACK and DECAY by eleven. VIBRATO DEPTH and GLIDE TIME share the audio taper: 10% of full value at half travel.

Quantity	Value	Notes
Pitch input	1 V/oct	0 V = C2, 65.41 Hz, at 8'
Internal sample rate	2 × host	HI; the filter at 1 × host under ECO
CV read rate	every 32 samples	GATE and RETRIG every sample
Filter cutoff	20 Hz × 2 ^{mark}	at 8'; 12 dB/oct each filter
Filter Q	0.71 / 4.7 (LP), 3.7 (HP)	RESO OFF / ON

ENV on the filter	up to +4 octaves	at the envelope's peak, ENV at ON
CUTOFF vibrato	± 0.4 oct / ± 4 oct	DEPTH at centre / full
Attack	2 ms to 1 s	time to peak; $\times 11$ with LONG
Held decay	τ 0.15 s to ∞	$\times 11$ with LONG
Release	τ 10 ms / 0.3 s	SUSTAIN off / on; 0.3 s $\times 11$ with LONG
VCA shut-off	1% of peak	−40 dB
Vibrato rate	2 to 15 Hz	centre 5.5 Hz
Vibrato depth	± 27 Hz at full	± 2.7 Hz at centre
Delay vibrato	0.6 s	linear fade-in
Repeat rate	2 to 25 Hz	centre 7.1 Hz; 50% duty
Portamento	τ 0 to 2 s	0.2 s at centre
Bender	−20 Hz, τ 80 ms	
CH I / CH II	0.8 Hz, 15–85% / 5 Hz, 40–60%	pulse width sweep
VCO 2	$\times 1$ to $\times 4$, FINE ± 50 cents	fixed carrier 110 to 440 Hz
OUT	± 5 V	per oscillator, before the filter
MIX	$0.25 \times \text{sum}$	
GAIN	0 to $\times 2$	unity at centre
CV outputs	0 to 5 V, or ± 5 V	see Section 9

The original instrument's times and ranges were not published. The values above are the module's, chosen to fit the instrument's documented behaviour; the shape of each response follows the circuit. The measurements in this manual are taken from the module's code: the filter responses by passing sine waves through the filter alone at the voice's internal rate, and everything else by running one voice at 48 kHz.

Troubleshooting

- **No sound from the effect section:** BALANCE is at 0, or EFFECT is off.
- **The filter goes quiet as a slider moves:** STOP is off, and LOW PASS is below HIGH PASS.
- **Vibrato is too wide on low notes and too narrow on high ones:** see Section 11.
- **Only some notes sound:** the cabinet's polyphony is lower than the number of channels on the cable.
- **MIX is quiet with one note:** MIX has four voices of headroom. Use GAIN, or OUT.