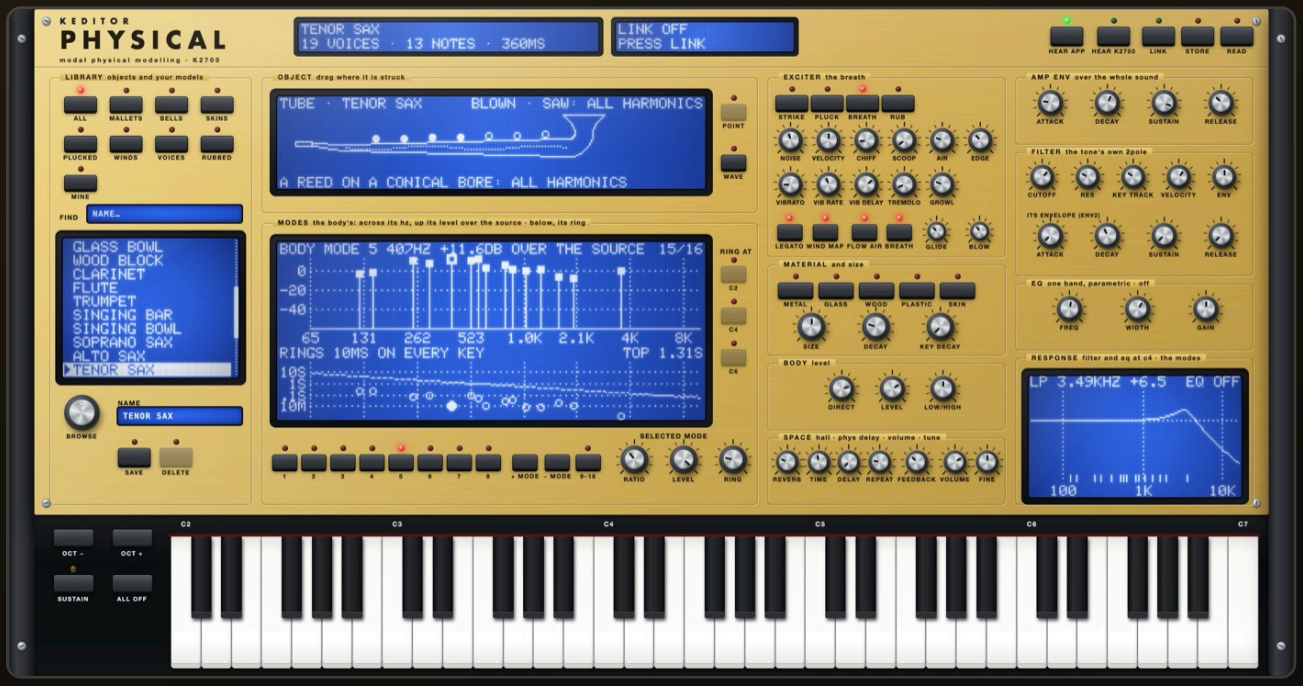
KURZWORLD

KEDITOR PHYSICAL

The complete tutorial
on physical modelling,
and the user manual

From one vibrating mass to a working program on your Kurzweil.



For the Kurzweil K2700

kurzworld.com

KEDITOR PHYSICAL: The Complete Tutorial and User Manual
First edition, November 2026.

© 2026 KURZWORLD. kurzworld.com/keditor-physical

Kurzweil, K2700 and VAST are trademarks of their respective owners, as are the names of the other instruments mentioned in this book. KURZWORLD is independent and is not affiliated with or endorsed by any of them.

Contents

PART ONE

Physical modelling 5

Sound from the thing that makes it 6
What a model knows that a recording does not 8
A mass on a spring, and the two numbers that describe it 9
Four ways to compute a vibrating object 10
Strike, pluck, blow, rub 14
Mode shapes, and the frequencies they ring at 17
Beating, double decay and notes that answer each other 21
How a vibration gets into the air 22
Why wood knocks and metal rings 23
What a linear model cannot do 25
Sixty years of modelling instruments 26

PART TWO

Making sounds 27

An object in six steps 28
What each kind of object wants 29
Marimba, xylophone, vibraphone, glockenspiel, wood block 30
Church bell, glass bowl, steel drum, tom 31
Harp and kalimba 32
Flute, clarinet and trumpet 33
One reed, four lengths of tube 34
Four singers and two choirs 35
Singing bar and singing bowl 36
Change one thing and listen 37
A ring is not a decay 38
Voices, and where they go 39
What your hands do 40

PART THREE

The editor 41

One panel, and the K2700 does the playing 42
26 objects, and your own models 43
A drawing you can strike 44
The object's spectrum, to edit 45
Strike, pluck, breath, rub 46
Rows of knobs for a sustained sound 47
Five vowels where the materials were 48
What it is made of, and where it is 49
Three shapers over the whole sound 50
LINK, STORE, READ 51
26 objects to start from, in one .K27 52

PART FOUR

Building it on a Kurzweil 55

The K2700 has no physical modelling. KEDITOR PHYSICAL builds it from its filters 56
A 2POLE LOWPASS at +48 dB rings like a bar 57
A marimba bar, field by field 60
One pulse, read by every mode 62
The level law, measured 63
An AMPENV that just stays out of the way 64
Pluck, point, and the top of the keyboard 65
A friction heard only through the modes 66
Sustained sound without a loop 67
Sharp bands, and a Pad 68
A flute and a clarinet, one sine for each harmonic 69
A vocal tract in series 72
One curve drives the tone and the pitch 74
A rasp that only exists when blown hard 75
An envelope, a filter and an EQ on every sound 77
A factory hall and the app's own delay 78
When it does not work 79
One program, and the model inside it 80
One file, and everything is found by name 81
A modal synthesizer on one page 82
Glossary 83

PART FIVE

User manual 85

Welcome 86
Getting started 86
The panel at a glance 87
The library 88
The OBJECT display 89
The MODES display 90
The exciter: strike, pluck, rub 91
The exciter: breath 93
The voices 94
Material and size 96
Body 96
Space 96
AMP ENV 97
Filter 97
EQ and RESPONSE 98
Working with the K2700 99
Playing it: the K2700's controls 99
The objects 100
Troubleshooting 101

About this guide

Describe an object and KEDITOR PHYSICAL turns it into a K2700 program: the modes it rings in, the mallet, breath or friction that sets it going, the stuff it is made of, where it is struck. Each mode becomes a resonating layer tuned by the key, so every note is a little object of its own, struck harder or softer, damped or left to ring.

Struck and plucked objects are modal synthesis, one pulse read by every mode. Blown and sung ones are a source through a body: four saxophones on fifteen body modes each, six voices through the formants of a vowel, a flute and a clarinet on their bores' own harmonics. All of it measured on the K2700, all of it ordinary K2700 programs: stored, they play with no computer attached.

26
objects to start from, in one .K27

4
exciters: strike, pluck, breath and rub

553 / Hz
seconds: the longest ring of a K2700 resonator

12
sessions measured on the K2700, after a first test

How to read it

Read it in order, or go straight to the part you need. Part one is the physics, for any instrument. Part two is how sounds are made, with the numbers of the 26 objects. Part three is the editor. Part four builds a modal synthesizer on a Kurzweil, step by step, down to every field on the front panel. The last part is the user manual.

The object to strike and the ring bench are on kurzworld.com/keditor-physical, where the mallet can be dragged and a mode's ring moved by hand.

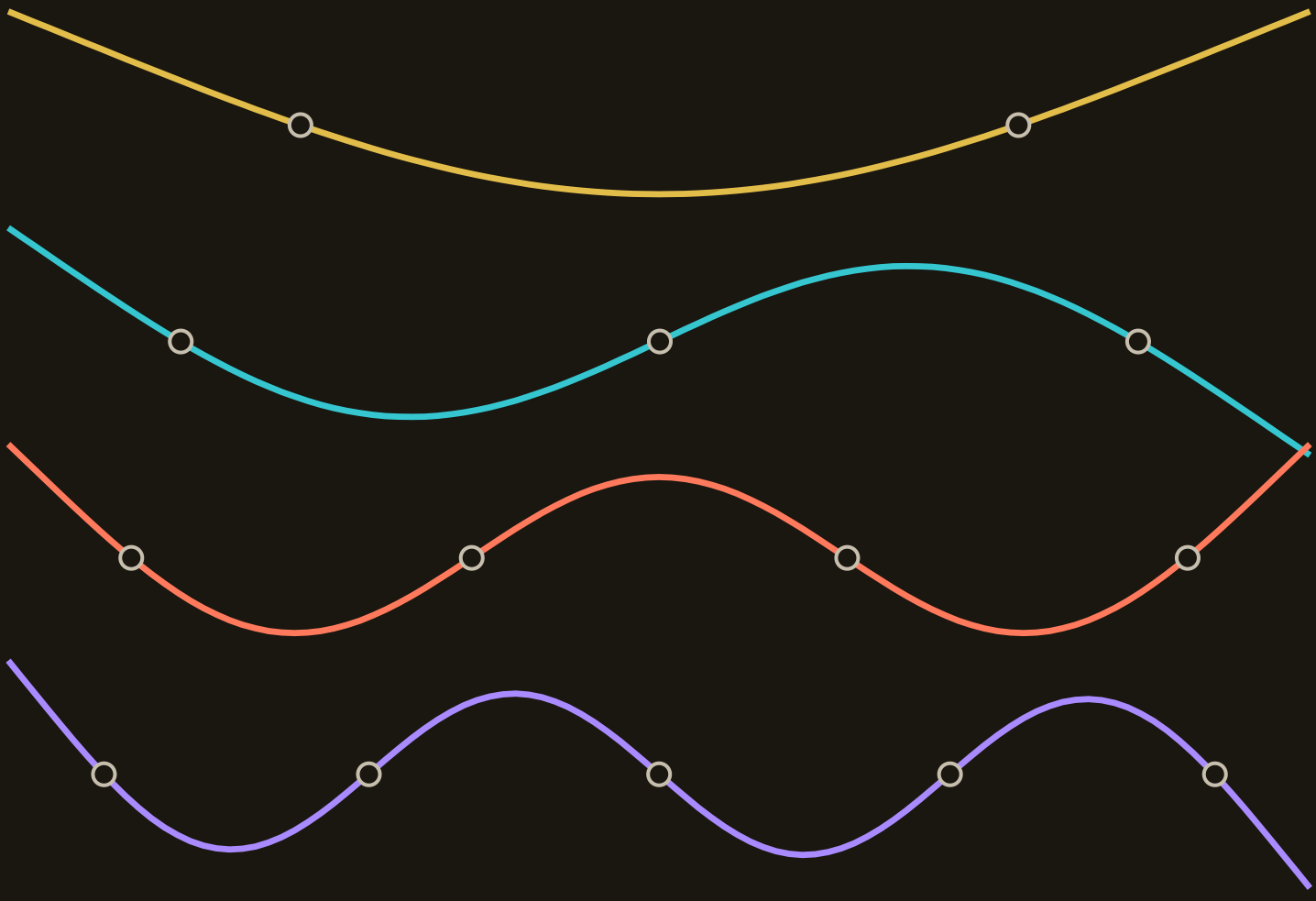
What you need

Platform	A native macOS app.
K2700	Required: a K2700 on USB, for the LINK, STORE and READ.
Objects	26 factory objects in a .K27 pack to load with FILL, and your own models.
Voices	3 to 19 voices a note: from 13 to 85 notes at once.

PART ONE

Physical modelling

What a vibration is, the four ways of computing one, what sets an object ringing, what shapes its modes, how it reaches the air and why it stops.



PHYSICAL MODELLING

Sound from the thing that makes it

Physical modelling makes a sound by simulating the object that makes it. A sample is a recording of a marimba; an additive patch builds a marimba's spectrum out of sine waves. A physical model describes the bar: the frequencies it can vibrate at, how fast each one dies away, what strikes it, and where. The sound follows from the description.

That is why a model behaves like an instrument. Strike harder and the mallet, in contact for less time, reaches higher modes: the note gets brighter as well as louder. Strike nearer the end of the bar and other modes wake. Make it of metal instead of wood and the upper modes ring on. None of it is programmed note by note; it comes out of the object.

Every vibrating object has its **modes**: shapes it can vibrate in, each at its own frequency, each with points that do not move at all, its nodes. A string's modes are its harmonics; a bar's are not; a drumhead's are made of circles and diameters. Strike the object on a node of a mode and that mode stays silent. Here are the first six of four objects, struck in the middle, on the shapes KEDITOR PHYSICAL uses.

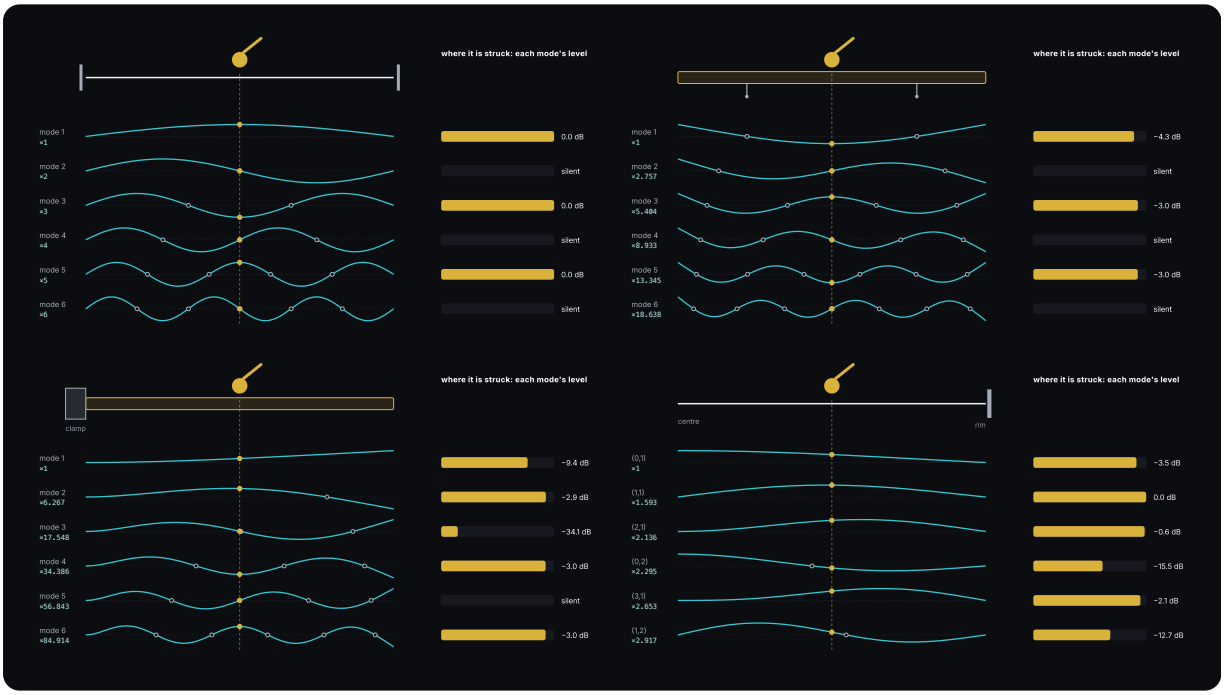


Fig. 1. The first six modes of a string fixed at both ends, a bar free at both ends (a marimba's), a tine clamped at one end (a kalimba's) and a circular membrane along its radius (a tom's), as KEDITOR PHYSICAL weighs them. The bars are how loud each mode is where the mallet is, against the loudest place to strike it.

THREE PARTS

Exciter, resonator, radiator

Acoustic instruments split the same way. An **exciter** puts energy in: a mallet, a finger, a reed, a pair of lips, a jet of air. A **resonator** stores it and sorts it into modes: a bar, a string, a column of air. A **radiator** couples it to the air and colours it: the tuned tube under a marimba bar, a harp's soundboard,

a clarinet's bell.

In struck and plucked instruments the exciter starts the sound and leaves. In blown ones the resonator drives the exciter back: the bore's pressure opens and shuts the reed, its returning wave moves the player's lips. That loop is what keeps a clarinet or a trumpet sounding at one pitch for as long as the player goes on.

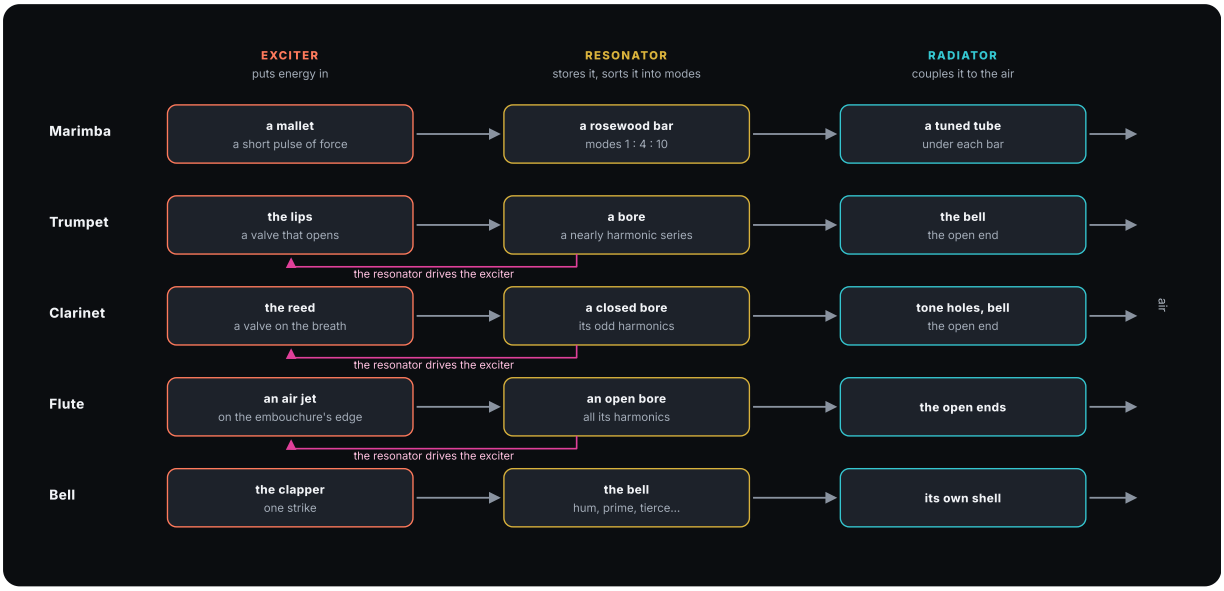


Fig. 2. Five instruments in their three parts. Pink: where the resonator drives the exciter back, the self-sustaining loop of the blown instruments.

WHY MODEL AT ALL

What a model knows that a recording does not

A sample is one performance of one object, frozen. A model is the object, and you can still do things to it.

What you ask	A sample	Additive	A physical model
Strike it harder	another recording, if someone made one	a second table of levels, written by hand	the contact shortens and the upper modes wake
Strike it somewhere else	a new set of recordings	new tables	each mode weighed again by its shape there
Make it of glass	not possible	every decay changed by hand	one law on every mode
Make it twice as long	pitched down, and wrong	new ratios and new decays	two octaves lower for a bar, ringing longer
Hold a note for a minute	a loop	easily	only if an exciter goes on feeding it
What it costs	memory	an oscillator a partial	a resonator a mode

What a sample has is the truth of one recording, every detail of the instrument and of the room. A model has only what you told it, so the art of modelling is knowing which few numbers matter. There are not many: the frequencies of the modes, their levels at the strike, how long each one rings, how the strike reaches them, and what happens when you play harder. The rest of this part is about those numbers.

ONE VIBRATION

A mass on a spring, and the two numbers that describe it

Everything that rings is, mode by mode, a mass on a spring with a little friction. Two numbers describe it: how fast it swings and how soon it stops.

Push a mass on a spring and let go. The spring pulls it back, it overshoots, and it swings at a frequency set by nothing but the stiffness and the mass: $f = (1 / 2\pi)\ \sqrt{(k / m)}$. Four times the stiffness is an octave up; four times the mass, an octave down. How hard you pushed does not change the pitch, which is what makes it an instrument.

Friction takes away the same share of the energy on every cycle. The same share every cycle is the same number of decibels every second, so a ring is a straight line on a decibel scale, and one number describes it: **T60**, the time it takes to fall 60 dB.

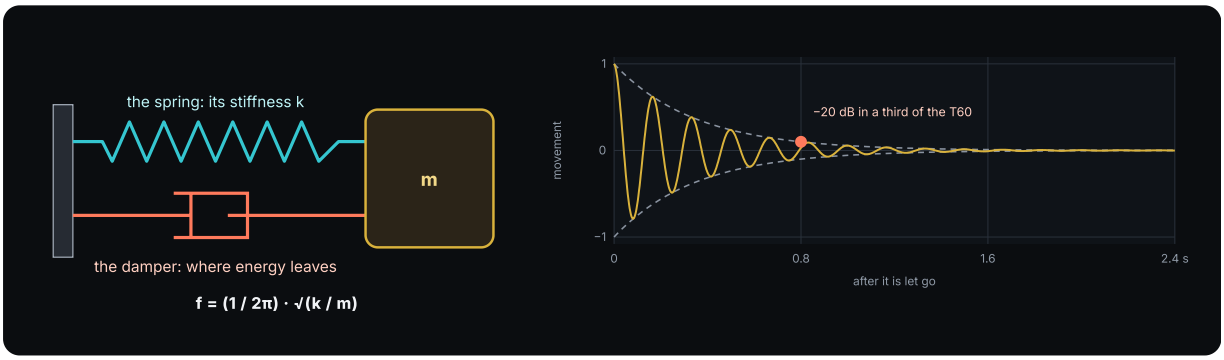


Fig. 3. Left: a mass, a spring and a damper. Right: what it does when let go, the same frequency all the way through and a size that falls by the same number of decibels every second.

A real object has many of these at once. A bar is not one mass on one spring but millions of them joined together, and the joined-up system has as many ways of swinging as it has pieces, each shape with its own stiffness and its own moving mass. Those shapes are the modes. Mode by mode the object behaves exactly like the mass on the spring, and struck gently its modes do not disturb each other: each rings by itself and they simply add up. That independence is called linearity, and the whole of modal synthesis rests on it.

TIME AND FREQUENCY

The same mode, seen twice

A decaying sine in time is a peak in frequency, and the two are one fact. The longer the ring, the narrower the peak. A mode's width in Hz, measured 3 dB down from its top, is about 2.2 divided by its T60, and its **Q** is its frequency over that width. A sharp peak means a long ring, and one cannot be had without the other.

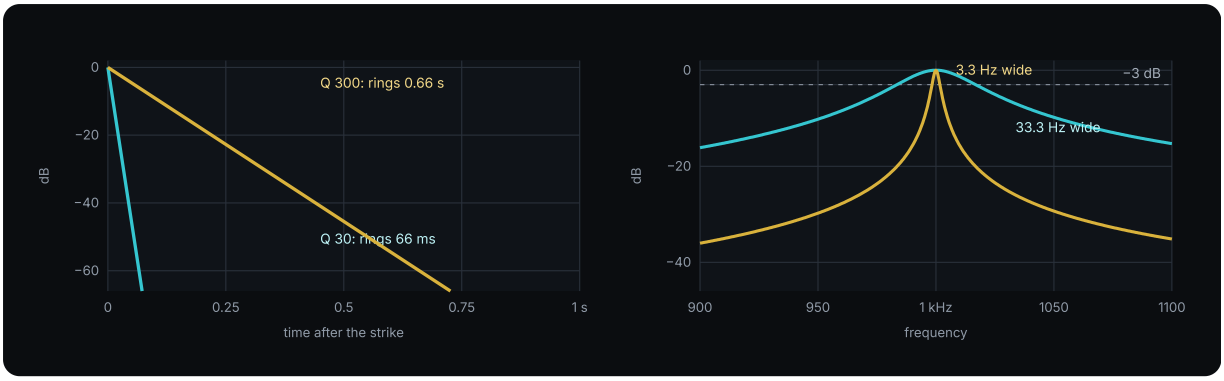


Fig. 4. The same two modes at 1 kHz in time and in frequency: a Q of 30 rings 66 ms and is 33 Hz wide, a Q of 300 rings 0.66 s and is 3.3 Hz wide.

That is why a resonant filter can be a mode. Feed it a click and it rings at its frequency for as long as its resonance says. Part four is built on this sentence.

THE METHODS

Four ways to compute a vibrating object

Physical modelling is a family of techniques, each a different trade between how much of the physics it keeps and how much computing it costs. Four of them matter here.

A SUM OF DECAYING SINES

Modal synthesis

A linear object struck once rings as a sum of decaying sine waves, one for each mode: $y(t) = \Sigma\, a_n \cdot e\hat{}(-6.91\ t\ /\ T60_n) \cdot \sin(2\pi\ f_n\ t)$, where f_n is the mode's frequency, $T60_n$ the time it takes to fall 60 dB and a_n how hard the strike sets it going. Each term is exactly what a two-pole resonant filter does when it is struck, so a modal synthesizer is an exciter feeding a bank of resonant filters in parallel, one a mode, their outputs summed.

In samples a resonator is two multiplications and two memories: $y_k = 2R \cos\theta \cdot y_{k-1} - R^2 \cdot y_{k-2} + x_k$, where $\theta = 2\pi\ f\ /\ fs$ sets its pitch and $R = e\hat{}(-6.91\ /\ (T60 \cdot fs))$ its ring. Modal synthesis is at its best on struck and plucked objects with inharmonic modes: bars, bells, plates, drums. Its cost grows with the modes, and a bell wants dozens.

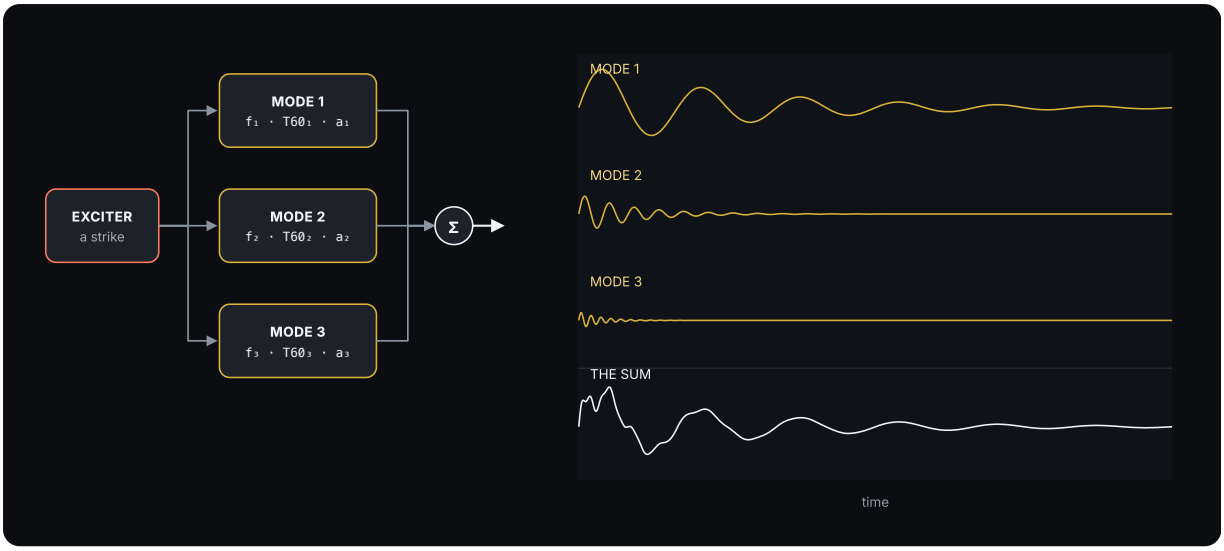


Fig. 5. Modal synthesis: one exciter, a resonator for each mode, their sum. Right: three modes of a struck bar, the higher the sooner gone, and the sound they make together.

WAVES IN DELAY LINES

Digital waveguides and Karplus-Strong

A string's motion is two waves travelling in opposite directions, reflected and inverted at each end. A **digital waveguide** keeps them in two delay lines as long as the string, the sample rate over the note's frequency, and gathers all the string's losses and stiffness into one filter in the loop. Every harmonic comes out at once for the cost of a single delay line, which makes the waveguide the cheapest model of harmonic, sustained instruments: strings, bores, the vocal tract.

Karplus-Strong is the simplest case: a burst of noise recirculating through one delay line and a two-point average. The average takes a little more of each harmonic on every pass, the upper ones most, and the noise becomes a plucked string. Put a nonlinear element at one end, a model of a reed or of a player's lips, and the loop sustains itself: the only method in which the model itself keeps a note going.

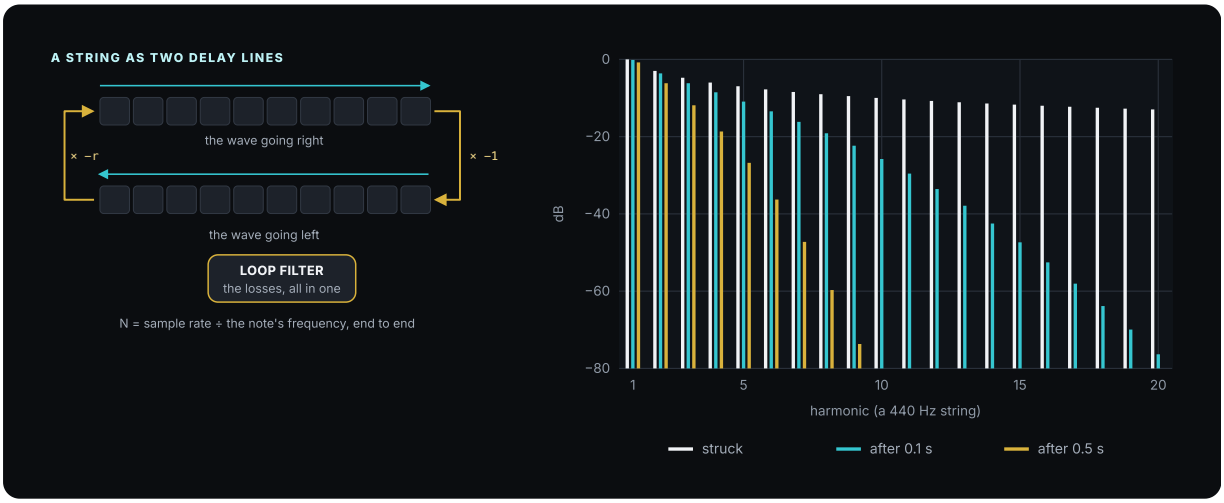


Fig. 6. Left: a string as two delay lines, inverted at the ends, its losses in one loop filter. Right: a plucked waveguide string at 440 Hz, its harmonics as struck and 0.1 and 0.5 s later: the upper ones die much faster.

POINT BY POINT

Mass-spring and finite differences

The most literal methods cut the object into small pieces and compute every one. In a **mass-spring** model a string or a plate is a lattice of masses joined by springs, each mass pushed by its neighbours. **Finite differences** solve the wave equation itself on a grid in space and time: the next displacement of every point from its own last two and its neighbours'. They handle anything, stiff strings, collisions, cymbals, a piano's hammer, felt and soundboard, a room. They are also by far the most expensive: millions of operations a second for a single string.

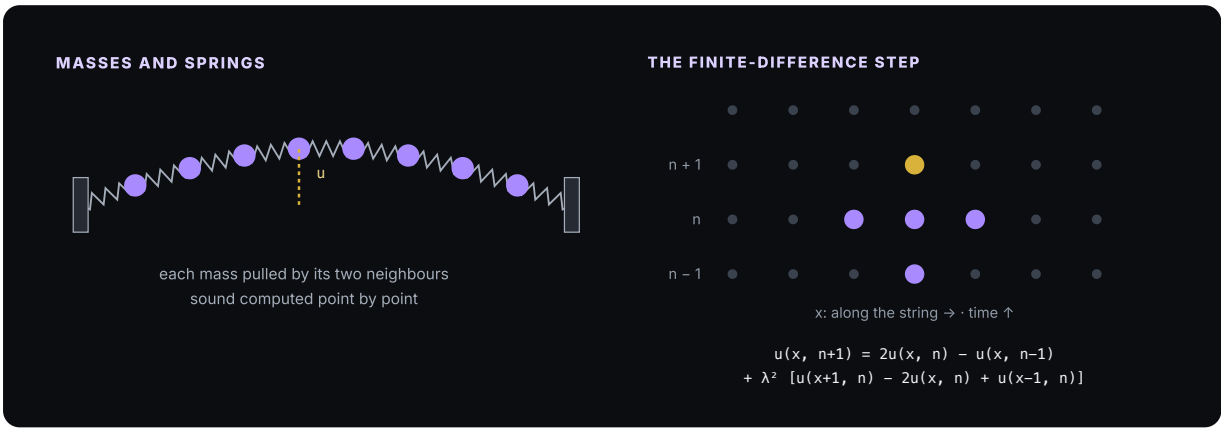


Fig. 7. Left: a string as masses and springs. Right: the finite-difference step: a point's next value (gold) from its own last two and its two neighbours' (violet); λ is the wave's speed in grid points a step, and must stay at 1 or under.

A RICH SOURCE, A FIXED COLOUR

Source-filter

The oldest and cheapest physical idea: a source rich in harmonics, shaped by a filter that stands for the resonator. The voice works this way, the vocal folds' buzz through the formants of the throat and mouth, and so, nearly, does a saxophone: a reed's tone, every harmonic in it, through the resonances of its bore and bell. The filter is linear and fixed, so it can be measured on a real instrument and copied. What source-filter cannot do by itself is the loop: the pitch is the source's, not the resonator's, so it never overblows or squeals.

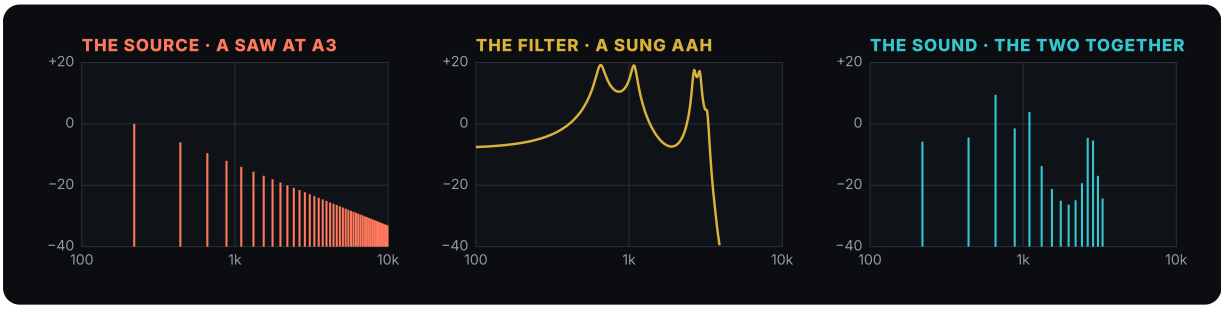


Fig. 8. Source-filter: a saw at A3 (220 Hz, every harmonic at 1/n), the five formants of KEDITOR PHYSICAL's Tenor Aah, and the two together: every harmonic lifted or sunk by the vowel where it falls.

Method	Best at	Sustains by itself	Cost	On the K2700
Modal	struck and plucked objects, inharmonic modes	no: a sustained exciter has to feed it	a filter a mode	**yes**: every mode a layer, every note its own
Waveguide, Karplus-Strong	strings, bores, the voice; blown with a nonlinear exciter	yes, with a reed or lips in the loop	one delay line a string	no delay line in a voice: delays live only in the effects, one for all the notes
Mass-spring, finite differences	anything, nonlinear too	yes	very high	no
Source-filter	the voice, blown sounds, bodies	no: the source sets the pitch	very low	**yes**: KEDITOR PHYSICAL's breath

Around them sit the hybrids: commuted synthesis, which folds a body's response into the excitation; a sampled attack over a modelled resonance, as in modelled pianos; and FM, which its inventor presented as a model of what we hear rather than of the instrument, though each of its operators can stand for a decaying mode.

EXCITERS

Strike, pluck, blow, rub

The exciter decides how the energy goes in, and much of an instrument's character lives there: its attack, how it answers to force, whether it sustains.

A PULSE OF FORCE

Strike

A mallet presses into the bar for a few milliseconds and leaves. Its force is close to a raised-cosine pulse, and the pulse's length is the mallet's hardness: a pulse T long excites well up to about 1/T and falls silent first at 2/T. A felt mallet in contact for 5 ms barely reaches 400 Hz; a brass one in contact for half a millisecond reaches past 4 kHz. A harder blow also presses the mallet in for less time, which is why a marimba gets brighter, and not only louder, as you play harder.

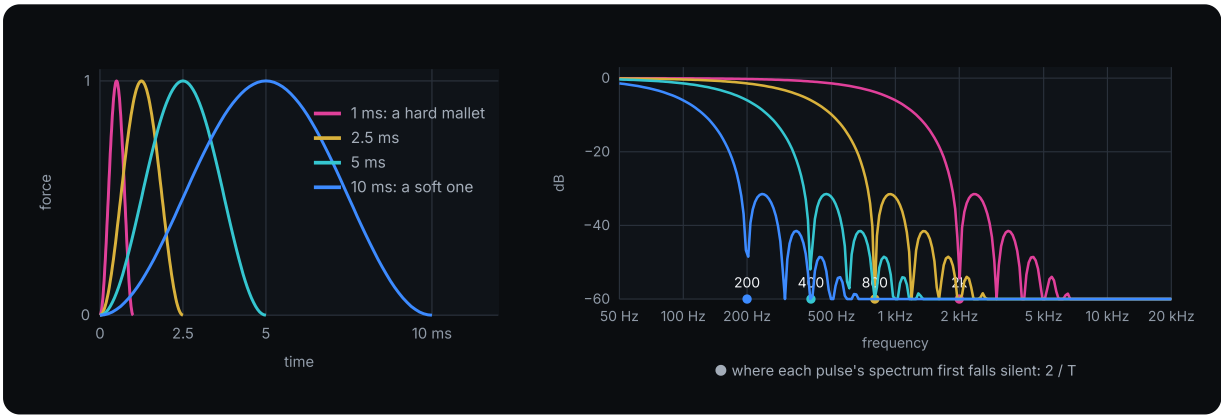


Fig. 9. Left: contact pulses from 1 to 10 ms. Right: their spectra. Each first falls silent at twice the inverse of its length (the dots): the shorter the contact, the higher the modes it reaches.

HARDER IS SHORTER

Force and contact

A mallet is a spring too, and not a linear one: the further it is pressed the stiffer it gets. Written as $F = K\,x^p$, a steel ball on a steel bar has $p = 1.5$, and felt has p around 3. The time in contact then follows the speed of the blow as $T \propto v^{((1 - p) / (1 + p))}$. Over a tenfold change of speed a hard mallet's contact shortens by a third and felt's by three times. That is why instruments played with felt change colour so much with force, and why a glockenspiel, played with brass, hardly does.

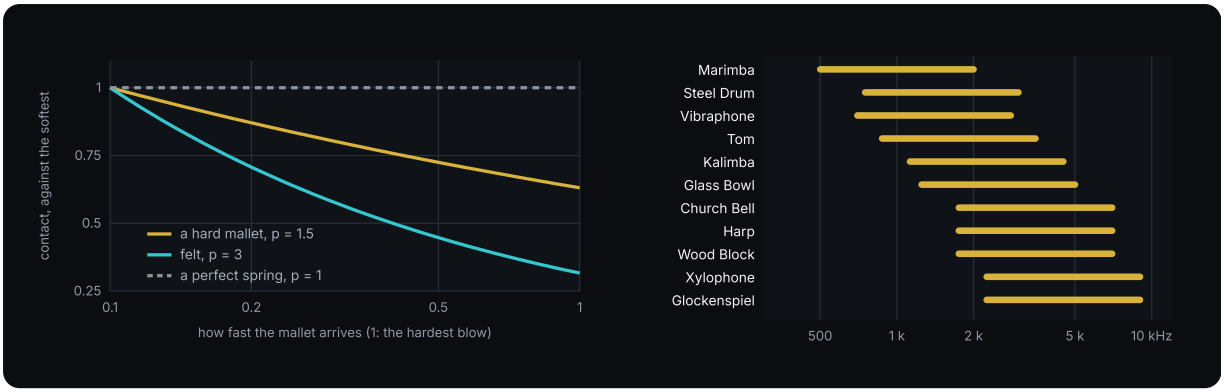


Fig. 10. Left: how long a mallet stays in contact against how fast it arrives. Right: the HARDNESS of the eleven struck and plucked objects, the mallet's low pass from the softest note to the hardest, two octaves on every one.

A SHAPE LET GO

Pluck

A finger pulls a string aside and lets it go from that shape; a hammer gives it a speed instead. The shape of a plucked string, a triangle with its corner at the point, has harmonics falling as $1/n^2$, 12 dB an octave; a struck string's fall as $1/n$, 6 dB an octave. Either way a harmonic with a node at the point is missing: pluck a string at a seventh of its length and its 7th, 14th and 21st harmonics are silent.

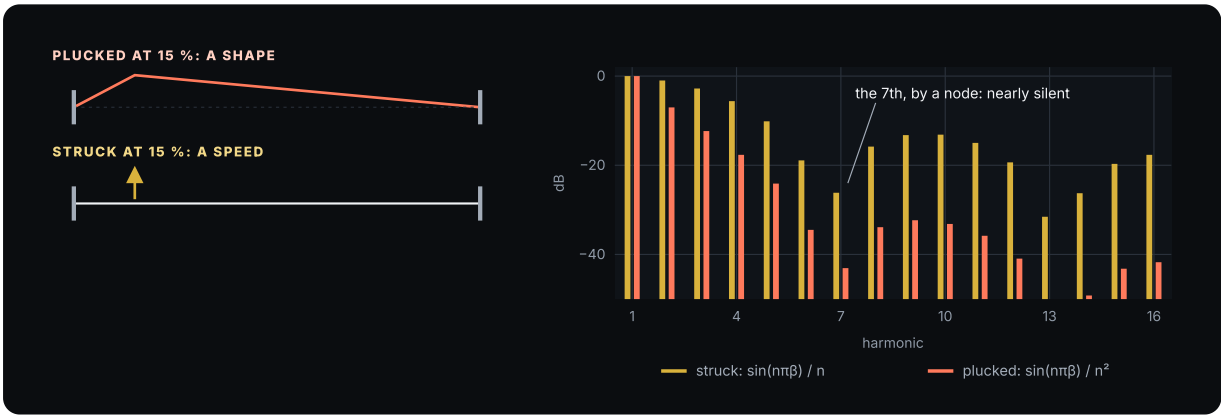


Fig. 11. A string at 15 % of its length, plucked (a shape) and struck (a speed), and its first sixteen harmonics: the pluck falls 6 dB an octave more; both lose the harmonics with a node near the point.

A VALVE, A JET

Breath and reed

A clarinet's reed is a valve that the breath closes. Past a point, the more pressure in the mouth over the bore, the less air it lets through: a negative resistance, which feeds energy into the bore at the frequency the bore sends back. A trumpet player's lips are a valve too, one that opens with pressure. A flute has no valve at all: a jet of air across the embouchure's edge is pushed in and out by the air column's own sound.

Which harmonics the bore gives back depends on its ends. A tube **open at both ends**, a flute's, has every harmonic. A cylinder **closed at one end** by a reed, a clarinet's, has only its odd ones in the low register: its first mode is a quarter of a wave, its next three quarters. A cone, a saxophone's or an oboe's, has them all again.

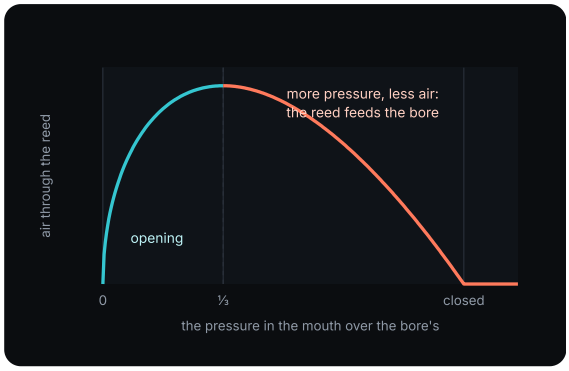


Fig. 12. A reed as a valve: the air through it against the pressure across it. Past a third of its closing pressure (coral) more pressure lets less air through, and the reed keeps the bore sounding.

FRICTION ON A FREE OBJECT

Rub

Rub the end of a metal bar and it sings; run a wooden stick round the rim of a singing bowl and it does the same. Friction grips the object, lets go and grips again, and that stick and slip holds a free object's own modes ringing. The pitch is the object's, not the player's: a rub picks the modes the friction can lock to, mostly the first. A bowl's modes come in close pairs, and a rubbed bowl beats slowly as they drift in and out of step.

RESONATORS

Mode shapes, and the frequencies they ring at

A resonator's modes are set by its shape, its material and the way it is held. They are the most important numbers in a physical model, and for simple shapes they can be written down.

ONE DIMENSION

Strings, bars and tines

A **string** under tension, fixed at both ends, has its modes at whole multiples of the first: its harmonics, each $\sin(n\pi x)$ in shape. Real strings are a little stiff and their upper modes run sharp, $f_n = n\, f_1 \sqrt{(1 + B\, n^2)}$, which a piano's tuning has to live with.

A **bar** free at both ends, a marimba's or a glockenspiel's, bends instead of stretching, and its modes go as the squares of a series of numbers: 1 : 2.756 : 5.404 : 8.933. That is why a plain bar sounds like a clang. Marimba and vibraphone bars are thinned underneath until their second and third modes sit at 4 and 10 times the first, a xylophone's at 3; each hangs on cords at its first mode's nodes, 22.4 % from each end, so that the cords do not damp it.

A **tine** clamped at one end, a kalimba's or a music box's, goes 1 : 6.267 : 17.55: its second mode lies far above, a bright tick in the attack.

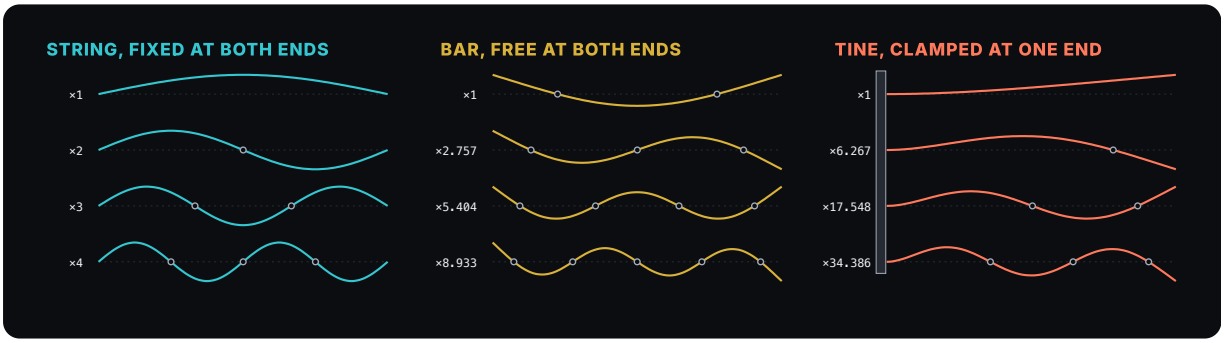


Fig. 13. The first four modes of a string fixed at both ends, a bar free at both ends and a tine clamped at one, each with its frequency over the first and its nodes.

INHARMONICITY

Stiffness stretches the series

A string is a very thin bar. It resists bending a little, and the resistance matters more the shorter the wave: $f_n = n\, f_1 \sqrt{(1 + B\, n^2)}$. B is tiny, about 0.0004 in the middle of a piano, and the upper partials still run many cents sharp of the whole multiples. A piano is tuned with its octaves stretched to live with it. Thick, short strings have the largest B, which is why the bass of a small piano clangs.

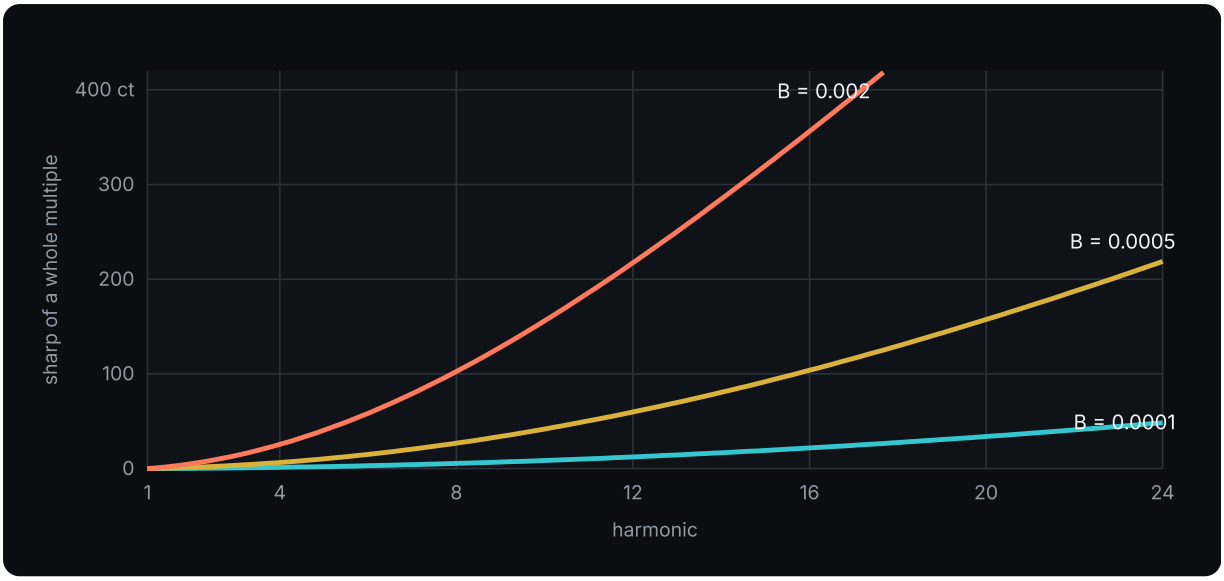


Fig. 14. How far a stiff string runs sharp of its harmonics, in cents, for three values of B.

TWO DIMENSIONS

Membranes and plates

A circular drumhead's modes are Bessel functions, $J_m(j_{mn}\, r)$, each named by two numbers: m nodal diameters and n nodal circles, the rim included. Their frequencies are the Bessel functions' zeros over the first: 1, 1.594, 2.136, 2.296, 2.653, 2.918, 3.156, 3.501, an inharmonic cluster heard as a thud with a pitch in it. Struck in the centre, only the modes with no diameter sound; drummers strike off centre for the rest.

Plates have modes in both directions; a flat plate's go roughly as $(m + 2n)^2$, the patterns Chladni made visible with sand. A steel pan's notes are panels of its surface hammered until their modes fall on harmonics, 1 : 2 : 3 : 4, which is why a pan sounds so clearly pitched.

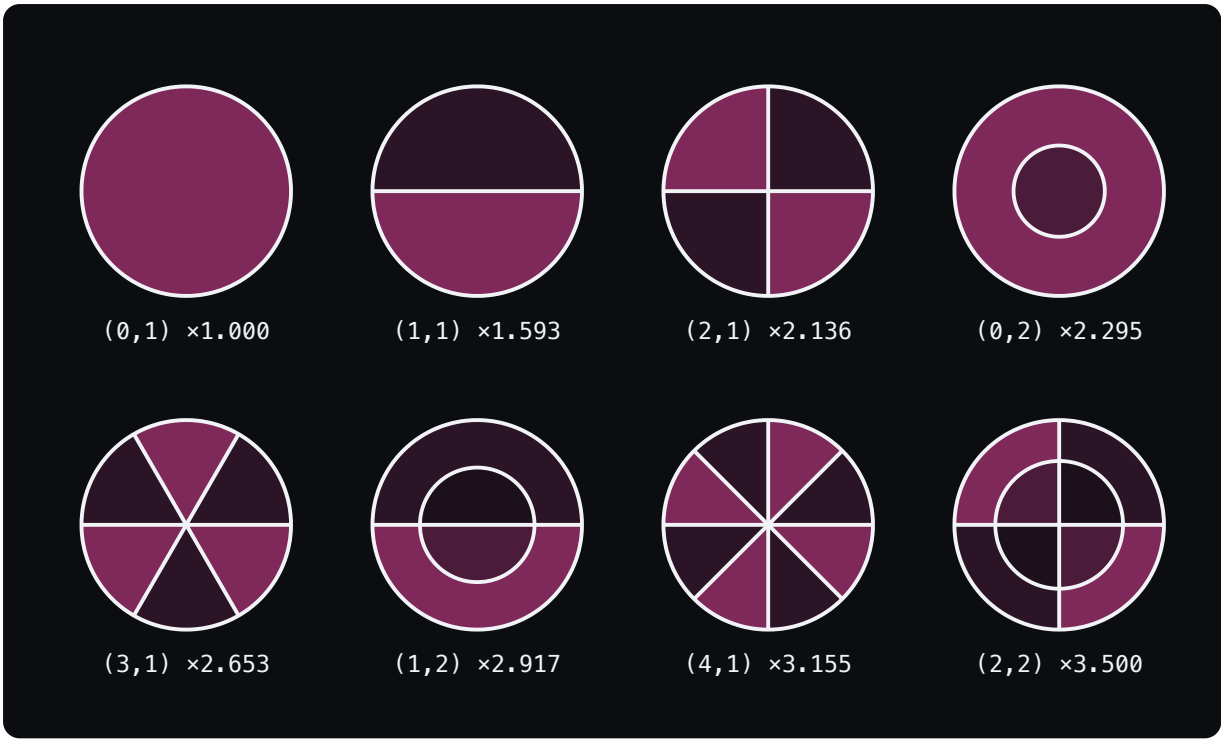


Fig. 15. A circular membrane's first eight modes from above. White: the nodal diameters and circles; the light and dark parts move in opposite directions. Under each, its (m, n) and its frequency over the first.

SHELLS

Bells and bowls

A bell is a shell. Its modes bend the rim into 4, 6, 8 or more waves round its circumference, and the founder tunes the profile until five of them land on a chord: the **hum** an octave under the note, the **prime** on it, the **tierce** a minor third above, the **quint** a fifth and the **nominal** an octave above. The note you hear, the strike note, is none of them alone: the ear makes it out of upper partials that sit nearly at 2 : 3 : 4.

A bowl is a bell without the tuning. Its rim bends in 2, 3, 4 and 5 waves, at frequencies near $m(m^2 - 1) / \sqrt{(m^2 + 1)}$: 1 : 2.8 : 5.4 : 8.8 for a thin, even rim, 1 : 2.71 : 5.06 : 8.0 in KEDITOR PHYSICAL's Singing Bowl.

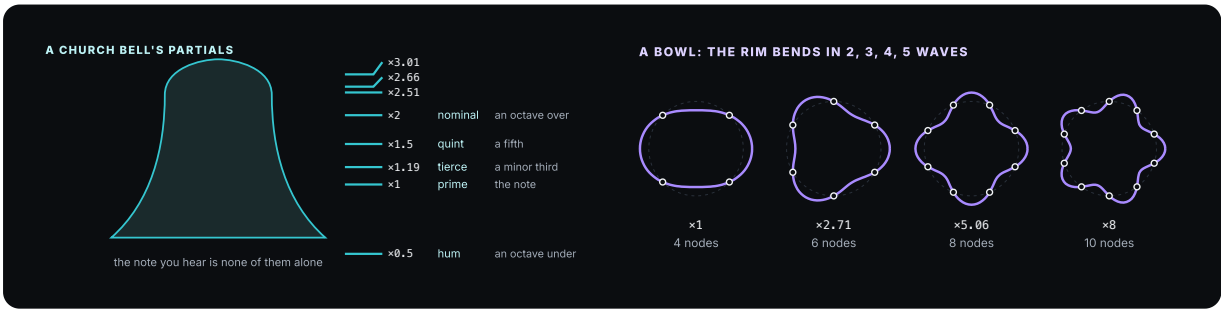


Fig. 16. Left: the eight partials of KEDITOR PHYSICAL's Church Bell, as it plays them. Right: a bowl's first four modes from above, its rim bent into 2, 3, 4 and 5 waves, with 4, 6, 8 and 10 nodes.

AIR

Bores and bodies

The air in a tube resonates like a string: open at both ends, every harmonic; closed at one end, the odd ones. Tone holes let the high frequencies out of the tube, which gives a clarinet its cut-off near 1.5 kHz; a trumpet's bell lets its high frequencies out and, with the mouthpiece, pulls its modes into a nearly harmonic series.

A body is a resonator that is not meant to set the pitch: a harp's soundboard, a singer's throat and mouth. Its modes are many, broad and fixed in frequency whatever the note, so each note's harmonics are coloured differently. The voice's are its formants: a tenor's sung aah has them near 650, 1080 and 2650 Hz, and a change of vowel moves them while the note stays where it is.

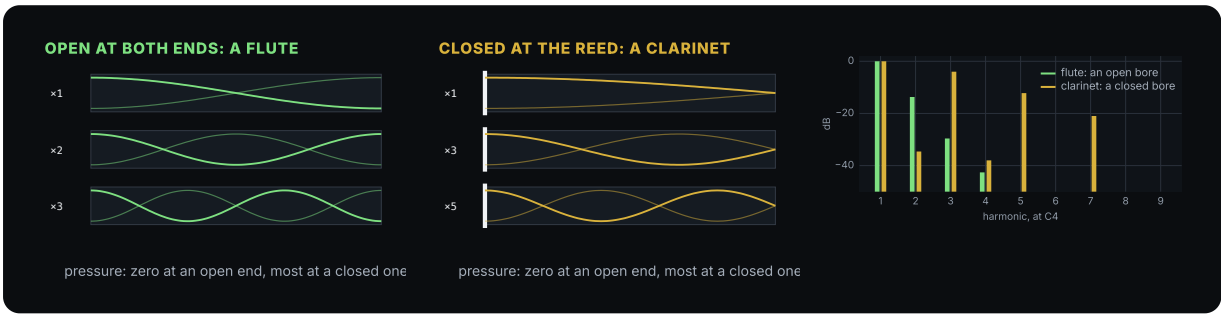


Fig. 17. Left and middle: the first three standing waves of pressure in a tube open at both ends and in one closed at the reed. Right: their harmonics at C4 as KEDITOR PHYSICAL's Flute and Clarinet play them on the K2700: the flute's falling in order, the clarinet's even ones 35 dB under its odd ones.

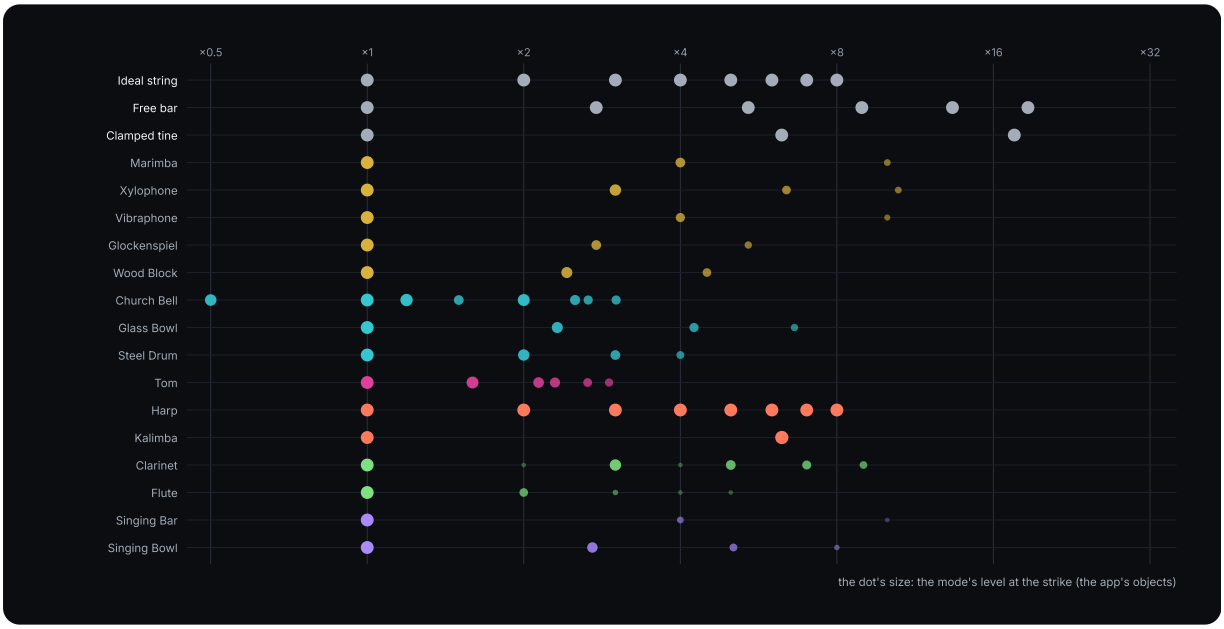


Fig. 18. Every mode of KEDITOR PHYSICAL's objects, and of an ideal string, a free bar and a clamped tine, over the first mode on a scale of octaves. A dot's size is how loud the mode is at the strike.

MODES THAT MEET

Beating, double decay and notes that answer each other

Real objects are seldom one clean set of modes. A few things happen when modes lie close together or share a support, and each of them can still be written as a list of modes.

Two modes a fraction of a hertz apart add and cancel in turn: the level dips and returns, once for every hertz between them. A bowl's modes come in such close pairs, because a perfect circle could bend with its nodes anywhere and a real one has a heavy side and a light side. Bells do the same, and a founder calls a bell with a slow, even beat a good one.

Two modes at the same frequency with different losses give a **double decay**: the sound drops fast, then lingers. A piano's note does it, its strings moving first together and later against each other. One list of modes holds it: two entries at nearly the same ratio with different rings.

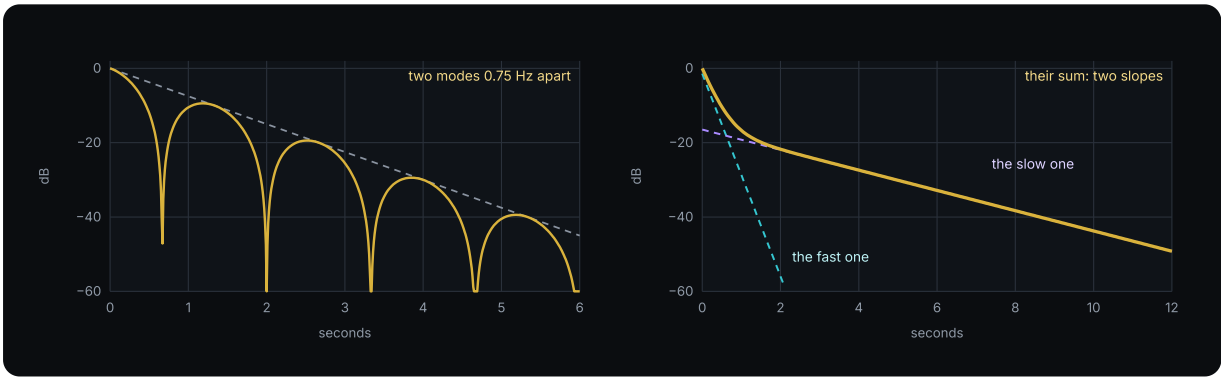


Fig. 19. Left: two equal modes 0.75 Hz apart, dipping once every 1.33 s under the straight line a single mode would draw. Right: a mode with a short ring and a quieter one with a long ring, and their sum: a decay in two slopes.

On the panel. Add a mode and set its RATIO to ×1.003 beside the one at ×1: at C4 that is 0.8 Hz of beating. Give it a longer RING instead and you have a double decay. It costs one voice a note.

Sympathetic resonance is the other thing that happens: a note you are not playing picks up what the others are doing, an open string or a vibraphone bar. It needs the sound of one note to reach the modes of another. A K2700 voice hears only its own note's layers, so KEDITOR PHYSICAL leaves that part of the sound to the hall.

RADIATION

How a vibration gets into the air

A bar on its own is nearly silent. What you hear depends on how well the vibration reaches the air, and instruments are built around that.

An object much smaller than the wavelength mostly pushes the air aside without compressing it. How much of its movement becomes sound goes, for a source of radius a, as $(ka)^2 / (1 + (ka)^2)$, with $k = 2\pi f / 343$. At 100 Hz a 3 cm source is about 16 dB less efficient than a 20 cm one, and that is the whole reason a small object has no bass.

Instrument makers answer in two ways. A **soundboard** is a large, light surface driven by a small, stiff vibrator: a harp's, a piano's. A **resonator** is a second tuned system: a marimba's tube, closed at the bottom and a quarter of a wave long, sits under the bar and takes up its first mode and nothing else.

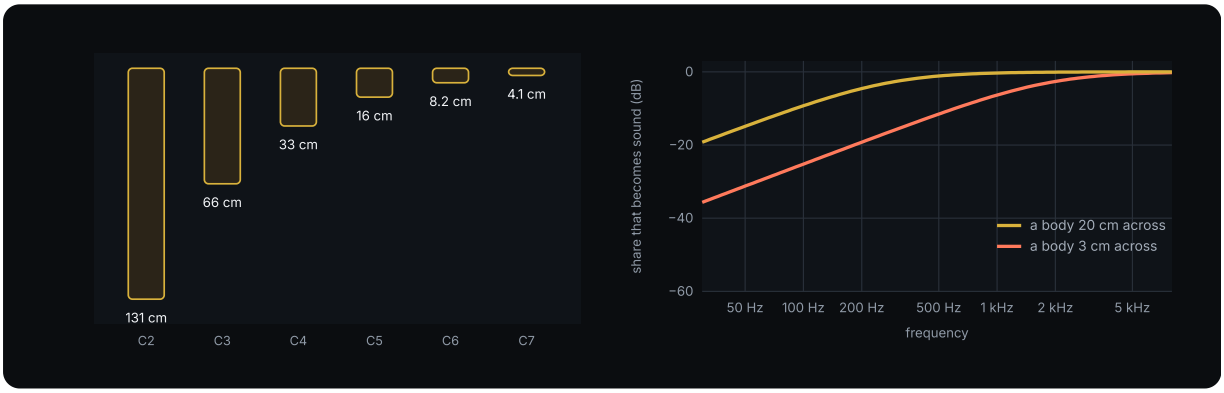


Fig. 20. Left: a marimba's resonator, a quarter of a wave long at each C. Right: how much of a small source's movement becomes sound, at two sizes.

A tube that draws energy out of the bar also shortens its ring, a trade every builder makes. In a model the radiator is one more filter on the whole sound, or simply a mode's level: a marimba's first mode is loud because of its tube, and its level on the panel says so. The body bands of KEDITOR PHYSICAL's winds and voices are the same idea: fixed resonances in Hz that colour every note differently.

LOSSES AND MATERIALS

Why wood knocks and metal rings

Two struck objects with the same modes sound made of different stuff because their modes die at different rates. How a material loses energy, and how that loss grows with frequency, is most of what the ear hears as wood, metal or glass.

A mode's ring is written as its **T60**, the time it takes to fall 60 dB, or as its **Q**, its frequency over its bandwidth. They are the same thing: a resonator of bandwidth B Hz falls 60 dB in 6.91 / (πB), about 2.2 / B seconds, so **T60 = 2.2 × Q / f**. A mode at 1 kHz that rings 2 s has a bandwidth of 1.1 Hz and a Q of 910.

Energy leaves in three ways: inside the material, by internal friction, which grows with frequency; into the air, by radiation, strongest from large, light surfaces; and through the supports. If every mode had the same Q, the rings would halve with each octave up. Metal and glass lose less than that and their upper modes ring on; wood and plastic lose more, and their upper modes are gone at once. KEDITOR PHYSICAL writes each material as one law, T60 = T(1 kHz) × (f / 1 kHz) ^ −a.

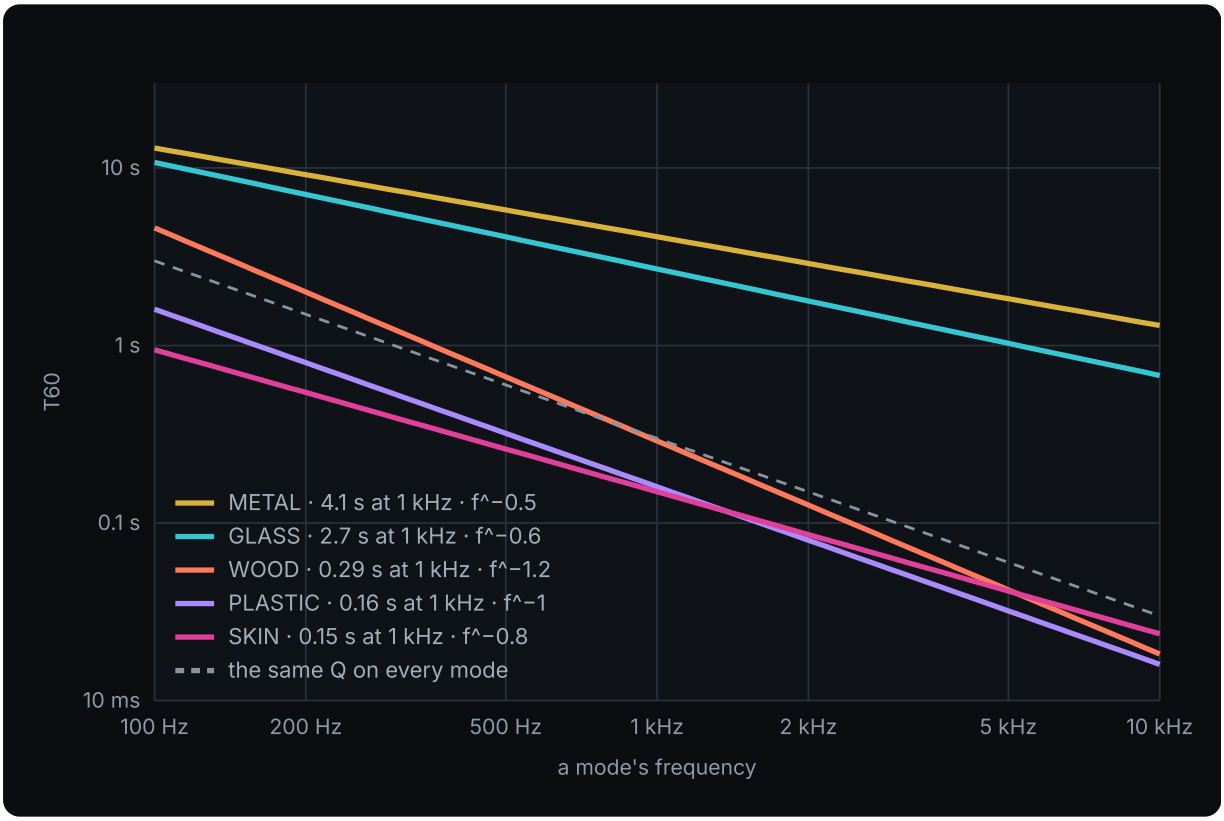


Fig. 21. The five materials on KEDITOR PHYSICAL's panel: how long a mode rings at each frequency. Dashed: the same Q on every mode.

Material	T60 at 1 kHz	a	How it sounds
METAL	4.1 s	0.5	long and bright, the upper modes nearly as long
GLASS	2.7 s	0.6	long and pure
WOOD	0.29 s	1.2	a knock with a pitch, the upper modes gone at once
PLASTIC	0.16 s	1.0	short and dull
SKIN	0.15 s	0.8	a thud

POSITION

Where it is struck

A strike at one point gives each mode the share its shape has there: $a_n \propto \varphi_n(x)$, the mode's displacement at the point over its largest. A free bar struck in the middle sounds its first and third modes and loses its second and fourth, which have a node there. Struck at 22.4 % of its length, on the first mode's node, it loses its fundamental, a thin, bell-like sound players avoid. A string plucked in the middle loses all its even harmonics and sounds hollow.

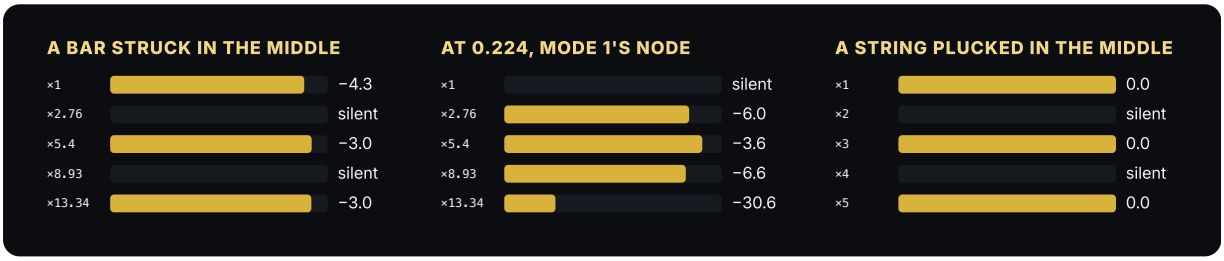


Fig. 22. Each mode's level where it is struck, against its loudest place: a free bar in the middle and at 0.224 of its length, and a string in the middle.

DAMPERS AND PEDAL

Damping

Some instruments let every note ring on, a glockenspiel or a bell; others damp it when the key or the hand lets go, a vibraphone with its felt bar, a harp under the palm, a piano. A damper is a large extra loss applied at once, and the sustain pedal takes it away.

THE LIMIT

What a linear model cannot do

Modal synthesis assumes that the modes never talk to each other. Several famous sounds are exactly what happens when they do.

The sound	What is happening	Why modes alone cannot do it
A gong's shimmer, building after the strike	the shell bends so far that energy moves from low modes into high ones	a mode only falls: nothing can make a high one grow after the strike
A string's pitch falling after a hard pluck	a large swing stretches the string, and the pitch drops as it dies	a mode has one frequency
A snare's rattle, a sitar's buzz	parts of the instrument hit each other	a collision is not a sum
A clarinet's squeak, a saxophone's multiphonic	the reed and the bore lock in another way	there is no loop for them to lock in
A saxophone blown hard	the reed beats shut and tears the flow once a period	the harmonics it adds depend on how hard it is blown

These are where the other methods earn their cost. On a K2700 the way round is to imitate what is heard: a filter that moves as a note dies, a second layer that opens with the force of the blowing. KEDITOR PHYSICAL's EDGE is one of those, a rasp heard only above a threshold of blowing, built in step 14 of Part four.

HISTORY

Sixty years of modelling instruments

The ideas came out of acoustics laboratories decades before computers were fast enough to play them, and each generation of chips brought one of them into instruments.

1962
A singing tract
Kelly and Lochbaum model the vocal tract as a chain of short tubes, waves passing and reflecting between them, and a computer sings Daisy Bell.

1971
The wave equation, solved
Hiller and Ruiz compute plucked and struck strings point by point with finite differences: minutes of computing for a second of sound.

1979
Masses and springs
Cadoz, Luciani and Florens begin CORDIS-ANIMA: instruments built of masses, springs and frictions, played through keys that push back.

1983
The pluck and the loop
Karplus and Strong find that noise in a delay line with an average sounds like a plucked string. McIntyre, Schumacher and Woodhouse show reeds, flutes and their kin to be one thing: a nonlinear exciter on a linear resonator.

1985–86
Digital waveguides
Julius Smith makes delay lines a general theory of strings and bores: travelling waves, the losses in one filter, scattering where tubes and strings meet.

Late 1980s
Modal synthesis
IRCAM's MOSAIC, later Modalys, brings modal analysis from engineering to music: any object as its modes, struck, plucked or blown.

1994
Waveguides in a keyboard
Yamaha puts waveguide models with nonlinear exciters in a keyboard, played with breath and expression, two notes at a time.

1995–97
Into synthesizers
Korg's Prophecy and Z1 and Technics' WSA1 put models of reeds, brass, strings and struck objects in keyboard players' hands.

2006–15
Software and modules
Modelled pianos with no samples at all, modal percussion in plug-ins, resonator modules that bring modes and strings to modular synthesizers.

2026
KEDITOR PHYSICAL
Modal synthesis on an instrument that has none: every mode a layer of a real K2700 program, every note its own.

The thread through all of it is the split between exciter and resonator, and the choice of how to compute each. KEDITOR PHYSICAL takes the modal side of the family, the one the K2700's own synthesis can play on every voice, and source-filter for what modal synthesis cannot sustain.

PART TWO

Making sounds

A method, what each family of objects asks for, the numbers of all 26 on the panel's own units, what to do with the ceiling, and what your hands can do.



A METHOD

An object in six steps

You can start anywhere on a panel, but this order wastes the least time, because each step depends on the ones before it.

1

Object

Start from the closest of the 26. A bar, a tube or a skin already has the right kind of modes.

2

Modes

On MODES, get the ratios right first, then the levels, then the rings. Listen at C2, C4 and C6.

3

Exciter

HARDNESS is most of the colour. Play soft and hard; VELOCITY is how far apart they are.

4

Material

Press one and listen to how the upper modes go. Then DECAY for the whole and KEY DECAY for the keyboard.

5

Point

Turn POINT on and drag the mallet. Listen to which modes leave and which come in.

6

Space

The hall last, and less than you think: a bar in a hall is a different instrument.

Mode 1 first. Everything else is heard against it. Set its level and its ring before you touch the others, and when a sound goes wrong come back to it.

Spend voices last. Every mode costs one voice for every note. If taking a mode away changes nothing you can hear, it was a voice you did not need.

Do not chase a level you could get elsewhere. A mode's LEVEL is its share of the strike. VOLUME is the program. LOW/HIGH tilts the keyboard. Each has its job, and the three together are how an object stays even from C2 to C6.

WHAT THE OBJECTS SHOW

What each kind of object wants

The 26 objects fall into seven families. Their numbers show what each kind of sound asks for, and the typical value in its family is a good first guess for a new one.

Family	Objects	Modes	Voices	Mode 1 asks	HARDNESS, CUTOFF or FRICTION	VELOCITY
Mallets	5	3 to 4	4 to 5	0.22 to 7 s	2 to 9 kHz	26 to 30 dB
Bells, bowls, pans	3	4 to 8	5 to 9	1.6 to 11 s	3 to 7 kHz	28 dB
Skins	1	6	7	0.5 s	3.5 kHz	32 dB
Plucked	2	2 to 8	3 to 9	2.2 to 3 s	4.5 to 7 kHz	26 to 30 dB
Winds	7	5 to 7 harmonics, or 1 to 15 bands	4 to 19	the key held	0.7 to 4.7 kHz	18 to 26 dB
Voices	6	5 formants	5	the key held	6 kHz	20 dB
Rubbed	2	3 to 4	4 to 5	7 to 10 s	1.2 to 2.5 kHz	16 to 20 dB

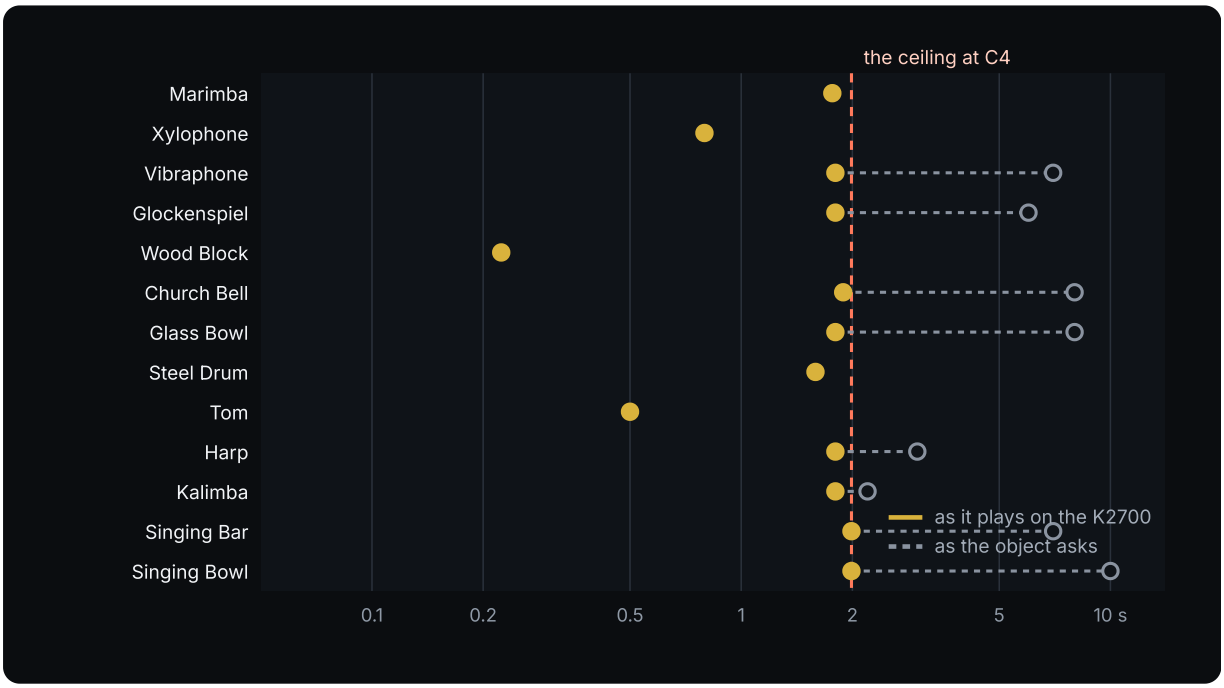


Fig. 23. The mode at ×1 of every struck, plucked and rubbed object, at C4: the ring it asks and the ring the K2700 plays. Those past the dashed line ring at the ceiling instead.

Short objects are wood and skin and, the Marimba's first mode apart, they stay inside what a resonator can hold. Long objects are metal and glass, and they all ask more than a resonator can hold at C4. That is a real difference in how they are programmed, and it comes back in the chapter on times.

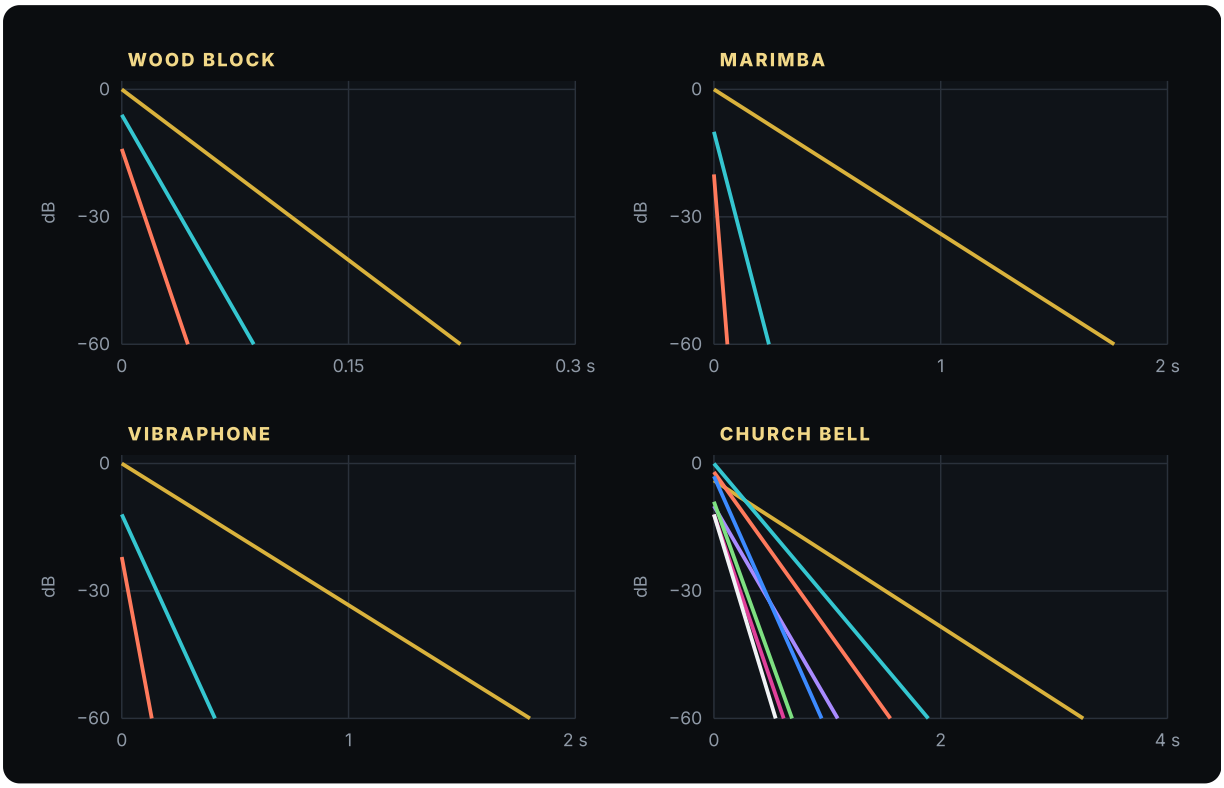


Fig. 24. Four objects, each mode's level against time at C4 as the K2700 plays it. The Wood Block's picture is 0.3 s across, the Marimba's and the Vibraphone's 2 s, the Bell's 4 s.

FIVE BARS

Marimba, xylophone, vibraphone, glockenspiel, wood block

Five bars, three kinds of tuning, four kinds of mallet.

The Marimba is the reference: a bar thinned underneath until its upper modes sit at 4 and 10, rosewood's short rings and a yarn mallet that barely reaches the second one when played softly. **The Xylophone** is tuned to the twelfth, 1 : 3, and struck with a hard mallet: the same family, and a much drier, brighter sound.

The Vibraphone is the Marimba's ratios in aluminium: seven seconds asked, and dampers on the key. **The Glockenspiel** is a plain free bar of steel, its ratios the ones the physics gives, and it is the only one of the five to use them. **The Wood Block** shows how short a sound can be and still have a pitch: a fifth of a second at C4.

Object	Ratios	Levels (dB)	Rings asked at C4 (s)	HARDNESS	VELOCITY	Dampers
Marimba	1 : 4 : 10	0, −10, −20	1.8, 0.30, 0.09	2 kHz	30 dB	no
Xylophone	1 : 3 : 6.4 : 10.5	0, −5, −14, −20	0.8, 0.27, 0.13, 0.08	9 kHz	28 dB	no
Vibraphone	1 : 4 : 10	0, −12, −22	7, 3.0, 1.8	2.8 kHz	30 dB	0.3 s
Glockenspiel	1 : 2.756 : 5.404	0, −10, −18	6, 3.6, 2.6	9 kHz	26 dB	no
Wood Block	1 : 2.42 : 4.5	0, −6, −14	0.22, 0.10, 0.06	7 kHz	28 dB	no

VEL SOFT is two octaves on all five, KEY TRACK 50 ct a key, the hall at 25 % and 2 s.

SHELLS AND SKINS

Church bell, glass bowl, steel drum, tom

Two dimensions, and modes that no longer line up in any simple way.

The Church Bell is the struck object that needs the most layers: hum, prime, tierce, quint, nominal and three partials above them. Its minor third, at ×1.19, is what makes it sound like a bell and not a chord. **The Glass Bowl** has no such tuning; its ratios are those of a rim and it is what happens to a bell when nobody tunes it.

The Steel Drum is the opposite: a panel of metal hammered until its modes are harmonics, so it sounds clearly pitched and brighter as it is played harder. **The Tom** is a membrane's first six modes, the Bessel ratios, close together and short: a thud with a pitch in it.

Object	Ratios	Levels (dB)	Rings asked at C4 (s)	HARDNESS
Church Bell	0.5 : 1 : 1.19 : 1.5 : 2 : 2.51 : 2.66 : 3.01	−4, 0, −2, −10, −3, −9, −12, −12	11, 8, 6.4, 4, 4.8, 2.8, 2.4, 2	7 kHz
Glass Bowl	1 : 2.32 : 4.25 : 6.63	0, −6, −12, −18	8, 5.3, 3.9, 3.1	5 kHz
Steel Drum	1 : 2 : 3 : 4	0, −5, −10, −16	1.6, 1.1, 0.83, 0.70	3 kHz
Tom	1 : 1.594 : 2.136 : 2.296 : 2.653 : 2.918	0, −3, −7, −9, −13, −15	0.5, 0.34, 0.27, 0.26, 0.23, 0.21	3.5 kHz

VELOCITY 28 dB on the first three and 32 dB on the Tom. The Bell's hall is 33 % and 3.5 s. VOLUME is +7 dB on the Bell, +9 on the Tom and +12 on the other two.

PLUCKED

Harp and kalimba

PLUCK is the same pulse as STRIKE, with the modes falling a further 6 dB an octave of their ratio: a string let go from a shape rather than hit.

The Harp plucks a string at 15 % of its length, near the node of its seventh harmonic, and that one mode drops to −26 dB: the point decides the colour of a string more than anything else. Eight modes make it the most expensive plucked object, nine voices a note. **The Kalimba** is the cheapest instrument here: a clamped tine, two modes, three voices. Its second mode, far above the first, is the bright tick at the start of each note.

Object	Ratios	Levels as played (dB)	Rings asked at C4 (s)	HARDNESS
Harp	1 to 8, harmonics	0, −1, −2.8, −5.6, −10.1, −18.9, −26.2, −15.8	3, 1.7, 1.2, 1, 0.83, 0.72, 0.63, 0.57	7 kHz
Kalimba	1 : 6.27	0, −14.4	2.2, 0.17	4.5 kHz

The Harp's panel levels are all 0 dB: the column here is what the pluck's fall and POINT make of them.

WINDS

Flute, clarinet and trumpet

Three ways of getting a blown note out of a K2700: a bore of sines, a closed bore of sines, a saw through a bell.

	Flute	Clarinet	Trumpet
WAVE	SINE, open bore	SINE, closed bore	SAW
Modes	×1 to ×5: 0, −14, −24, −32, −40	×1 2 3 4 5 7 9: 0, −35, −5, −38, −10, −12.5, −17	a band at 1.2 kHz, +4 dB
Cutoff	700 Hz	1.5 kHz, the same on every key	2.35 kHz, Res +7 dB
VELOCITY	18 dB	20 dB	26 dB
NOISE, CHIFF	−44 dB, 22 dB	−38 dB, 3 dB	−40 dB, 6 dB
AMP ENV	70 ms, 80 ms	35 ms, 70 ms	30 ms, 60 ms
VIBRATO	6 ct, 5 Hz, after 0.3 s, TREMOLO 3 dB	none	5 ct, 5.5 Hz, after 0.6 s, TREMOLO 1 dB
BLOW	+30 ct	−12 ct	+25 ct
EDGE, GROWL	no EDGE, GROWL 8 dB	0.25, 4 dB	0.15, 4 dB
Voices a note	6	9	4

The Flute has most of its character in the first 50 ms: a CHIFF of 22 dB over a breath that afterwards almost vanishes. Blown harder it goes sharp, and its GROWL is a flutter-tongue. **The Clarinet** has no vibrato and an enormous gap between its odd and even harmonics, 35 dB, until the upper register closes it from A#4. **The Trumpet** stays a saw because its harmonics run far past the seventh, loud and high, and seven sines would have cut them off.

FOUR SAXOPHONES

One reed, four lengths of tube

A saxophone is the most expensive sound in the library: a saw, a direct path, an edge, fifteen body bands and a breath, 19 voices a note, played one note at a time.

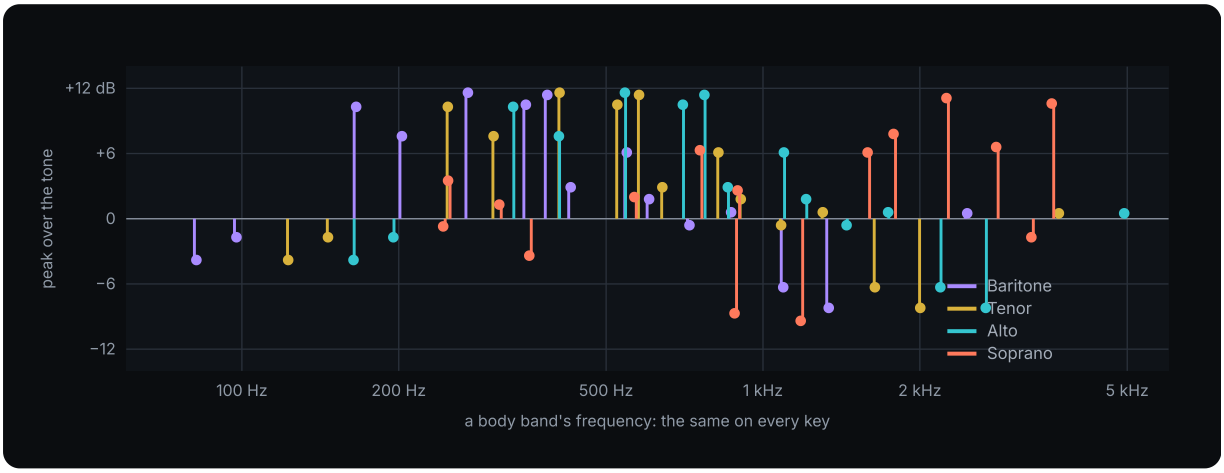


Fig. 25. The fifteen body bands of each saxophone, each band's peak over the tone. The Alto, Tenor and Baritone are one body scaled by the length of the tube; the Soprano has its own.

	Soprano	Alto	Tenor	Baritone
Cutoff	1.6 kHz	4.66 kHz	3.49 kHz	2.33 kHz
Res	+5 dB	+6.5 dB	+6.5 dB	+6.5 dB
DIRECT, its low cut	+2.1 dB, 800 Hz	−0.2 dB, 1068 Hz	−0.2 dB, 800 Hz	−0.2 dB, 534 Hz
VOLUME	+11 dB	+8 dB	+9 dB	+11 dB
Size	82 cm	1.23 m	1.65 m	2.48 m

All four: VELOCITY 24 dB, NOISE −34 dB, CHIFF 4 dB, attack 35 ms, release 80 ms, VIBRATO 10 ct at 5 Hz after 0.5 s, BLOW −15 ct, EDGE 0.5, GROWL 6 dB, GLIDE 200 keys a second.

The Tenor's bands are the Alto's at three quarters of the frequency and the Baritone's are half of it, the ratios of their lengths. That is the most physical thing in the program: the body scales, the reed does not.

They are played as a wind is. WIND MAP gives the aftertouch to the breath, the pitch bend to the lips and the mod wheel to the vibrato. LEGATO keeps one voice and slides between notes. BREATH ties the brightness and the pitch to how hard the note is being blown. FLOW AIR makes the air ride the tone, in bursts at the note's own period.

SIX VOICES

Four singers and two choirs

The voice is the textbook case of source-filter: a buzz at the note's pitch, and five resonances that do not move with it.

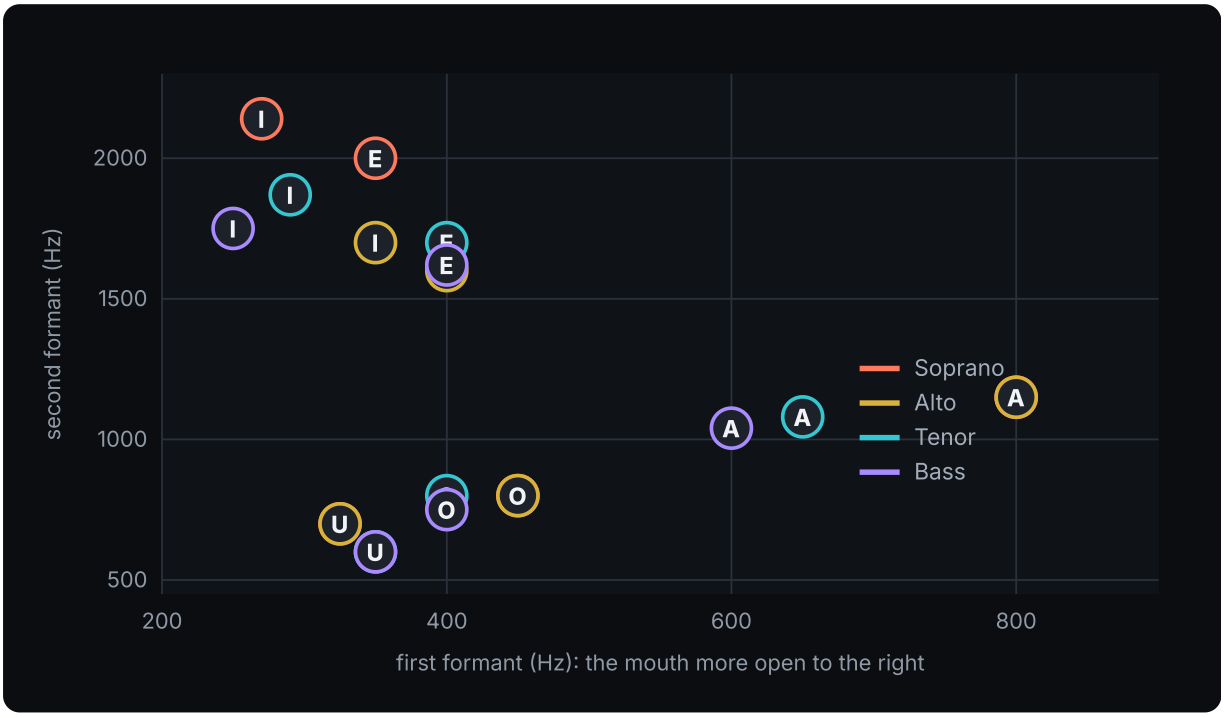


Fig. 26. The five sung vowels of the four voices on the plane of the first two formants. The vowels sit where they do because the mouth and the tongue move these two resonances.

Voice	Type	First vowel	On the wheel	VIBRATO	GLIDE
Soprano Aah	Soprano	A	O	40 ct at 5.5 Hz	60 keys a second
Alto Ooh	Alto	U	A	30 ct at 5.5 Hz	60 keys a second
Tenor Aah	Tenor	A	E	35 ct at 5.5 Hz	60 keys a second
Bass Ooh	Bass	O	A	24 ct at 5.5 Hz	60 keys a second
Choir Aah	Alto, three saws 9 ct apart	A	U	12 ct at 5.2 Hz	chords
Choir Ooh	Alto, three saws 9 ct apart	U	A	12 ct at 5.2 Hz	chords

Formant	Soprano A	Alto U	Tenor A	Bass O
1	800 Hz, 80 wide	325 Hz, 50 wide	650 Hz, 80 wide	400 Hz, 40 wide
2	1150 Hz, 90	700 Hz, 60	1080 Hz, 90	750 Hz, 80
3	2900 Hz, 120	2530 Hz, 170	2650 Hz, 120	2400 Hz, 100
4	3900 Hz, 130	3500 Hz, 180	2900 Hz, 130	2600 Hz, 120
5	4950 Hz, 140	4950 Hz, 200	3250 Hz, 140	2900 Hz, 120

Each voice has all five vowels: A, E, I, O and U, on MATERIAL's five buttons.

A formant's level comes from where it is and how wide it is, as it does in a real tract, so its LEVEL knob rests: you move a formant across and change its RING, which here is its width. A soloist glides and has a vibrato that arrives late. A choir starts slower, 180 ms against 90, with three saws a little apart and a calm vibrato.

The wheel takes the voice to a second vowel. With AUTO on the voice does it by itself at each note, holding the first vowel for HOLD and moving into the second over SLIDE: a diphthong. A rising one, into a more open vowel, holds its first vowel only 40 ms; a falling one holds it 350 ms and turns at the end.

RUBBED

Singing bar and singing bowl

A friction held on the object: the modes sing while the key is down, and ring on when it is let go.

Both are objects from the strike family with the mallet taken away. The Singing Bar is the Vibraphone's bar with its upper modes much weaker, since a friction locks mostly to the first. The Bowl's modes are a rim's. Both swell slowly, and the wheel or the aftertouch opens the friction and makes it louder, an octave and 6 dB at full pressure.

	Singing Bar	Singing Bowl
Ratios	1 : 4 : 10	1 : 2.71 : 5.06 : 8
Levels (dB)	0, −20, −34	0, −8, −16, −24
Rings asked at C4 (s)	7, 3.0, 1.8	10, 7, 4, 2.5
FRICTION	2.5 kHz	1.2 kHz
VEL SOFT	one octave	one octave
VELOCITY	20 dB	16 dB
AMP ENV	0.35 s, 0.12 s	0.8 s, 0.3 s
Hall	33 %, 3 s	33 %, 3.5 s

OBJECTS THAT DO NOT EXIST

Change one thing and listen

Each of these is one or two moves from a factory object, and each teaches what those moves do.

Start from	Do this	What you get
Marimba	press METAL	the marimba's tuning with every mode ringing long: a vibraphone with no dampers
Church Bell	press WOOD	the chord of a bell, over at once: a knock with a harmony in it
Tom	press METAL	a membrane's ratios ringing: something between a gong and a tuned drum
Glass Bowl	press SKIN	a rim's ratios with a thud's decay
Harp	drag POINT to the middle	every even harmonic gone: a hollow, clarinet-like pluck
Marimba	turn POINT on, drag to 0.224	mode 1 on its node: a thin sound with no fundamental
Kalimba	move mode 2 to ×4	a tuned tine, closer to a toy piano
Steel Drum	add a mode at ×1.003	a slow beat in the note
Vibraphone	exciter RUB	the Singing Bar, with its upper modes louder
Singing Bowl	exciter STRIKE	the same bowl hit with a mallet
Xylophone	SIZE up 12 semitones	a bar 1.41 times longer, an octave down, ringing longer
Flute	WAVE to the closed bore	a clarinet's bore with a flute's breath
Tenor Sax	SIZE up 7 semitones	the same reed on a longer body: the note stays where the key is, the bands move down
Bass Ooh	VOICE to Soprano	the same vowel on a soprano's formants

Go back to the object with the library at any time. What you want to keep goes to MY MODELS with SAVE, under its own name, and to the K2700 with STORE.

TIMES

A ring is not a decay

T60 is the time to fall 60 dB, and most of that time you do not hear. In a mix a note seems to stop about 30 dB down: a T60 of 2 s sounds like one second.

Key	A mode there	Longest ring on the K2700	Good for
C2	65 Hz	7.4 s	anything
C3	131 Hz	3.8 s	bells and bars, with room to spare
C4	262 Hz	2.0 s	wood, skin, short metal
C5	523 Hz	1.0 s	a tuned wood bar; metal is held back
C6	1047 Hz	0.53 s	short objects only

For each mode, not each note: a mode at ×4 of C4 is at the C6 line.

When an object asks more than this, the MODES display shows what you asked and what you will get. There are several honest answers.

Let it be. A bell's top modes dying sooner than they would is not what the ear objects to, as long as mode 1 is long. **Move the object down.** One octave down the ceiling doubles. **Give the time to the hall.** A hall of 3 to 5 s behind a mode at its ceiling is what the Church Bell does, and the tail you hear is largely the hall's. **Thin the modes up top.** A mode at ×10 that lasts 90 ms at C4 lives far inside the ceiling; it is only the long ones that hit it.

KEY DECAY

What the K2700 does with the time

KEY DECAY says how the rings follow the keys: T60 ∝ f^−KEY DECAY. At 1 a ring halves an octave up, and every key plays the same Res, which is how a struck resonator rings. At 0 the ring stays the same and the Res rises half a dB a key. MATERIAL sets KEY DECAY to its own a: wood falls faster up the keyboard than metal.

WHAT A NOTE COSTS

Voices, and where they go

A note takes one voice for the exciter and one for each mode. The K2700 has 256.

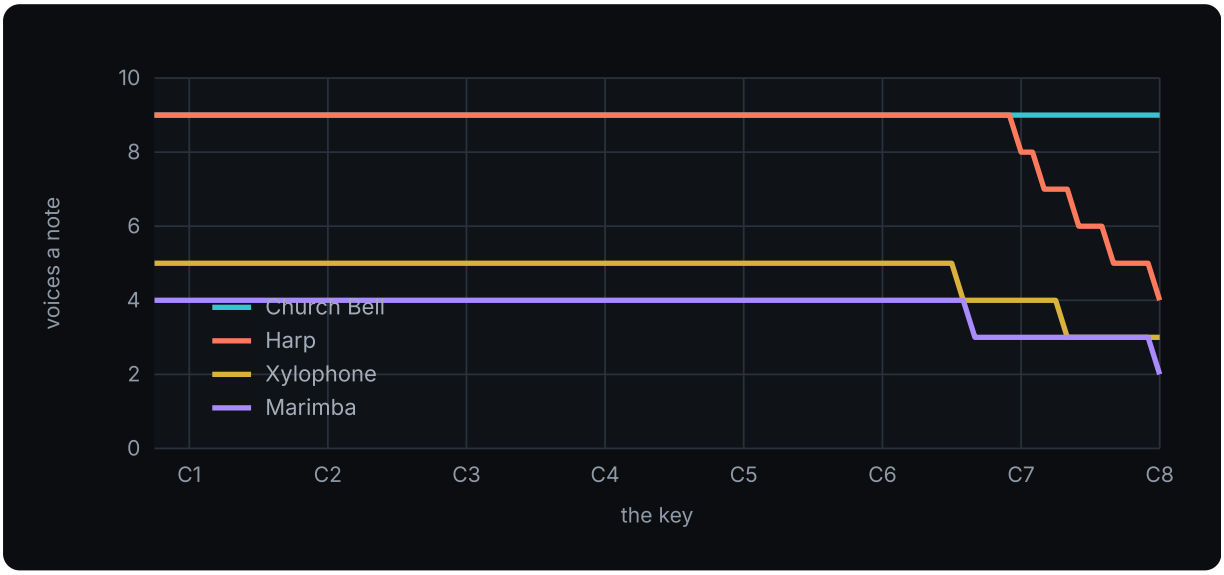


Fig. 27. Voices a note across the keyboard. A mode stops at the key where it would pass 16 kHz, so high notes cost fewer voices.

Divide 256 by the voices a note and you have the notes the object can hold at once: 64 marimba notes, 28 bells, 13 saxophones. That is why the saxophones play one note at a time anyway: a wind does, and a legato chain costs one note's worth of voices however long the phrase.

The status display at the top always shows the count: voices a note, notes at once. Take a mode away and watch them change. The EQ on a mode or a bore's harmonic costs nothing extra, because its key zones never sound together; on a breath through a body it goes on the direct sound, one voice more unless the object already has that layer, as the saxophones do.

PLAYING

What your hands do

A model answers to what you do. Here is what each control reaches.

What you do	Strike, pluck	Rub	Breath, wind map off	Breath, wind map on	Voices
Velocity	level (VELOCITY) and the mallet's low pass	level and the friction	level and the tone's corner	the same	the same
Key up	the ring goes on, or DAMPERS	the friction stops, the modes ring on	the note ends	the note ends	the note ends
Sustain pedal	holds the dampers off	as any K2700 note	as any K2700 note	as any K2700 note	as any K2700 note
Aftertouch		the friction: an octave, 6 dB	the pressure: an octave, 6 dB	the pressure alone	the pressure alone
Mod wheel		as aftertouch, whichever is higher	as aftertouch, whichever is higher	more vibrato	the second vowel
Pitch bend	the note	the note	the note	the lips: the pitch, and darker going down	the note
Knob 8, CC 3			GROWL	GROWL	
Knob 9, CC 9	the hall's time	the hall's time	the hall's time	the hall's time	the hall's time

The delay's REPEAT is CC 84 and its FEEDBACK CC 19.

Velocity is two things at once, and that is the difference between a model and a sample set played louder: the level moves by the object's VELOCITY in dB, and the brightness moves by VEL SOFT in octaves. On a marimba a soft note is 30 dB down and two octaves darker.

PART THREE

The editor

Every section of the panel: the library, the object and its modes, the four exciters, the material, the envelope, the filter, the EQ, the space, and what reaches your K2700.



THE EDITOR

One panel, and the K2700 does the playing

KEDITOR PHYSICAL has one window and no pages. Everything on it describes the object, and every change becomes a K2700 program at once.

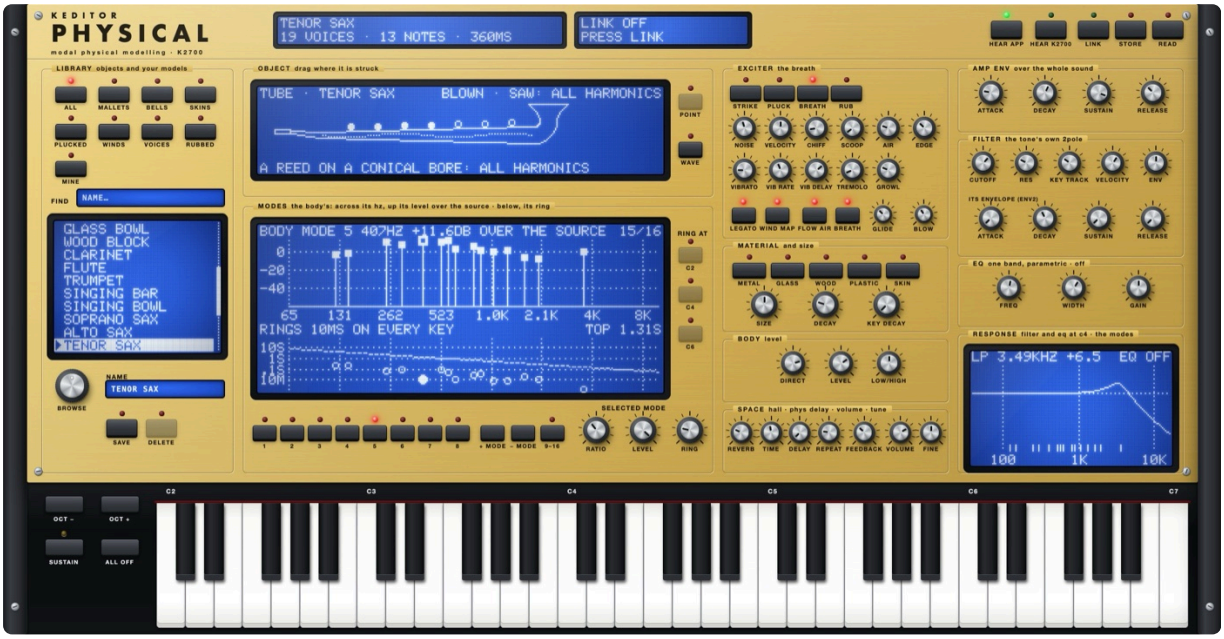


Fig. 28. The whole panel, on the Tenor Sax.

Where	What it holds
Header	the status display, the LINK's display, HEAR APP, HEAR K2700, LINK, STORE and READ
LIBRARY, on the left	the families, FIND, the list, BROWSE, NAME, SAVE and DELETE
OBJECT, top middle	the object as a drawing, the mallet to drag, POINT and WAVE
MODES, under it	the modes as stems above, their rings below, the selected mode's RATIO, LEVEL and RING
EXCITER, MATERIAL, BODY, SPACE	what sets it ringing, what it is made of, how it sits on the keyboard, where it is
AMP ENV, FILTER, EQ, RESPONSE	the three shapers on the whole sound, and a picture of what they do
The keyboard	61 keys for the mouse, OCT −, OCT +, SUSTAIN and ALL OFF

Knobs turn with a drag up or down or the wheel; hold Shift for fine steps; on most knobs a double-click returns the default. Each shows its value on the status display as you move it. A button that does nothing for the current object is dimmed, and a knob that depends on another says so in its value: GLIDE reads WITH LEGATO, BLOW reads WITH BREATH.

The status display at the top names the program and shows what a note costs: voices, notes at once, and the time the envelope runs for. It also says when modes are at the K2700's top.

User manual: the panel at a glance, page 87

LIBRARY

26 objects, and your own models

The library lists the objects by family, and your own models under MINE and, marked with a star, in the family they started from.



Fig. 29. LIBRARY: ALL, MALLETS, BELLS, SKINS, PLUCKED, WINDS, VOICES, RUBBED and MINE, a search by name, and BROWSE.

The family buttons narrow the list. **FIND** narrows it by name as you type. **BROWSE** runs through what is left; each one loads at once and, with the LINK on, is in the K2700's edit buffer a moment later.

NAME is the program's name, 16 characters. **SAVE** keeps the model in the app, in MY MODELS, under that name, and a model of the same name is replaced. **DELETE** removes the chosen one of MY MODELS; the factory objects cannot be removed.

User manual: the library, page 88

OBJECT

A drawing you can strike

The OBJECT display draws what you are playing: the bar on its cords, the membrane from above and from the side, the bore with its keys. It knows the shape of the mode you have selected.

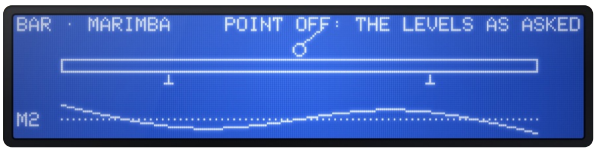


Fig. 30. The Marimba on the OBJECT display: the bar on its cords, the mallet, and mode 2's shape with its nodes.

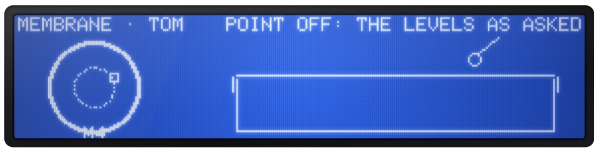


Fig. 31. The Tom from above and from the side, and its mode 4, (0,2), with a nodal circle.



Fig. 32. The Kalimba: a tine clamped at one end, its second mode.

POINT weighs each mode by the object's shape where the mallet is: a string's harmonics by $\sin(n\pi x)$, a bar's and a tine's by their bending shapes, a membrane's by its Bessel modes. Drag the mallet and the levels on MODES follow. Plates, bells and bowls are played where they are played and have no point.

WAVE is a breath's source, five positions: SAW, every harmonic, for a reed on a cone; SQUARE, a closed tube's odd ones; PULSE, the lips; SINE on an open bore and SINE on a closed one. On a voice WAVE picks one singer or a choir.



Fig. 33. The Church Bell, and its mode from above.

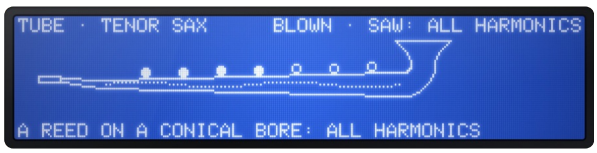


Fig. 34. The Tenor Sax: a reed on a conical bore, all its harmonics.

User manual: the OBJECT display, page 89

MODES

The object's spectrum, to edit

Each mode is a stem, across by its ratio to the note, up by its level. Below, each mode's ring at C2, C4 or C6 as the K2700 will play it, and the ceiling there.

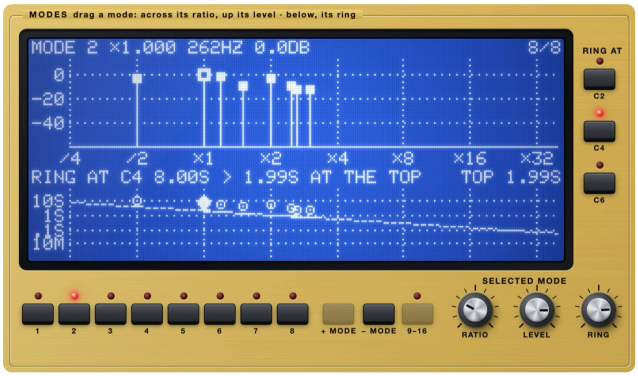


Fig. 35. The Church Bell on MODES: its eight modes above, their rings at C4 below, the ceiling dashed. Mode 2 asks 8 s and gets 1.99.

Drag a stem to move a mode: across, snapping to the harmonics, from ×¼ to ×40; up, its level. **Double-click** to add one. The buttons underneath choose a mode; **+ MODE** and **− MODE** add and remove.

RATIO, LEVEL and RING set the selected mode exactly: ×0.25 to ×40, −60 to +12 dB, 10 ms to 60 s (from 1 ms on a breath). A ring cut by the ceiling shows both: what you asked and what the K2700 gives. **RING AT C2, C4, C6** chooses the key the lower half is drawn for.

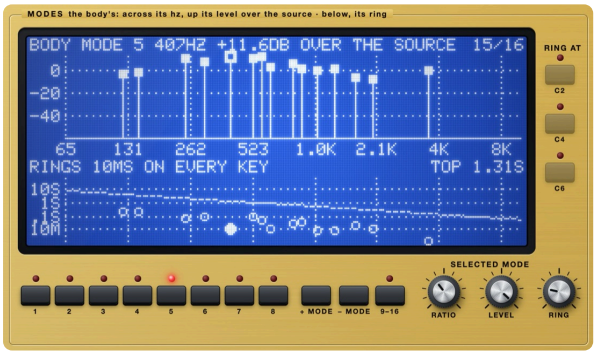


Fig. 36. The Tenor Sax's body on MODES: fifteen modes in Hz, the same on every key, each its level over the source.

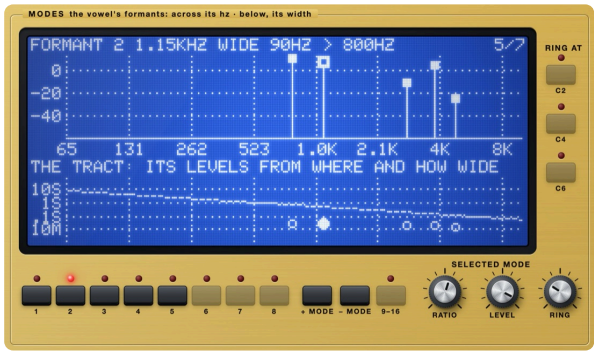


Fig. 37. A voice on MODES: five formants across by their frequency, below each its width.

The exciter	A mode is	RATIO	LEVEL	RING	How many
Strike, pluck, rub	a resonator, tuned by the key	over the note	its share of the strike	how long it rings at C4	8
Breath on a body	a band fixed in Hz	in Hz, on every key	its peak over the source	its Q, as a ring	16
Breath on a bore	a sine at its harmonic	over the note	against the first	how long after the key	7
Voice	a formant	in Hz, on every key	the tract's own	its width	5, up to 7

A body of more than eight modes puts the mode buttons on a second page, 9–16.

User manual: the MODES display, page 90

EXCITER

Strike, pluck, breath, rub

EXCITER picks one of four and shows its own knobs. A strike and a pluck have four; a rub, the same four on a friction; a breath has rows.

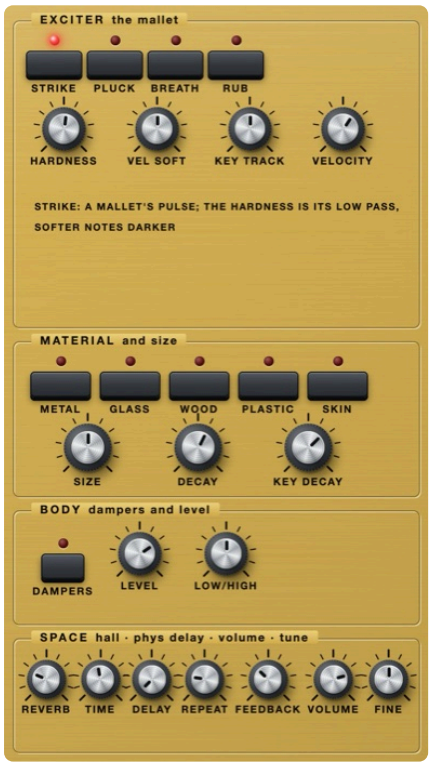


Fig. 38. EXCITER, MATERIAL, BODY and SPACE for a strike.

Knob	Range	What it is
HARDNESS	200 Hz to 16 kHz	the mallet's low pass at C4 at full velocity
VEL SOFT	0 to 4 octaves	how much darker the softest note is
KEY TRACK	0 to 100 ct a key	how the corner follows the keys
VELOCITY	0 to 48 dB	the range of level from softest to hardest

On a rub the first knob is FRICTION: the noise's low pass.

User manual: the exciter, page 91

BREATH

Rows of knobs for a sustained sound

A breath is a source held by the key, and it has more to shape: how it starts, how it wavers, how it is played.



Fig. 39. The EXCITER for a breath, with its rows of knobs.

Knob	Range	What it is
NOISE	−60 to 0 dB	the breath against the tone
VELOCITY	0 to 48 dB	the range of level
CHIFF	0 to 30 dB	the breath's burst at the start, over its level
SCOOP	0 to 200 ct	how far under the note the pitch starts
AIR	300 Hz to 8 kHz	the centre of the breath's band
EDGE	0 to 1.5	the rasp blown hard, its level against the tone
VIBRATO	0 to 60 ct	its depth
VIB RATE	0 to 12 Hz	its speed
VIB DELAY	10 ms to 3 s	when it arrives
TREMOLO	0 to 12 dB	how much the level swings with it
GROWL	0 to 24 dB	the swing of knob 8, at 24 Hz
GLIDE	0 to 600 keys a second	with LEGATO, the slide between notes
BLOW	−60 to +60 ct	with BREATH, how far the pitch moves from soft to loud

Button	On	Off
LEGATO	one voice, no new attack; the notes slide into each other	every note its own
WIND MAP	aftertouch the pressure, pitch bend the lips, wheel more vibrato	pressure on the wheel or the aftertouch, whichever is higher
FLOW AIR	the breath rides the tone: noise times tone, in bursts at the note's period	the air is a noise band of its own
BREATH	one breath drives the note: the tone opens as it swells and darkens as it dies, the pitch moves with BLOW	the tone as set, the scoop its own

WIND MAP and FLOW AIR need a body; a bore and a voice do without them.

The tone's brightness is the FILTER's and its attack and release are the AMP ENV's: on a breath those sections take over from what they do on a strike.

User manual: the breath, page 93

VOICES

Five vowels where the materials were

On a voice MATERIAL's five buttons become A, E, I, O and U. A click chooses the vowel; a Shift-click, the second vowel the wheel takes it to.



Fig. 40. A voice: the vowels, then VOICE, ENSEMBLE, SHINE, AUTO, HOLD and SLIDE.

Control	Range	What it is
VOICE	Soprano, Alto, Tenor, Bass	whose formants
ENSEMBLE	0 to 50 ct	on a choir, how far the outer saws are from the middle one
SHINE	0 to +30 dB	the singer's brightness from 3 kHz up
AUTO	on or off	on: each note holds the first vowel, then slides into the second
HOLD	0 to 2 s	how long the first vowel is held
SLIDE	20 ms to 3 s	how long it takes to reach the second

The vowels' formants are fixed for each of the 20 combinations; a formant's LEVEL rests because it comes from where it is and how wide.

User manual: the voices, page 94

MATERIAL, BODY, SPACE

What it is made of, and where it is

The sections under the EXCITER set the object's losses, its place on the keyboard and the room around it.

Section	Control	Range	What it is
MATERIAL	METAL, GLASS, WOOD, PLASTIC, SKIN		one loss law on every mode; its LED stays lit while the rings follow it
	SIZE	±24 semitones, shown in cm	retunes the object, as $1/L^2$ for a bar or tine and $1/L$ for the rest, and a larger one rings longer. On a breath through a body it is the body's: the note stays
	DECAY	50 ms to 20 s	mode 1's ring at C4; the others keep their share of it
	KEY DECAY	0 to 1.5	T60 ∝ f^−that across the keys
BODY	DAMPERS	on or off	the key up damps the ring; the sustain pedal holds it
	DIRECT	−40 to +12 dB	on a breath, the source heard directly
	LEVEL	−40 to −6 dBFS	mode 1's ring at C4 at full velocity
	LOW/HIGH	±6 dB an octave	the level across the keyboard
SPACE	REVERB, TIME	0 to 100 %, 0.5 to 10 s	the send to the K2700's hall, and its time
	DELAY, REPEAT, FEEDBACK	0 to 100 %, ¼ to 1½ beats, 0 to 90 %	PHYS Delay, at the K2700's tempo
	VOLUME	−30 to +24 dB	the program's Out Gain
	FINE	±100 ct	the tuning of a strike, a pluck, a rub or a bore

User manual: material, body and space, page 96

AMP ENV, FILTER, EQ

Three shapers over the whole sound

On the right of the panel, for every object, except that a voice has no EQ. Part four shows how each is built.



Fig. 41. AMP ENV, FILTER, EQ and RESPONSE on the Marimba: the filter at 1.8 kHz with +6 dB of Res, the EQ +9 dB, the modes marked.

Control	Range
ATTACK, RELEASE	at once to 10 s; 20 ms to 5 s. On a breath or a rub, 10 ms to 5 s each
DECAY, SUSTAIN	to 20 s; 0 to 100 %
CUTOFF	50 Hz to 20 kHz; at the top the filter is off. On a breath, 200 Hz to 16 kHz
RES	−12 to +24 dB. On a breath, 0 to +24 dB
KEY TRACK	0 to 200 ct a key. On a breath, 0 to 100 ct
VELOCITY	0 to 4 octaves darker at the softest
ENV	±4 octaves at its top, and its own A, D, S, R
EQ FREQ, WIDTH, GAIN	40 Hz to 16 kHz; 0.1 to 4 octaves; ±24 dB, off under 0.25 dB

RESPONSE draws the filter and the EQ at C4 at full velocity, with a tick where each mode is, so you can see which ones they move.

On a strike or a pluck the attack is a swell into the ring and the release is the dampers; with no dampers the note rings on and RELEASE has nothing to do. **On a breath or a rub** they are the exciter's own attack and release. **On a breath** the FILTER is the tone's own 2POLE.

User manual: the AMP ENV, page 97

YOUR K2700

LINK, STORE, READ

The app writes programs. Your K2700 plays them.

1

LINK

Choose the MIDI port and the channel. The model goes to the K2700's edit buffer as you edit, and nothing is stored there without STORE.

2

HEAR

HEAR K2700 plays the panel's keys on the K2700; HEAR APP sounds them in the app. Play any MIDI keyboard on the Mac as well.

3

STORE

Pick a USER ID, 4096 to 8191, and a name. If the ID holds a program you are asked first. PHYS Delay goes first if the K2700 lacks it, with SELECT IT the K2700 goes to the program, and the program is read back to check it.

4

READ

Opens a program KEDITOR PHYSICAL stored, by the model in its Info.

When you turn a knob the LINK sends only what changed: a few parameter messages for most knobs, the whole program when the layers change, and the Info a second later. When the K2700 is sitting on another program the display says so, and your edits stay in the app until you send them with LINK or by clicking that display.

User manual: working with the K2700, page 99

THE FACTORY OBJECTS

26 objects to start from, in one .K27

Eleven struck and plucked, seven blown, six sung and two rubbed, each with its modes, its exciter and its level, by the laws measured on the K2700. The pack loads with FILL into free USER IDs, replacing nothing; pick any of them on the K2700 and READ puts it in the app.

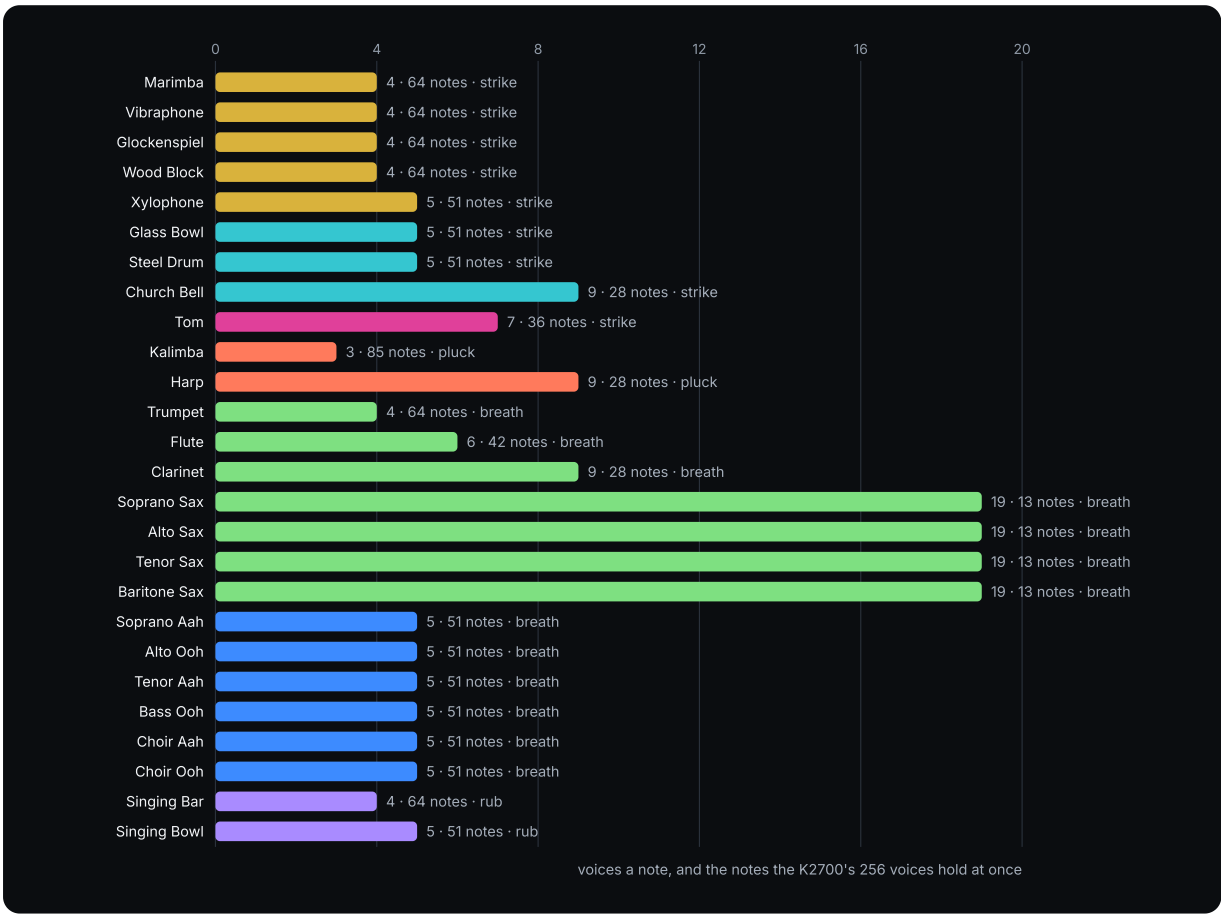


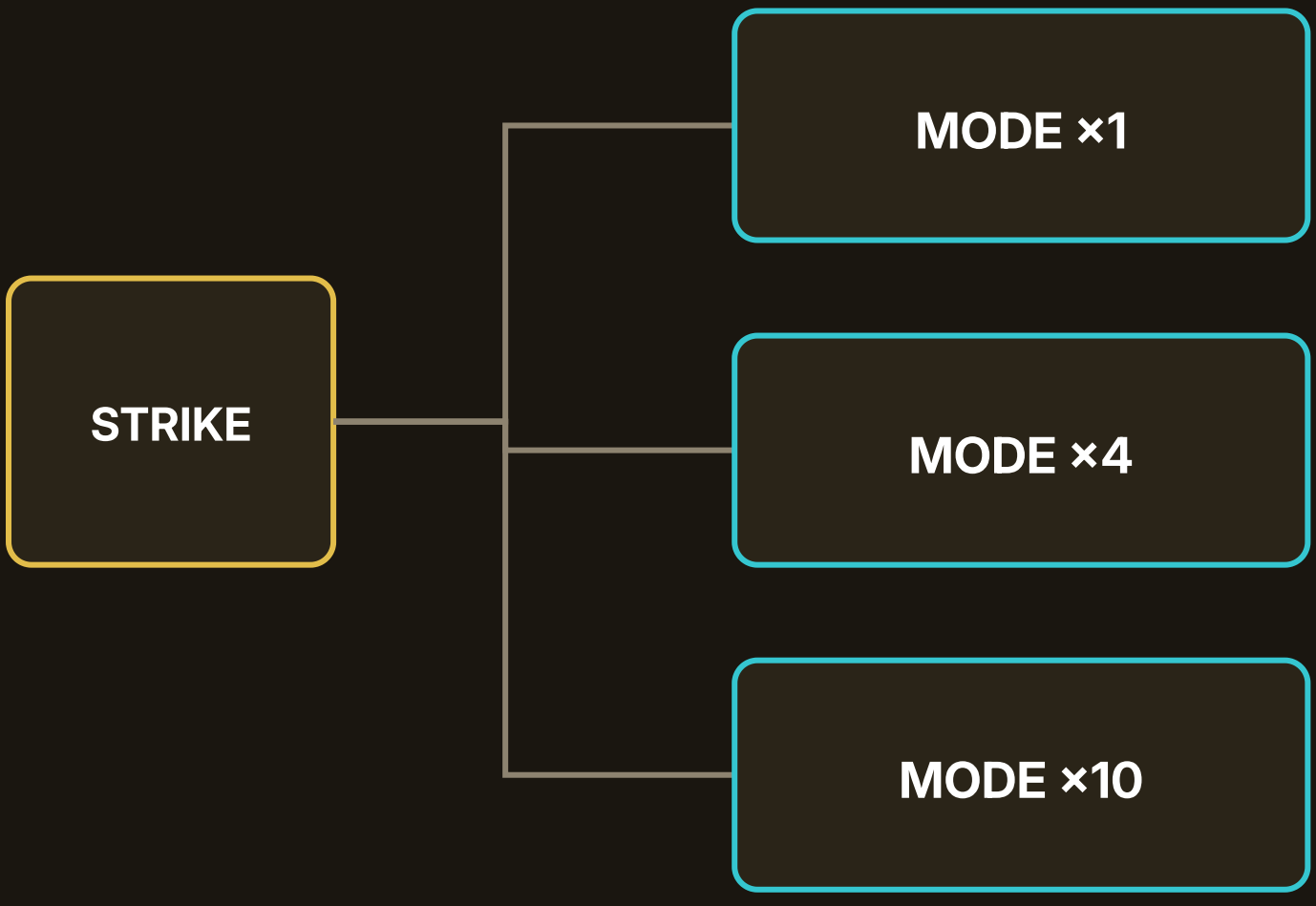
Fig. 42. Voices a note for each object, and the notes the K2700's 256 voices hold at once with it.

Object	Exciter	Resonator	Modes	Voices a note
Marimba	strike	a rosewood bar, 1 : 4 : 10	3	4
Xylophone	strike	a hard wood bar, 1 : 3 : 6.4 : 10.5	4	5
Vibraphone	strike	an aluminium bar, 1 : 4 : 10, with dampers	3	4
Glockenspiel	strike	a free steel bar, 1 : 2.756 : 5.404	3	4
Wood Block	strike	a short block of wood	3	4
Church Bell	strike	hum, prime, tierce, quint, nominal and three upper partials	8	9
Glass Bowl	strike	a glass rim, 1 : 2.32 : 4.25 : 6.63	4	5
Steel Drum	strike	a pan's note, tuned to its harmonics	4	5
Tom	strike	a circular membrane	6	7
Harp	pluck	a nylon string, plucked at 15 % of its length	8	9
Kalimba	pluck	a clamped tine, 1 : 6.27	2	3
Clarinet	breath	a closed bore: odd harmonics, the even ones rising from A#4	7	9
Flute	breath	an open bore: its harmonics	5	6
Trumpet	breath	a saw with a moving corner and the bell's band	1	4
Soprano Sax	breath	a reed on a cone: a saw and a body of 15 modes	15	19
Alto Sax	breath	a reed on a cone: a saw and a body of 15 modes	15	19
Tenor Sax	breath	a reed on a cone: a saw and a body of 15 modes	15	19
Baritone Sax	breath	a reed on a cone: a saw and a body of 15 modes	15	19
Soprano Aah	breath	the five formants of a sung vowel, one voice	5	5
Alto Ooh	breath	the five formants of a sung vowel, one voice	5	5
Tenor Aah	breath	the five formants of a sung vowel, one voice	5	5
Bass Ooh	breath	the five formants of a sung vowel, one voice	5	5
Choir Aah	breath	the same tract on three saws a little apart	5	5
Choir Ooh	breath	the same tract on three saws a little apart	5	5
Singing Bar	rub	a vibraphone bar	3	4
Singing Bowl	rub	a bowl, 1 : 2.71 : 5.06 : 8	4	5

PART FOUR

Building it on a Kurzweil

A modal synthesizer out of a K2700's filters, in seventeen steps: from one resonant filter, through a program you can make by hand, to the voices, the breath and the effects.



ON THE K2700

The K2700 has no physical modelling. KEDITOR PHYSICAL builds it from its filters

A K2700 has no delay line in a voice and no modal resonator among its synthesis functions. What VAST has is a 2POLE LOWPASS whose resonance goes up to +48 dB, and Cascade: one layer's output can be another layer's input. Struck by a short pulse, a 2POLE LOWPASS at +48 dB rings as a decaying sine at its cutoff, tuned by the key: a mode. One exciter layer feeding a layer for each mode is a modal synthesizer, on every voice, for every note.

KEDITOR PHYSICAL compiles a physical description, the object's modes, the exciter, the material, the size, where it is struck, into an ordinary K2700 program. The LINK sends it to the K2700's edit buffer as you edit, STORE writes it to a USER ID, and from then on the K2700 plays it by itself, with no computer attached. Nothing in the instrument changes: every layer, filter and envelope is one its own panel opens and edits.

The laws in this part of the page were measured on the K2700 over USB, in a first test and twelve sessions after it: tuning, ring times, levels key by key and mode by mode, harmonics, attacks.



Fig. 43. The program for a strike, the Marimba's, with its own values. Layer 1 makes the pulse and is never heard itself; every mode layer reads it through its alternate input. A mode is a 2POLE LOWPASS at its ratio of the note, following the keys 100 cents a key, its Res set by its ring. The modes are summed into the factory hall on aux 1 and the app's own delay on aux 2.

One voice a mode

A note takes a voice for the strike and one for each mode: the Marimba 4, the Church Bell 9. The K2700's 256 voices hold 64 marimba notes at once, or 28 bells.

The same strike, every time

The pulse is the same on every note, so two strikes at one velocity sound alike, as a real mallet's do. A noise click did not: on the K2700 it rang each strike at a level of its own.

A program like any other

Nothing hidden and nothing to install on the K2700: it opens, plays and edits on its own panel like a factory program, and stores in the USER bank.

ONE MODE

A 2POLE LOWPASS at +48 dB rings like a bar

Everything rests on one measured fact: struck by a pulse, the K2700's 2POLE LOWPASS rings for T60 = 2.2 × Q / Hz, with Q = 10 ^ (Res / 20). +48 dB of Res is a Q of 251: two seconds at C4.

A resonant low pass's peak is a mode: the higher the Res, the taller and narrower the peak and the longer the filter rings after a click. The first test on the K2700 struck a single 2POLE LOWPASS following the keys and measured its ring at C2, C4 and C6. At Res +48 dB it rang 7.3, 2.05 and 0.54 s, at +36 dB 2.07, 0.54 and 0.13 s: 12 dB less Res, a ring four times shorter, just as Q = 10 ^ (Res/20) says. Every ring was a clean sine at the key's pitch, within a few cents.

Later sessions found one correction: under 1 kHz the K2700's resonator rings a little shorter than the law, 0.90 to 0.93 of it at 130 to 260 Hz and 0.81 at 65 Hz. The compiler counts it and gives the bass modes the Res they need.

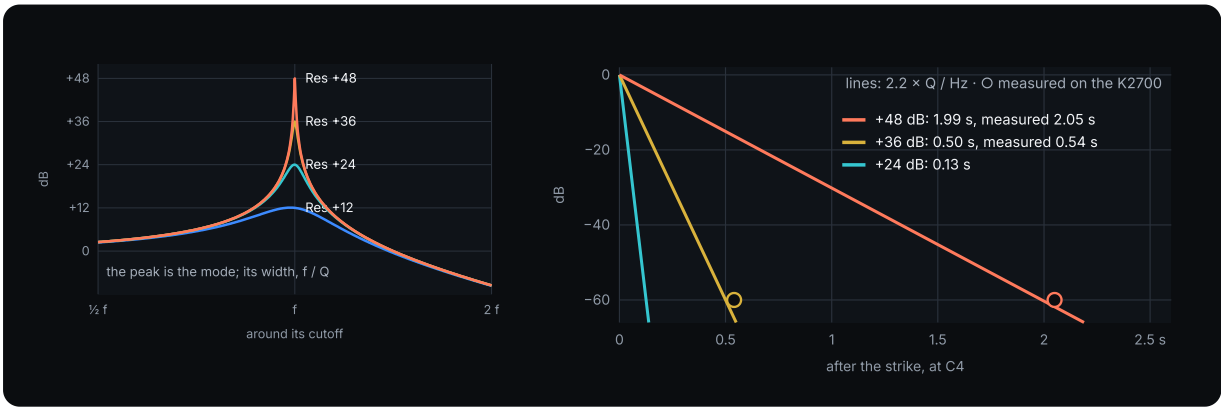


Fig. 44. Left: a 2POLE LOWPASS around its cutoff, the peak taller and narrower as the Res rises. Right: how long it rings at C4 at three settings, by the law and as measured on the K2700 (circles).

Res	Q	T60 at C2, 65 Hz	at C4, 262 Hz	at C6, 1047 Hz
0 dB	1	30 ms	8 ms	2 ms
+12 dB	4	118 ms	32 ms	8 ms
+24 dB	15.8	0.47 s	0.13 s	33 ms
+36 dB	63	1.86 s	0.50 s	0.13 s
+48 dB	251	7.42 s	1.99 s	0.53 s

2.2 × Q / Hz with the K2700's shorter bass, as the compiler plans each mode.

The compiler turns each mode's ring into Res: Res = 20 · log10(T60 × f / 2.2), less what the layer's own envelope takes, in the K2700's half-dB steps. The Res follows the keys too. With KEY DECAY at 1 a ring halves an octave up and the Res stays the same on every key, as a struck resonator's would; at 0 the ring stays the same and the Res rises half a dB a key.

THE RING BENCH

One mode, in numbers

A mode at C4 that asks 1.80 s. The numbers are the ones the compiler works out: the Res it writes, the ring the K2700 plays with that Res, and the ceiling at that frequency.

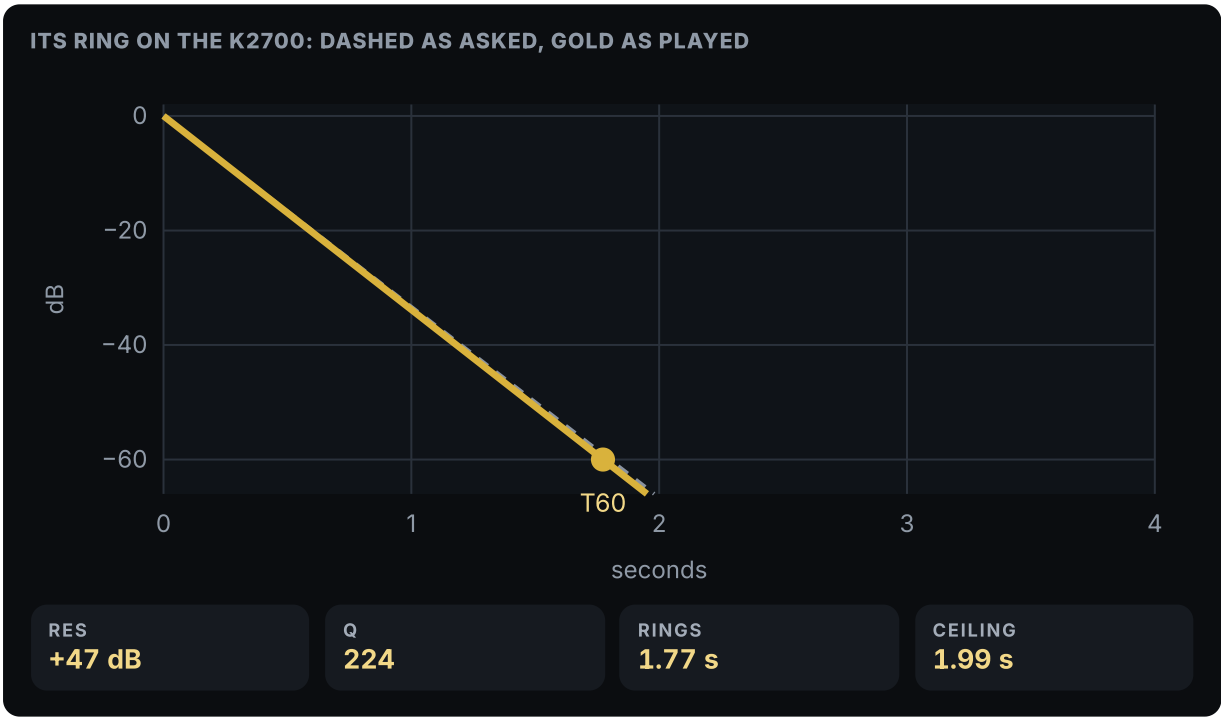


Fig. 45. Dashed, the ring asked; gold, what the K2700 plays.

553 / HZ SECONDS

The ceiling

+48 dB is as far as the K2700's Res goes, and it sets the longest ring a mode can have: 2.2 × 251 / f, **553 / Hz seconds**, a little less in the bass. Seven seconds at C2, two at C4, half a second at C6. A marimba, a xylophone, a tom or a wood block fit easily. A vibraphone, a glockenspiel, a bell or a

glass bowl ask for 6 to 11 s in the middle of the keyboard and get 2; in the bass they ring long. KEDITOR PHYSICAL draws the ceiling under every mode and says when a ring is cut to it.

Ways round it were tried on the K2700. Two 2POLEs in series rang 2.06 s at C4 against 1.88 for one, too little to matter; a slow, quiet re-excitation could not hold a mode up; and a narrow BANDPASS, at 0.02 of an octave, saturated into a square wave and went on sounding after the notes.

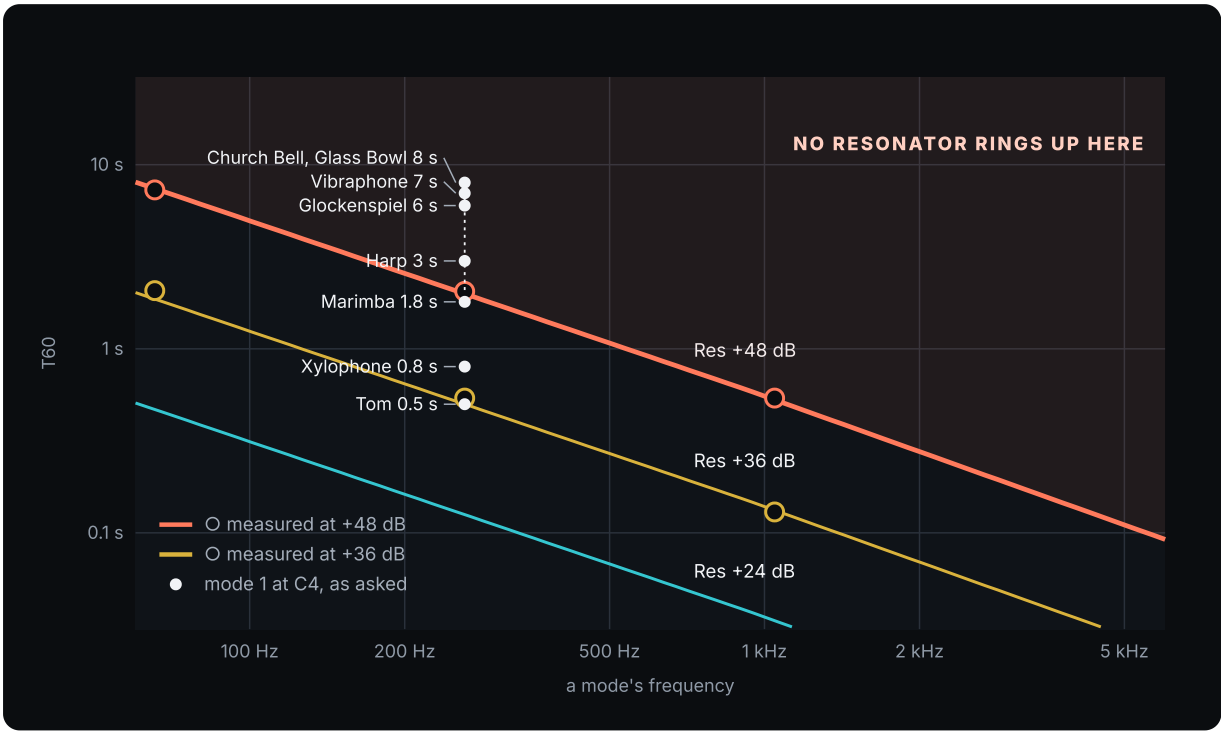


Fig. 46. The ceiling: at Res +48, +36 and +24 dB, the longest a mode can ring at each frequency, with the K2700's measurements (circles). The white dots are mode 1 at C4 as eight of the objects ask it: those above the coral line ring at the ceiling instead.

ON THE K2700'S OWN PANEL

A marimba bar, field by field

KEDITOR PHYSICAL writes this for you, but it is an ordinary K2700 program, and you can build the first one by hand with the values the compiler writes. Four layers: a strike and three modes.

Start from any simple program in **PROGRAM**, then **EDIT**. **CHANNEL/LAYER** changes layer and the soft button **NEW LYR** adds one. Give the first two layers the whole keyboard, C-1 to G9: a layer can only be read by another for the same note.

ALG PAGE

The four layers

Layer	KEYMAP	ALG	Alt Input	Blocks	AMP Adjust
1 · Strike	Silence	2	none	F1 SQUARE · F2 GAIN · F3 LOPASS · F4 GAIN	−96 dB
2 · Mode 1	Silence	107	Layer 1	F1 NONE · F2 2POLE LOWPASS	+7 dB, VelTrk 30 dB
3 · Mode 2	Silence	107	Layer 1	F1 NONE · F2 2POLE LOWPASS	−2 dB, VelTrk 30 dB
4 · Mode 3	Silence	107	Layer 1	F1 NONE · F2 2POLE LOWPASS	−12 dB, VelTrk 30 dB

DSP CTL, DSP MOD, ENV2

The strike

Block	Value	KeyTrk	VelTrk	Src1, Depth
F1 SQUARE, Sqr Pch	−120 st	0 ct		its phase reset by Note On
F2 GAIN	−96 dB			ENV2, 96 dB
F3 LOPASS, LP Frq	500 Hz	50 ct	2400 ct	
F4 GAIN	−96 dB	0.02 dB		ENV2, 82 dB

500 Hz is the softest note: 2400 cents of VelTrk takes the hardest to 2 kHz, the Marimba's HARDNESS.

Page	Field	Value
AMP ENV	Mode	User
AMP ENV	Att1; Dec1; Rel1	0 s to 100 %; 30 s to 0 %; 0.02 s to 0 %
AMP ENV	Decay KeyTrk	2.000x
ENV2	Att1; Dec1	0 s to 100 %; 0.005 s to 0 %
LAYER	Low, High; Ignore Release	C-1, G9; On

DSP CTL, LFO+, LAYER

The modes

Layer	LP Frq	KeyTrk	LP Res	Res KeyTrk	High Key	FUN1 a
2 · ×1	261.63 Hz	100 ct	+48 dB	−0.02 dB	G9	0.46
3 · ×4	1046.50 Hz	100 ct	+43 dB	0 dB	107, B7	0.26
4 · ×10	2616.26 Hz	100 ct	+40.5 dB	0 dB	91, G6	0.14

Page	Field	In layers 2, 3 and 4
LFO+	FUN1	diode(a − b), a from the table, b = KeyNum
LFO+	FUN2	min(a, b), a = FUN1, b = 0.18
DSP MOD	AMP Src1, Depth	FUN2, 76 dB
AMP ENV	Mode, Att1, Dec1, Rel1	User, 0 s to 100 %, 25 s to 0 %, 0.02 s to 0 %
AMP ENV	Decay KeyTrk	2.000x
LAYER	Ignore Release	On

COMMON AND FX

The rest of the program

On **COMMON**, Output Gain +12 dB. On **FX**, aux 1 to Hall Reverb 1 with a send of 25 %.

Play from C2 to C6, soft and hard: a pitched knock with its second mode two octaves above the first, darker when played softly, each note a little object of its own. **SAVE** it to a USER ID and it is a program like any other. Every step that follows explains one of these numbers.

THE STRIKE AND THE CASCADE

One pulse, read by every mode

Layer 1 makes the strike. It is never heard itself: each mode's layer reads it through Cascade, the K2700's alternate input, and rings.

The strike layer (ALG 2) starts with a SQUARE oscillator at −120 semitones, 0.26 Hz, its phase reset on Note On: through the few milliseconds of a strike it is one steady level. Two GAINs opened by ENV2 for 5 ms cut it into a pulse. Between them a one-pole LOPASS is the mallet's hardness, opened two octaves by the velocity and following the keys half a semitone a key; the second GAIN carries the level's key tracking. The layer's own AMP stays at −96 dB.

Each mode is a layer of its own (ALG 107) whose input is layer 1, taken after its four functions and before its AMP. Its 2POLE LOWPASS sits at the mode's ratio of the note and follows the keys 100 cents a key, so the whole object is tuned by the key. Its AMP is the mode's level, with the object's range of velocity (30 dB on the Marimba), and its envelope lets it ring to the end. A mode that would pass 16 kHz stops at the key where it would, so high notes use fewer voices. The strike's envelope outlasts the modes' by 10 %, so no mode loses its input before it ends.

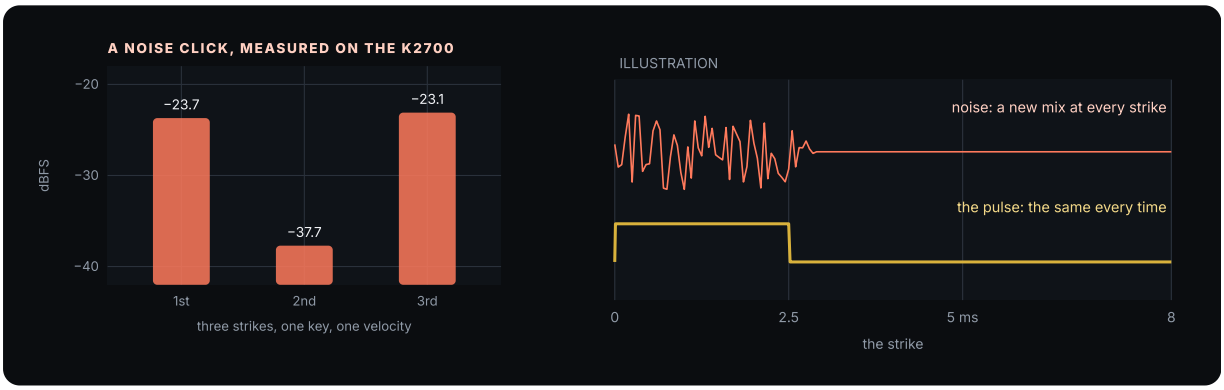


Fig. 47. Why the strike is a pulse. Left: three identical strikes with a noise click, measured on the K2700, 14 dB apart. Right: noise is a new mix of frequencies at every strike; a pulse is the same every time.

The first strike was a click of noise, and on the K2700 three identical strikes rang 2.5 to 15 dB apart: the share of a noise burst that falls on a mode's frequency is a matter of chance, by about 5.6 dB. A real mallet does not do that. With the pulse, 29 sets of identical strikes on the K2700 differed by a median of 0.06 dB. The pulse's length, 2.5 to 20 ms, did not change its level at 262 or 1046 Hz on the K2700, so the hardness is all in the LOPASS.

CALIBRATION

The level law, measured

How loud a mode rings depends on the pulse, the mode's AMP and where on the keyboard it plays, and only the K2700 can say how much. Sessions on the K2700 measured it, strike by strike and mode by mode, and fitted the law the compiler uses: a mode's ring is its AMP plus the pulse plus the program's gain, −21.0 dB, −0.40 dB per octave of the mode's ratio, −0.15 dB per octave of the key above C4, and −7.12 dB per octave of the mode's frequency under 235 Hz. The Res does not change it.

The bass correction is written into the program. Each mode layer works out with two FUNs how far its key lies under the key where the mode crosses 235 Hz: FUN1 = diode(that key − KeyNum), FUN2 = min(FUN1, 0.18). FUN2 drives the AMP by 76 dB: 0.59 dB a key, at most 13.7 dB. The K2700 adds it note by note.

The result on the K2700: every key from C2 to C6 within −1.2 and −0.1 dB of its plan, mode 1 at −0.3 dB, the modes under 3 kHz −0.27 dB on average and all of them within 1.9 dB rms. What is left are weak upper modes the mallet cuts.

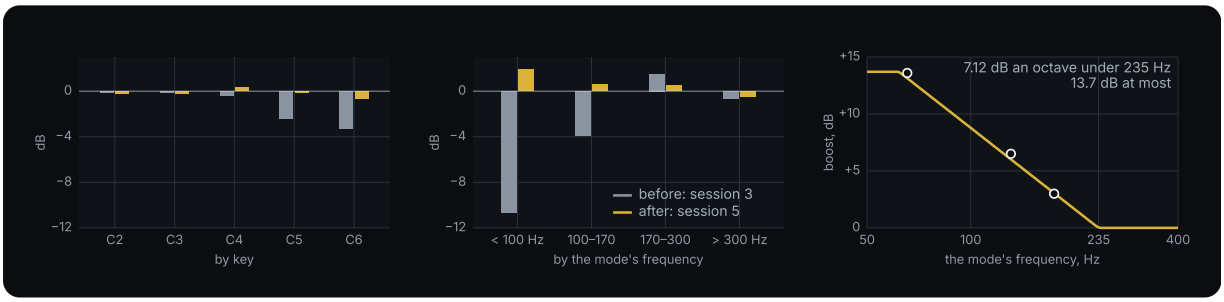


Fig. 48. The strike against its plan on the K2700, before and after the correction, by key and by the mode's frequency; and the bass's boost the compiler writes in each mode's FUNs, with what it gives (circles).

The AMP, measured

A sine from −12 to +24 dB of AMP, and a saw to +18, rose within 0.1 dB of a line of slope 1: the K2700's AMP is linear in dB, and the compiler can count on it.

The envelope's law

An AMPENV level is not linear in dB: 75 % plays at −8.6 dB, 50 % at −18.1, 10 % at −40.2. A sustain is written through that law.

A reference in every session

Later sessions put a reference sine between takes, so that a change in the recording's level could never pass for a change in a program.

THE AMPENV

An AMPENV that just stays out of the way

The resonator rings by itself. The envelope's whole job is not to stop it too soon, and to stop it in the end.

Every layer of a strike has an AMPENV in User mode: an attack of nothing to 100 %, then a single Dec1 down to 0 %, as long as 15 times the longest ring the program gives at C4, at most 60 seconds. A K2700 Dec1 falls straight in dB, 96 dB in its time, so its T60 is 0.625 of what the page says, and the ring you asked for is the resonator's and the envelope's together: $1 / T60 = 1 / \text{ring} + 1 / (0.625 \times \text{Dec1})$. The compiler gives the resonator a little more Res to pay for it.

Under the page's Decay KeyTrk, 2.000x makes the envelope twice as fast each octave up, exactly as a ring does. Without dampers every layer has **Ignore Release** on, so the note rings on after the key; with dampers it is off, and Rel1 is the damper's time. The exciter's own envelope is 10 % longer than the modes': a layer whose input stops takes its reader's voice with it.

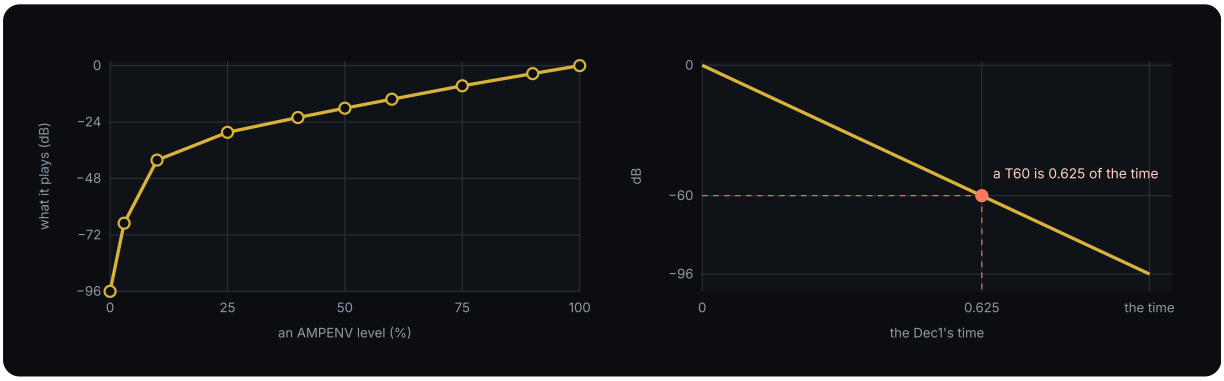


Fig. 49. Left: an AMPENV level against what it plays, as measured on the K2700. Right: a Dec1 falls straight in dB, so a T60 is 0.625 of its time.

A sustain is written through the left-hand curve. If the AMP ENV asks for −3 dB the page says 91 %, because 90 % plays −3.4 dB and 100 % plays 0.

The K2700's envelope grid	Steps
under 15 ms	0, 2, 5, 10 ms
to 2 s	20 ms
to 5 s	40 ms
to 10 s	0.1 s
to 15 s	0.5 s
to 25 s	1 s
to 60 s	5 s

LEVELS FROM SHAPE

Pluck, point, and the top of the keyboard

Three things that change a mode's level or its keys, and cost nothing.

Pluck is the strike's own pulse. The compiler takes a further 20 log10(ratio) dB off each mode's level, 6 dB an octave of its ratio: a string let go from a shape, not given a speed.

Point multiplies each mode by its shape where the mallet is, over its largest value along the object, and then raises the whole object so the loudest mode keeps the level asked. Nothing moves when you drag except the modes' AMPs.

The top. A mode that would pass 16 kHz stops at the key where it would. A mode's layer has a High Key of 60 + 12 log2(16000 / its Hz at C4): the Marimba's ×10 ends at key 91, G6. It is not only tidiness: above that key the layer's voice is not used at all.

The Marimba	High Key
Strike	G9
Mode 1 ×1	G9
Mode 2 ×4	107, B7
Mode 3 ×10	91, G6

That is why a program's key range differs from layer to layer, and why high notes cost fewer voices.

THE RUB

A friction heard only through the modes

A rub is built like a strike with one change: its exciter goes on for as long as the key is down.

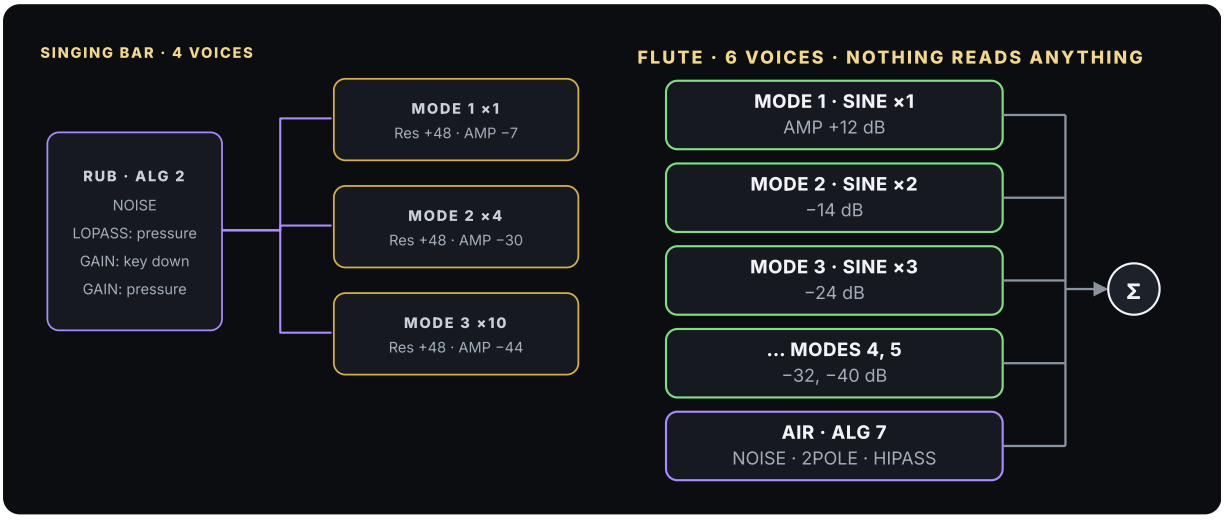


Fig. 50. Left: the Singing Bar, a friction layer read by a layer per mode. Right: the Flute, one sine a harmonic and the air, with nothing reading anything.

Layer 1 (ALG 2) is NOISE, a LOPASS that the velocity and the pressure open, a GAIN gate that ENV2 holds open while the key is down, and a level GAIN that the pressure raises. Its AMP stays at −96 dB. The modes are the strike's layers, ALG 107, tuned by the key.

A resonator's share of a noise grows with its frequency and its Q, because its peak is Q tall and f / Q wide. Each mode's AMP takes 10 log10(π f Q / 2) off for it, the friction layer's GAIN key tracks by −(2 − KEY DECAY) × 3 dB an octave to take the rest back, and each mode's AMP gets back the 1.2 dB an octave of its frequency by which rubbed modes fell short of that law.

The AMPENV's release is the modes' ring, not the friction's. Let the key go and ENV2's release shuts the friction in the time of the AMP ENV's RELEASE, while the modes go on ringing.

BREATH AND RUB

Sustained sound without a loop

A reed and a player's lips sustain because the resonator drives the exciter. A K2700 voice has no path back, so KEDITOR PHYSICAL plays them the source-filter way: the source makes the pitch, the body's resonances colour it, and a band of noise is the breath.



Fig. 51. The Tenor Sax's program, 19 voices a note: the tone, never heard itself; the direct, the edge, 15 body layers each a band fixed in Hz, and the air, all reading it.

The tone (layer 1, ALG 6) is a saw on a cone or a brass bore, every harmonic in it; on a bore that plays its own harmonics, a sine (below). It plays the note's pitch with its phase reset on every note, into a 2POLE LOWPASS that the velocity and the pressure open: full pressure, the mod wheel or the aftertouch, whichever is higher, makes it an octave brighter and 6 dB louder. Its small Res is a soft formant, and ENV2 starts it darker so that the harmonics arrive after the fundamental, as a wind's do. The vibrato is LFO1 on the pitch, brought in after its delay by ASR1, and on the level for a wind's tremolo; ENV3 slides the pitch up into the note, a breath's scoop. On the saxophones the tone's own AMP stays shut and a layer of its own reads it, the direct sound, over 800 Hz on the Tenor, so that the body carries what lies under.

The body is a layer for each of its modes, reading the tone (ALG 107): a HIPASS, a 2POLE LOWPASS and a HIPASS, all three at the mode's frequency. At the centre their phases cancel, +90° from the two high passes and −90° from the resonance, so each band adds to the direct sound at its peak instead of fighting it, its gain there Res − 6 dB. The bands are fixed in Hz, as a body's are: each note's harmonics fall on them differently.

The air (the last layer, ALG 7) is NOISE through a 2POLE LOWPASS and a HIPASS over the note, a band that follows the key: the air in a bore. Its envelope bites at the start, a reed's chiff or a flute's puff, then holds well under the tone. On the saxophones it is a resonant noise at two and a half times the note, multiplied by the tone itself (ALG 121), so the air moves with every cycle.

On the K2700 every one of them did what was asked: the vibrato's depth within a cent or two, the colour by octave within 1 dB on the flute and the Singing Bar, nothing left sounding after the key, and the bowl and the Singing Bar ringing on as they should.

FIXED POINT

Sharp bands, and a Pad

Sharp bands run into a limit of the K2700's DSP. Its blocks are fixed point, and a block's output clips 6 dB over full scale: a band sharper than about Res +18, fed the full saw, has its 2POLE stuck near +20 dB at the peak, the band near +14, and distorts. So the first HIPASS of every band over Res +15 pads its input by 6, 12 or 18 dB, one step for every 6 dB its Res passes +15, and the layer's AMP makes them up. Each band then plays its true peak within 0.4 dB up to Res +36; the broad bands, the trumpet's among them, are untouched.

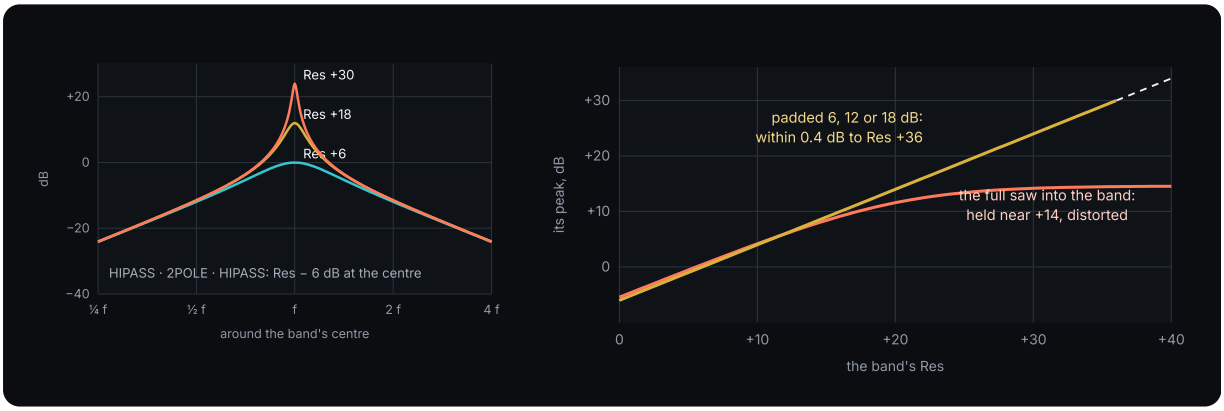


Fig. 52. Left: a body band, HIPASS · 2POLE LOWPASS · HIPASS at one frequency, at three Res settings. Right: its peak against its Res: as asked (dashed), fed the full saw without a Pad (coral), and with the Pad on its first HIPASS (gold).

THE BORES

A flute and a clarinet, one sine for each harmonic

A flute's jet is nearly a sine, and its air column turns it into the bore's own harmonics. So the Flute and the Clarinet have no body and no direct sound: each mode of the bore is a layer of its own, a SINE at its harmonic of the note.

Each harmonic's layer (ALG 6) is a SINE at its mode's pitch over the note, its phase started with the note so they all line up, with the scoop, the vibrato and the 2POLE LOWPASS a single tone would have. A mode's level is exactly what its harmonic plays: raise the Flute's mode 2 by 12 dB and its second harmonic rises 12.0 dB, nothing else. The LOWPASS leaves the upper harmonics fainter the softer the note is blown and the higher it is, as a real flute does. Each sine runs 12 dB under full scale (its Pad), its AMP making it up, so it stays a sine. The breath is the air layer with a centre of its own near 3.2 kHz, loud for the first 50 ms, then only a trace.

The Clarinet is the same on a closed bore: its odd harmonics strong, ×1, ×3, ×5, ×7 and ×9, its even ones 35 to 38 dB under. A real clarinet's even harmonics grow in its upper register, so each even mode plays in three stretches of keys, three layers that never sound together: as asked up to A4, 6.5 dB louder from A#4 and rising 2.5 dB a key to A5, then held. It costs no voice more: 9 voices a note in 13 layers.

The Clarinet on the K2700	H2	H3	H4	H5	H7
G3	−34.9	−4.2	−37.0	−9.4	−15.9
C4	−34.6	−4.0	−38.0	−12.2	−21.0
C5	−24.6	−10.7	−38.2	−25.1	−34.7
G5	−12.6	−18.6	−28.4	−33.0	−43.5

Each harmonic against the first, in dB, as measured on the K2700. Every one was within 1.4 dB of the plan; at C5 and G5 the even harmonics play their upper-register layers.

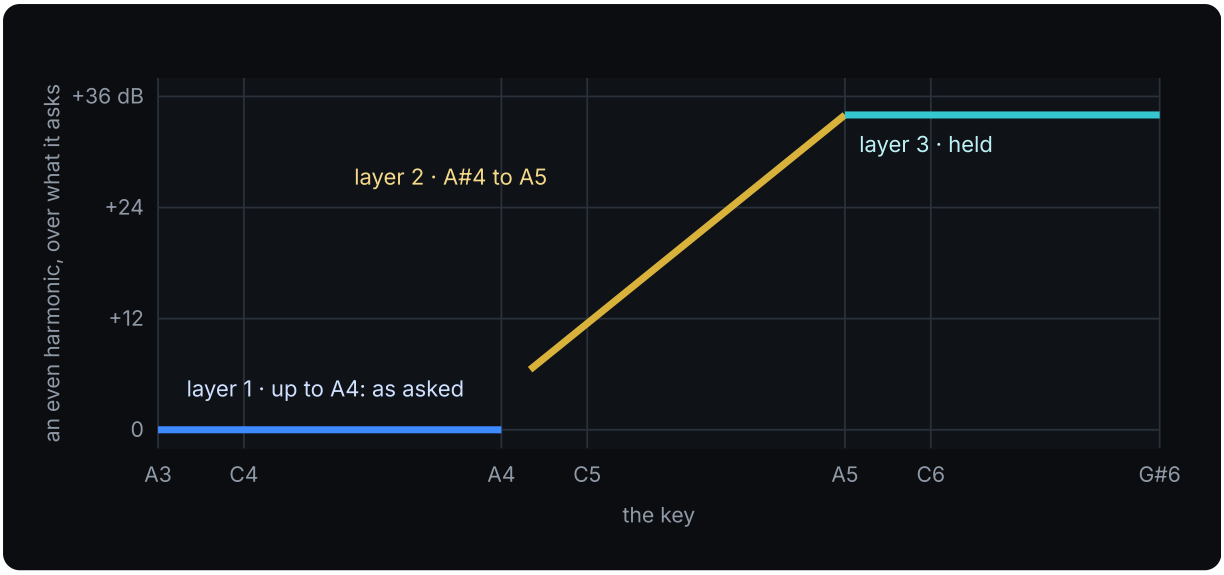


Fig. 53. An even harmonic of the Clarinet against what it asks, across the keys: three layers that never sound together, so the upper register costs no voice.

One trap in measuring it: on the K2700 the high modes sit up to a cent sharp of the exact multiple, about 1 Hz at 2 to 4 kHz, and read at the exact multiple with a 0.75 s window they looked up to 29 dB weak. Read at their peaks, they matched. The Flute's colour, octave by octave, came out within 0.6 dB of what was asked.

The Trumpet stays a saw through a moving corner and the bell's band near 1.2 kHz: its harmonics run far past the seventh (at C4, loud, H8 to H12 are only 12 to 23 dB down), which seven sines would cut off.



Fig. 54. The Flute: the head and its embouchure, the keys, the open foot; under it the third harmonic's standing wave, three half waves.



Fig. 55. The Clarinet: the reed, the closed bore and the bell, with the third mode's three quarter waves, closed at the reed.

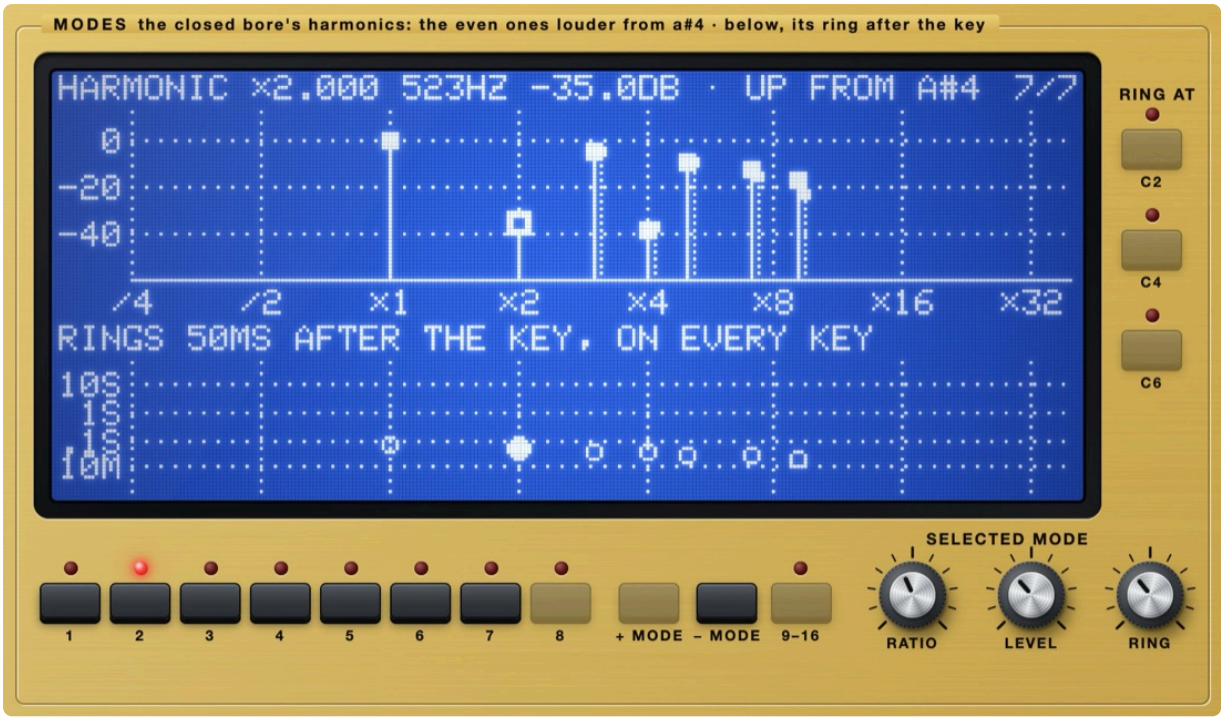


Fig. 56. The Clarinet on MODES: the closed bore's harmonics by level, the even ones marked as louder from A#4.

THE TRACT

A vocal tract in series

A voice's layers do not sum. Each reads the one before, as a formant synthesizer's filters do, and only the last is heard.

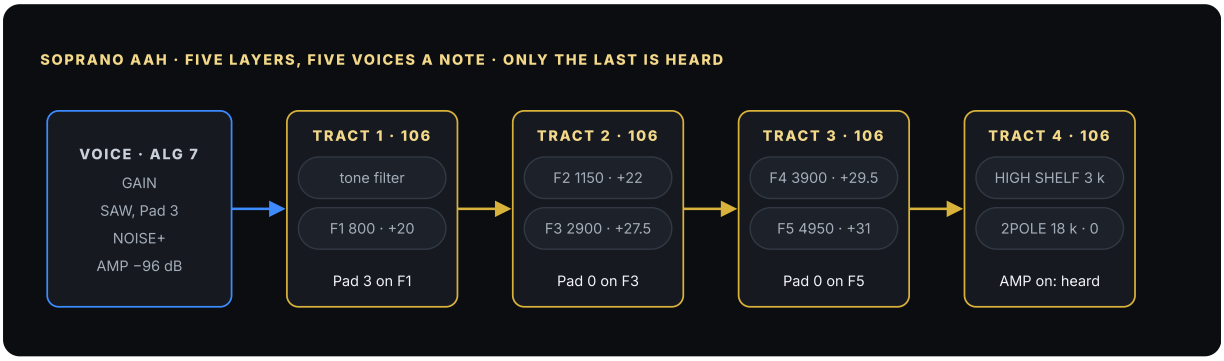


Fig. 57. The Soprano Aah. Layer 1 makes the buzz and a little noise; four layers of two blocks each hold the tone filter, the five formants, the singer's brightness and a flat filter to fill the last place.

Each formant is a 2POLE LOWPASS at its frequency, its Res its Q: 20 log10(Hz / width). A chain of low passes passes the source whole under the first formant, and each formant's level then comes from where it is and how wide it is, which is how a tract behaves. A soprano's A has formants at 800, 1150, 2900, 3900 and 4950 Hz.

The source is a saw (ALG 7: a GAIN, a two-block SAW, NOISE+ for the breath through the tract), 18 dB under full scale on its Pad, so that a formant on a strong harmonic keeps under the blocks' ceiling; the last layer's AMP makes it up. A choir is three saws (ALG 5: TRIPLE SAW) and a second layer with the tone's filter and the breath; with that filter out of the tract, the tract is one layer shorter and the choir is still five voices.

ALT INPUT

Each passage costs 24 dB

On the K2700 what a layer hands on through the Alt Input comes 24 dB under what it plays when heard, and a voice has four such passages. Left at their defaults, the voices play 58 to 73 dB down. The answer is in the Pad: the second 2POLE of each layer that another layer reads goes at Pad 0, which gives the 24 dB back, and the first formant keeps its Pad 3, without which a soprano's G5 on A distorts. The levels came up to −12 to −27 dB, within 1.5 to 3.7 dB of plan.



Fig. 58. What each layer hands on: every passage −24 dB, and level with Pad 0 on each passing layer's second 2POLE.

THE WHEEL, AND AUTO

A second vowel

A second vowel is the same chain with each formant moved. The wheel drives each frequency by the cents between the two vowels and each Res by the difference between their Qs. With AUTO on, FUN1 = max(the wheel, ASR2) drives them instead, and ASR2 is the diphthong: its delay is HOLD, its attack is SLIDE, a straight ramp in cents, and its release is 30 seconds, so the note's tail stays on the second vowel.

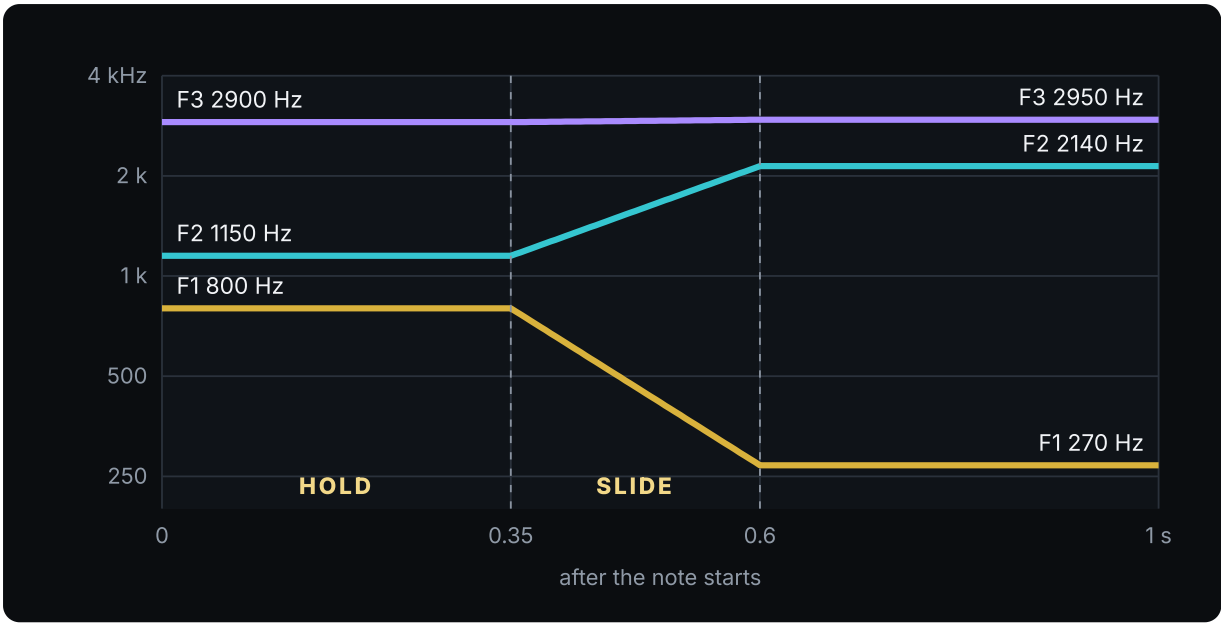


Fig. 59. A soprano singing A into I: each formant held for HOLD, then moving in a straight line in cents for SLIDE.

BREATH

One curve drives the tone and the pitch

A real wind's brightness and pitch both follow how hard it is being blown, from moment to moment. BREATH gives them one source.

FUN1 = (AMPENV + pressure) / 2: the note's own envelope and the aftertouch, averaged. The tone's 2POLE gets it at 2400 cents, and so the corner is written an octave under the panel's value at full sustain. At the sustain with no aftertouch FUN1 is a half, and there the corner reaches the panel's value; full aftertouch adds an octave.

The pitch gets it too. The panel's BLOW is the pitch's movement from soft to loud, half on the velocity and the rest on FUN1, and the program's Fine is set to keep the note in tune at the sustain, with no aftertouch, at velocity 64. A reed goes flat when blown harder, BLOW −12 to −15 ct. Lips and a jet go sharp, +25 and +30. That is why the Clarinet's first layer reads Fine +9 ct and the Trumpet's −19 ct.

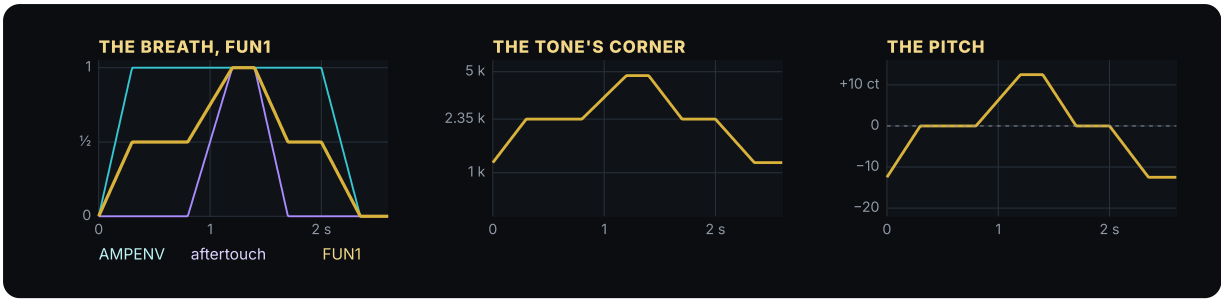


Fig. 60. The Trumpet. Left: the AMPENV, the aftertouch and FUN1. Middle: the tone's corner at full velocity. Right: its pitch at velocity 64, in tune at the sustain with no aftertouch.

WIND MAP adds two FUNs. FUN3 = PWheel / 2 + the pressure (or FUN1, with BREATH on), on the corner: the bend is the lips, and bending down darkens the note. FUN4 = max(ASR1, MWheel), on the vibrato: the wheel adds what the delayed rise would give.

EDGE AND GROWL

A rasp that only exists when blown hard

A reed blown hard beats shut once a period, and new harmonics appear high up. The Edge layer imitates what that sounds like, and stays shut until it is needed.

It is a layer of its own (ALG 102) reading the tone: a HIPASS at 1.5 kHz, a DIST at +24 dB, the HIPASS again and a LOPASS at 3 kHz. On the Clarinet the DIST comes first, squaring its fundamental, then two HIPASSes and the LOPASS. The DIST is always torn; what changes is whether you hear it. A drive that followed the blowing jumped in level as it started to clip.

The opening is three FUNs. FUN2 = (FUN1 + 2 × velocity) / 3 is how hard the note is being blown. FUN3 = diode(FUN2 − 0.6). FUN4 = FUN3 + FUN3. FUN4 drives the AMP by 80 dB, so the layer is 64 dB under its top at 0.6 of the blowing, opens a little at full velocity, and all of it with full aftertouch.

GROWL is LFO2 at 24 Hz on the Edge's AMP, by knob 8 (CC 3). An open bore has no reed to tear, so on the Flute GROWL swings the sines' and the air's levels instead, up to 12 dB: a flutter-tongue.



Fig. 61. The Edge layer's level against how hard the note is blown. The dots are velocity 100 and 127 with no aftertouch, and 127 with full aftertouch.

SHAPING IT

An envelope, a filter and an EQ on every sound

Three sections on the right of the panel work on any object, and each is built from what the program already has, so that none of them spends a voice where it can be helped.

AMP ENV, attack, decay, sustain and release, uses the AMPENV's three attack segments on every layer you hear: up to the top in the attack, down to the sustain in the decay, held. On a strike or a pluck the attack is a swell into the ring and the release is the dampers; with the sustain under 100 % the ring falls on from it as it would from the top. On a breath or a rub they are the exciter's own attack and release, and the decay and sustain make a sforzando.

FILTER is a 2POLE LOWPASS with cutoff, Res, key track, velocity and an envelope of its own on ENV2. On a strike, a pluck or a rub it goes on every mode, after its resonator, by turning the mode's layer from ALG 107 to ALG 106: the same voices, and with the cutoff at its top the program is byte for byte what it was. On a breath it is the tone's own 2POLE.

EQ is one PARAMETRIC band: $y = x + (G - 1) \times$ a band pass, its width the distance between the -3 dB points of the notch it would cut at $G = 0$. A mode is one frequency, so on a mode the EQ is only a level; but a mode moves with the key, into the band and out of it, so the compiler splits its layer into **key zones**, each with its own level and key tracking, within 1 dB of the curve. The zones never sound together and cost no voice. On a breath through a body the direct sound has every harmonic, so it goes through a layer of its own with a real PARAMETRIC EQ (ALG 108, one voice more unless the object already has that layer), its Pad 6 dB lower for every 6 dB of boost so it cannot clip.

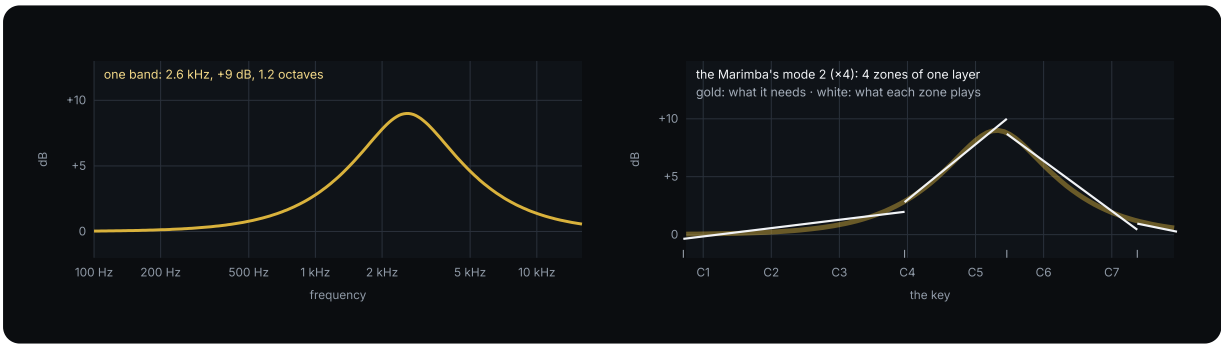


Fig. 62. Left: an EQ band, 2.6 kHz, +9 dB, 1.2 octaves. Right: the Marimba's second mode (×4) through it across the keyboard: the gain it needs on each key (gold) and the four key zones of its one layer that give it (white).

The AMP ENV and the FILTER reach the K2700 as single parameters while you turn them. Switching the EQ on or off changes how many layers there are, so the LINK sends the program whole.

HALL AND DELAY

A factory hall and the app's own delay

The hall is the K2700's factory Hall Reverb 1 on aux 1, which every K2700 has; its time is the K2700's knob 9, CC 9, 0.5 to 10 s, and the panel's TIME sends the value that gives it. The delay is PHYS Delay, the app's own chain on aux 2: one delay box, its repeat from a quarter of a beat to a beat and a half at the K2700's tempo on CC 84, its feedback 0 to 90 % on CC 19.

A K2700 loads a program's aux chains when it enters that program, not when its edit buffer changes. So when the LINK goes on, KEDITOR PHYSICAL reads which program the K2700 is on; if that program's effects are not its own, the display says whose you are hearing, and STORE with SELECT puts the K2700 on the stored program, after which everything plays with its own hall and delay.

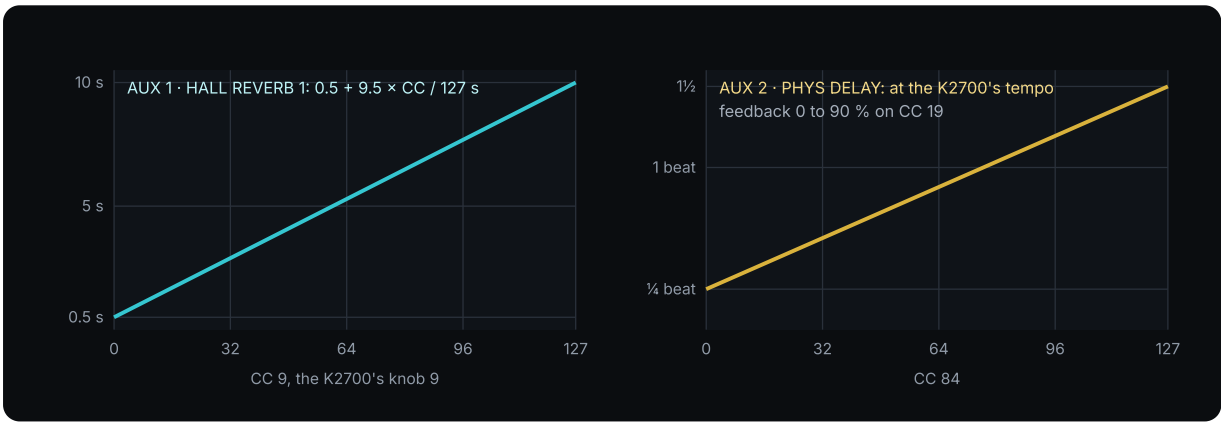


Fig. 63. Left: the hall's time against CC 9. Right: PHYS Delay's repeat against CC 84, in beats of the K2700's tempo.

Levels for chords

Each object's volume keeps a four-note chord at full velocity, hall included, under −3 dBFS.

No samples

Every layer plays the Silence keymap and makes its own sound, so a program loads and plays on any K2700.

Checked on every change

The 26 objects are compiled, read back and opened again in the panel, their programs compared byte for byte.

WHEN IT DOES NOT WORK

When it does not work

Each of these cost a session on the K2700.

What you hear	Why	What to do
Nothing at all	the exciter's two gates are shut, or a mode is not reading layer 1	ENV2's Depth on both GAINs, Alt Input on every mode
Each strike at its own level	a noise click: its share at a mode is chance	a pulse: a SQUARE at −120 semitones, two gates
A whistle under every note	one gate leaves the source 96 dB down, and a resonator makes a tone of it	two gates in series
The ring stops too soon	the exciter layer ended first, and took its readers with it	its AMPENV 10 % longer than theirs
High notes ring as long as low ones	the envelope's Decay KeyTrk is 1.000x	2.000x, as long as KEY DECAY is 1
The bass is quiet	under 235 Hz the K2700's ring falls 7.12 dB an octave	the FUN1 and FUN2 boost
A band distorts	the DSP is fixed point: a block's output clips 6 dB over full scale	Pad on its first HIPASS, the AMP making it up
A narrow BANDPASS goes on sounding	at 0.02 octaves it saturates into a square	a 2POLE LOWPASS instead
A voice is almost silent	24 dB at every Alt Input passage	Pad 0 on each passing layer's second 2POLE
A sine is not a sine	at full scale it gains a third harmonic	12 dB of Pad, the AMP making it up
A controller does nothing	a K2700 program hears only what has a PARAMS label	a label for it, with its entry value
The hall is another program's	a K2700 loads aux chains when it enters a program	STORE and select it
The decay is faster than the page says	a Dec1 is 96 dB in its time	T60 = 0.625 × the time
The sustain is not where you set it	AMPENV levels are not linear in dB	write it through the law: 75 % is −8.6 dB
The program will not fit	32 layers, and the EQ's key zones add up	widen the zones, or take a mode away

User manual: troubleshooting, page 101

WHAT GOES TO THE K2700

One program, and the model inside it

Everything KEDITOR PHYSICAL does ends up in one K2700 program, which the LINK sends and STORE writes. This is what it holds.

Part	What KEDITOR PHYSICAL writes
Program	the name (16 characters), the object's category, the keywords physical and modal; the panel's volume as the program's Out Gain, −30 to +24 dB
Strike, pluck	layer 1 the pulse (ALG 2), then a layer for each mode (ALG 107, or ALG 106 with the FILTER), in key zones with the EQ
Breath	layer 1 the tone (ALG 6); the direct through a layer of its own when the EQ or its high pass needs one (ALG 108); a band for each body mode (ALG 107, up to 16); the air (ALG 7). A bore: a SINE layer for each harmonic (up to 7) and the breath
Rub	layer 1 the friction (ALG 2), then a layer for each mode (ALG 107)
Effects	aux 1 the factory Hall Reverb 1 and its send; aux 2 PHYS Delay, the app's own chain, and its send
Entry values	the hall's time on CC 9 (the K2700's knob 9), the delay's repeat on CC 84 and its feedback on CC 19
PARAMS labels	Reverb Time, Delay Time and Delay Fdbk: without a label, a K2700 program does not hear the controller
Info	KPHYS+ and the model, six bits a character, about a hundred characters: the modes' ratios to a quarter of a cent and their rings, the exciter, the material, every knob a program cannot say by itself

1

LINK

Every change compiles the program again. The LINK sends only what changed into the K2700's edit buffer: a few parameter messages for most knobs, the whole program when the layers change, and the Info a second later.

2

STORE

Writes PHYS Delay first if the K2700 lacks it (asking), then the program to a USER ID (asking before it replaces one), reads it back to check it, and with SELECT IT ON THE K2700 selects it there.

3

READ

Opens a program KEDITOR PHYSICAL stored, by the model in its Info; a body of more than seven modes takes the rest from the program's own Body layers.

4

MY MODELS

Keeps your models in the app under their names, beside the object each one started from.

EVERYTHING BY NAME

One file, and everything is found by name

The factory objects are one .K27 with their programs and PHYS Delay. Loading it gives every object an ID the K2700 chooses, so nothing in KEDITOR PHYSICAL may depend on an ID.

1

LOAD

KEDITOR PHYSICAL FACTORY.K27 goes on with FILE > LOAD, FILL. Each object takes the first free USER ID and references between them are kept. Nothing is replaced.

2

The chain

At LINK on, the app looks for PHYS Delay at chain 5030 and, if that ID holds something else, by name among the USER chains from 5000 to 5255. If it is missing it asks before writing it, and it never writes over another object.

3

The programs

A program carries its name and its Info, which starts KPHYS+. READ goes by the Info: renaming a program on the K2700 does nothing to it.

4

The modes

The Info holds the eight modes of a strike and the first seven of a body. A body of fifteen is read from the program's own Body layers: each band's frequency, Res and AMP.

Renaming PHYS Delay on the K2700 makes the app lose it, and it would offer to write another. Renaming a program does nothing: the name is yours.

THE WHOLE RECIPE

A modal synthesizer on one page

Everything Part four builds, field by field. All values at C4.

Piece	Where	What
Every layer	KEYMAP	Silence, C-1 to G9 but for the High Key below
The strike	ALG 2	F1 SQUARE −120 st, KeyTrk 0, Note On · F2 GAIN · F3 LOPASS · F4 GAIN · AMP −96 dB
The pulse	DSP MOD, ENV2	F2: −96 dB, ENV2 Depth 96 · F4: −96 dB, ENV2 Depth 82 · ENV2 Dec1 5 ms to 0 %
The mallet	DSP CTL	LOPASS at HARDNESS ÷ 2^(VelTrk / 1200), VelTrk 2400 ct, KeyTrk 50 ct
A mode	ALG 107	Alt Input Layer 1 · F1 NONE · F2 2POLE LOWPASS at ratio × 261.63 Hz, KeyTrk 100 ct
Its ring	LP Res	20 log10(R × Hz / (2.2 × q)), R = 1 / (1 / T60 − 1 / (0.625 × Dec1)), q = 1.004 − 0.032 log2(1000 / Hz) under 1 kHz, 0 to +48 dB
Its level	AMP Adjust	level + 7 + 0.4 log2(ratio) dB, for a LEVEL of −16 dBFS; VelTrk the object's range
The bass	LFO+, DSP MOD	FUN1 diode(a − KeyNum), a = (60 + 12 log2(235 / Hz)) / 128 · FUN2 min(FUN1, 0.18) · AMP Src1 FUN2, Depth 76 dB
The top	LAYER	High Key 60 + 12 log2(16000 / Hz)
The envelope	AMP ENV	User: 0 s to 100 %; Dec1 15 × the longest ring to 0 %; Decay KeyTrk 2.000x
The dampers	LAYER, AMP ENV	none: Ignore Release On · with them: Off, Rel1 the damper's time
The exciter's envelope	AMP ENV	10 % longer than the modes'
The sound	COMMON	Output Gain +12 dB
A pluck	AMP Adjust	−20 log10(ratio) dB more on each mode
A rub	ALG 2	NOISE · LOPASS · GAIN by ENV2, held · GAIN
A body band	ALG 107	HIPASS · 2POLE LOWPASS · HIPASS at one Hz, KeyTrk 0; its first Pad 6 dB a step past Res +15
A bore's harmonic	ALG 6	SINE at the harmonic, Note On, Pad 12 dB, then the 2POLE
A formant	ALG 106	two 2POLEs a layer, each reading the last; Res 20 log10(Hz / width); second one Pad 0
The hall	FX	aux 1, Hall Reverb 1; entry on CC 9
A controller	PARAMS	a row with a label, or the program does not hear it

WORDS

Glossary

The words this page uses, in the sense it uses them.

Word	What it means
ALG	a VAST layer's wiring: which DSP blocks the sound goes through, in what order
Alt Input	a layer's input from another layer for the same note: what makes a cascade
AMPENV	a layer's level envelope; a Dec1 falls 96 dB in its time
ASR	a simple envelope with a delay, an attack and a release; each layer has two
Bessel modes	the shapes of a circular membrane
Body	a resonator that does not set the pitch: its modes are fixed in Hz
Bore	the air column of a wind instrument
Cascade	layers feeding each other through the Alt Input
Ceiling	the longest ring a K2700 resonator can have: 553 / Hz seconds, a little less in the bass
Contact	the time a mallet touches the object; the shorter, the higher the modes it reaches
Edit buffer	where the K2700 holds the program being edited, before it is stored
Exciter	what puts the energy in: a mallet, a finger, a reed, a jet, a bow
Formant	a resonance of the vocal tract
FUN	a function generator: two control sources, one equation, one new control source
Inharmonic	modes that are not whole multiples of the first
Key tracking	how far a value follows the note played
Label	a controller's row on the PARAMS page, without which the program does not hear it
Layer	one voice of a VAST program
Linear	modes that do not disturb each other: each rings by itself and they add up
LINK	the USB connection that sends every change to the K2700's edit buffer
Modal synthesis	a sound made as a sum of decaying sines, one a mode
Mode	one of the shapes an object can vibrate in, with its own frequency and ring
Node	a point of a mode that does not move
Pad	a block's input level, in 6 dB steps
Point	where the object is struck; each mode is weighed by its shape there
Q	a mode's frequency over its width; T60 = 2.2 × Q / Hz
Radiator	what couples the vibration to the air: a tube, a soundboard, a bell
Res	a K2700 filter's resonance in dB; Q = 10^(Res / 20)
Resonator	what stores the energy and sorts it into modes

Word	What it means
Ring	how long a mode sounds: its T60
Source-filter	a rich source through a fixed colouring filter
Strike note	the pitch you hear from a bell, made by the ear from upper partials
T60	the time a mode takes to fall 60 dB
USER	the K2700's IDs from 4096 up, where your programs and chains live
Voice	one note's worth of one layer; the K2700 has 256
Waveguide	a string or tube modelled as two travelling waves in delay lines

PART FIVE

User manual

Every control, message and workflow of the editor, section by section.



Welcome

KEDITOR PHYSICAL is a physical-modelling editor for your Kurzweil K2700. You describe an object, the modes it rings in, what sets it going, what it is made of and where it is struck, and the app turns that into a real K2700 program, mode by mode. Each mode is a resonating layer tuned by the key, so every note is a little object of its own.

It works with your K2700 connected by USB: each move you make reaches it as you make it, and a finished sound is stored on it with one button. Stored, it plays with no computer attached.

- **One panel.** Everything about the object is in view: its drawing, its modes, the exciter, the material, the envelope, the filter, the EQ and the space.
- **Four exciters.** STRIKE and PLUCK, a mallet's pulse; BREATH, a source through a body or a bore; RUB, a friction that holds the modes singing.
- **Honest about the instrument.** The panel shows what each sound costs in voices and says when a ring asks more than a K2700 resonator can hold.
- **26 objects to start from,** and your own models kept in the app under their own names.

Getting started

What you need

- A Mac with macOS 12 or later.
- A Kurzweil K2700 and a USB cable to its USB COMPUTER port. MIDI travels on that cable.
- To have the factory objects on the K2700 as programs: *KEDITOR PHYSICAL FACTORY.K27*, loaded on the K2700 with FILE > LOAD, FILL. It takes free USER IDs and replaces nothing.

First sounds

1. Open KEDITOR PHYSICAL.
2. Play the keyboard at the bottom of the window with the mouse, or any MIDI keyboard connected to the Mac.
3. Pick another object from the LIBRARY, or turn **BROWSE**.
4. Turn a knob: drag up or down, or use the mouse wheel. Hold `Shift` for fine steps; double-click most knobs to return them to their default. Its value shows on the status display at the top.
5. Connect the K2700 and press **LINK** (see Working with the K2700). Press **HEAR K2700** and the panel's keys play the K2700.
6. Press **STORE** when you like what you hear.

The app sounds by itself for trying things out, with **HEAR APP**. The K2700's own sound is the one that counts: what a program does on the instrument was measured on the instrument, and the app can only come close.

The panel at a glance

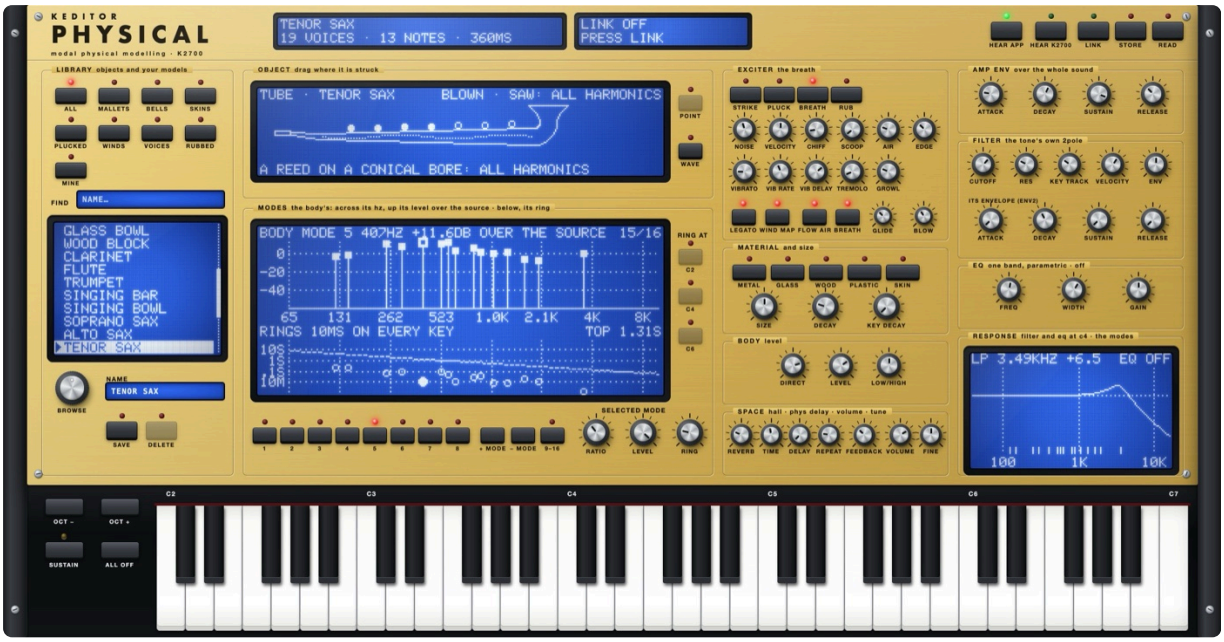


Fig. 64. The whole panel, on the Tenor Sax.

Where	What it holds
Header	The status display, the LINK's display, HEAR APP, HEAR K2700, LINK, STORE and READ
LIBRARY	The families, FIND, the list, BROWSE, NAME, SAVE and DELETE
OBJECT	The object as a drawing, the mallet to drag, POINT and WAVE
MODES	The modes above, their rings below, the selected mode's RATIO, LEVEL and RING
EXCITER	STRIKE, PLUCK, BREATH or RUB, and its knobs
MATERIAL	Five materials, SIZE, DECAY and KEY DECAY. On a voice, the five vowels
BODY	DAMPERS, DIRECT, LEVEL and LOW/HIGH
SPACE	REVERB, TIME, DELAY, REPEAT, FEEDBACK, VOLUME and FINE
AMP ENV, FILTER, EQ	Three shapers over the whole sound
RESPONSE	A picture of the filter and the EQ at C4, with the modes marked
The keyboard	61 keys, OCT −, OCT +, SUSTAIN and ALL OFF

The status display

The top line names the program, with the object it started from on the right. The second line shows what a note costs: voices, notes the K2700 can hold at once, and the time the envelope runs for. It takes turns with what you need to know: how many modes are at the K2700's top, and any note from the compiler, such as an AMP that has passed +24 dB. While you turn a knob it shows the knob's value.

Knobs and buttons

- Drag a knob up or down, or use the wheel. `Shift` is fine. On most knobs a double-click returns the default.

- A button that does nothing for the current object is dimmed. A knob that depends on another says so in its value: GLIDE reads WITH LEGATO, BLOW reads WITH BREATH.
- A button's LED shows that it is on.

The library



Fig. 65. The library.

- **The family buttons** narrow the list: ALL, MALLETS, BELLS, SKINS, PLUCKED, WINDS, VOICES, RUBBED and MINE.
- **FIND** narrows it by name as you type.
- **The list.** Click a name to load it.
- **BROWSE** runs through what the list shows. Each one loads at once, and with the LINK on is in the K2700's edit buffer a moment later.
- **NAME** is the program's name, 16 characters.
- **SAVE** keeps the model in the app under that name, in MY MODELS. A model of the same name is replaced.
- **DELETE** removes the chosen one of MY MODELS, after asking.

Your own models appear under MINE, and with a star in the family of the object they started from. Loading another object does not change what you have saved, and does not store anything on the K2700.

The OBJECT display

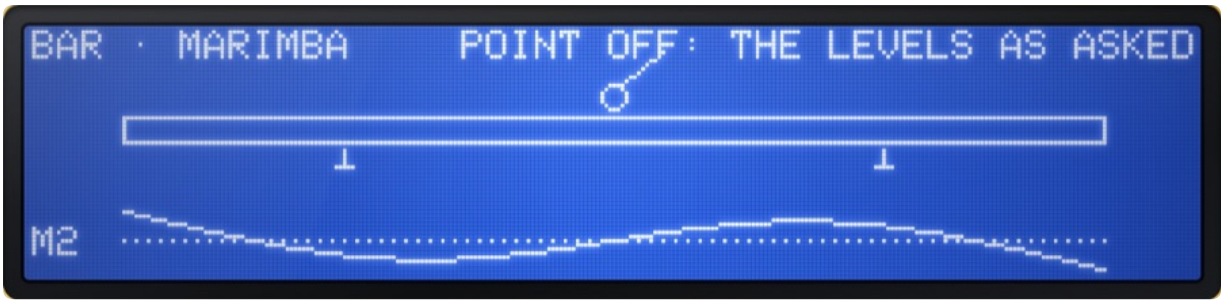


Fig. 66. The Marimba: the bar on its cords, the mallet, and mode 2's shape with its nodes.

The display draws the object and, under it, the shape of the selected mode. On a wind it draws the standing wave of the selected harmonic.

POINT

With POINT on, drag the mallet along the object. Each mode is weighed by its shape at that place: a string's harmonics by $\sin(n\pi x)$, a bar's and a tine's by their bending shapes, a membrane's by its Bessel modes. The levels on MODES follow as you drag. A string or a bar goes from the end to the middle, a tine from the clamp, a membrane from the centre to the rim. Plates, bells and bowls are played where they are played, so POINT is dimmed on them.

WAVE

On a breath, WAVE steps through the source:

WAVE	What it is	What the modes are
SAW	every harmonic: a reed on a cone	the body's, in Hz
SQUARE	a closed tube's odd harmonics	the body's, in Hz
PULSE	the lips	the body's, in Hz
SINE, open bore	a flute's jet	the bore's own harmonics, over the note
SINE, closed bore	a clarinet's reed	the same, its even harmonics louder from A#4

On a voice, WAVE picks one singer or a choir of three saws a little apart.

The MODES display

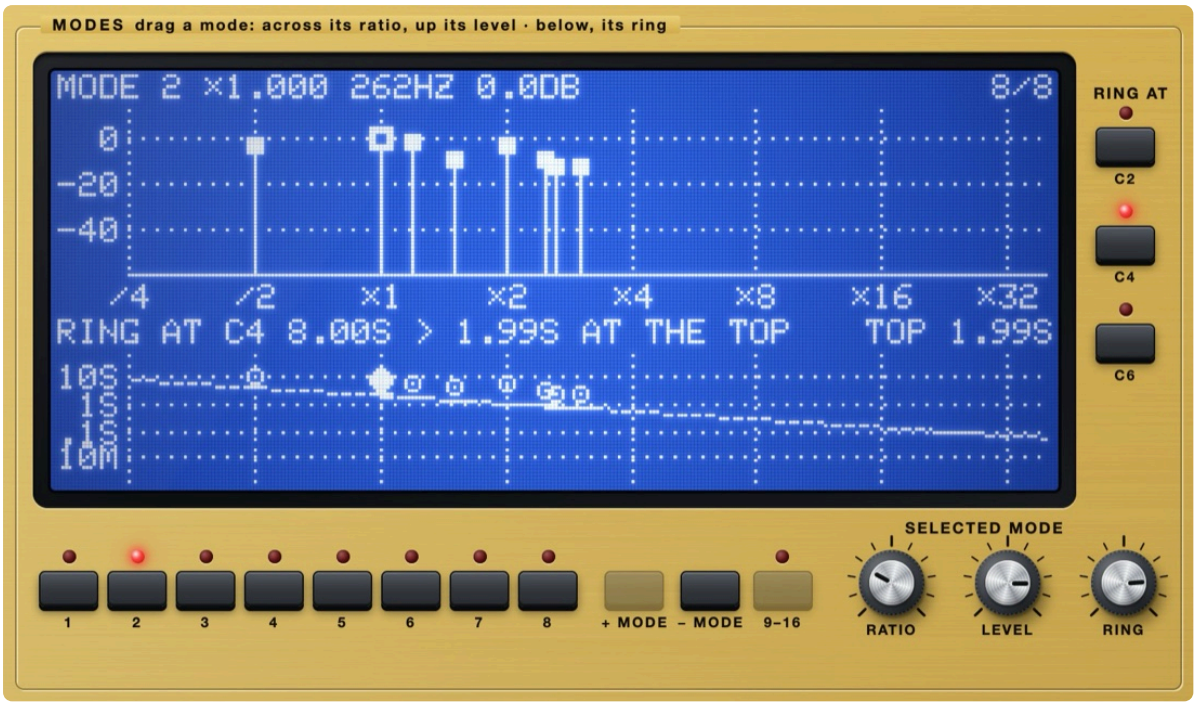


Fig. 67. The Church Bell on MODES: the modes above, their rings at C4 below, the K2700's ceiling dashed.

The stems

- **Drag a stem** to move a mode: across for its ratio to the note, snapping to the harmonics, up for its level.
- **Double-click** to add a mode.
- The buttons under the display choose a mode. **+ MODE** and **− MODE** add and remove one. **9–16** shows the second page of a body with more than eight modes.

The selected mode

Knob	Range	What it is
RATIO	×0.25 to ×40	The mode's frequency over the note. On a body or a formant it reads in Hz, the same on every key
LEVEL	−60 to +12 dB	Its share of the strike, or its peak over the source on a body. A formant's level is the tract's, so this knob rests on a voice
RING	10 ms to 60 s; from 1 ms on a breath	How long it rings at C4. On a body, its Q, shown as a ring. On a bore, how long it sounds after the key. On a formant, its width

The rings

The lower half shows each mode's ring at C2, C4 or C6: press **RING AT** to choose. The dashed line is the K2700's ceiling there, the longest a mode of that frequency can ring: 553 / Hz seconds, a little less in the bass. A ring cut by the ceiling shows both what you asked and what the K2700 gives.

How many modes: 8 for a strike, a pluck or a rub, 16 for a body, 7 for a bore, 5 formants for a voice, up to 7. Each mode is one voice for every note; a voice holds two formants a layer.

The exciter: strike, pluck, rub

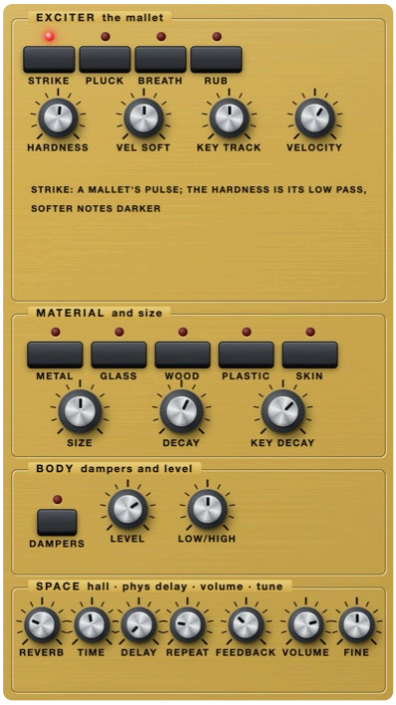


Fig. 68. A strike: four knobs.

Knob	Range	What it does
HARDNESS	200 Hz to 16 kHz	The mallet's low pass at C4 at full velocity: the modes above it are struck softer
VEL SOFT	0 to 4 octaves	How much darker the softest note is
KEY TRACK	0 to 100 ct a key	How the low pass follows the keys
VELOCITY	0 to 48 dB	The range of level from the softest strike to the hardest

STRIKE is a mallet: a short pulse through that low pass. **PLUCK** is the same pulse with the modes falling a further 6 dB an octave of their ratio, as a string let go from a shape.

RUB holds a friction on the object, and its first knob is **FRICTION**: the friction's low pass. The modes sing while the key is down and ring on when it is let go. The AMP ENV's attack and release are the friction's.


EXCITER the friction
STRIKE
PLUCK
BREATH
RUB
FRICTION
VEL SOFT
KEY TRACK
VELOCITY
MATERIAL and size
METAL
GLASS
WOOD
PLASTIC
SKIN
SIZE
DECAY
KEY DECAY
BODY level
LEVEL
LOW/HIGH
SPACE hall · phys delay · volume · tune
REVERB
TIME
DELAY
REPEAT
FEEDBACK
VOLUME
FINE

Fig. 69. A rub.

The exciter: breath



Fig. 70. A breath, with its rows of knobs.

Knob	Range	What it does
NOISE	−60 to 0 dB	The breath against the tone
VELOCITY	0 to 48 dB	The range of level
CHIFF	0 to 30 dB	The breath's burst at the start, over its level
SCOOP	0 to 200 ct	How far under the note the pitch starts
AIR	300 Hz to 8 kHz	The centre of the breath's band at C4. Untouched, it sits a little over the note and follows it
EDGE	0 to 1.5	The rasp blown hard, its level against the tone at the top. Needs BREATH, on a reed or the lips
VIBRATO	0 to 60 ct	The vibrato's depth
VIB RATE	0 to 12 Hz	Its speed
VIB DELAY	10 ms to 3 s	When it arrives
TREMOLO	0 to 12 dB	How much the level swings with it
GROWL	0 to 24 dB	What the K2700's knob 8 (CC 3) swings at 24 Hz: the rasp, or on a flute the tone and the air, up to 12 dB
GLIDE	0 to 600 keys a second	With LEGATO, the slide between notes
BLOW	−60 to +60 ct	With BREATH, how far the pitch moves from soft to loud: a reed goes flat, lips and a jet go sharp

How it is played

Button	On	Off
LEGATO	One voice and no new attack: the notes slide into each other	Every note its own
WIND MAP	The aftertouch is the pressure, the pitch bend the lips (and darker going down), the mod wheel more vibrato	The pressure is the wheel or the aftertouch, whichever is higher
FLOW AIR	The breath rides the tone, in bursts at the note's period	The air is a noise band of its own
BREATH	One breath drives the note: the tone opens as it swells and darkens as it dies, and the pitch moves with BLOW	The tone as set, the scoop its own

WIND MAP and FLOW AIR are for a breath through a body; a bore and a voice do without them. On a breath the FILTER is the tone's own filter and the AMP ENV's attack and release are the breath's, so those sections take over the tone's brightness and its start and end.

The voices



Fig. 71. A voice: MATERIAL's buttons become the vowels.

On a voice the MATERIAL section is the **VOWEL** section. A click on A, E, I, O or U chooses the vowel. A `Shift`-click chooses the second vowel, the one the mod wheel takes the voice to; on the same vowel it removes it.

Control	Range	What it does
VOICE	Soprano, Alto, Tenor, Bass	Whose formants
ENSEMBLE	0 to 50 ct	On a choir, how far the outer saws are from the middle one
SHINE	0 to +30 dB	The singer's brightness from 3 kHz up

AUTO	on or off	A diphthong: each note holds the first vowel, then slides into the second
HOLD	0 to 2 s	How long the first vowel is held
SLIDE	20 ms to 3 s	How long it takes to reach the second

With AUTO on, the times are set for you when you choose the vowels: a rising diphthong, into a more open vowel, holds its first vowel 40 ms and moves in 120 ms; a falling one holds it 350 ms and moves in 250 ms. The mod wheel still takes the voice to the second vowel.

On MODES a voice has five formants, across by their frequency and with their width on RING. A formant's LEVEL rests, because its level comes from where it is and how wide it is.

Material and size

Material	T60 at 1 kHz	KEY DECAY	Sound
METAL	4.1 s	0.5	Long and bright, the upper modes nearly as long
GLASS	2.7 s	0.6	Long and pure
WOOD	0.29 s	1.2	A knock with a pitch, the upper modes gone at once
PLASTIC	0.16 s	1.0	Short and dull
SKIN	0.15 s	0.8	A thud

A material sets every mode's ring by one law, T60 = T(1 kHz) × (f / 1 kHz) ^ −a, and KEY DECAY to its a. Its LED stays lit while the rings follow it, and goes out when you change a ring by hand.

Knob	Range	What it does
SIZE	±24 semitones, shown in cm	Retunes the object: as 1/L² for a bar or a tine, as 1/L for the rest. A larger one rings longer by the same law. On a breath through a body it is the body's: its modes move and the note stays where the key is
DECAY	50 ms to 20 s	Mode 1's ring at C4. The others keep their share of it
KEY DECAY	0 to 1.5	How the rings follow the keys. 1: half as long an octave up, as a struck resonator. 0: the same everywhere

Body

Control	Range	What it does
DAMPERS	on or off	On a strike or a pluck. On: the key up damps the ring, in the AMP ENV's RELEASE, and the sustain pedal holds it. Off: the notes ring on
DIRECT	−40 to +12 dB	On a breath through a body, the source heard directly
LEVEL	−40 to −6 dBFS	Mode 1's ring at C4 at full velocity
LOW/HIGH	±6 dB an octave	The level across the keyboard

Space

Knob	Range	What it does
REVERB	0 to 100 %	The send to the K2700's factory Hall Reverb 1 on aux 1
TIME	0.5 to 10 s	The hall's time, on the K2700's knob 9 (CC 9)
DELAY	0 to 100 %	The send to PHYS Delay, the app's own chain, on aux 2
REPEAT	¼ to 1½ beats	At the K2700's tempo, on CC 84
FEEDBACK	0 to 90 %	On CC 19
VOLUME	−30 to +24 dB	The program's Out Gain

FINE	±100 ct	The tuning of a strike, a pluck, a rub or a bore

A K2700 loads a program's aux chains when it enters that program, not when its edit buffer changes. While you are editing with the LINK on, the hall and the delay you hear are those of the program the K2700 is on; the display says whose. STORE with SELECT IT ON THE K2700 puts the K2700 on the stored program, and from there it plays its own.

AMP ENV

Knob	On a strike or pluck	On a breath or rub
ATTACK	A swell into the ring, at once to 10 s	The exciter's attack, 10 ms to 5 s
DECAY	The fall from the top to the sustain, up to 20 s	The same: a sforzando
SUSTAIN	The level held, 0 to 100 %. With the ring it goes on falling from there	The level held, 0 to 100 %
RELEASE	The dampers' time, 20 ms to 5 s. With no dampers it has nothing to do: the note rings on	The exciter's release, 10 ms to 5 s; a rub's modes ring on after it

Filter

A 2POLE LOWPASS. On a strike, a pluck or a rub it goes on every mode, after its resonator, and at the top of CUTOFF it is off. On a breath it is the tone's own filter, and CUTOFF is the tone's brightness.

Knob	Range	What it does
CUTOFF	50 Hz to 20 kHz; on a breath, 200 Hz to 16 kHz	At C4, at full velocity
RES	−12 to +24 dB; on a breath, 0 to +24 dB	Its resonance
KEY TRACK	0 to 200 ct a key; on a breath, 0 to 100 ct	How it follows the keys
VELOCITY	0 to 4 octaves	How much lower it is at the softest velocity
ENV	±4 octaves	Its envelope's depth, at its top
ATTACK, DECAY, SUSTAIN, RELEASE	to 10 s, 20 s, 0 to 100 %, 10 s	Its envelope, the K2700's ENV2

EQ and RESPONSE



Fig. 72. AMP ENV, FILTER, EQ and RESPONSE on the Marimba.

Knob	Range	What it does
FREQ	40 Hz to 16 kHz	The band's centre
WIDTH	0.1 to 4 octaves	Its width
GAIN	±24 dB	Its boost or cut. Under 0.25 dB it is off

On a mode the EQ is only a level, since a mode is one frequency, so the app splits each mode's layer into key zones. The zones never sound together and cost no voice. A bore's harmonics work the same way. On a breath through a body the direct sound goes through a real parametric EQ, one voice more unless the object already has that layer. A voice has no EQ. Switching the EQ on or off changes how many layers there are, so the LINK sends the program whole.

RESPONSE draws the filter and the EQ at C4 at full velocity, with a tick where each mode is.

Working with the K2700

LINK

1. Connect the K2700's USB COMPUTER port to the Mac.
2. Press **LINK**, choose the MIDI port and the channel, and confirm.
3. The LINK's display shows *K2700 LINKED* and the channel. Press LINK again to go off.

The model goes into the K2700's edit buffer on that channel, and nothing is stored there without STORE. If the K2700 has no PHYS Delay, the app asks before writing it.

Each change sends only what changed: a few parameter messages for most knobs, the whole program when the layers change, and the Info a second later.

If the K2700 is sitting on another program the display reads *K2700 ON ANOTHER PROG* and your edits stay in the app. Press LINK, or click that display, to send the model there.

HEAR

HEAR APP sounds the panel's keys in the app. **HEAR K2700** plays them on the K2700, with the LINK on. **ALL OFF**, beside the keyboard, lets go of every key held on the panel and of the sustain pedal. **All Sound Off**, in the app's menu or with `Command`-period, stops everything.

STORE

1. Press **STORE**. Give it a name, 16 characters, and a USER ID from 4096 to 8191.
2. Leave **SELECT IT ON THE K2700** ticked to put the K2700 on that program afterwards.
3. If the ID holds a program the app says which and asks before replacing it.

The app writes PHYS Delay first if the K2700 lacks it, writes the program, reads it back to check it and tells you so.

READ

Press **READ** and give a program ID, 1 to 8191. Only a program stored by KEDITOR PHYSICAL opens, because the model travels in the program's Info. A body of more than seven modes takes the rest from the program's own layers.

Playing it: the K2700's controls

Control	What it does
Velocity	The level and the brightness, on every exciter
Aftertouch	The pressure on a breath or a rub: an octave brighter and 6 dB louder at full pressure
Mod wheel	The pressure too, whichever of the two is higher; with WIND MAP, more vibrato; on a voice, the second vowel
Pitch bend	The note; with WIND MAP, the lips: the pitch, and darker going down
Knob 8 (CC 3)	GROWL, on the objects that have one
Knob 9 (CC 9)	The hall's time

CC 84, CC 19	The delay's repeat and feedback
Sustain pedal	Holds the dampers off

A K2700 program hears a controller only if it has a label on its PARAMS page. KEDITOR PHYSICAL writes these labels for you: Reverb Time, Delay Time, Delay Fdbk, and Vowel, Vibrato or Growl where they apply.

The objects

Family	Objects
Mallets	Marimba, Xylophone, Vibraphone, Glockenspiel, Wood Block
Bells	Church Bell, Glass Bowl, Steel Drum
Skins	Tom
Plucked	Harp, Kalimba
Winds	Flute, Clarinet, Trumpet, Soprano Sax, Alto Sax, Tenor Sax, Baritone Sax
Voices	Soprano Aah, Alto Ooh, Tenor Aah, Bass Ooh, Choir Aah, Choir Ooh
Rubbed	Singing Bar, Singing Bowl

KEDITOR PHYSICAL FACTORY.K27 holds all 26 as K2700 programs, with PHYS Delay. Load it on the K2700 with FILE > LOAD, FILL, and it takes free USER IDs and replaces nothing. Pick any of them on the K2700 and READ puts it in the app.

Troubleshooting

What happens	What to do
LINK FAILED	Check the USB cable and that the K2700 is on and in Program mode; try another port in the LINK's dialog. Close other apps that are using the K2700
Nothing sounds from the panel's keys on the K2700	Press HEAR K2700, and check the LINK is on and on the channel your K2700 is listening to
K2700 ON ANOTHER PROG	Press LINK or click the display to send the model there. Or STORE with SELECT
The hall or the delay is not the one you set	You are hearing the effects of the program the K2700 is on. STORE with SELECT IT ON THE K2700
A ring is shorter than you asked	The mode is at the K2700's ceiling. Move the object down, let the hall carry the tail, or accept it: MODES shows both numbers
Notes are stolen, or chords thin out	Each mode is a voice for every note. Remove the modes you cannot hear; the status display shows the count
READ says it is not one of its programs	Only programs stored by KEDITOR PHYSICAL open, because the model is in their Info
A knob does nothing	It depends on another control, and the status display says so as you turn it. GROWL needs EDGE, except on a flute; EDGE and BLOW need BREATH; GLIDE needs LEGATO
The delay does not sound on the K2700	The K2700 needs PHYS Delay. Press LINK and answer yes when asked, or STORE, which writes it
The K2700 sounds different from the app	It will: the K2700 is the instrument, and the app only comes close. Trust the K2700
A note hangs	Choose All Sound Off in the app's menu, or press `Command`-period

KURZWORLD

KEDITOR PHYSICAL

A real-time physical modelling editor for your Kurzweil K2700: modes, mallets, breath and friction, and every sound an ordinary program that your keyboard plays and keeps.

K2700

kurzworld.com/keditor-physical