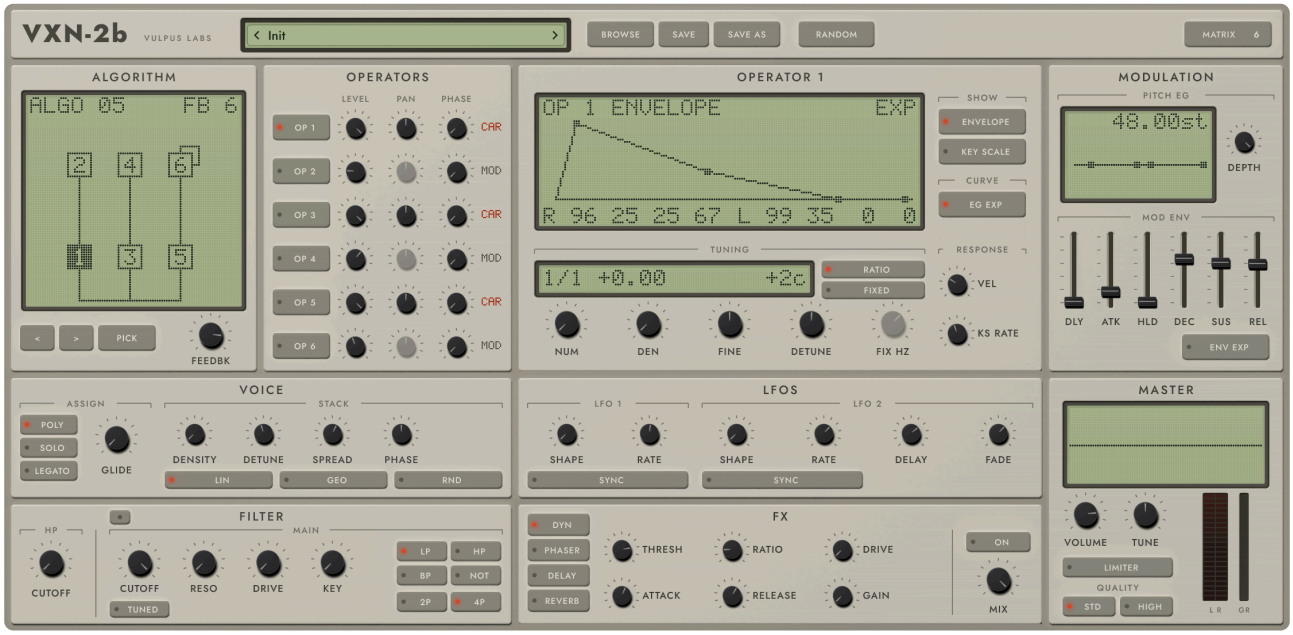
vxn-2b

Six-operator FM synthesizer · CLAP plugin and web instrument



vxn-2b is a polyphonic FM synthesizer. Each voice has six sine-wave operators, wired together by one of thirty-two algorithms, each operator with its own envelope, tuning, velocity response and key scaling. A voice can stack up to eight copies of itself on one note, detuned and spread. Two LFOs, a pitch envelope, a modulation envelope and a sixteen-route matrix move it; a ladder filter, dynamics, phaser, delay and reverb finish it.

This manual describes every control. Its pictures of the faceplate are drawn by the plugin's own code, and its graphs are measured by running the plugin's engine. The example patches in the last chapters are factory presets: load them by name and play.

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Overview

What it is

vxn-2b is the successor to vxn-2. It plays vxn-2's factory sounds, converted, through a new faceplate and a cleaner engine: a pure sine in every operator, oversampling chosen by **QUALITY**, and a ladder filter that is neutral when it is open.

Frequency modulation makes sounds by letting one oscillator bend the phase of another. An operator that is heard is a **carrier**; an operator that only bends another is a **modulator**. The louder a modulator, the more harmonics its carrier grows; the ratio between their frequencies decides which harmonics. That is where the bells, electric pianos, glassy basses and metallic stabs come from.

Signal path

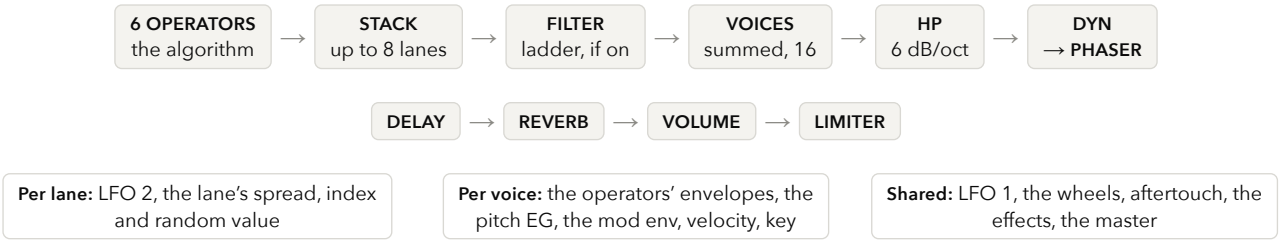


Figure 1. One voice, then the shared chain. Everything up to the voices' sum runs at the rate **QUALITY** sets (Section 11); the effects run at the host's rate, but for the dynamics' drive, and the phaser at **HIGH**.

Each operator has its own envelope, so a modulator's envelope shapes the timbre and a carrier's the level. There is no separate amplifier envelope or fixed filter envelope: the **MOD ENV** and the matrix (Section 8) do what those would.

The faceplate

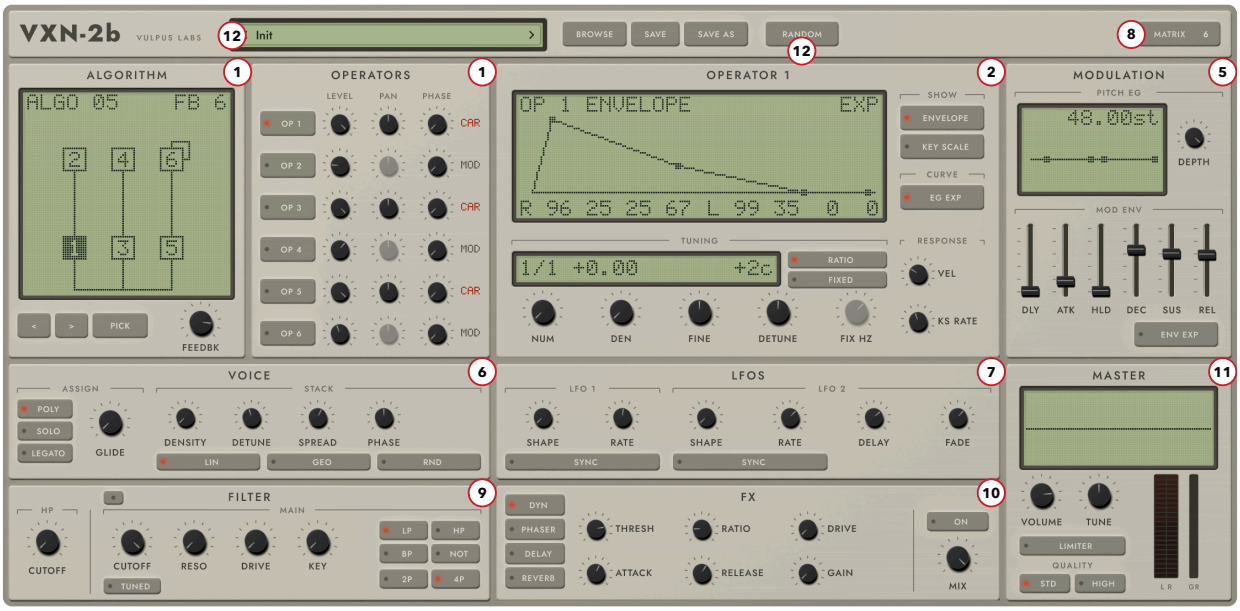


Figure 2. The faceplate. Each number is the section of this manual that describes it.

(1) **ALGORITHM, OPERATORS**	the algorithm, feedback, each operator's level	(2) **OPERATOR**	the selected operator: tuning, response
(5) **MODULATION**	pitch EG and mod env	(6) **VOICE**	Poly, Solo, glide; the stack
(7) **LFOS**	two low-frequency oscillators	(8) **MATRIX**	opens the routing
(9) **FILTER**	high-pass and ladder filter	(10) **FX**	dynamics, phaser, delay, reverb
(11) **MASTER**	scope, volume, tune, limiter, quality, meters	(12) **Preset bar, RANDOM**	presets, and a new random sound

Sections 3 and 4 are the selected operator's envelope and key scaling, both drawn and edited on its LCD. The faceplate has one page; the **OPERATOR** plate shows one of the six operators at a time, and the **FX** plate one of the four effects.

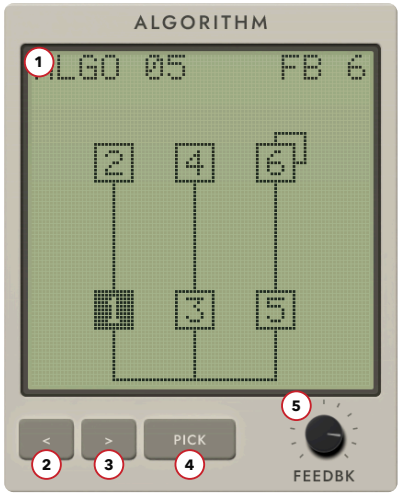
Knobs turn by dragging up and down, or scrolling. A key is on when its lamp is lit. Hover over a control to see its value. A control that has no effect in the current setting is dimmed, and still works: **PAN** on a modulator, the ratio knobs on a fixed-frequency operator.

Init

A new instance starts from the Init patch, an electric piano:

- Algorithm 5: three pairs, ops 2, 4 and 6 each modulating ops 1, 3 and 5. **FEEDBK** 6 on op 6.
- Op 2, at 14:1 and level 17, is the piano's tine; ops 4 and 6, at 1:1, give it body.
- Ops 1 and 5 are detuned +2 and −5 cents, so the carriers beat gently. **VOICE SPREAD** is routed to ops 1 and 3's pans, so a stack spreads across the stereo field.
- One lane a voice (**DENSITY** 1), **POLY**, **QUALITY** Standard, the filter off, every effect off.

1 · Algorithm and operators



1. **LCD** — the algorithm, its number, the feedback
2. **‹** — the previous algorithm
3. **›** — the next algorithm
4. **PICK** — all 32, to choose by sight
5. **FEEDBK** — feedback, 0 to 7

The **algorithm** decides which operators modulate which, and which are heard. The LCD draws it: each box is an operator, a line from one box down to another means the upper one modulates the lower, and the boxes on the bottom row are the carriers. The operator selected below is drawn filled. Click a box to select that operator.

‹ and › step through the algorithms; **PICK** shows all thirty-two at once, as on the right, and a click chooses one. Changing the algorithm never changes the operators' own settings.

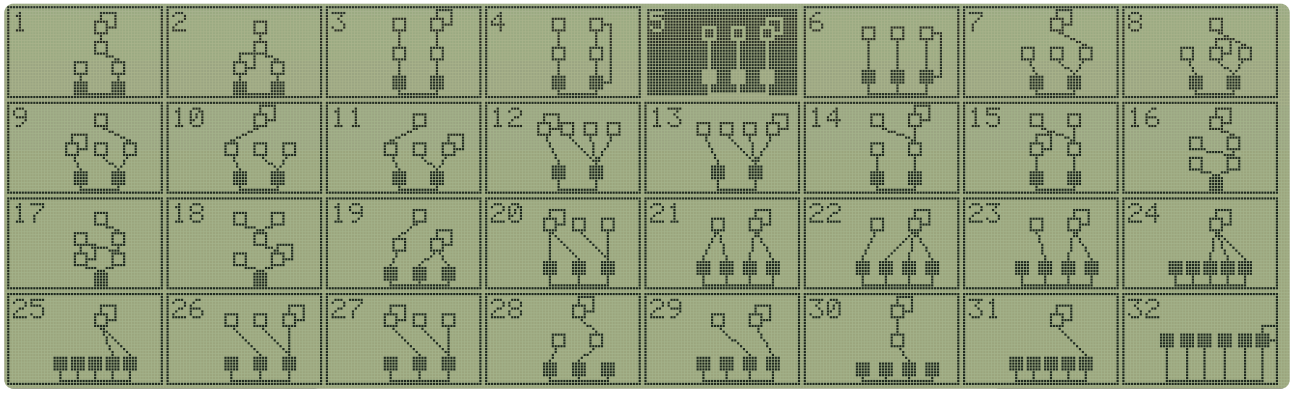


Figure 3. PICK: every algorithm. Algorithm 32 makes all six operators carriers, an organ of sines; algorithm 1 is a four-operator chain and a pair.

FEEDBK feeds one operator's output back into its own modulation input. Every algorithm has one feedback loop, drawn on the LCD as the line that turns back on itself. In 30 algorithms it is one operator modulating itself; in algorithms 4 and 6 it wraps round three and two operators. At 0 the operator is a sine. As feedback rises it grows harmonics, much as a saw does, and near 7 it breaks into noise.

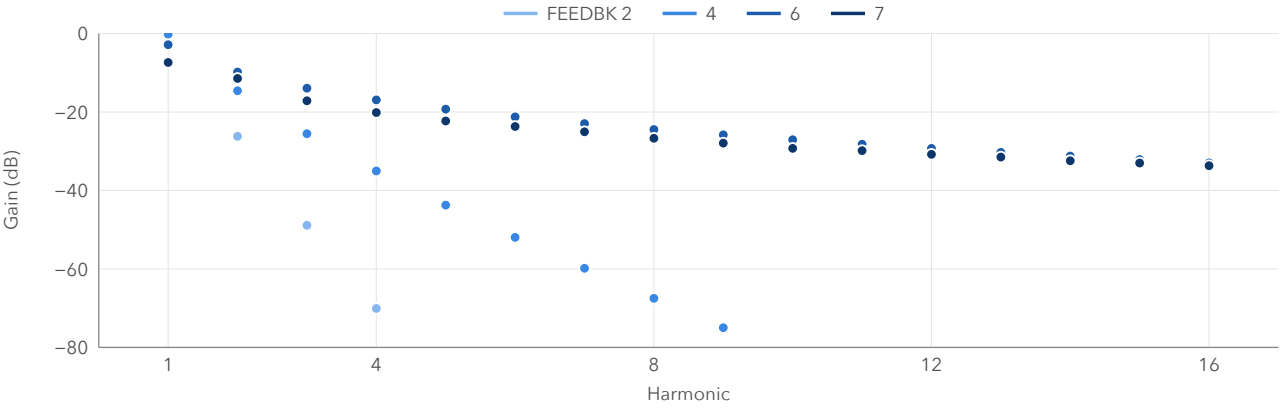


Figure 4. Op 6 alone (algorithm 32) at C3, its harmonics at four **FEEDBK** settings, in dB from its fundamental at **FEEDBK** 0. At 7 the "harmonics" are the peaks of a noisy spectrum.

The operators



1. **OP 1–6** — select the operator shown in OPERATOR
2. **LEVEL** — output level, 0 to 99
3. **PAN** — a carrier's place in the stereo field
4. **PHASE** — where the operator starts each note
5. **CAR / MOD** — what the algorithm makes it

The **OPERATORS** plate holds every operator's three most-used controls at once. The key at the left of each row selects that operator for the **OPERATOR** plate (Sections 2 to 4).

LEVEL is an operator's output. On a carrier it is loudness; on a modulator it is how far it bends its carrier, the **modulation index**, and so how bright. The scale is logarithmic: each step is 0.75 dB above level 20, and steeper below it, so 99 is full, 91 is 6 dB down and 0 is silent.

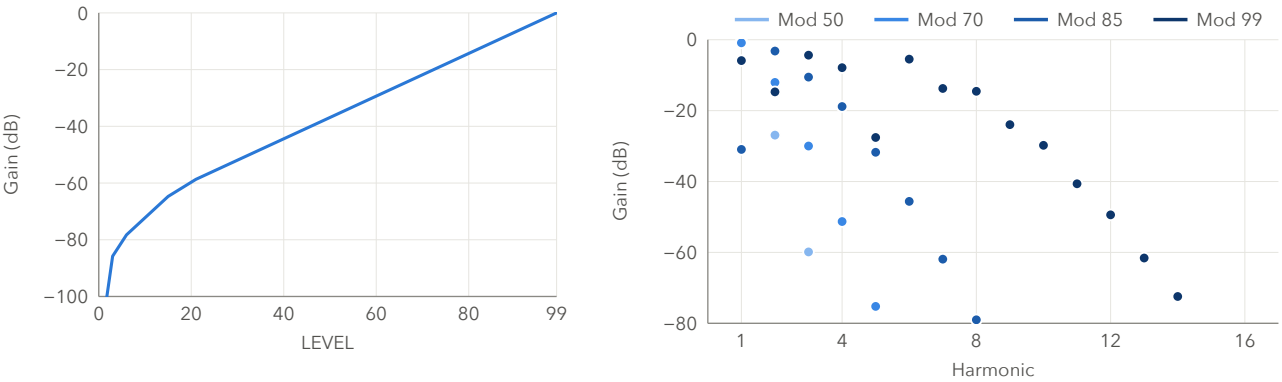


Figure 5. Left: a carrier's output against **LEVEL**, from its level at 99. Right: algorithm 1, op 2 modulating op 1 at the same frequency (1:1), op 1's harmonics for four levels of op 2, in dB from op 1 alone. Each step of the modulator's level brings in more of the upper harmonics.

PAN places a carrier in the stereo field. A modulator's pan is not heard, as its output only modulates, so its **PAN** is dimmed. **PHASE** sets where in its cycle the operator starts at each note, from 0 to one whole cycle. Two carriers at the same pitch and opposite phases cancel; a modulator's phase changes the attack of its carrier.

CAR or **MOD**, beside each row, says what the algorithm makes that operator.

2 · The selected operator: tuning and response



1	**LCD**	the envelope or the key scaling	2	**ENVELOPE**	show the envelope (Section 3)
3	**KEY SCALE**	show the key scaling (Section 4)	4	**CURVE**	the shown graph's curves
5	**Readout**	the tuning	6	**RATIO**	tuned to the key
7	**FIXED**	a fixed frequency	8	**NUM**	ratio numerator, 1 to 32
9	**DEN**	ratio denominator, 1 to 8	10	**FINE**	hundredths added to NUM
11	**DETUNE**	cents, −100 to +100	12	**FIX HZ**	frequency when FIXED, 1 Hz to 9.77 kHz
13	**VEL**	velocity sensitivity, 0 to 7	14	**KS RATE**	envelope speed across the keys, 0 to 7

The **OPERATOR** plate shows the operator selected in **OPERATORS**, or by a click on its box in the algorithm. Its title says which.

Tuning

At **RATIO** an operator plays the key's frequency times **NUM** over **DEN**, with **FINE** adding hundredths to **NUM**: 1/1 is the key, 2/1 an octave up, 3/2 a fifth up, 14/1 the fourteenth harmonic. The ratio between a modulator and its carrier sets which harmonics FM makes: a whole number keeps them on the carrier's harmonic series; a fraction, or a **FINE** offset, makes them inharmonic, as a bell's are. The ratio is exact, so a 14:1 modulator stays on the fourteenth harmonic.

DETUNE moves the operator by cents, −100 to +100, as a pitch offset added to the key. Two carriers a few cents apart beat slowly against each other.

At **FIXED** the operator ignores the key and plays **FIX HZ**, from 1 Hz to 9.77 kHz. A fixed modulator gives every note the same sidebands, which is how struck metal and drums are made; a fixed carrier is a drone. **FIXED** dims the ratio knobs, and **RATIO** dims **FIX HZ**. The readout shows the ratio, its fine offset and detune, or the frequency:



Figure 6. Op 1 at **FIXED**: the ratio knobs dim and **FIX HZ** wakes.

Response

VEL sets how much the key velocity moves the operator's level, from none at 0 to most at 7. Velocity adds to the level rather than only taking away: struck hard, a sensitive operator goes above its **LEVEL**. On a modulator, velocity is therefore brightness.

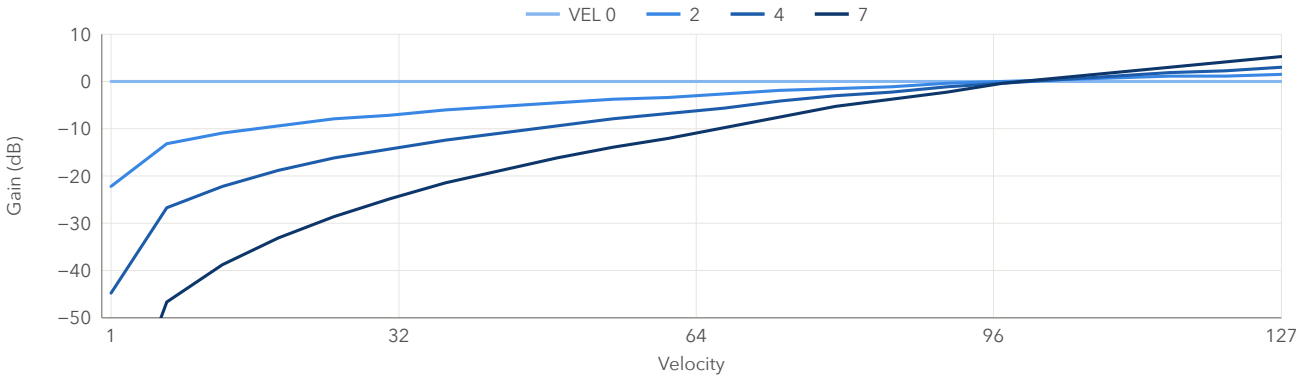


Figure 7. An operator's level against velocity, in dB from its level at **VEL** 0, at four **VEL** settings. At **VEL** 7, velocity 127 lifts it 5.3 dB above its **LEVEL**.

KS RATE speeds up all four envelope rates on higher notes, and slows them on lower notes, about A3 (Section 4).

3 · Operator envelopes

Every operator has its own envelope of four rates and four levels. **ENVELOPE** in **SHOW** draws the selected operator's on its LCD, with its values along the bottom; drag a point to change it.

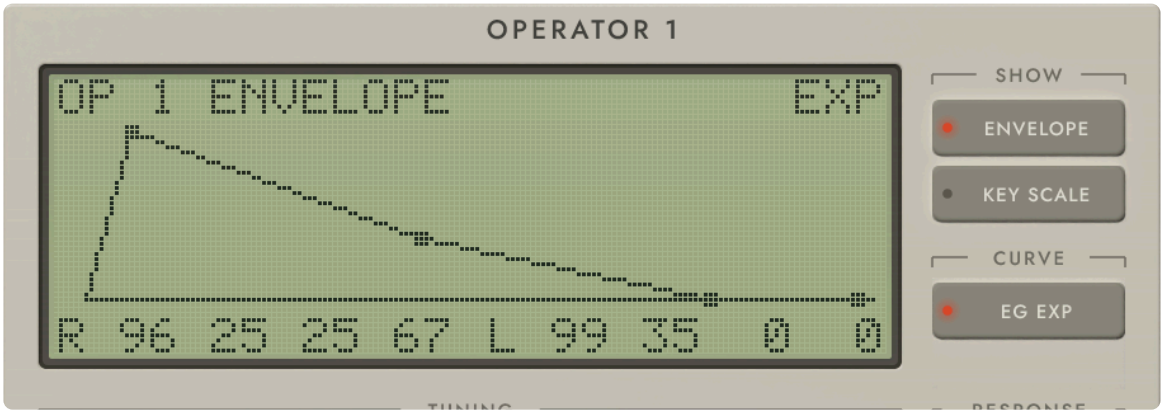


Figure 8. Op 1's envelope. The points are, left to right, L1, L2, L3 and L4; the line between each pair is drawn at the speed its rate sets.

At a key, the level moves from L4 to L1 at rate R1, then to L2 at R2, then to L3 at R3, and holds at L3 while the key is held. When the key is let go it moves to L4 at R4. Levels and rates both run from 0 to 99. A rate is a speed, not a time: a larger move at the same rate takes longer. A level may be above or below the one before it, so a "decay" can rise.

On a carrier the envelope is the note's loudness. On a modulator it is the note's brightness over time: a modulator that decays fast gives a bright attack that mellows, which is a piano, a bell, a pluck.

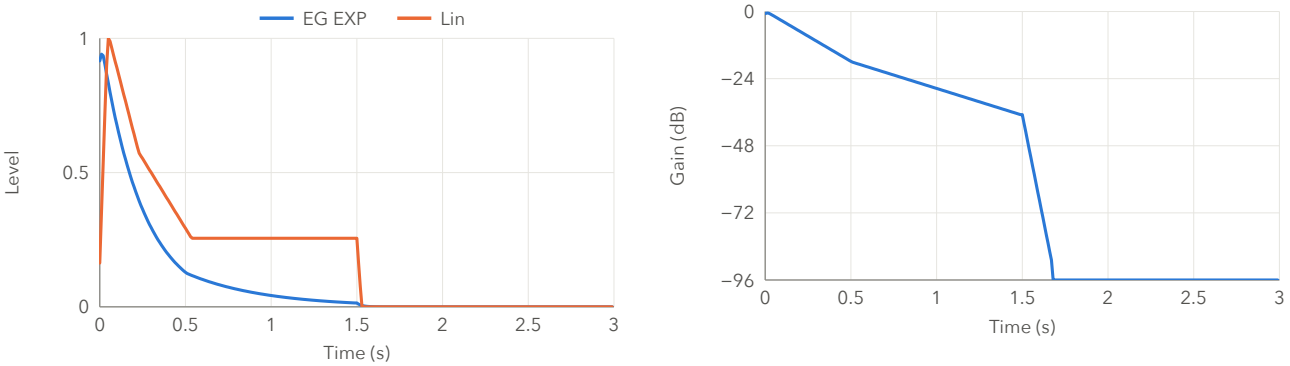


Figure 9. One carrier's envelope, R 75 45 35 60, L 99 75 50 0, the key held for 1.5 s. Left: its level, at **EG EXP** and with it off. Right: the **EG EXP** curve in dB, where each segment is a straight line.

EG EXP, in **CURVE**, sets the envelope's levels and its march: lit (the default), levels follow the same scale as **LEVEL**, 0.75 dB a step, and each segment moves evenly in decibels, which is how a struck or plucked sound dies away. Off, levels are linear in amplitude and the segments move evenly in amplitude, which gives softer fades and a slower apparent decay.

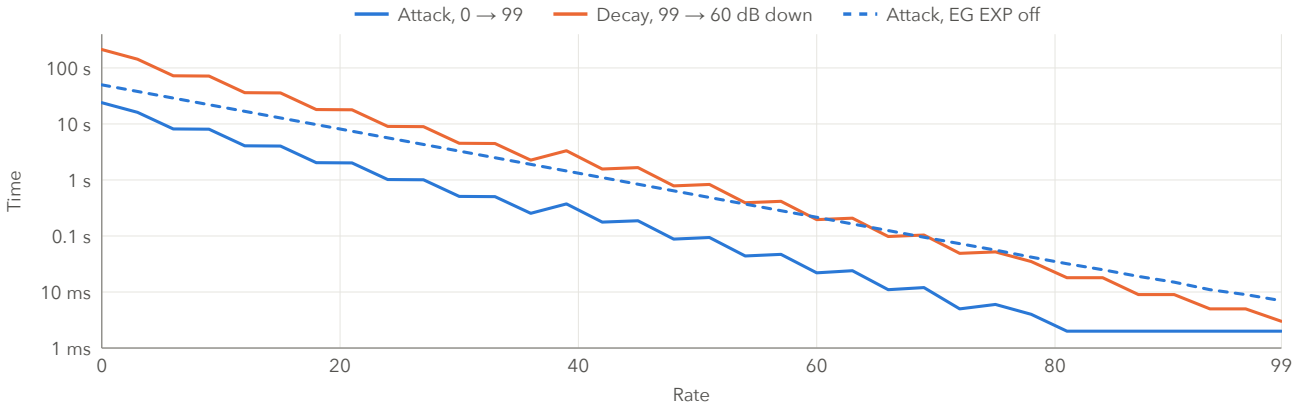


Figure 10. How long a full segment takes at each rate. Rate 99 attacks in 0.002 s; at rate 0 a fall of 60 dB takes 213 s.

4 · Key scaling

KEY SCALE in **SHOW** draws the selected operator's level scaling across the keyboard: a break point, and a depth and curve on each side of it. Drag the break point sideways to move it, and each side's end up or down to set its depth and direction. The bottom of the LCD names the break point and the two curves.

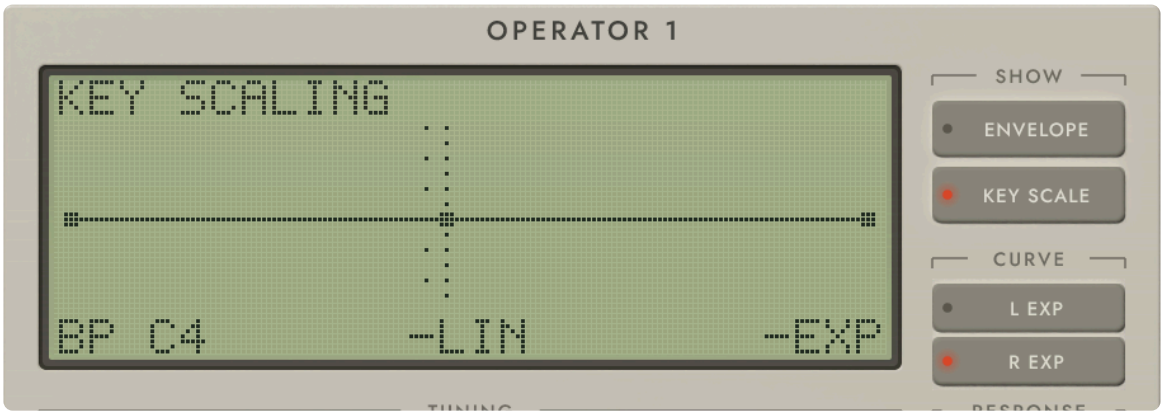


Figure 11. Op 1's key scaling: break point C4, both sides at depth 0.

Key scaling adds to or takes from the operator's level above and below the break point, more the further the key is from it. On a modulator it keeps high notes from turning harsh, or low notes from turning thin; on a carrier it balances the level across the keyboard. A side's curve is linear (so many decibels a semitone) or exponential (gentle near the break point, steep far from it), and cuts (−) or boosts (+). **L EXP** and **R EXP** in **CURVE** switch each side between the two; dragging a side through zero switches it between cut and boost. The scaling begins a few semitones below the break point. A boost cannot lift an operator above full level, so on an operator at 99 only a cut is heard.

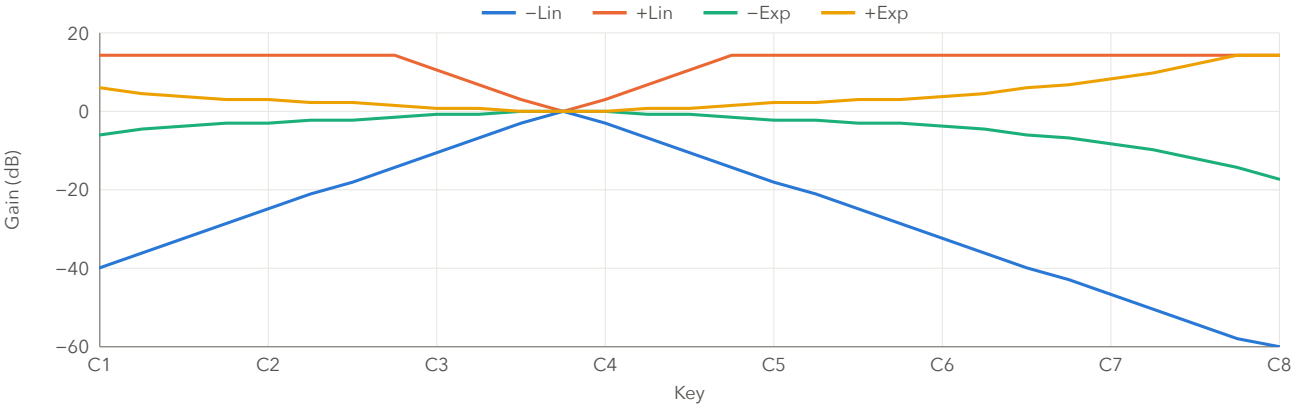


Figure 12. Both sides at depth 60, break point C4, an operator at level 80: its level across the keyboard against the same key unscaled, for each curve.

KS RATE, in **RESPONSE**, makes the whole envelope faster on high notes and slower on low ones, as real strings and bars decay faster the higher they sound. At 0 every key is the same; at 7 each octave above A3 is 1.41 times faster, so C8 runs 4.4 times as fast as A3, and C1 0.39 times.

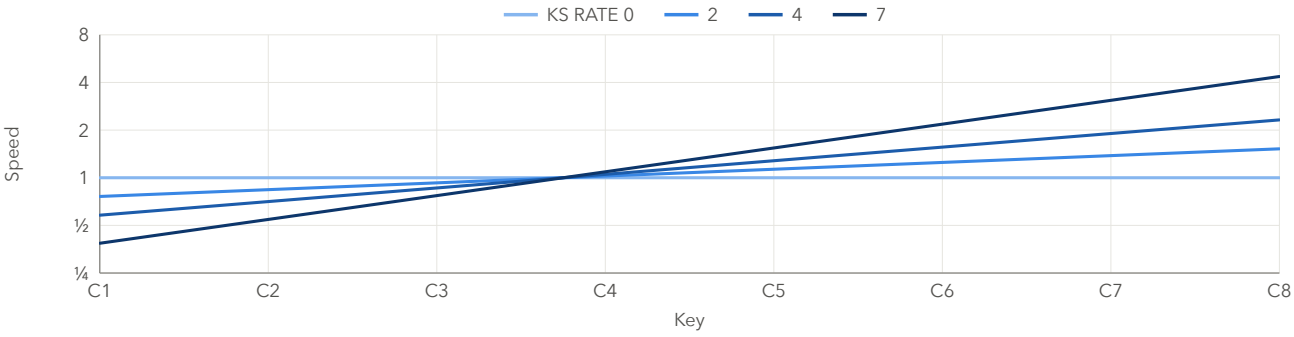
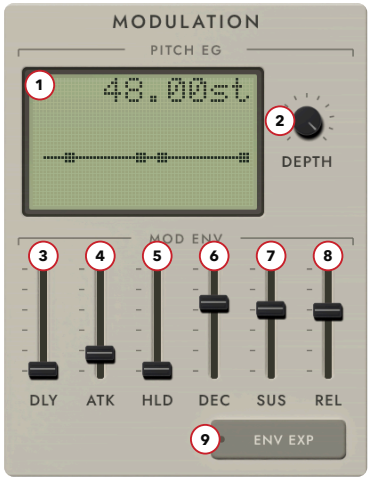


Figure 13. How much faster the envelope runs at each key, against A3.

5 · Pitch EG and mod env



1. **PITCH EG** the pitch envelope, edited on its LCD
2. **DEPTH** its full swing, 0 to 48 semitones
3. **DLY** mod env delay, 0 to 4 s
4. **ATK** attack, 0 to 4 s
5. **HLD** hold at the peak, 0 to 4 s
6. **DEC** decay, 0 to 4 s
7. **SUS** sustain level, 0 to 1
8. **REL** release, 0 to 4 s
9. **ENV EXP** the mod env's curve

Pitch EG

The pitch envelope bends every operator's pitch together, by four rates and four levels as an operator's envelope does (Section 3), but its levels run from −99 to +99, below and above the key's pitch. +99 is up by **DEPTH** semitones and −99 down by as many. It holds at L3 while the key is held, and returns to L4 on release; with every level at 0, the default, it does nothing. Drag its points on its LCD; the readout shows **DEPTH**, or the value of a point being dragged.

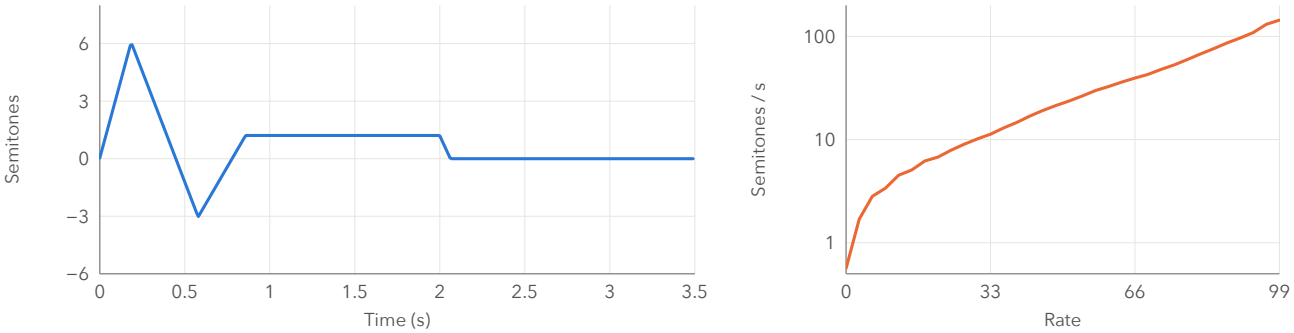


Figure 14. Left: R 60 50 40 45, L +50 −25 +10 0, **DEPTH** 12, the key held for 2 s. Right: how fast the pitch EG moves at each rate, from 0.56 to 144 semitones a second.

Its rate is a speed in semitones a second, so a shallower **DEPTH** also makes the same envelope arrive sooner. The pitch EG is also a matrix source (Section 8), to bend one operator alone.

Mod env

The mod env is a general envelope for the matrix: it does nothing until a route uses it. After a key it waits **DLY**, rises to 1 over **ATK**, holds there for **HLD**, falls to **SUS** over **DEC**, and holds at **SUS** while the key is held; on release it falls to 0 over **REL**. At 0, **DLY** and **HLD** are skipped.

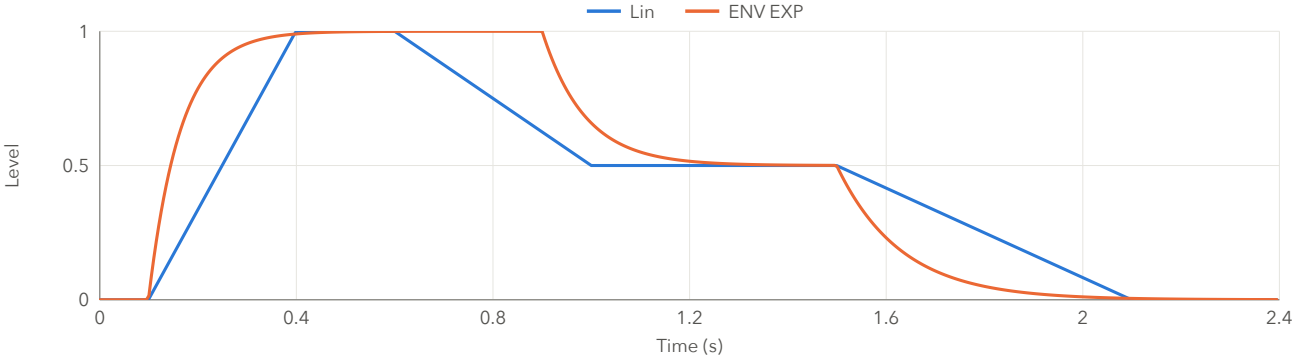


Figure 15. DLY 100 ms, ATK 300 ms, HLD 200 ms, DEC 400 ms, SUS 0.5, REL 600 ms, the key held for 1.5 s.

ENV EXP lit makes each stage a curve that moves fast at first and settles into its target, reaching 99% of the way in the stage's time; off, each stage is a straight line.

6 · Voices and stacks



1 **POLY**	up to 16 notes	2 **SOLO**	one note at a time
3 **LEGATO**	Solo: no new strike when notes overlap	4 **GLIDE**	portamento, 0 to 2 s
5 **DENSITY**	lanes in each note's stack, 1 to 8	6 **DETUNE**	the stack's detune, 0 to 50 cents
7 **SPREAD**	the stack's VOICE SPREAD, 0 to 1	8 **PHASE**	how far apart the lanes start
9 **LIN, GEO, RND**	how the lanes are spaced		

Poly and Solo

At **POLY** vxn-2b plays up to sixteen notes; a seventeenth takes the quietest voice. At **SOLO** it plays one, and letting go of a key returns to the last key still held. With **LEGATO** on, a key played while another is held changes the pitch without a new strike: the envelopes carry on.

GLIDE slides each note's pitch from the note before, in a straight line in semitones taking the **GLIDE** time, at **POLY** and **SOLO** alike. At **POLY** a new note takes the free voice nearest in pitch, so slides stay short. At 0 there is no glide.

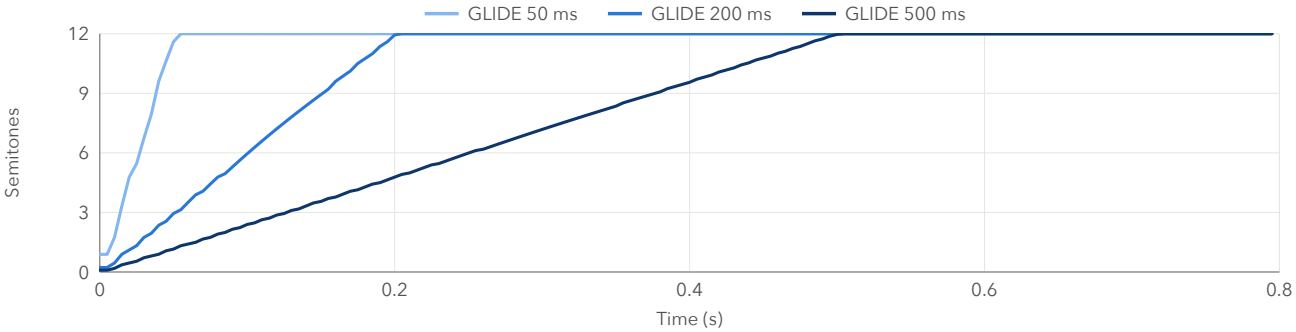


Figure 16. SOLO, LEGATO: C4 held, then C5. The pitch from the second key.

The stack

Each note is a **stack** of up to eight **lanes**, set by **DENSITY**: eight copies of the whole voice, all six operators, sounding together. Sixteen notes of eight lanes are 128 voices in all. With **DENSITY** at 1 a note is one voice.

DETUNE fans the lanes out in pitch, up to 50 cents either side, while the middle of the stack stays at the key, so a patch thickens without going out of tune. **LIN**, **GEO** and **RND** space them: evenly, gathered towards the middle, or at random for each note.

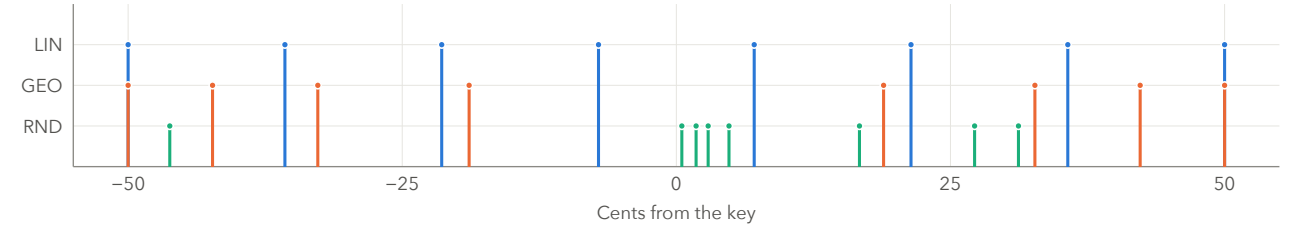


Figure 17. Where the eight lanes of one note sound, **DETUNE** at 50, under each spacing: measured from the spectrum of a held note.

SPREAD sets the **VOICE SPREAD** source: each lane's place in the stack, from −1 to +1, times **SPREAD**. It does nothing by itself; Init routes it to the carriers' pans, so a stack fans across the stereo field. Route it elsewhere, to a modulator's level for example, and the outer lanes sound different from the middle (Section 8).

PHASE starts each lane a little later than the one before, as a share of a cycle of the note: at 0 every lane starts together and the attack is hard; turned up, the lanes start apart and the note softens into being. Each lane is the same sound, delayed, whatever its operators' ratios.

7 · LFOs



1 **LFO 1 SHAPE**	sine, triangle, saw up, saw down, pulse, S&H	2 **RATE**	0.01 to 50 Hz
3 **SYNC**	rate as a note value of the tempo	4 **LFO 2 SHAPE**	as LFO 1's
5 **RATE**	0.01 to 50 Hz	6 **DELAY**	LFO 2 waits, 0 to 4 s
7 **FADE**	then fades in, 0 to 4 s	8 **SYNC**	rate as a note value

The LFOs are matrix sources: they do nothing until routed (Section 8).

LFO 1 is one LFO for the whole patch, running freely: every note hears the same point of its cycle. **LFO 2** runs in every lane of every note, starting from the beginning of its cycle at each note, then waiting **DELAY** and fading in over **FADE** — the delayed vibrato of a singer or a string player. Init routes **VOICE RAND** to LFO 2's phase, so each lane's LFO 2 starts at a different point, and slot 1 is ready to route LFO 2 to pitch at depth 0.

With **SYNC** on, **RATE** chooses a note value of the host's tempo instead, from 1/1 to 1/32, dotted and triplet, and LFO 1 lines up with the bar when the host starts playing.

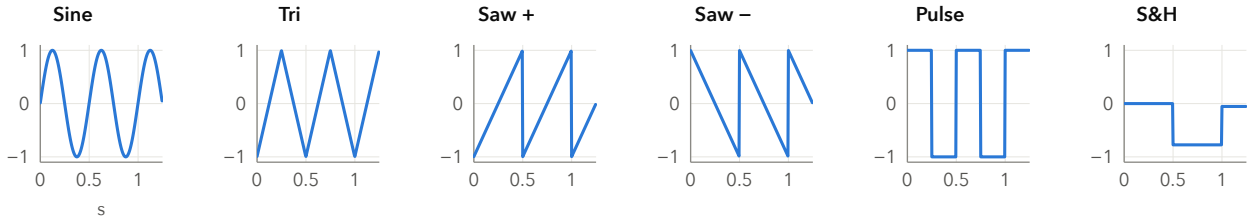


Figure 18. LFO 1's shapes at 2 Hz. Every shape swings from −1 to +1; S&H holds a new random value each cycle.

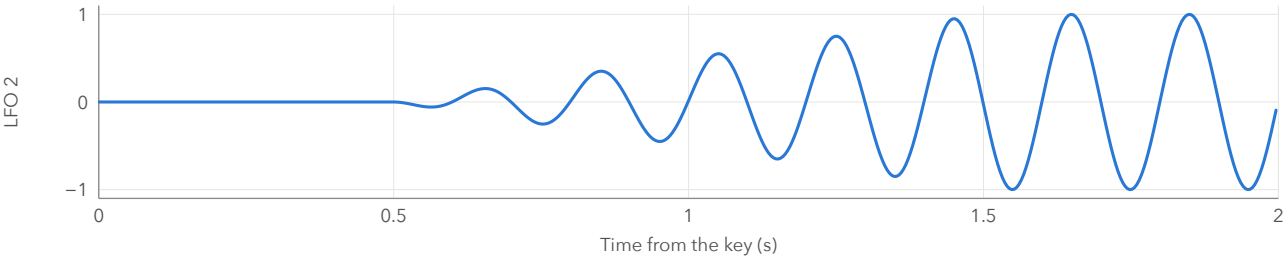


Figure 19. LFO 2, a 5 Hz sine, **DELAY** 0.5 s, **FADE** 1 s.

8 · The modulation matrix

MATRIX, at the top right, opens the matrix over the faceplate; the number on the key counts the routes in use. Click the cross, or outside the matrix, to close it.



Figure 20. The matrix, with Init's six routes.

Each of the sixteen rows routes one **Source** to one **Dest** by an amount, **Depth**, from −1 to +1. Click a name to choose from a list; drag the depth bar, or double-click it to type. **On** switches a row without losing it, and **×** clears it. Rows 1 to 8's depths can be automated by the host.

Sources

Source	Range	What it is
LFO 1	−1 to +1	the patch's LFO
LFO 2	−1 to +1	each lane's LFO
Pitch EG	−1 to +1	the pitch envelope, −1 to +1 of its swing
Mod Env	0 to 1	the mod env
Mod Wheel	0 to 1	MIDI CC 1
Aftertouch	0 to 1	channel pressure
Velocity	0 to 1	how hard the key was struck
Key	0 to 1	the note, across the keyboard
Voice Idx	0 to 1	the lane's number in its stack
Voice Spread	−1 to +1	the lane's place in its stack, times SPREAD
Voice Rand	0 to 1	a random value for each lane, drawn at each note

Destinations

Every operator has four destinations: **Pitch**, **Level**, **Pan** and **Phase**, and a fifth, **Stack Pitch**, a pitch offset that keeps the operator's ratio to the rest of its stack. The others:

Destination	At depth 1	What it moves
Global Pitch	24 st	every operator's pitch
LFO 1 Rate	4	LFO 1's rate, in octaves
LFO 2 Rate	4	LFO 2's rate, in octaves
LFO 2 Phase	1	where each lane's LFO 2 starts, in cycles

Stack Detune	1	added to DETUNE
Stack Spread	1	added to SPREAD
Delay Mix	1	the delay's MIX
Reverb Mix	1	the reverb's MIX
Feedback	7	added to FEEDBK
Cutoff	4	the filter's cutoff, in octaves
Resonance	1	added to RESO
Filter Drive	4	the filter's DRIVE
Global EG Rate	4	every operator envelope's speed, in octaves
Pitch EG Rate	4	the pitch EG's speed
Mod Env Rate	4	the mod env's speed

At depth 1 an operator's **Pitch** and **Stack Pitch** move 24 semitones and its **EG Rate** four octaves of speed; **Level** adds the source to the operator's envelope as it plays, and **Pan** and **Phase** move across their own ranges.

The pitch destinations' depth is cubed, so small depths give fine vibrato: depth 0.25 swings 0.38 semitones, depth 0.5 3 semitones, and depth 1 the full 24.

Curves and Scale By

Curve shapes the source before the depth. **Lin** passes it as it is; **Exp** squares it, slow at first; **Log** takes its root, fast at first. **Bipolar** turns a 0-to-1 source into −1 to +1, and **Abs** folds a −1-to-+1 source to 0 to 1, each with the same three shapes.

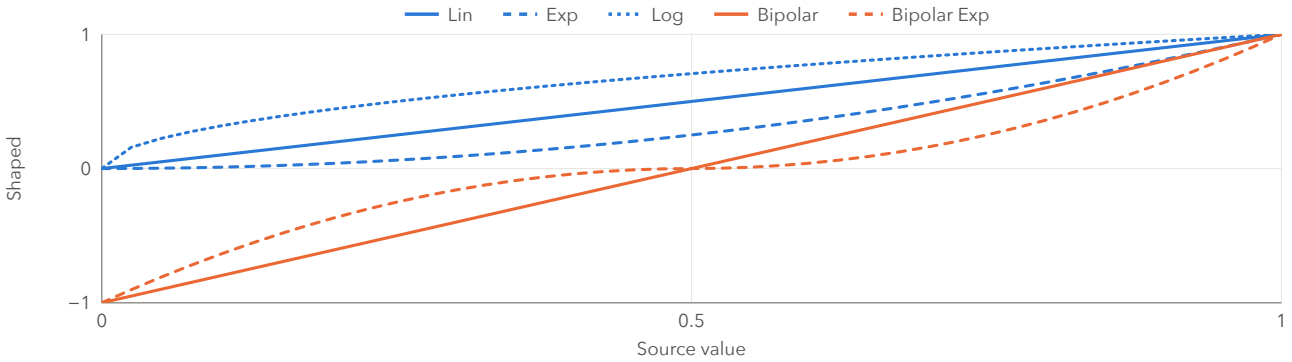


Figure 21. The curves, over a unipolar source's travel.

Scale By multiplies the route by a second source, shaped by **Scale Curve**: mod wheel × LFO 2 is vibrato that the wheel brings in.

Warnings

Some routes cannot do what they say. A source that differs from lane to lane (**LFO 2**, the voice sources) routed to a destination that has one value for the whole stack, or the whole patch (**Cutoff**, the effects' mixes, the LFO rates), would have to pick one lane's value; an LFO routed to its own rate chases itself. vxn-2b marks such a row in red, with a short note, and still plays it.

9 · Filter and high-pass



1	**HP CUTOFF**	the high-pass, 20 Hz to 18 kHz	2	**On**	the ladder filter in or out
3	**CUTOFF**	16 Hz to Open	4	**RESO**	resonance, 0 to 1
5	**DRIVE**	colour, 1 to 64	6	**KEY**	cutoff follows the key, 0 to 1
7	**TUNED**	CUTOFF by note, C0 to C4	8	**LP, HP, BP, NOT**	the mode
9	**2P, 4P**	12 or 24 dB/octave			

The high-pass

HP CUTOFF is a gentle high-pass, 6 dB an octave, on the sum of every voice, before the effects. It is always in. At 20 Hz, its lowest, it only clears the DC offset that feedback makes; raise it to thin a sound's low end. It is not a matrix destination, and it has no resonance.

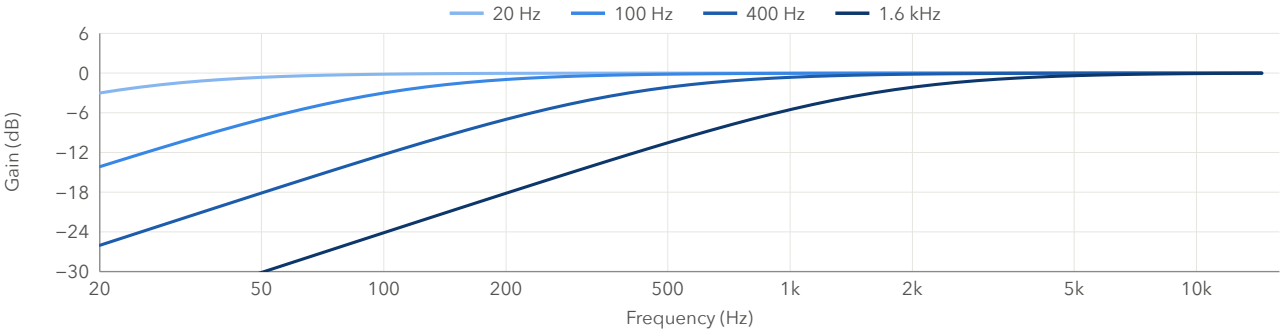


Figure 22. The high-pass at four settings, the filter off.

The ladder filter

The key at the top left of **MAIN** switches the ladder filter in. It filters each note's stack, after its operators, before the voices are summed. It is off at Init and in most FM sounds: FM makes its timbre with the modulators. Switched on with **CUTOFF** at the top of its travel, **Open**, and **DRIVE** at 1, the low-pass changes almost nothing audible.

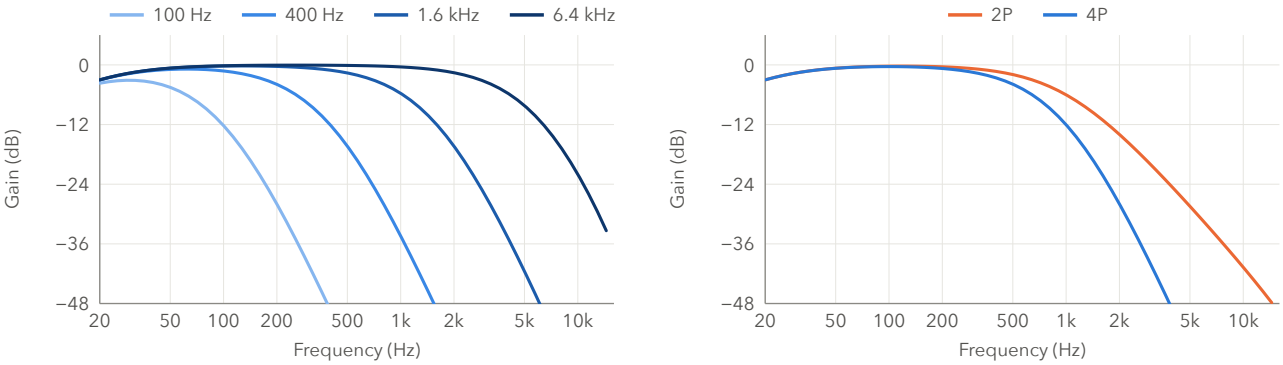


Figure 23. Left: the low-pass, 4P, at four cutoffs. Right: 2P and 4P at 1 kHz.

LP, **HP**, **BP** and **NOT** (notch) choose what the filter passes; **2P** and **4P** how steeply, 12 or 24 dB an octave.

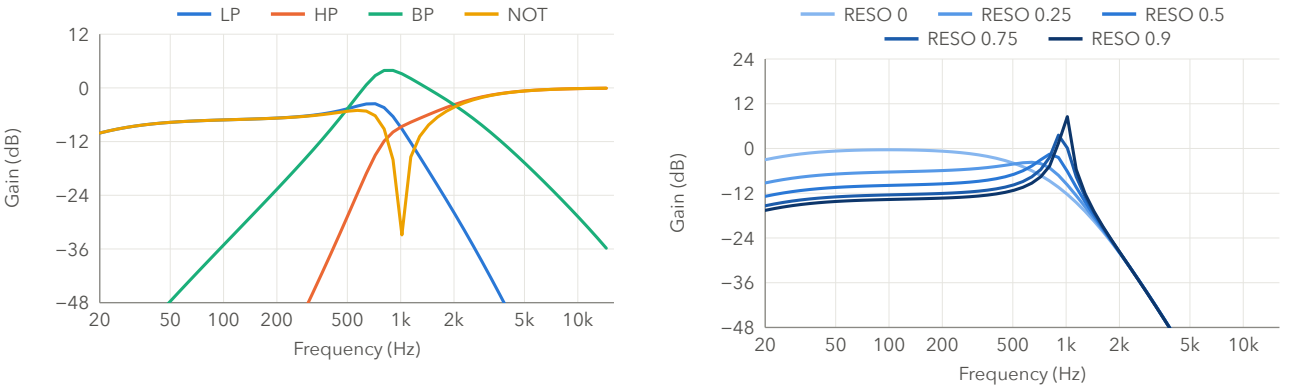


Figure 24. Left: the four modes at 1 kHz, **RESO** 0.3. Right: the low-pass at 1 kHz as **RESO** rises.

RESO adds a peak at the cutoff. Near the top it rings on its own, and the filter whistles at the cutoff's pitch; the whistle follows the notes' carriers, dying with them, so it doesn't outlast the sound. **KEY** moves the cutoff with the key: at 1 it moves an octave for an octave. **TUNED** makes **CUTOFF** step by semitones from C0 to C4 and read as a note, which with **KEY** at 1 and some resonance makes a tuned resonance.

DRIVE is colour, not level: it pushes the signal harder into the ladder's saturating stages and turns the result back down, so the level stays within a few decibels as the harmonics rise.

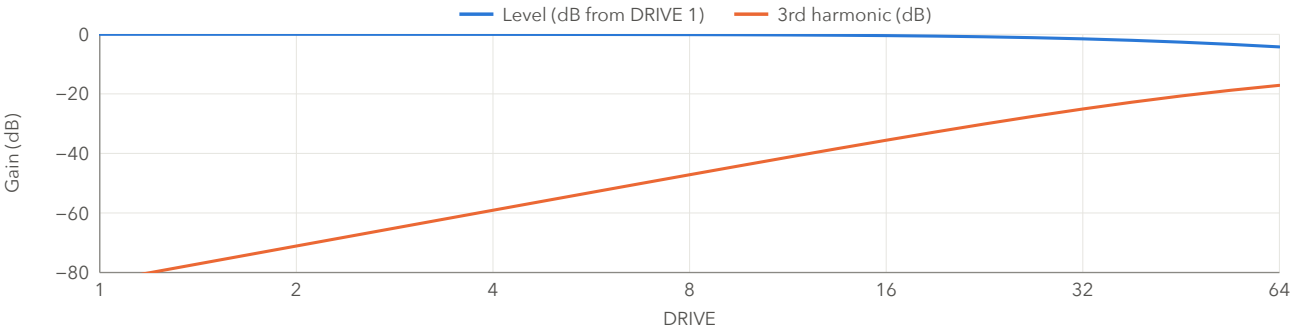
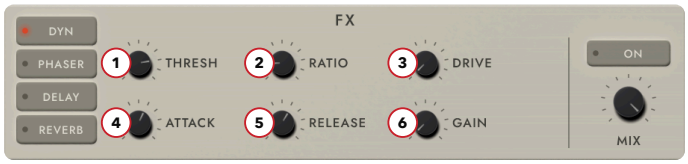


Figure 25. A full-level 200 Hz sine through the open low-pass: its level, and its third harmonic against the fundamental, as **DRIVE** rises.

10 · Effects

The keys at the left of **FX** show one effect's controls: **DYN**, **PHASER**, **DELAY** or **REVERB**. They run in that order, after the high-pass. Each has **ON** and **MIX** at the right: **MIX** blends the effect with what reaches it. All four are off at Init.

Dynamics



1 **THRESH**	−60 to 0 dB	2 **RATIO**	1 to 20	3 **DRIVE**	saturation, 0 to 36 dB
4 **ATTACK**	0.1 to 200 ms	5 **RELEASE**	5 to 1000 ms	6 **GAIN**	make-up, 0 to 24 dB

A compressor and a saturator. Above **THRESH** the level rises by 1 dB for every **RATIO** dB in, reached over **ATTACK** and let go over **RELEASE**; **GAIN** restores the level it took. It comes first so it can even out FM's sharp attacks before the time effects. **DRIVE** pushes the signal into a soft clipper, at twice the host's rate so that it doesn't alias.

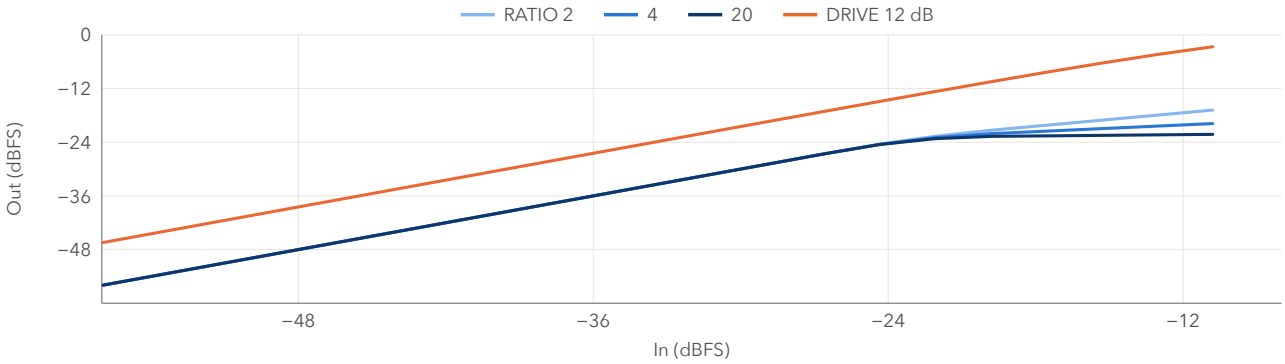


Figure 26. The level out against the level in, a steady 1 kHz tone, **THRESH** −24 dB; and **DRIVE** 12 dB with no compression.

Phaser



1 **RATE**	the sweep, 0.05 to 8 Hz	2 **DEPTH**	how far it sweeps
3 **FEEDBK**	−0.9 to +0.9	4 **STEREO**	the right channel's sweep against the left, 0° to 180°

Four all-pass stages in each channel make two notches that sweep up and down. **FEEDBK** deepens them, and its sign moves where they sit. At **STEREO** 180° the channels sweep in opposite directions, which swirls; at 0° they sweep together.

Delay



1 **PING** ping-pong: repeats alternate sides
2 **TIME** 1 ms to 4 s, or a note value
3 **SYNC** TIME as a note value of the tempo
4 **FEEDBK** repeats, 0 to 0.95

A stereo echo. **FEEDBK** sets how much of each repeat is fed back for the next. With **SYNC** on, **TIME** chooses a note value, 1/1 to 1/32, dotted and triplet, of the host's tempo.

Reverb

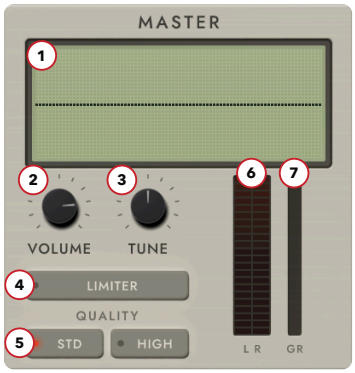


1 **SIZE** the room's size
2 **DECAY** 0.1 to 20 s
3 **DAMP** how fast the highs die

An eight-line feedback delay network. **DECAY** is the time for the tail to fall 60 dB; **DAMP** makes the high frequencies die sooner, as soft furnishings do.

DECAY	Measured, DAMP 0	Measured, DAMP 0.5
0.5 s	0.47 s	0.47 s
1 s	0.99 s	0.98 s
2 s	2.21 s	2.2 s
4 s	4.59 s	4.42 s
8 s	7.54 s	6.99 s

11 · Master



1	**Scope**	the output's waveform
2	**VOLUME**	−60 to +6 dB
3	**TUNE**	−100 to +100 cents
4	**LIMITER**	a safety limiter, last
5	**QUALITY**	STD or HIGH
6	**L R**	output meters
7	**GR**	the limiter's gain reduction

VOLUME is the last gain before the limiter; Init's −6 dB leaves headroom for most patches. **TUNE** moves the whole instrument by up to a semitone either way. **LIMITER** holds the output just under full scale, looking 2 ms ahead and letting go over 100 ms, so that a loud patch or a big chord doesn't clip; it is off at Init. **GR** shows how much it is taking off.

Quality

QUALITY sets the rate the voices run at, the operators and filter, against the host's. A higher rate costs more processing and reduces aliasing: the inharmonic tones heard when a sound's harmonics pass half the sample rate and fold back. In FM they come from high modulator levels in the top octaves, from feedback, and from the filter's saturation.

- **STD** runs the voices at the host's rate while the filter is off, which suits most FM sounds, and at twice it while the filter is on.
- **HIGH** runs them at four times the host's rate, and the phaser at twice. In the web build it stops at twice.

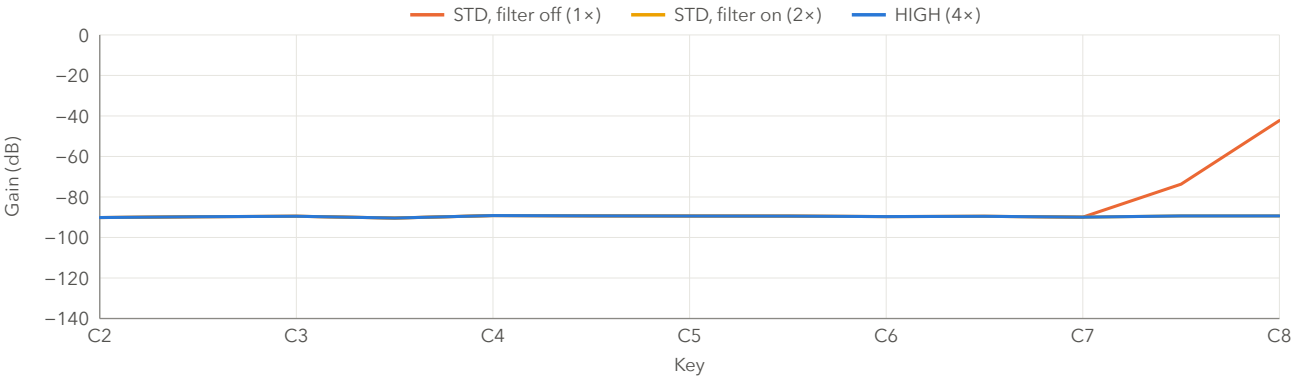


Figure 27. Alias energy against the harmonics, for a bright two-operator FM tone (algorithm 1, op 2 at level 90 into op 1, 1:1), across the keyboard.

A change of **QUALITY** takes effect at once, with no gap; the reported latency is the same at both, 6 samples.

MIDI and the host

vxn-2b plays notes and velocity, pitch bend (±2 semitones), the mod wheel (CC 1), sustain (CC 64) and channel aftertouch. It does not respond to polyphonic aftertouch or MPE. It follows the host's tempo for synced LFOs and the delay; stopping the transport releases every note.

12 · Presets

The preset bar shows the current preset's name; ‹ and › step through the presets. **BROWSE** opens the browser of factory and user presets, by category. **SAVE** overwrites the current preset if it is a user preset, and otherwise acts as **SAVE AS**, which asks for a name and folder. A preset holds every setting, **QUALITY** among them.

The factory bank holds vxn-2's sounds, converted, in nine categories — Bass, Bell, Brass, Ensemble, Keys, Lead, Pad, Pluck and Texture — and a Utility folder. Each has a note in the browser saying how it is made.

RANDOM, in the header after **SAVE AS**, makes a new sound, one undo step. It picks one of twelve kinds — Bass, Keys, Bell, Mallet, Organ, Brass, Pluck, Lead, Pad, Ensemble, Texture or FX — and builds the whole patch in that kind's manner: the algorithm, the operators' ratios, envelopes and levels, the stack, the modulation and the matrix. Effects come from a choice of none, one or two of reverb, delay and phaser to suit the kind; the dynamics stay off. **MASTER** — **VOLUME**, **TUNE**, **LIMITER** and **QUALITY** — stays as it was. The sound gets a two-word name, and the name's tooltip gives its kind and a five-character seed, "Random Pad, seed 3F2AK": quote the seed to report a sound. **SAVE AS** then offers a user folder named after the kind. In the web build the key pulses until it is first used.

13 · Patches

Seven factory presets, each chosen to show one part of the instrument. Load each by name. Each is drawn as it loads, with its operators and its matrix.

Electric Boogaloo

Keys · algorithm 5 · FEEDBK 5.3

Operators and velocity. Algorithm 5's three pairs. Op 2 is a 14:1 modulator with **VEL** 7: the piano's tine, a strike of upper harmonics that only appears when you play hard. Play softly and the tone is round; dig in and the bell comes in on top. Four lanes at a few cents' **DETUNE**, spread by Init's pan routes, are its chorus.

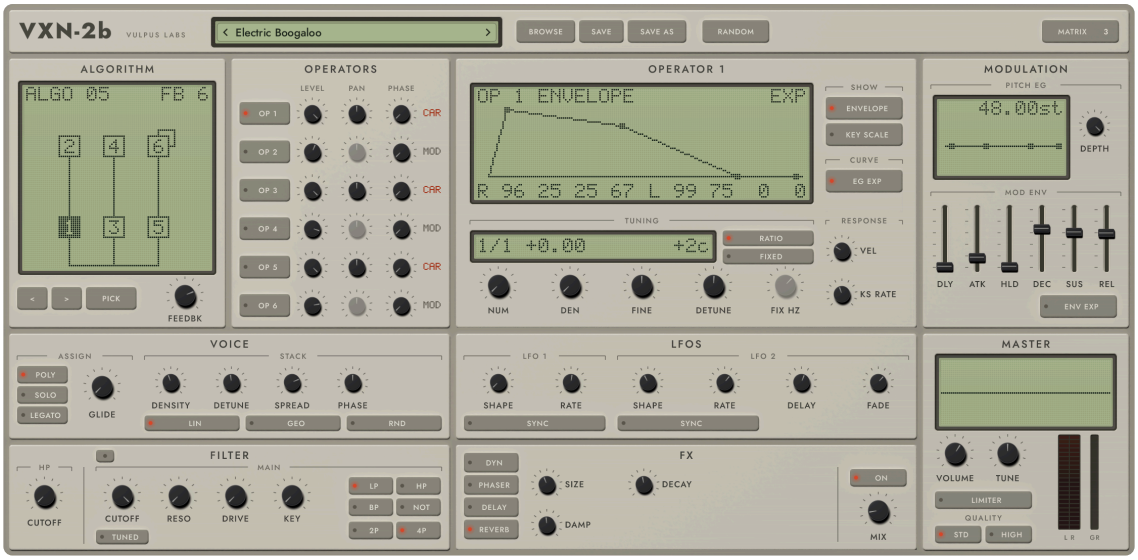


Figure 28. Electric Boogaloo, as it loads.

Op	Role	Tuning	Detune	Level	VEL
1	CAR	1/1 +0.00	2 ct	99	2
2	MOD	14/1 +0.00	0 ct	58	7
3	CAR	1/1 +0.00	0 ct	99	2
4	MOD	1/1 +0.00	0 ct	89	6
5	CAR	1/1 +0.00	-5 ct	99	0
6	MOD	1/1 +0.00	5 ct	79	6

Slot	Source	Dest	Depth	Curve	Scale By
1	Voice Spread	Op 1 Pan	0.80	Lin	–
2	Voice Spread	Op 3 Pan	-0.80	Lin	–
3	Voice Spread	Op 5 Pan	0.50	Lin	–

Also different from Init: Feedback 5.260, LFO2 Shape Saw+, LFO2 Rate 5.10 Hz, LFO2 Delay 180.00 ms, PEG R1 99, PEG R2 50, PEG R3 35, Stack Density 4, Stack Detune 9.00 ct, Stack Spread 0.750, Reverb On On, Reverb Size 0.420, Reverb Decay 1.60 s, Reverb Damp 0.480, Reverb Mix 0.130, Master Vol -19.05 dB.

Campanile

Bell · algorithm 5 · FEEDBK 5.5

Inharmonic ratios. Tubular bells. The modulators sit at ratios that are not whole numbers — 11/4, 27/5 and 32/5 — so the sidebands fall between the harmonics, where a struck tube's partials are. Ops 1 and 3, carriers 7 cents apart, beat slowly as the note dies.

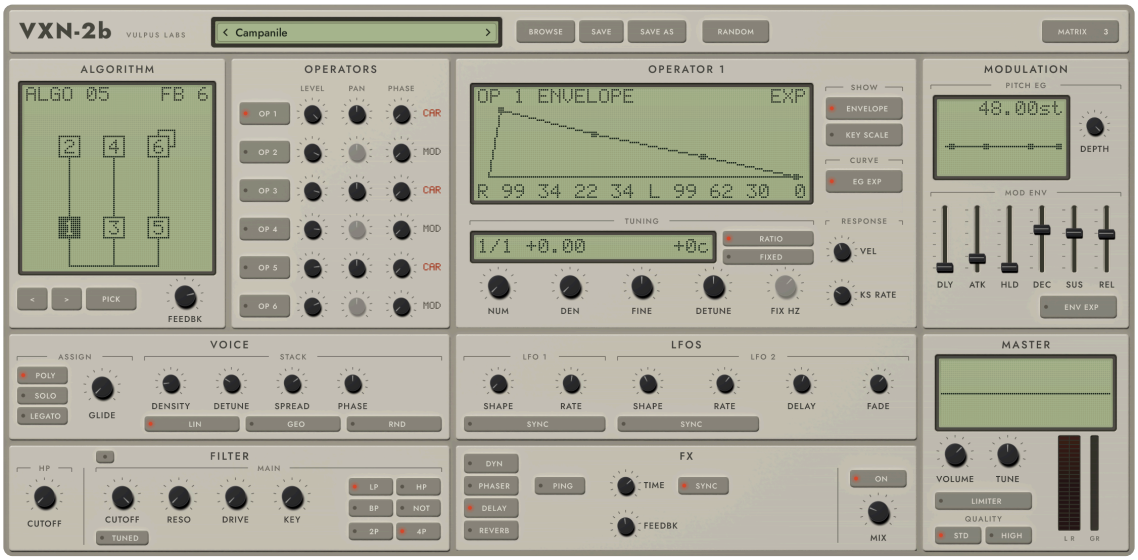


Figure 29. Campanile, as it loads.

Op	Role	Tuning	Detune	Level	VEL
1	CAR	1/1 +0.00	0 ct	99	3
2	MOD	11/4 +0.04	0 ct	92	6
3	CAR	1/1 +0.00	-7 ct	88	3
4	MOD	27/5 +0.00	5 ct	84	6
5	CAR	9/1 +0.00	0 ct	80	7
6	MOD	32/5 +0.00	0 ct	74	7

Slot	Source	Dest	Depth	Curve	Scale By
1	Velocity	Op 6 Level	0.52	Exp	–
2	Voice Spread	Op 1 Pan	0.70	Lin	–
3	Voice Spread	Op 3 Pan	-0.70	Lin	–

Also different from Init: Feedback 5.490, LFO2 Shape Saw+, LFO2 Rate 5.10 Hz, LFO2 Delay 180.00 ms, PEG R1 99, PEG R2 50, PEG R3 35, Stack Density 2, Stack Detune 4.00 ct, Stack Spread 0.700, Delay On On, Reverb On On, Reverb Size 0.820, Reverb Decay 5.00 s, Reverb Damp 0.300, Reverb Mix 0.320, Master Vol -15.93 dB.

Undertow

Bass · algorithm 16 · FEEDBK 3.5

The filter and the mod env. A bass where five modulators feed one carrier, then the ladder filter, low-pass from 400 Hz. The mod env, routed to **Cutoff**, opens it at each note and lets it close over the next half second, so every note barks and then sinks. Velocity reaches the cutoff and op 2's level, so a hard note is brighter twice over.

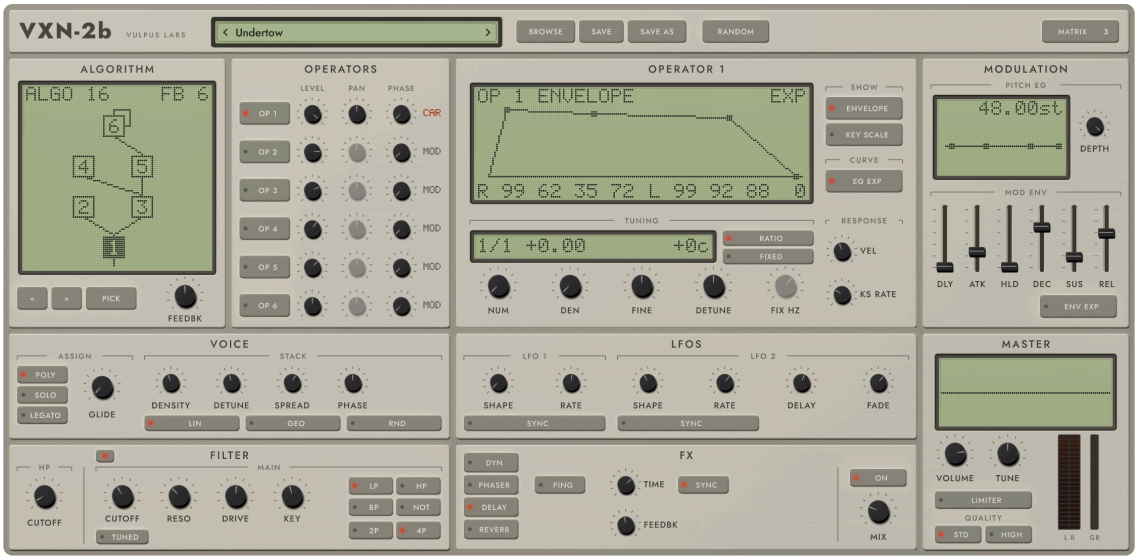


Figure 30. Undertow, as it loads.

Op	Role	Tuning	Detune	Level	VEL
1	CAR	1/1 +0.00	0 ct	99	3
2	MOD	1/1 +0.00	0 ct	82	6
3	MOD	2/1 +0.00	0 ct	74	3
4	MOD	3/1 +0.00	0 ct	62	3
5	MOD	1/1 +0.00	0 ct	66	3
6	MOD	4/1 +0.00	0 ct	50	3

Slot	Source	Dest	Depth	Curve	Scale By
1	Mod Env	Cutoff	0.58	Lin	–
2	Velocity	Cutoff	0.30	Lin	–
3	Velocity	Op 2 Level	0.35	Lin	–

Also different from Init: Algorithm 16, Feedback 3.490, LFO2 Shape Saw+, LFO2 Rate 5.10 Hz, LFO2 Delay 180.00 ms, PEG R1 99, PEG R2 50, PEG R3 35, Mod Env A 6.00 ms, Mod Env D 420.00 ms, Mod Env S 0.180, Mod Env R 200.00 ms, Stack Density 4, Delay On On, Reverb On On, Reverb Size 0.250, Reverb Decay 0.90 s, Reverb Mix 0.070, Master Vol -6.83 dB, Filter Enable On, Filter Cutoff 400.00 Hz, Filter Reso 0.340, Filter Drive 8.800, Filter KeyTrk 0.450, HP Cutoff 28.00 Hz.

Slow Weather

Pad · algorithm 5 · FEEDBK 2.0

The stack. A slow pad: six lanes of **DENSITY**, detuned and spread wide, with gentle modulators and long envelopes. The mod env brings the harmonics in, LFO 2 shimmers in each lane, and the reverb and ping-pong delay are wide. Change **DENSITY** to 1 to hear one lane.

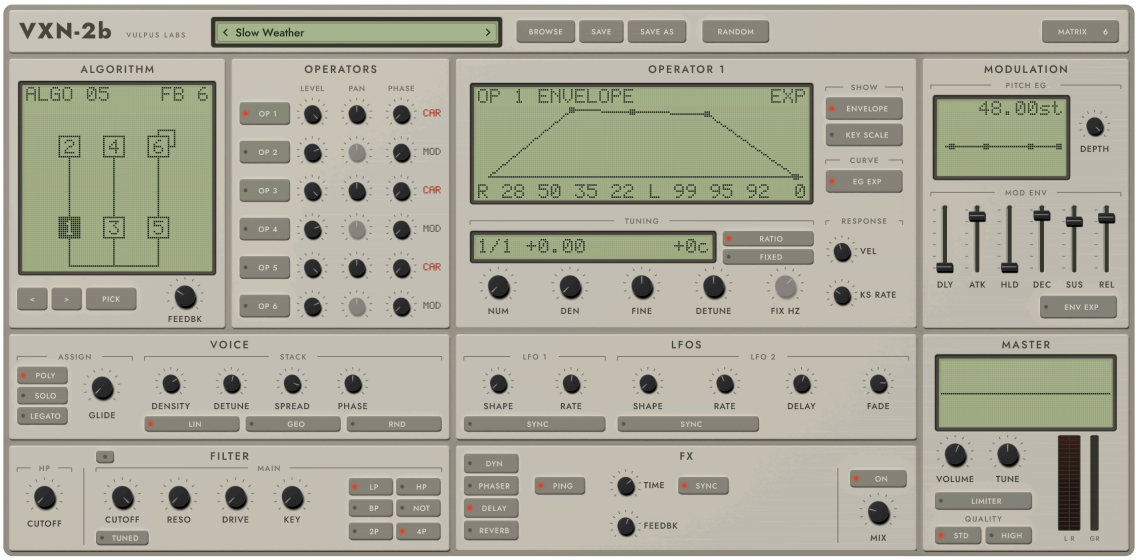


Figure 31. Slow Weather, as it loads.

Op	Role	Tuning	Detune	Level	VEL
1	CAR	1/1 +0.00	0 ct	99	3
2	MOD	1/1 +0.00	0 ct	74	3
3	CAR	1/1 +0.00	0 ct	99	3
4	MOD	1/1 +0.00	0 ct	76	3
5	CAR	1/1 +0.00	-4 ct	99	3
6	MOD	1/1 +0.00	4 ct	74	3

Slot	Source	Dest	Depth	Curve	Scale By
1	LFO 2	Global Pitch	0.02	Lin	–
2	Mod Env	Op 2 Level	0.35	Lin	–
3	LFO 2	Op 4 Level	0.15	Lin	–
4	Voice Spread	Op 1 Pan	1.00	Lin	–
5	Voice Spread	Op 3 Pan	-1.00	Lin	–
6	Voice Spread	Op 5 Pan	1.00	Lin	–

Also different from Init: Feedback 2.000, LFO2 Rate 0.80 Hz, LFO2 Delay 180.00 ms, LFO2 Fade 1200.00 ms, PEG R1 99, PEG R2 50, PEG R3 35, Mod Env A 1500.00 ms, Mod Env D 2000.00 ms, Mod Env S 0.800, Mod Env R 1400.00 ms, Stack Density 6, Stack Detune 12.00 ct, Stack Spread 0.900, Delay On On, Delay FB 0.550, Delay Mix 0.220, Ping-Pong On, Reverb On On, Reverb Size 0.850, Reverb Decay 6.00 s, Reverb Mix 0.450, Master Vol -21.57 dB.

Tidal Lock

Pad · algorithm 21 · FEEDBK 3.0

The pitch EG and the mod env. Every note scoops: the pitch envelope falls almost a semitone (L1 −8 at **DEPTH** 12) in its first tenth of a second and is back on the key by 0.4 s. The matrix also routes it to two modulators at opposite depths, so the timbre bends with the pitch. The mod env, slow at 2.4 s, opens the filter under held notes.

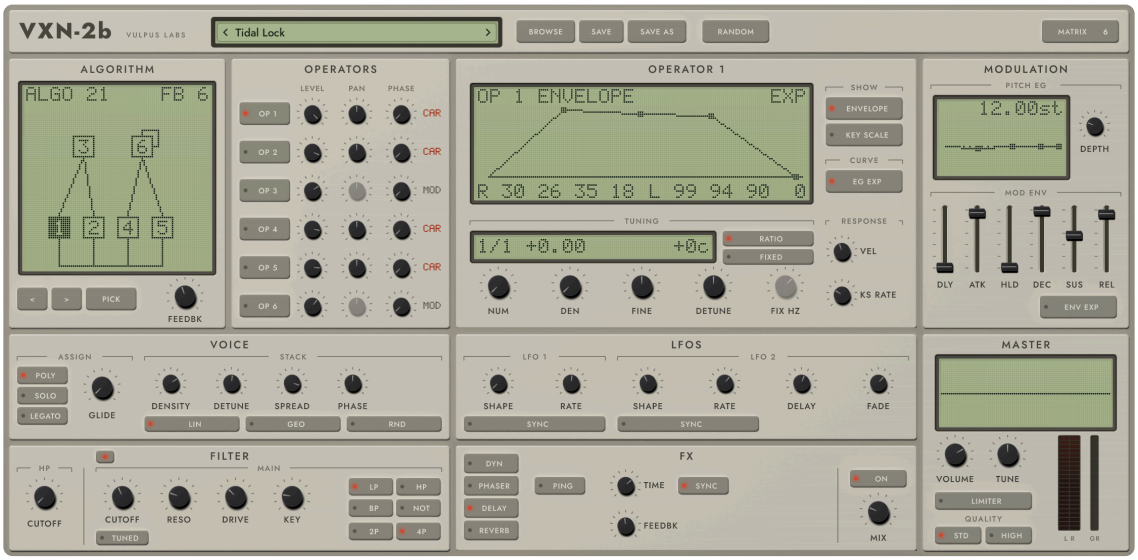


Figure 32. Tidal Lock, as it loads.

Op	Role	Tuning	Detune	Level	VEL
1	CAR	1/1 +0.00	0 ct	99	3
2	CAR	2/1 +0.00	-8 ct	91	3
3	MOD	5/2 +0.00	0 ct	70	3
4	CAR	3/1 +0.00	6 ct	87	3
5	CAR	4/1 +0.00	-5 ct	84	3
6	MOD	7/2 +0.00	0 ct	64	3

Slot	Source	Dest	Depth	Curve	Scale By
1	Pitch EG	Op 3 Pitch	0.45	Lin	–
2	Pitch EG	Op 6 Pitch	-0.35	Lin	–
3	Mod Env	Cutoff	0.50	Lin	–
4	Voice Spread	Op 1 Pan	0.90	Lin	–
5	Voice Spread	Op 4 Pan	-0.90	Lin	–
6	Voice Rand	Op 2 Phase	1.00	Lin	–

Also different from Init: Algorithm 21, Feedback 3.000, LFO2 Shape Saw+, LFO2 Rate 5.10 Hz, LFO2 Delay 180.00 ms, PEG R1 22, PEG R2 18, PEG R3 35, PEG L1 -8, PEG Depth 12.00 st, Mod Env A 2400.00 ms, Mod Env D 3200.00 ms, Mod Env S 0.550, Mod Env R 2200.00 ms, Stack Density 6, Stack Detune 11.00 ct, Stack Spread 0.900, Delay On On, Reverb On On, Reverb Size 0.880, Reverb Decay 7.00 s, Reverb Damp 0.550, Reverb Mix 0.400, Master Vol -12.28 dB, Filter Enable On, Filter Cutoff 480.00 Hz, Filter Reso 0.240, Filter Drive 4.000, Filter KeyTrk 0.200.

Semaphore

Texture · algorithm 22 · FEEDBK 4.0

LFO 1 and the matrix. LFO 1 runs sample-and-hold, synced to the tempo, and steps two operators' levels, and the cutoff, to a new random value every eighth note, so one held key plays a pattern. The ping-pong delay is synced too, so the steps and the echoes agree.

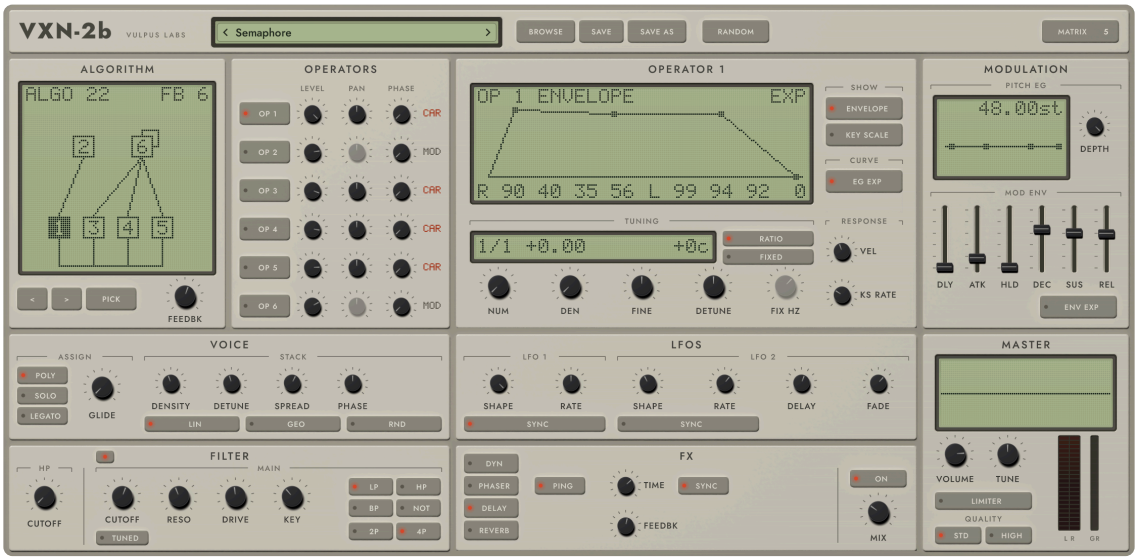


Figure 33. Semaphore, as it loads.

Op	Role	Tuning	Detune	Level	VEL
1	CAR	1/1 +0.00	0 ct	99	3
2	MOD	2/1 +0.00	0 ct	80	3
3	CAR	3/1 +0.00	5 ct	90	3
4	CAR	4/1 +0.00	-6 ct	86	3
5	CAR	6/1 +0.00	0 ct	82	3
6	MOD	5/1 +0.00	0 ct	72	3

Slot	Source	Dest	Depth	Curve	Scale By
1	LFO 1	Op 6 Level	0.55	Lin	–
2	LFO 1	Op 2 Level	0.40	Lin	–
3	LFO 1	Cutoff	0.22	Lin	–
4	Voice Spread	Op 3 Pan	0.90	Lin	–
5	Voice Spread	Op 4 Pan	-0.90	Lin	–

Also different from Init: Algorithm 22, Feedback 4.000, LFO2 Shape Saw+, LFO2 Rate 5.10 Hz, LFO2 Delay 180.00 ms, PEG R1 99, PEG R2 50, PEG R3 35, Stack Density 4, LFO1 Shape S&H, LFO1 Rate 1/8, LFO1 Sync On, Delay On On, Delay FB 0.520, Delay Mix 0.300, Ping-Pong On, Reverb On On, Reverb Size 0.700, Reverb Decay 3.40 s, Reverb Mix 0.260, Master Vol -5.78 dB, Filter Enable On, Filter Cutoff 1600.00 Hz, Filter Reso 0.420, Filter Drive 7.200, Filter KeyTrk 0.350.

Chaos

Utility · algorithm 32 · FEEDBK 7.0

Feedback at its edge. One operator, op 6 in algorithm 32, at full level with **FEEDBK** 7. Softly played it is a buzzing, periodic tone; **VEL** 7 lifts its level, and so its loop, past the point where feedback turns chaotic, from about velocity 110. The mod wheel, through the matrix, does the same at any velocity.

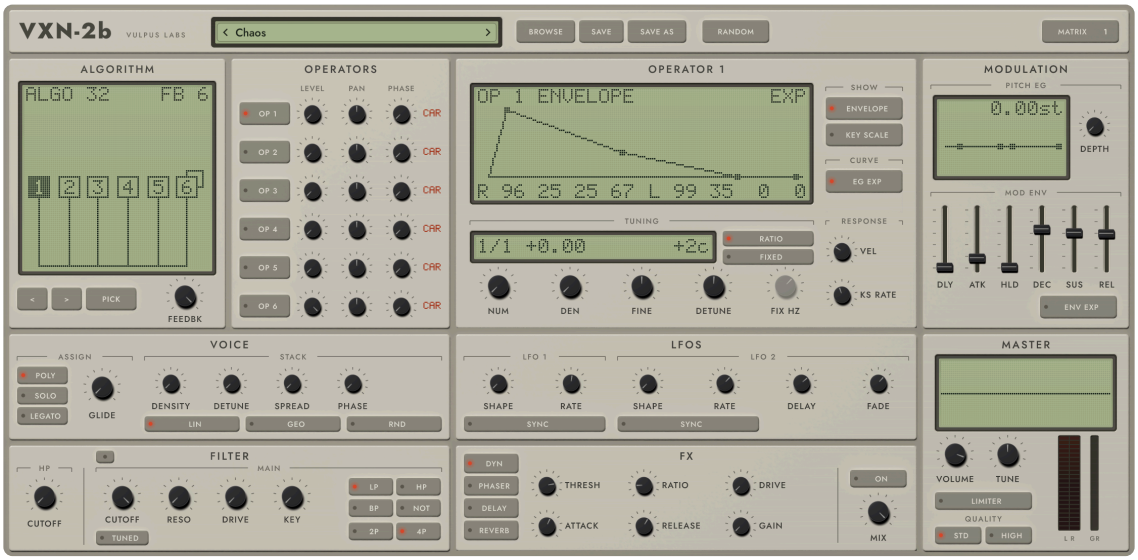


Figure 34. Chaos, as it loads.

Op	Role	Tuning	Detune	Level	VEL
1	CAR	1/1 +0.00	2 ct	0	2
2	CAR	14/1 +0.00	0 ct	0	7
3	CAR	1/1 +0.00	0 ct	0	2
4	CAR	1/1 +0.00	0 ct	0	6
5	CAR	1/1 +0.00	-5 ct	0	0
6	CAR	1/1 +0.00	0 ct	99	7

Slot	Source	Dest	Depth	Curve	Scale By
1	Mod Wheel	Op 6 Level	1.00	Lin	–

Also different from Init: Algorithm 32, Feedback 7.000, PEG Depth 0.00 st, Stack Detune 0.00 ct, Stack Spread 0.000, Stack Phase 0.000, Master Vol 0.00 dB.

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Algorithms

Algo	Carriers	Modulation	Feedback	Algo	Carriers	Modulation	Feedback
1	1 3	2→1 4→3 5→4 6→5	6	17	1	2→1 3→1 4→3 5→3 6→5	2
2	1 3	2→1 4→3 5→4 6→5	2	18	1	2→1 3→1 4→3 5→4 6→4	3
3	1 4	2→1 3→2 5→4 6→5	6	19	1 4 5	2→1 3→2 6→4 6→5	6
4	1 4	2→1 3→2 5→4 6→5	4→6	20	1 2 4	3→1 3→2 5→4 6→4	3
5	1 3 5	2→1 4→3 6→5	6	21	1 2 4 5	3→1 3→2 6→4 6→5	6
6	1 3 5	2→1 4→3 6→5	5→6	22	1 3 4 5	2→1 6→3 6→4 6→5	6
7	1 3	2→1 4→3 5→3 6→5	6	23	1 2 4 5	3→2 6→4 6→5	6
8	1 3	2→1 4→3 5→3 6→5	4	24	1 2 3 4 5	6→3 6→4 6→5	6
9	1 3	2→1 4→3 5→3 6→5	2	25	1 2 3 4 5	6→4 6→5	6
10	1 4	2→1 3→2 5→4 6→4	3	26	1 2 4	3→2 5→4 6→4	6
11	1 4	2→1 3→2 5→4 6→4	6	27	1 2 4	3→2 5→4 6→4	3
12	1 3	2→1 4→3 5→3 6→3	2	28	1 3 6	2→1 4→3 5→4	5
13	1 3	2→1 4→3 5→3 6→3	6	29	1 2 3 5	4→3 6→5	6
14	1 3	2→1 4→3 5→4 6→4	6	30	1 2 3 6	4→3 5→4	5
15	1 3	2→1 4→3 5→4 6→4	2	31	1 2 3 4 5	6→5	6
16	1	2→1 3→1 4→3 5→3 6→5	6	32	1 2 3 4 5 6		6

“2→1” means op 2 modulates op 1. Feedback names the operator that feeds back into itself, or the pair the loop runs between.

Tapers

Knobs whose range is wide are tapered, so that the middle of their travel is the middle of what is useful:

Knob	0	¼	½	¾	Full
CUTOFF	16 Hz	128 Hz	1000 Hz	4472 Hz	20000 Hz
HP CUTOFF	20 Hz	141 Hz	1000 Hz	4243 Hz	18000 Hz
GLIDE	0 ms	19 ms	100 ms	455 ms	2000 ms
LFO RATE	0.01 Hz	0.14 Hz	2 Hz	10 Hz	50 Hz
Mod env times	0 ms	14 ms	100 ms	638 ms	4000 ms
Stack DETUNE	0 ct	3.3 ct	10 ct	23.3 ct	50 ct
Delay TIME	1 ms	10 ms	100 ms	632 ms	4000 ms
FIX HZ	1 Hz	10 Hz	100 Hz	988.5 Hz	9772 Hz

Ranges

Control	Range	Init
LEVEL	0 to 99, 0.75 dB a step above 20	ops: 99, 17, 99, 64, 99, 42
NUM / DEN	1 to 32 / 1 to 8	—
FINE	−100 to +100 hundredths	0
DETUNE (op)	−100 to +100 cents	—
FIX HZ	1 Hz to 9.77 kHz	440 Hz
VEL, KS RATE	0 to 7	—
EG rates, levels	0 to 99	—
KS depths	0 to 99	0

FEEDBK	0 to 7	6
Pitch EG levels	−99 to +99	0
DEPTH (pitch EG)	0 to 48 semitones	48
Mod env times	0 to 4 s	—
DENSITY	1 to 8 lanes	1
Stack DETUNE	0 to 50 cents	8
GLIDE	0 to 2 s	0
LFO RATE	0.01 to 50 Hz	LFO 1 2.4, LFO 2 5.6
LFO 2 DELAY, FADE	0 to 4 s	400, 320 ms
CUTOFF	16 Hz to Open	Open
DRIVE	1 to 64	1
HP CUTOFF	20 Hz to 18 kHz	20 Hz
VOLUME	−60 to +6 dB	−6 dB
Voices	16 notes × up to 8 lanes	
Latency	6 samples	

Troubleshooting

No sound an algorithm's carriers at **LEVEL** 0 are silent whatever the modulators do. Check the **CAR** operators' levels and envelopes (an L1 of 0 never sounds).

A harsh, gritty top end high modulator levels and feedback on high notes alias. Try key scaling on the modulators (Section 4), or **QUALITY HIGH**.

Notes cut off in a busy passage a seventeenth note takes the quietest voice. Lower **DENSITY** or the release times.

A route does nothing it may be switched off in the matrix, or marked red (Section 8). A source such as the mod env does nothing until routed.

The level jumps on loading a preset the old sound fades over a few milliseconds and the new one starts fresh, so notes held across a preset change are released.

Too loud, or clipping lower **VOLUME**, or switch on **LIMITER**.