bOW

VEL	FOrCE	9rIP	WIdtH	HP >	nOISE
cap	cap	cap	cap		
trk	trk	trk	trk	trk	trk

POLE

res

| LP | F0 | 1 | 2 | 3 | 4 | 5 | amp |

| 9 | a | l | n |
| F | F 9 | F 9 | F 9 | F 9 | F 9 |

275 336 672 1178 2323 3043

StrIn9

| POSItIOn | LP | StIFF | FEEd | FrEq | amt |
| cap | trk | trk | | | |

2800

OVErSamPLE
4x   8x   16x
baSE   3C   5C

boing2
bOWEd StrIn9

	wheel bow vel			wheel str lp
	track bow vel			wheel position
	env1 bow vel			vel lfo4 amt
	env1 grip			wheel lfo4 amt

mOdULatIOn

rate   amt

dESt   force   rEtrI9   HOLd   rESEt rate

rate   amt

dESt   lfo1 amt   rEtrI9   HOLd   rESEt rate

PHaSE	SYnC	ratE		bIaS	amt	dESt
			~			pitch
			~			lfo1 rate
			~			env2 amt
			~			position

| OCt | 9LIdE | bEnd | a | d | S | R | amp |

aLt bOW
rESEt

mOnO
LE9   POLY

Boing2

Boing2 is a bowed string synthesizer.

Boing2 models the junction of the string and bow mathematically. This method has characteristics of other synthesis types and of acoustic instruments. Understanding how oscillation is produced helps to create the best results in use.
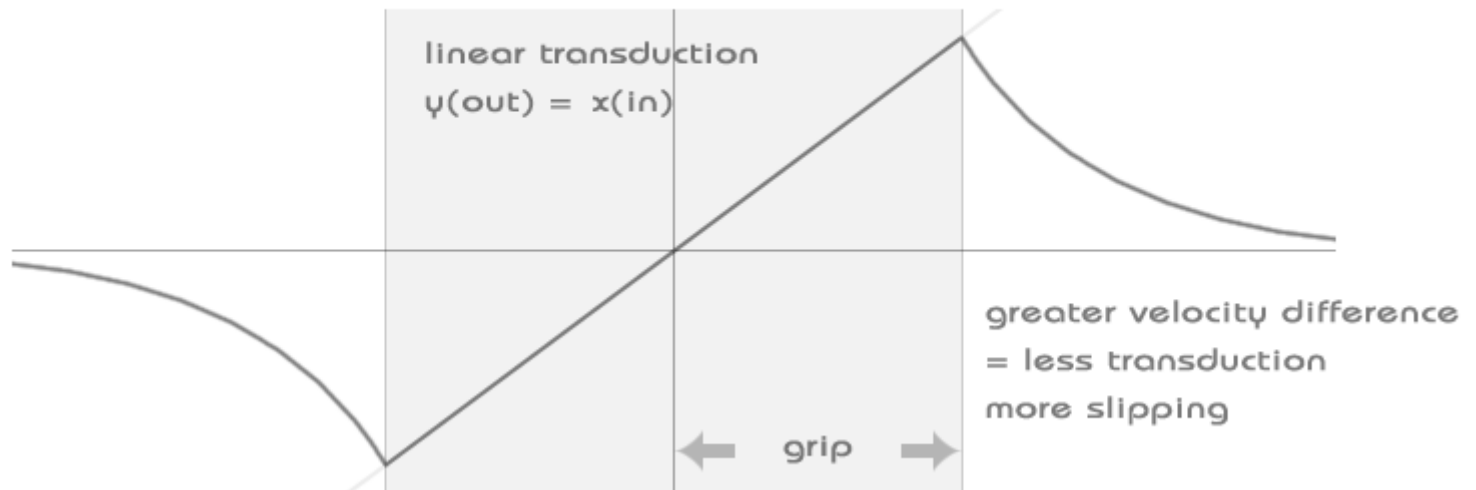
In an acoustic bow, the period of oscillation is produced by a stick-slip interaction between the string and bow. The string is pushed by the bow until the returning vibrations along the string are greater than the grip of the bow. In ideal performance, each stick-slip is one wavecycle.

Boing2 applies the friction model to oversampled, stiffness dispersion filtered waveguide strings coupled with a mass-spring modeled bridge.

The body is modeled with a 5 band banded waveguide and Helmholtz resonator to produce the acoustic "air tone."

bow - string junction transform

x(in) = velocity difference (bow vel. - string vel.)

linear transduction

y(out) = x(in)

greater velocity difference
= less transduction
more slipping

← grip →

This curve (recognised as the Freidlander-Keller transform) illustrates the friction algorithm. The x - axis represents the velocity difference between the string and the bow, defined as (bow velocity - returning string velocity).

If the difference in velocity between the string and the bow is too great, the junction will slip. If the difference is not more than the grip coefficient, the string sticks to the bow and all of the force at the junction is transduced to it.

This synthesis algorithm allows parameter configurations that will not produce a tone, and the coefficients work interactively to define the minimum settings for oscillation. Lower coefficient settings can be driven to oscillation with an initial spike. Many of the presets demonstrate this using fast envelopes. A high passed filtered noise source (12 or 18db/oct) added to the junction can also be used to induce tone.

bOW

VEL   FORCE   GRIP   WIdtH   HP >   NOISE
cap   cap   cap   cap   cap

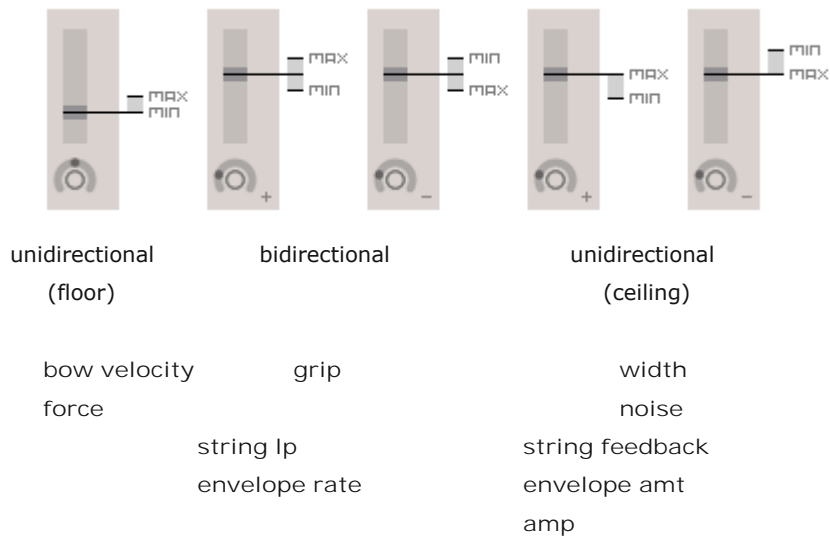trk   trk   trk   trk   trk   trk

POLE

Each parameter has a cap and a unique tracking contour and velocity response to assist in limiting performance to usable settings.
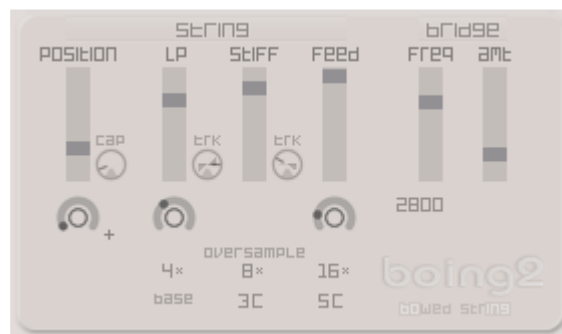
The majority of patches have settings similar to those illustrated as high grip coefficients can smooth the transition between non-oscillating and oscillating settings.

Bow width is efficiently implemented in this model by modulating the grip coefficient by the output at the junction, as rosin temperature changes during bowing has been shown to affect timbre. I rationalise that a wider bow produces more response at the junction, as raising the setting sounds increasingly dimensional. Most patches require settings in the lower slider range to oscillate.

Velocity is applied as is suited for the parameter and should be intuitive in use.

unidirectional (floor)	bidirectional	unidirectional (ceiling)
bow velocity	grip	width
force		noise
	string lp	string feedback
	envelope rate	envelope amt
		amp

Tracking is either linear (string lp, noise hp) or uses a soft s-curve that dips in the middle of the third octave (vel, force, and grip). Tracking for noise amt and string stiffness applies the upper part of this curve as attenuation for the upper keyboard range.

The string panel contains parameters shared with other waveguide models. Tracking for string stiffness is intended here for reducing the perceived thickness of high strings. Linear tracking can be assigned using the modulation panel.

Three oversampling rates are selectable by key range to improve rendering at high pitches and reduce cpu for lower notes. Low sample rate modes (displaying in green) are available for slow computers that omit the bridge and bow width functions.

The string is modeled with delays tuned to the pitch. The length of these delays is also dependent on the position and stiffness settings. In addition to improving timbre, high oversampling rates can increase the range of these parameters and the note range.

The bridge is modeled with a first order mass-spring. The lateral rocking frequency of the bridge contributes to the timbre, violins having a peak around 2.5-3kHz.

The simple mass-spring bridge inexpensively improves emulation, although the purity of the oscillator can also create squeaky harmonic resonances. These are known as "wolf tones" by players of the cello, and are best avoided by locating which notes resonate with the bridge frequency and then slightly retuning the bridge by holding [ctrl] for fine tuning. The same technique can be used for resonance bands on the body.
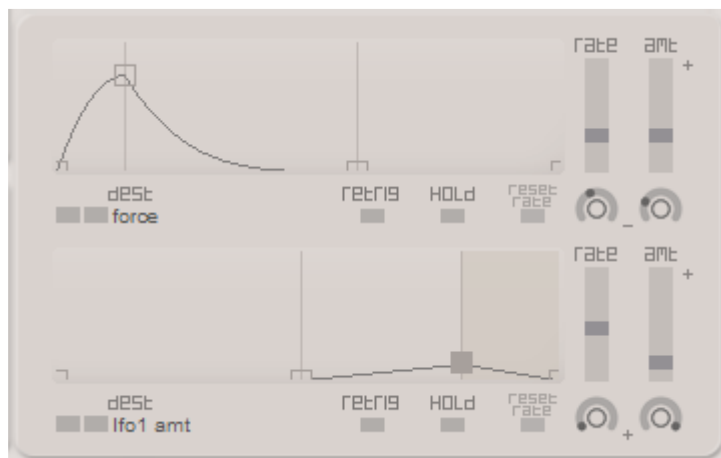
The body resonator consists of two elements. Acoustic body resonances are modeled with a five band banded waveguide, and the f0 Helmholtz resonance, or "air tone" is effectively modeled with a first order mass-spring.

The top group of sliders set the output volume of each band, the knobs under set the gain (feedback) for each band, f0 acting similarly to f1-5 although it pertains to a different algorithm.

Banded waveguides use bandpass filters to divide the input signal. Each band is then routed to a delay set to the same frequency as the filter. The output of each delay is routed back to the input. Overlapping bands, or bands at integer resonances (such as octaves) with high gain should be avoided due to feedback.

The mix knob can be used to audition the resonator and set the initial lowpass appropriately. Configuring the resonator may be best accomplished using an offline method of signal analysis to prepare data. An excellent document concerning resonant frequencies of violin construction can be found at:

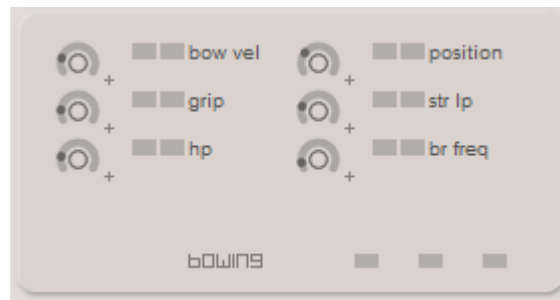http://www.speech.kth.se/music/acviguit4/part7.pdf

The graphic 8 stage envelope modules are the work of Chris Kerry. Clicking in between stages will open the envelope menu where contour, repeat, sustain and display options are available.
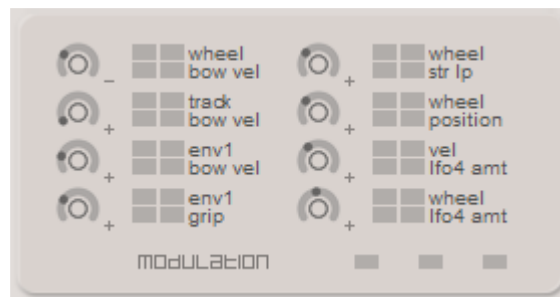
The envelope will retain the same overall duration when editing points with the exception of the rightmost edit point. The rate of the envelope can be reset to the slider value. The envelope also offers pickup/retrigger modes and can be set to hold the level at release.

Modulation of many parameters is difficult to hear. It is often helpful to temporarily assign an envelope to pitch in order to hear its duration.

bow vel

grip

hp

position

str lp

br freq

bOWING

The bowing alternation function uses a resettable counter to apply six coefficients on alternate notes. This can produce a subtle difference in tone resembling the different bowing movement, or can be used more prominently. As negative coefficients can be applied, bowing alternation could be assigned to raise the amount of envelope 2, and lower the amount of envelope 1 to zero, so that one contour can be used for each direction.

Envelopes used in this fashion can be attenuated for several destinations using modulation routing.

wheel bow vel

track bow vel

env1 bow vel

env1 grip

wheel str lp

wheel position

vel lfo4 amt

wheel lfo4 amt

mODULatION

Assigning modulators to several destinations can emulate cohesive acoustic performance. The modulation panel uses a heirachal format for routing:

send	sources	destinations
7 - 8	external modulation	lfo 1-4, envelopes
5 - 6	+ lfo 3-4	lfo 1-2, envelopes
3 - 4	+ envelopes	lfo 1-2
1 - 2	+ lfo 1-2	audio signal path

						tonic
1	16 / 15	7	3 / 2			a
2	9 / 8	8	8 / 5			
3	6 / 5	9	5 / 3			Fine
4	5 / 4	10	9 / 5			
5	4 / 3	11	15 / 8			on
6	7 / 5					

tUNING

Just intonations are optioned from the tuning panel. Numeric values can be up to four digits long. The mouse drag region is split into two zones for digits and hundreds.

The tuning is applied from the indicated tonic, and a fine tune constant of up to half a semitone can be set. The knob has a region in the middle to assist in resetting.

Standard LFOs may be synced to host rate at 64, 32, 16, 8, 4, 2, 1, 2/3, 1/2, 1/3, 1/4, 1/6, 1/8, 1/12, 1/16, 1/24, 1/32, 1/48 and 1/64 measures. Bias controls also have a region in the center for resetting them to zero.

This work is inspired by Julius Smith's model for the Korg Z1, and bears gratitude to his persistent documentation

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