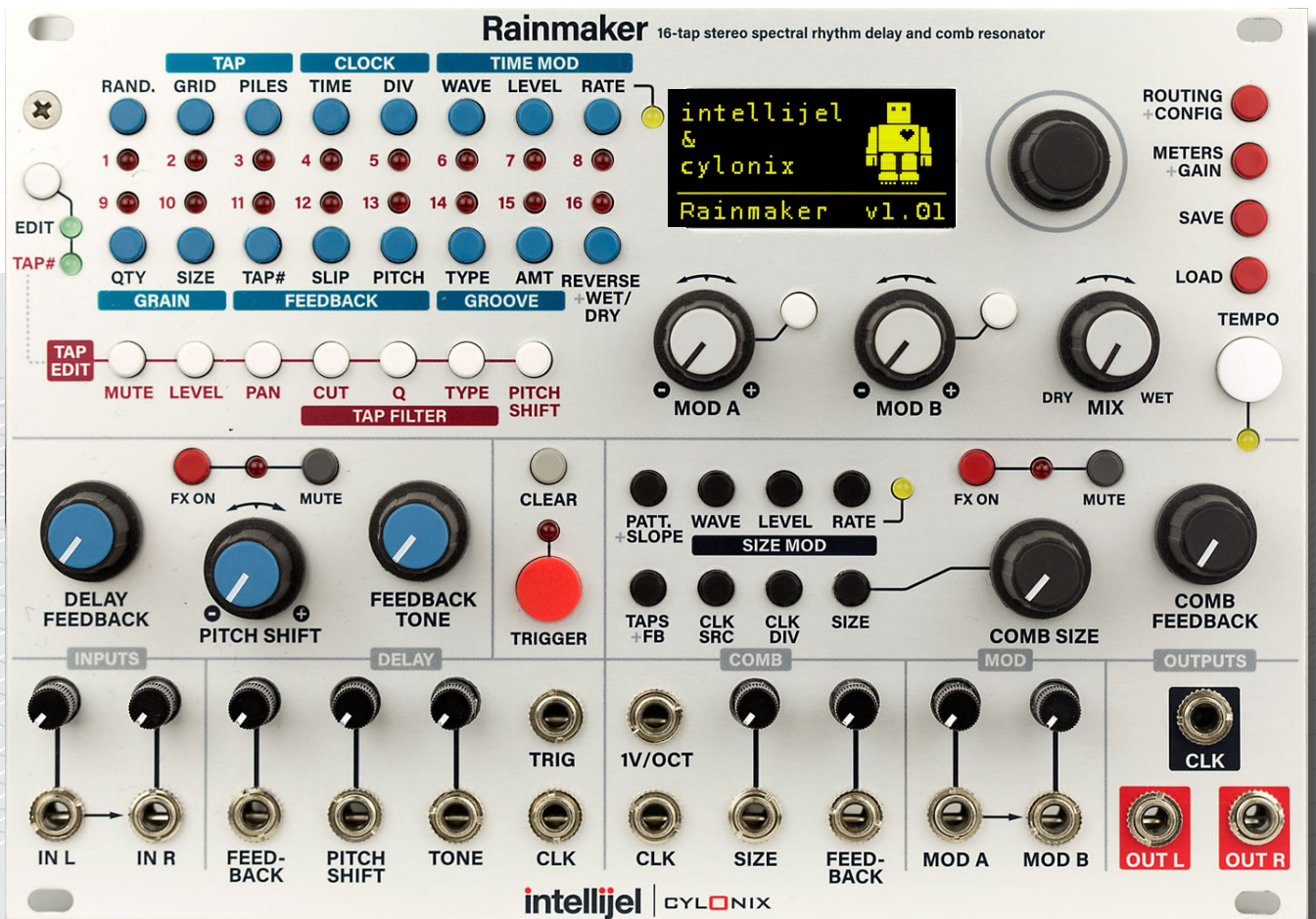


# Rainmaker

16-tap stereo spectral rhythm delay and comb resonator Eurorack module

## User Manual v1.09



## OVERVIEW

The *intellijel/Cylonix RAINMAKER* eurorack-format module provides a high-quality (96KHz sampling rate with 32-bit internal processing) *stereo rhythmic delay* and *stereo comb resonator* effect.

A delay line in its most basic form takes in an audio signal and then sends it out again, but delayed in time, much like your voice echoes in a large empty hall. The Rainmaker module expands on this basic idea, allowing multiple (up to 16!) echoes to be generated, with various effects applied to the echoes, such as pitch shifting and resonant filtering. The stereo rhythm delay has 16 taps, each with its own resonant 2nd-order filter and granular pitch shifter. The filters have independently adjustable resonance and cutoff frequency, and can be set to either lowpass, bandpass, highpass or bypass operation. The filters are also capable of self-oscillation, enabling modal synthesis techniques. The granular pitch shifters have a range of 15 semitones up or 16 semitones down. One of the taps outputs can be sent back to be mixed with the input in order to create regenerating echo effects. The feedback signal has a lowpass/highpass tone control and its own pitch shifter. The tap delay times can range from 0.1 millisecond up to a maximum of 20 seconds. The overall delay times can be set with the rotary encoder, the tap tempo button, or synced to an external clock.

A comb resonator is a special version of a simple delay line, where the delayed output is mixed with the input. When the input sound has a repetitive (harmonic) character, such as a sustained note from a violin, then the delayed signal will sometimes reinforce the input signal and at other times cancel out the input signal. This leads to peaks and valleys in the frequency response of the resonator, hence the name “comb filter”. The stereo comb resonator section expands upon this simple idea in having many (up to 64) time-delayed taps which are summed together. This produces a deep comb filter or resonating effect. At large comb sizes (long time delays) a multiple echo effect is produced. The density of the resonator can be varied from 2 to 64 taps. The tap with the longest delay time is fed back to the input. High feedback levels, with short comb sizes, produce “Karplus-Strong” types of plucked string sounds. The relative timing of the 64 taps are set according to one of 16 different preset patterns, which provide different resonator timbres or echo rhythms. The comb size can be set either with the rotary encoder, an external clock or through a transposable 1v/oct input voltage.

The Rainmaker module has extensive voltage control capabilities. Direct voltage control is available for the delay feedback level and tone, the global pitch shift for all delay taps, the comb resonator size, and comb feedback level. There are two assignable modulation inputs, which can be assigned to different parameters in each preset. A trigger input with assignable functionality can trigger built-in types of noise bursts, freeze the delay buffer, reverse the delay, randomize parameters, mute taps, and much more.

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## STEREO RHYTHM DELAY SECTION

The stereo rhythm delay line has 16 time-delayed taps, each with its own resonant 2nd-order multi-mode state-variable filter and granular pitch shifter. The filters have independently adjustable resonance and cutoff frequency, and can be set to either lowpass, bandpass, highpass or bypass operation. The granular pitch shifters have a range of 15 semitones up to 16 semitones down.

Any one of the 16 taps can be selected to be fed back to the input for echo or regeneration effects. The feedback signal has a first order lowpass/highpass tone control filter and its own granular pitch shifter.

The tap delay times can range from 0.1 millisecond up to a maximum of 20 seconds. The overall delay times can be set either by manual entry with the rotary encoder, with a tap tempo entry, or through an external clock. The relative timings of the individual taps are set to one of 16 different preset “grooves”, or rhythms. The overall delay time can be modulated with an internal low frequency oscillator (LFO) with adjustable wave shape.

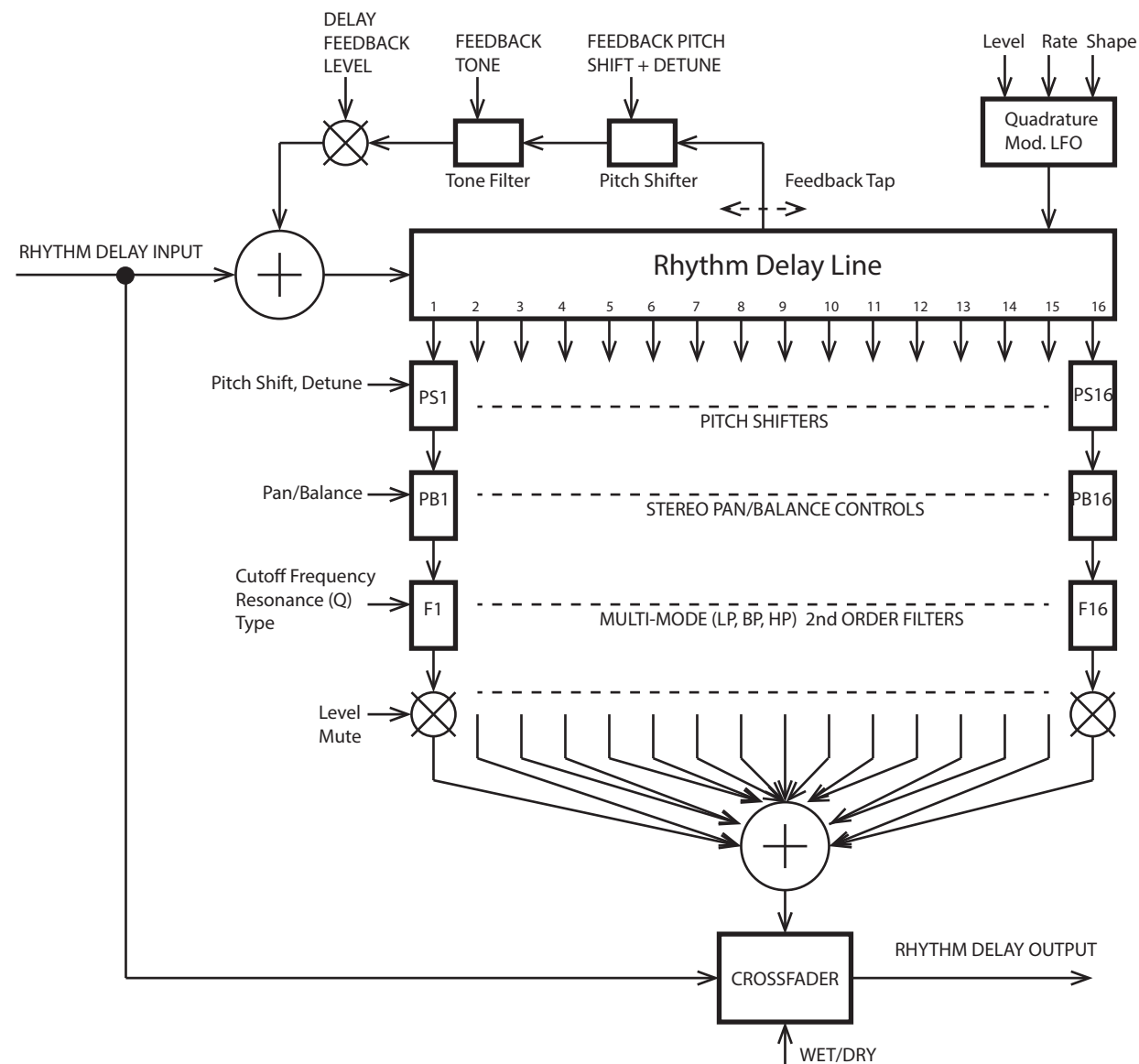


Figure 1. Rhythm delay section block diagram.

## STEREO RESONANT COMB FILTER SECTION

The stereo comb resonator section has 64 time-delayed taps which are summed together. This produces a deep comb filter or resonating effect. At large comb sizes (long time delays) a multiple echo effect is produced. The density of the resonator can be varied from 1 tap all the way up to 64 taps.

The relative timing of the 64 taps are set according to one of 16 different preset patterns, which provide different resonator timbres or echo rhythms. The comb size can be set either with the rotary encoder, an external clock or through a transposable 1v/oct input voltage. The comb size can be modulated with an internal low frequency oscillator (LFO) with adjustable wave shape.

The tap with the longest delay time (tap 64) is fed back to the input. The amount of signal being fed back is adjustable. High feedback levels, with short comb sizes, can produce “Karplus-Strong” types of plucked string sounds. The feedback signal passes through a simple fixed low pass filter and a selectable nonlinearity. The nonlinearity can provide a different quality to the resonant sound when the feedback level is high.

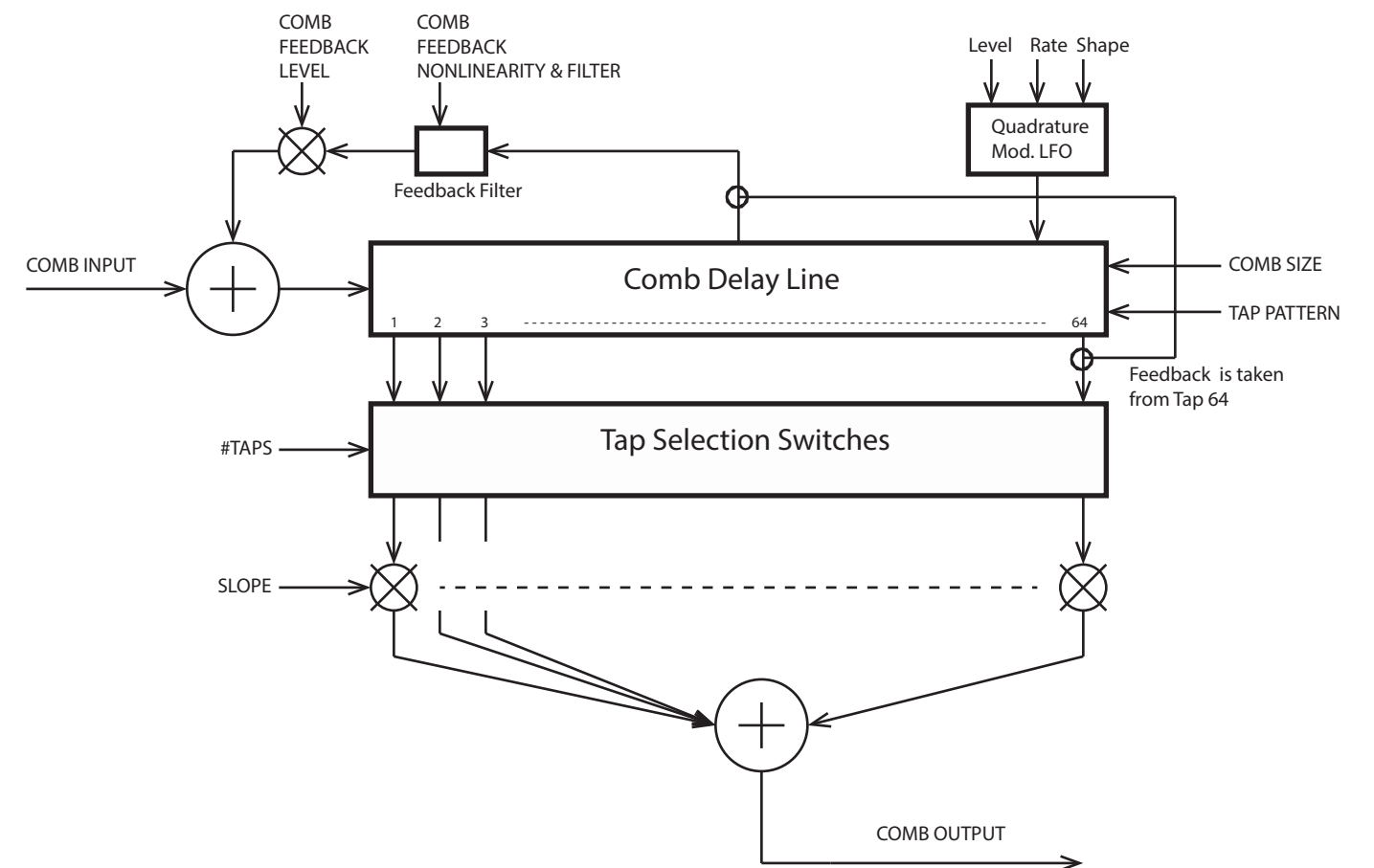


Figure 2. Comb resonator section block diagram.

# FRONT PANEL ELEMENTS

A user of the Rainmaker module interacts with it through the module's front panel. The elements comprising the user interface are one of six types: BUTTONS, OLED DISPLAY, LEDs, POTENTIOMETERS, ROTARY ENCODER, JACKS.

Information about the various parameter values and module configuration is provided by the LEDs (light emitting diodes) and by the OLED (organic light emitting diode) display (item 1 in the figure below).

Most of the buttons on the Rainmaker front panel select various parameters to be displayed and/or edited. Some buttons change the operational mode of the module, such as the FX ON, MUTE, and EDIT/TAP# buttons. The other buttons execute various functions, such as the TEMPO, CLEAR and TRIGGER buttons.

The module contains eight large rotary potentiometers. These are the blue, white, and black knobs with a small indicator mark on top. They allow the user to quickly change important parameters of the module, such as feedback settings. There are also nine small rotary potentiometers (the thin black shafts with small white indicator marks on top) which are used to attenuate the external input signals. The potentiometers will typically be used during performances to dynamically change the behaviour of the module's effects.

The primary means for user setting of the module parameters is via the digital rotary encoder (item 2 in the figure below). Unlike the potentiometers, the rotary encoder can be turned indefinitely. Turning the encoder is typically used to change parameters as indicated in various displays. The rotary encoder can also be *pushed*, which engages a switch. This is used to initiate various actions, such as saving or loading of a preset.

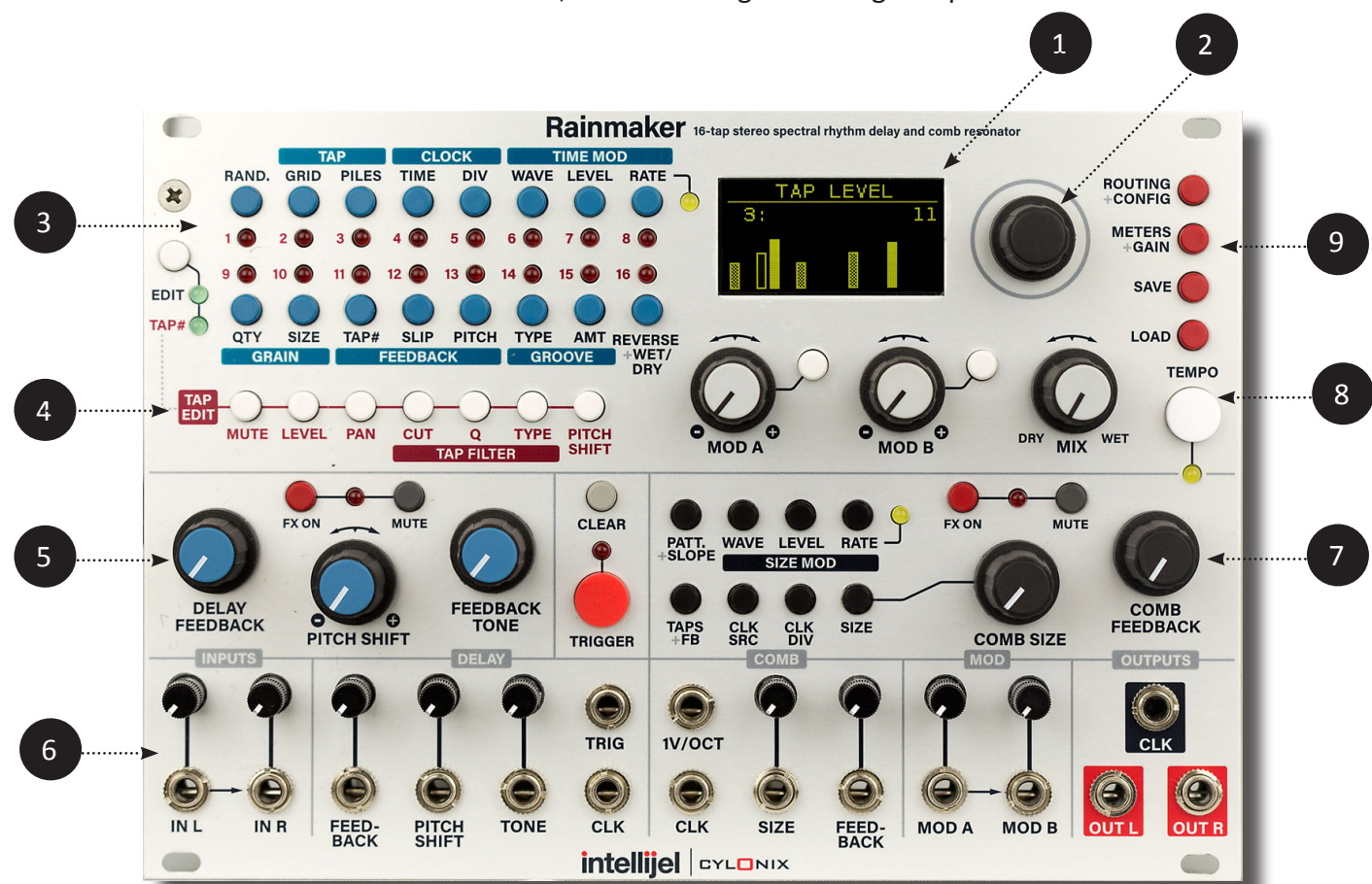


Figure 3. Rainmaker module front panel.

The functions of the various front panel elements are described in the following sections.

## Global Rhythm Delay Parameter Editing

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- **EDIT/TAP#** Pressing the EDIT/TAP# button alternates between EDIT mode and TAP# mode. In TAP# mode, the numbered blue buttons in the upper left of the module select which tap is being edited, while when in EDIT mode the buttons select various rhythm delay parameters to be edited. The associated parameters are described in the following sections.
- **1 - RAND** Displays the current destination of the randomization action (i.e. which parameters of the module will be randomized). The currently active destination is selected from the list of possible choices by turning the rotary encoder. The available destinations are listed in the table below. When in this display mode, pressing the rotary encoder switch (by pushing on the rotary encoder) will execute a single randomization action on the currently selected destination. Also, if the TRIGGER MODE (see later in the manual) is set to Randomize, then pressing the big red TRIGGER button or receipt of a positive pulse in the external TRIG input will cause the execution of a single randomization action.

Rand. Destination	Description
Groove times	The relative timings of the 16 rhythm delay taps will be perturbed from their current values. The altered groove times are not saved in presets, however.
Tap mutes	The per-tap mutes are randomly turned on or off. This is useful for randomly selecting taps without affecting their levels.
Tap levels	The per-tap levels are randomized.
Tap pans	The left-right pans/balances of the taps are randomized.
Tap filter cuts	The cutoff frequency of each tap's filter is randomized. This has no effect on the sound if the filter type is set to NONE.
Tap filter Qs	The resonance (Q) of each tap's filter is randomized. This has no effect on the sound if the filter type is set to NONE.
Tap filter types	The type of the multi-mode filter for each tap is randomly set to one of NONE, LP (lowpass), BP (bandpass), or HP (highpass).
Tap pitch shifts	The pitch shift applied to each tap output is randomly set to an integer value between -16 and +15 semitones.
Tap detunes	The detuning (slight pitch shift amount) applied to each tap is randomly set to a value from -32 to +31 (a value of 32 corresponds to one semitone)

Rand. Destination	Description
All taps	The per-tap parameters (MUTE, LEVEL, PAN, CUT, Q, TYPE, PITCH SHIFT, DETUNE) are all randomized.
All delay	All of the rhythm delay global parameters are randomized, except for RAND. DESTINATION, TIME, and WET/DRY amount.
All taps & delay	All the per-tap and global rhythm delay parameters are randomized (i.e. the combination of the two previous settings - All taps and All delay).
All comb	All of the comb resonator section parameters are randomized, except for COMB SIZE and CLK SRC.
All delay & comb	All the global rhythm delay parameters and all the comb parameters are randomized.
All	All the per-tap and global rhythm delay parameters and all the comb parameters are randomized.
Random	Randomly selects one of the 15 modes listed above.

- **2 - TAP : GRID** Displays the current GRID and STACK settings. Turning the rotary encoder will change the GRID value. The GRID value defines the relation between the BEAT TIME and the nominal tap delay times according to the formula :  $(tap\ delay\ time = BEAT\ TIME * tap\ number / GRID)$ . GRID values are expressed in multiples of Taps/Beat. As an example, if the GRID value is 4 / beat, this means that the nominal delay time for tap #4 will be equal to the BEAT time, the nominal delay time for tap #8 will be equal to twice the BEAT time, and so on. The BEAT TIME is the time value shown in the CLOCK : TIME display screen. The actual delay time for a tap will deviate from its nominal value depending on the selected GROOVE TYPE and GROOVE amount. Possible GRID values are 1, 2, 3, 4, 6, 8, 12 and 16.
- **3 - TAP : STACK** Displays the current GRID and STACK settings. Turning the rotary encoder will change the number and size of the tap stacks. A tap “stack” is a collection of taps that are all given the same delay time, which will be the delay time of the last tap in the stack. Making stacks of taps is useful when you want to apply multiple effects at a given time. For example, you can make a four-note Major 7th chord by selecting 4 stacks of 4 taps, setting the levels of taps #1, 2, 3 and 4 to maximum with all other taps muted or set to zero level, and setting tap #1 to have a pitch shift of 0, tap #2 to have a pitch shift of +4, tap #3 to have a pitch shift of +7, and tap #4 to have a pitch shift of +11. Then an input sound will be echoed with a delay time equal to the tap delay time for tap #4, but will be harmonized as a Maj7 chord.
- **4 - CLOCK : TIME** Displays the current beat time in milliseconds and in beats per minute (BPM), as well as the clock division factor. Turning the rotary encoder will change the beat time. If there is a clock signal connected to the (left-hand) CLK input, the beat time will follow the clock period, multiplied by the clock division factor, and the rotary encoder will have no effect. The beat time can also be changed by pushing the large white TEMPO button repeatedly. Pushing on the encoder while rotating it will change the Time value in larger increments, to speed up going from one time setting to another.

- **5 - CLOCK : DIV** Displays the current beat time in milliseconds and in beats per minute (BPM), as well as the clock division factor. Turning the rotary encoder will change the DIV (clock division factor) value. When a clock signal is connected to the (left-hand) CLK input jack the beat time will follow the period of the clock signal, multiplied by the DIV value. Possible DIV settings are /1, /2, /3, /4, /6, /8, /12, /16, /24, /32, /48, /64, /96, /128, /192, /256.
- **6 - TIME MOD : WAVE** Displays the waveshape, level, and rate of the rhythm delay time modulation LFO (low-frequency oscillator). Turning the rotary encoder will change the shape of the modulating waveform. Possible settings are : OFF (no modulation), Sinusoid, Triangle, Vibrato 1, Vibrato 2 (a faster vibrato), Down Chirp (a sinewave with decaying frequency), Up Chirp (a sinewave with increasing frequency), Random.
- **7 - TIME MOD : LEVEL** Displays the waveshape, level, and rate of the rhythm delay time modulation LFO. Turning the rotary encoder will change the amount of modulation applied to the tap delay times. The Level setting ranges from 0 (no modulation) to 15 (time modulation of 10 msec in amplitude).
- **8 - TIME MOD : RATE** Displays the waveshape, level, and rate of the rhythm delay time modulation LFO. Turning the rotary encoder varies the period or rate of the modulation LFO. Rate values are displayed in Hertz (Hz). Pushing on the encoder while rotating it will change the Rate value in larger increments, to speed up going from one rate setting to another.
- **9 - GRAIN : QTY** Displays the number and size of grains used by the granular pitch shifters. Turning the rotary encoder changes the number of grains (Quantity). Possible choices are 1, 2, 4, and 1, no envelope. The grain shape is triangular for the first 3 settings, but is rectangular for the final setting (1, no envelope). If more than 1 grain is used, the grains will overlap in time. For Quantity = 2 the overlap is fixed at 50%. In the case of Quantity = 4 the overlap is nominally 25%, but there is a small random shift in time for each grain. This is added to prevent excessive comb filtering that would otherwise result.
- **10 - GRAIN : SIZE** Displays the number and size of grains used by the pitch shifters. Turning the rotary encoder changes the size (time interval) of each grain. Possible choices are 5 msec, 10 msec, 21 msec, 42 msec, 84 msec, 168 msec, 336 msec and 671 msec.
- **11 - FEEDBACK : TAP#** Displays the left and right channel feedback tap numbers, and the feedback time slip amount. When first entering this display page, the left channel’s feedback tap# is highlighted. Pressing the button again will highlight the right channel feedback tap#. When Tap# L is highlighted, turning the rotary encoder will change both the L and R feedback tap#s. When Tap# R is highlighted then only the Tap# R value will change. Possible values range from 1 to 16, indicating that feedback is taken from the associated delay line tap. There are two additional settings available, however. When set to “ALL”, the feedback is taken from the post-filter, post-tap-mix output. In this case there is no pitch shifting applied. When set to “COMB SIZE” the feedback is taken from a variable position tap whose delay time is set to be equal to the COMB SIZE parameter. This allows the COMB SIZE controls (e.g. the 1V/oct input) to adjust the feedback time. This can be used to provide short, tuned, feedback effects without altering the rhythm of the 16 rhythm delay line taps.
- **12 - FEEDBACK : SLIP** Displays the left and right channel feedback tap numbers, and the feedback time slip amount. Turning the rotary encoder will fine tune the feedback delay time either ahead or behind the selected tap’s delay time. This can be used to provide “rushing/dragging” echo effects. Possible values range from -16 to 0 (no offset) to +15. The extreme settings (-16 and +15) provide an offset of 1/2 the nominal delay interval (the interval with the groove amount set to 0) between taps.

- **13 - FEEDBACK : PITCH** Displays the pitch shift and detune amounts for the left and right feedback channels. When this display page is first entered, the Pitch L parameter is highlighted, and turning the rotary encoder will change *both* the Pitch L and Pitch R values. Pressing the button again will highlight the Pitch R parameter. Turning the rotary encoder will then change only the Pitch R value. Pressing the button again will highlight the Detune L parameter, and turning the rotary encoder will change *both* the Detune L and Detune R parameters. Pressing the button again will highlight the Detune R parameter, and turning the rotary encoder will change only the Detune R parameter. Pressing the button once more will bring the display back to the initial case, where the Pitch L parameter is highlighted.
- **14 - GROOVE : TYPE** Displays the GROOVE type and the GROOVE amount. Turning the rotary encoder changes the groove type. A groove is a set of relative timings for the 16 rhythm delay taps. The simplest groove is the “Straight” groove, in which the taps are evenly spaced in time. In the “Swing” groove the time interval between taps alternate between one-third of a beat and two-thirds of a beat. There are 16 different groove types available, as listed in the following table. The timings shown in the table are approximate - the actual timings have a higher resolution.

Groove Type	Groove Timing Pattern
Straight	
Swing	
Hard Swing	
Reverse Swing	
Alternate Swing	
Accelerando	
Ritardando	
Waltz Time	
Half Swing	
Roller Coaster	

Groove Type	Groove Timing Pattern
Quintuple Time	
Uniform Random1	
Uniform Random2	
Uniform Random3	
Early Reflection	
Late Reflection	

- **15 - GROOVE : AMT** Displays the groove amount. A groove amount of 0 gives the default “Straight” groove pattern, where the tap delay times are equally spaced. A groove amount of 100 gives the selected Groove type pattern. Groove amounts between 0 and 100 provide a blending of the Straight and selected Groove type patterns. This is useful, for example, when adjusting the amount of “Swing”, when the Groove type is set to “Swing”. Turning the rotary encoder changes the groove amount. Pressing down on the rotary encoder while turning it increases the encoder step size to speed up the entry.
- **16 - REVERSE+WET/DRY** Displays whether the Reverse effect is on or off, and the internal rhythm delay wet/dry mix. When this display page is first entered, the Reverse mode is highlighted and turning the rotary encoder clockwise turns the Reverse effect ON, while turning it counter-clockwise turns the effect OFF. When Reverse is turned ON, the input buffer is played back in reverse through the rhythm delay line for a time equal to the feedback tap time. At the end of this time the playback jumps to the current time and starts playing backwards again. See the diagram on the next page for a depiction of the reverse mode’s operation. The reverse mode can also be turned on or off with the TRIGGER button or TRIG signal (see the description of the TRIGGER action later in the manual).

When the REVERSE-WET/DRY button is pressed again, the Wet/Dry mix will be highlighted. Turning the rotary encoder will change the Wet/Dry value. The Wet/Dry mix adjusts the mixing of the input and the output of the rhythm delay line. This is useful, for example, when the module is configured to have the rhythm delay follow the comb resonator. The effect of the internal rhythm delay wet/dry mixer is distinct from that of the global Wet/Dry mix control located on the module’s front panel. That control adjusts the mixing of the module’s overall input (from the two jacks INL and INR located on the lower left had part of the panel) and the module’s overall output.

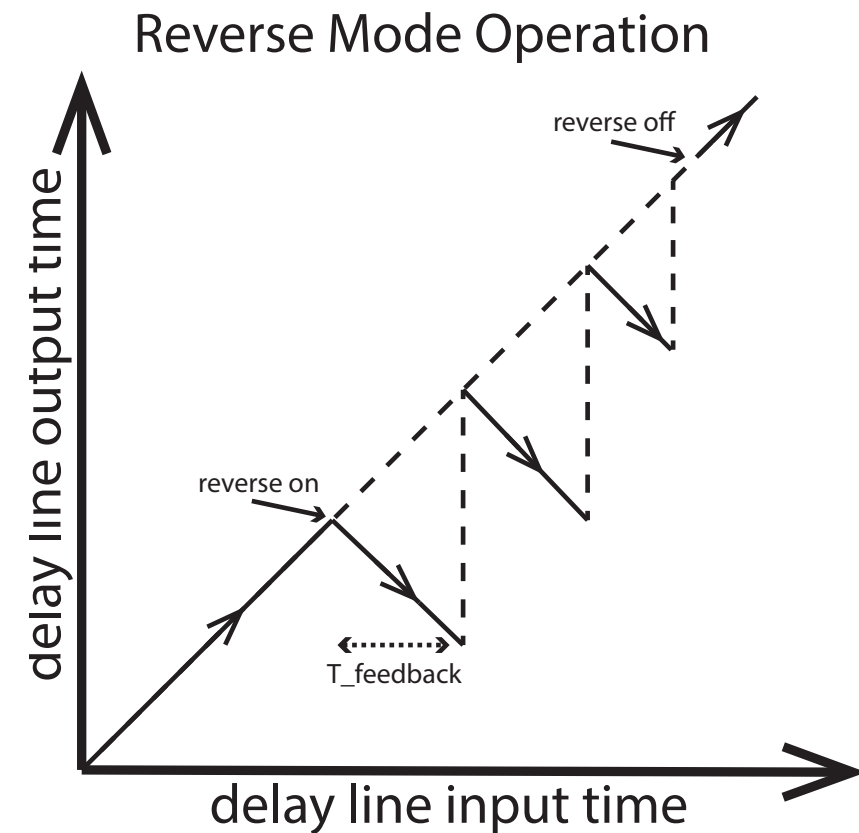


Figure 4. Delay line read pointer behaviour when “reverse” is activated.

- PING-PONG** When displaying the TAP# (11) or SLIP (12) edit pages, the PING-PONG state can be toggled on or off. This is done by pressing the rotary encoder. When PING-PONG is turned on, a little crossed-arrows icon will appear to the right of the FEEDBACK label on the top line of the display, as shown in the figure below. When PING-PONG is turned on the LEFT and RIGHT feedback channels are swapped. That is, the LEFT channel of the feedback tap output is fed back into the RIGHT channel of the rhythm delay input, and vice-versa. In this way a bouncing of echoes from side to side can be obtained.



Figure 5. LEFT: The TAP# edit display when Ping-Pong is OFF. RIGHT: The TAP# edit display when Ping-Pong is ON.

The “TAP EDIT” buttons allow the setting and display of the per-tap parameters. The per-tap parameters are as follows:

- MUTE** Mutes/un-mutes the selected tap. When muted, the output for that tap is removed from the rhythm delay output sum.
- LEVEL** Adjusts the gain applied to the tap output before summing with the other taps. The range of values is 0 to 15, with the corresponding gains increasing exponentially (so that, for example, the gain increases more from value 14 to 15 than it does from 1 to 2). A value of 0 will set the gain to zero, effectively muting that tap. Every tap that has a gain of more than 0 will have its corresponding tap# LED lit up (these are the numbered LEDs in the upper left hand part of the module). This provides a convenient way to see which taps are active, and contributing to the rhythm delay output.
- PAN** The action of this parameter setting depends on the module’s configuration (STEREO or MONO). In the stereo configurations, it acts as a *balance* control, while in the mono configurations it acts as a *pan* control. The range of values is from 7L (panned fully left, or balanced so that just the left channel comes through) through 0 (panned to center, or balanced so that both the left and right channel are at full level), to 7R (panned fully right, or balanced so that just the right channel comes through).
- CUT** Adjusts the cutoff frequency of the tap’s multimode filter. The range of values is from 0 to 4095. These values are approximately equal to the cutoff frequency in Hertz. When the tap filter is configured as a lowpass filter, then the frequencies above the cutoff frequency will be attenuated. Conversely, When the tap filter is configured as a highpass filter, then the frequencies below the cutoff frequency will be attenuated. When configured as a bandpass filter, the frequencies above AND below the cutoff frequency will be attenuated. When the filter type is set to None, the filter is bypassed and the CUT setting has no effect. Pushing on the encoder while rotating it will change the CUT value in larger increments, to speed up going from one cutoff frequency setting to another.
- Q** Adjusts the resonance (or Q) of the tap’s multimode filter. There is a range from 0-15 for the Q value. Higher values give higher filter Q. At high Q values the filter will strongly emphasize those frequencies near the filter’s cutoff frequency. The filter is easily overdriven at high Q values leading to distortion. This can be a useful effect, but if it is undesired, the input level should be reduced.
- TYPE** Allows the tap’s multi-mode filter to be configured as either - None (in which case there is no filtering applied), Lowpass, Bandpass, and Highpass.
- PITCH SHIFT** The pitch of the selected tap’s output is shifted by a multiple of semitones. The range is from -16 to +15 semitones. Negative values will shift the pitch to lower frequencies while positive values will shift the pitch higher.
- DETUNE** This parameter is accessed by pressing the PITCH SHIFT button a second time. The DETUNE is a small (less than 1/2 a semitone) pitch shift. It is added to the pitch shift amount set via the PITCH SHIFT button.

The TAP EDIT buttons have different functions depending on whether the module is in EDIT mode or TAP# mode, as indicated by the LEDs under the EDIT/TAP# button. When in TAP# mode, pressing one of the TAP EDIT buttons selects one of the parameters to edit one tap at a time. The OLED display will indicate the parameter being edited (on the first line at the top of the display), and the values of the parameter for all 16 taps will be shown in a bar graph at the bottom of the OLED display. The tap that is being edited at any given time is determined by pressing its associated numbered button in the two rows of buttons in the upper left of the module, and will be distinguished in the display by an outlined bar (the other bars will be filled). The LED for the tap number being edited will flash. The LEDs for all taps whose *level* is greater than zero will be lit. The number of the tap being edited will be indicated in the OLED display (on the second line from the top, at the left), along with its current value. (on the second line from the top, at the right) Turning the rotary encoder will change the value of the selected parameter for that particular tap.

The exception to this behaviour is for the mute parameter. When MUTE is selected, the tap LEVEL parameter values will be displayed. If one of the numbered tap select buttons is pushed while MUTE is selected, the mute value (on or off) for that tap number will be toggled (i.e. its value will switch from on to off or off to on). The mute status for a tap is indicated in the LEVEL display by having its bar shown with a crosshatched pattern. An example of the OLED display while editing the LEVEL for tap # 3 is shown in the figure below. In the figure, taps #1, #6, and #10 are muted.



Figure 6. An example of the display when editing the LEVEL parameter for tap #3. Taps 1, 6, and 10 are muted. The tap number (3) being edited is shown in the left hand part of the second line of text, and the value of that tap's LEVEL parameter (11) is shown in the right hand part of the second line of text.

When in EDIT mode the "TAP EDIT" buttons select which per-tap parameter is being displayed as in TAP# mode, but there is no editing of individual tap parameter values. Instead, if the rotary encoder is *pushed* while in this mode, then the selected parameter for all of the taps can be set at the same time to the same level. Turning the rotary encoder will move this level up or down. There are up to 32 different levels that can be set in this way (depending on which per-tap parameter is being edited). This is a quick way to set the parameter for all of the taps to the same value (e.g. set them all to zero or to the maximum value).

If the rotary encoder is pushed a second time then turning the rotary encoder will have a different behaviour, this time cycling between a set of preset ramp patterns. These patterns are shown in the figure below. This is a quick way to set the per-tap parameters to an increasing or decreasing or ramp, for example if you want to create a swell or decay in level, or a filter sweep.

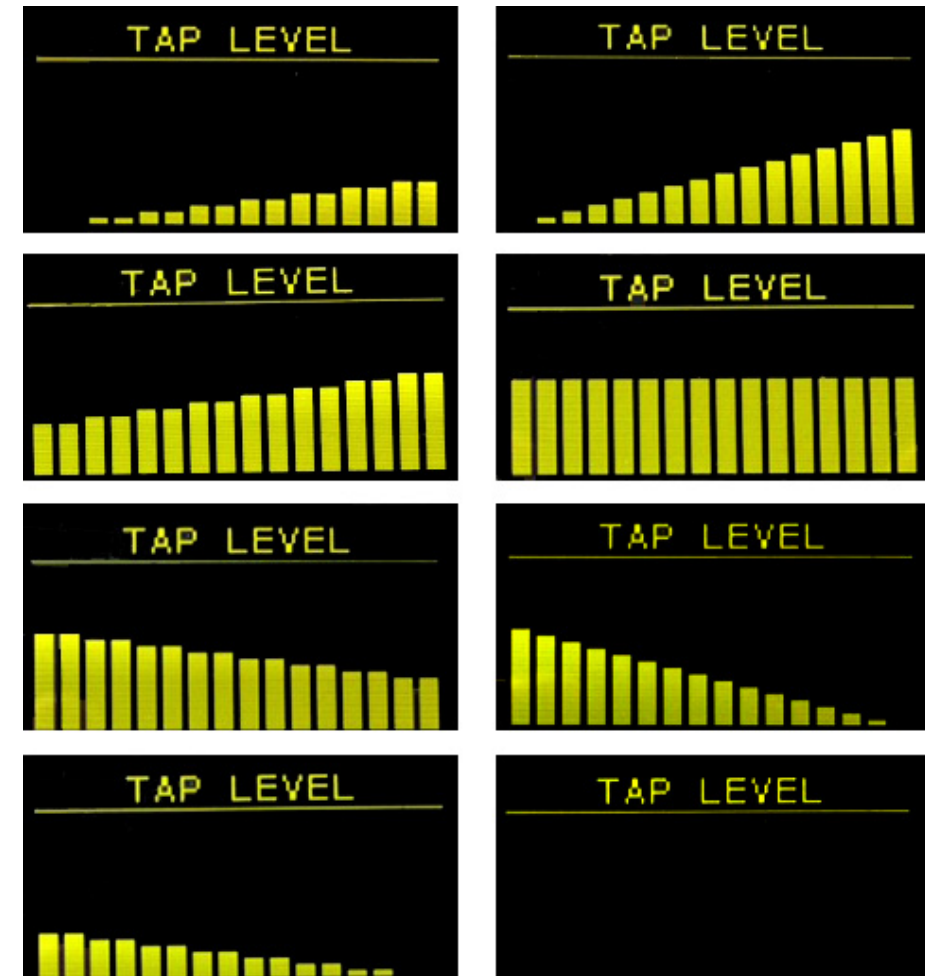


Figure 7. The set of 8 preset ramp-like per-tap parameter patterns. These patterns are accessed by pressing the rotary encoder twice while in EDIT mode.

Note that when going from EDIT to Tap # mode, the display will change from the current display mode to the last TAP EDIT mode previously selected. For example, suppose you are in EDIT mode and displaying the GRID edit display. Pressing the EDIT/TAP# button the first time after power-up, the display will change to the TAP LEVEL display. Now suppose you press the PAN button, bringing up the TAP BALANCE display. Upon pressing the EDIT/TAP# button, to go into EDIT mode, the display will stay in the TAP BALANCE display. Suppose then you press PILES, bringing up the TAP display with the Piles line highlighted. Then, pressing the EDIT/TAP# button to go back to TAP# mode will take you to the TAP BALANCE (pan) display, and not the TAP LEVEL display.



## Rhythm Delay Controls

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- **FX ON** The red button switches the rhythm delay effect on or off. When the effect is on the red LED to the right of the button will be constantly lit up. When the effect is off, the LED will also be turned off. When the effect is turned off the rhythm delay section input signal is passed directly to the rhythm delay output. That is, the FX ON button acts as a *bypass* switch.
- **MUTE** Mutes/un-mutes the rhythm delay section. When the rhythm delay effect is muted, the red LED in between the FX ON and MUTE buttons will flash on and off. The muting effect is on the input to the rhythm delay, and when muted the rhythm delay input will be set to zero. The output will continue to regenerate if the delay feedback is turned up.
- **DELAY FEEDBACK** This potentiometer controls the amount of the rhythm delay feedback tap that is mixed in with the input signal. The source of the feedback signal can be edited by pressing the FEEDBACK:TAP # button when the EDIT LED is lit.
- **PITCH SHIFT** Turning this knob will adjust the amount of the global pitch shift that is added to all 16 rhythm delay taps. It has a range of approximately +/- 2 octaves. It does not affect the pitch of the feedback signal. There is a dead band around the 12 o'clock position of the knob where the pitch shift is set to zero.
- **FEEDBACK TONE** The feedback signal is passed through a first order lowpass/highpass filter before being mixed with the input. At the 12 o'clock position the filter is flat, and all frequencies are passed through unattenuated. Turning the knob clockwise will produce a highpass effect, with the cutoff frequency increasing as the knob is turned. Turning the knob counter-clockwise will produce a lowpass effect, with the cutoff frequency decreasing as the knob is turned.
- **CLEAR** Pressing this button will clear both the rhythm delay and comb delay line memory. This is useful for eliminating persistent echoes that are unwanted when changing presets, or noise caused by excess feedback. The TRIGGER button and TRIG input can also be configured to clear the memory when activated.
- **TRIGGER** Pressing the big red button will generate a trigger event. The behaviour of the module to a trigger event is set in the ROUTING+CONFIG edit display (see the description of this display in section 9 of the manual). Likewise, a positive going pulse on the TRIG input jack will also generate a trigger event.

## Input/CV/Output Jacks and Attenuators

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The bottom part of the module contains the 1/8" jacks that are used to bring audio signals, trigger and timing clock signals, and control voltages into the unit, as well as jacks for outputting the tempo clock and the processed audio. Each input has an attenuator control which adjust the amount of the signal that passes into the module.

- **INPUTS** Provides the Left (IN L) and Right (IN R) channel inputs to the module. The routing of the inputs to the rhythm delay and the comb depend on the settings made in the ROUTING+CONFIG edit screen (see section 9 of this manual). There is an arrow pointing from the IN L jack to the IN R jack marked on the panel. This indicates that the IN L jack is *normalled* to the IN R jack. This means that if no cable is plugged into the IN R jack, then the signal being input to IN L will be passed to IN R.
- **DELAY** This section contains control voltage inputs for the rhythm delay feedback amount, global pitch shift (applied to all taps) and the feedback filter tone control. These control voltage signals are added to the voltages from the DELAY FEEDBACK, PITCH SHIFT, and FEEDBACK TONE potentiometers. This section also includes the TRIG and CLK inputs. Positive going pulses at the TRIG input will generate trigger events, and a repetitive square wave signal input to the CLK input will override the TEMPO button and set the DELAY CLOCK time (beat time) to the period of the CLK input wave, multiplied by the DELAY CLOCK DIV value.
- **COMB** This section contains control voltage inputs for the comb feedback amount and the comb size. These control voltage signals are added to the voltages from the COMB FEEDBACK and COMB SIZE potentiometers. There is also the 1V/OCT control voltage input. When the CLK SRC parameter is set to COMB SIZE then the comb size will follow the sum of the COMB SIZE control voltage, the voltage from the COMB SIZE potentiometer and the 1V/OCT signal. Each 1 volt increase in the 1V/oct signal will cut the comb size in half. Note that the 1V/OCT input does not have an associated attenuator. This is to ensure that the 1V/OCT relation between the 1V/OCT input and the comb size always follows the correct exponential function. The SIZE input, on the other hand, does have an attenuator, therefore the relationship between the SIZE control voltage and the comb size is not necessarily 1 volt per octave. This section also includes a CLK input. When the CLK SRC parameter is set to COMB CLK a repetitive square wave signal input to the CLK input will set the comb size to the period of the CLK input wave, multiplied by the comb CLK DIV value.
- **MOD** This section includes the two control voltage inputs for the MOD A and MOD B signals. These signals can be directed to one of many different parameters that do not already have direct voltage control inputs of their own. The MOD A input is normalled to MOD B, i.e. when there is no cable plugged into the MOD B jack, the signal from MOD A is connected to MOD B as well. Both of the MOD A and MOD B inputs have an attenuator, which can be used to adjust the amount of modulation.
- **OUTPUTS** There are three outputs for the module - OUT L, OUT R and CLK. OUT L and OUT R are the left and right channel audio outputs. CLK is a 0 to +5V square wave signal derived from the flashing TEMPO LED (the yellow LED in the middle right side of the module). The period of the CLK output wave is equal to the rhythm delay's DELAY CLOCK Time (or BEAT TIME). This can be used to synchronize other modules or devices, such as LFOs to the rhythm delay beat time.

## Comb Parameter Editing

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This section contains the main controls and parameter setting buttons for the comb effect.

- PATT+SLOPE** Displays the comb tap time pattern, the slope of the tap levels, and the number of taps. When this button is first pressed, the selected pattern is highlighted. Turning the rotary encoder changes the selection of the comb tap time pattern. There are 16 different tap time patterns: Uniform, Flat Middle, Early Comb, Fibonacci, Flat Comb, Late Comb, Rev. Fibonacci, Ess Comb, Rand Uniform, Rand Middle, Rand Early, Rand Fibonacci, Rand Flat, Rand Late, Rend Rev. Fib, and Rand Ess. The latter 8 patterns are perturbed versions of the first 8 patterns. The relative tap timings in the 16 patterns are shown in the figure below.

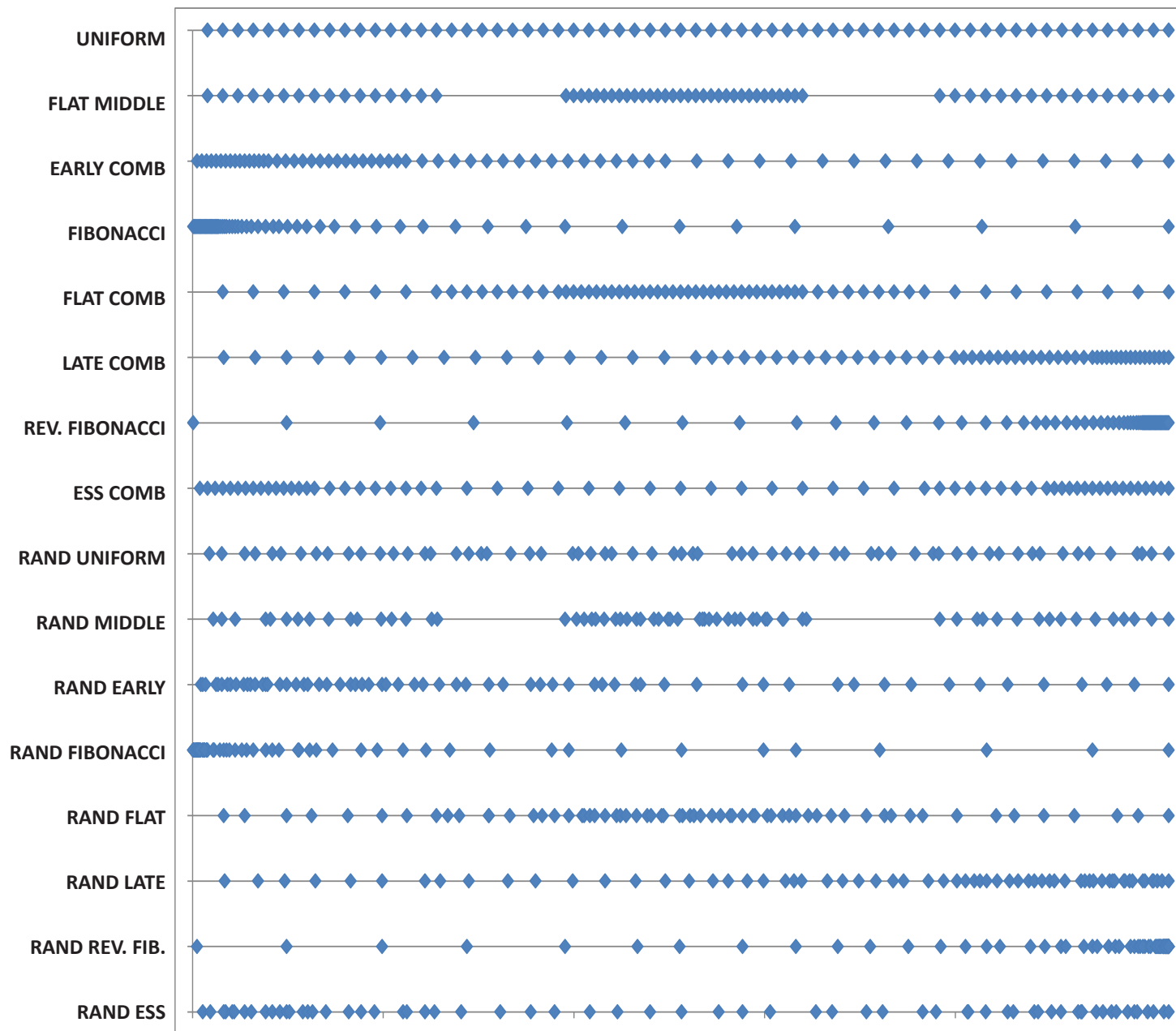


Figure 8. The 16 different comb tap time patterns.

Pressing the PATT+SLOPE button a second time will highlight the Slope parameter, and turning the rotary encode will change the slope pattern to either Flat, Rising, Falling, or Rise/Fall. The slope patterns alter the relative amplitude or level of the tap signals before they are summed. At large comb sizes this is useful for creating crescendos, swells, or decaying sounds. At short comb sizes the different slope patterns give different timbres to the resonant sound.

- SIZE MOD : WAVE** Displays the waveshape, level, and rate of the rhythm delay time modulation LFO (low-frequency oscillator). Turning the rotary encoder will change the shape of the modulating waveform. Possible settings are : OFF (no modulation), Sinusoid, Triangle, Vibrato 1, Vibrato 2 (a faster vibrato), Down Chirp (a sinewave with decaying frequency), Up Chirp (a sinewave with increasing frequency), Random.
- SIZE MOD : LEVEL** Displays the waveshape, level, and rate of the rhythm delay time modulation LFO. Turning the rotary encoder will change the amount of modulation applied to the tap delay times. The Level setting ranges from 0 (no modulation) to 15 (time modulation of 10 msec in amplitude).
- SIZE MOD : RATE** Displays the waveshape, level, and rate of the rhythm delay time modulation LFO. Turning the rotary encoder varies the period or rate of the modulation LFO. Rate values are displayed in Hertz (Hz). Pushing on the encoder while rotating it will change the Rate value in larger increments, to speed up going from one rate setting to another.
- TAPS+FB** Displays the comb tap time pattern, the slope of the tap levels, and the number of taps. When this button is first pressed, the #Taps parameter is highlighted, and turning the rotary encoder will change the number of taps. This parameter defines the number of taps being summed to provide the comb output and ranges from 1 to 64. As the #Taps value is reduced from 64, taps will drop out of the sum being sent to the output. This dropping of taps is done in a way which makes the distribution of taps as uniform as possible. The order of taps dropping out is shown in the figure below. Tap 64 is always sent to the output.

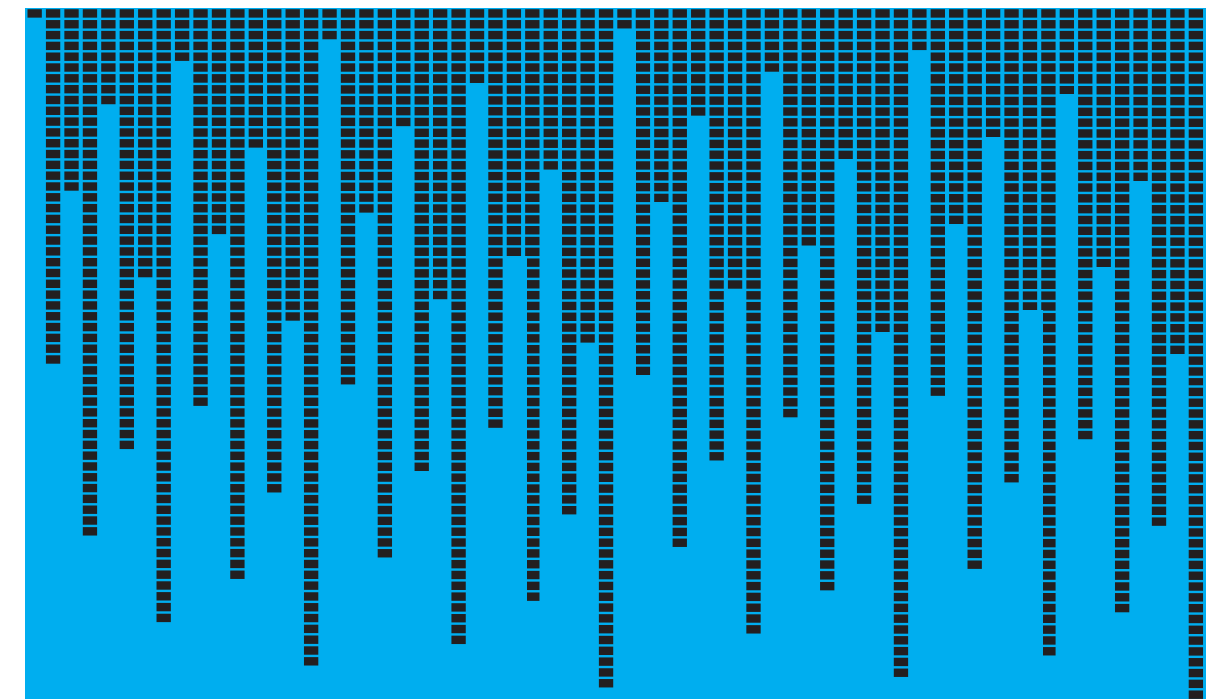


Figure 9. The comb taps included (black squares) in the comb output sum as a function of the number of taps (decreasing from top to bottom from 64 down to 1)..

When the TAPS+FB button is pressed a second time the COMB FEEDBACK edit page is displayed. This allows the configuration of the feedback filtering and feedback path nonlinearity. There are four possible settings:

- ◇ **Guitar** In this configuration there is no nonlinearity, and the feedback filter is set to a simple exponential averaging. This gives a structure similar to that used in the classic Karplus-Strong string synthesis, hence the name “Guitar”.
- ◇ **Sitar** In this configuration the feedback filtering is the same as for guitar, but there is an added nonlinearity in that the comb size is modulated slightly by a rectified version of the comb input signal. This models the effect of the curved bridge of a sitar, where the length of the string changes slightly depending on the string’s displacement. The effect of the nonlinearity is only noticeable at higher feedback levels and is most pronounced when doing pitch bends (i.e. when the comb size is changing).
- ◇ **Clarinet** In this configuration the feedback filtering is the same as for guitar, but there is a nonlinearity in the feedback path. This causes the generation of odd harmonics, giving the sound a “hollow” character similar to that of a square wave.
- ◇ **Raw** In this configuration the output of tap #64 is fed directly back into the input, with no filtering or nonlinearity applied.

Don’t be afraid to turn up the comb feedback beyond the point where self-oscillation occurs! By using the 1V/OCT input to control the comb size, you can “play” the comb resonator as a sound source, since the frequency of the self-oscillation will be determined by the comb size. The sound of the self-oscillation will be different in the different COMB FEEDBACK modes. The cleanest sound is obtained when in Clarinet mode, while the Sitar mode will give a more haotic noise unless the feedback level is very close to the self-oscillation threshold. The Raw mode will give the typical distorted amp feedback sounds, while the Guitar mode will give an interesting noisy phased sort of sound.

- **CLK SRC** Displays the clock source (highlighted), the current comb time in milliseconds, and the clock division factor. Turning the rotary encoder will change the source of the signal defining the comb size. The choices are COMB CLK, COMB SIZE, and Encoder. When *COMB CLK* is selected, and a clock signal is connected to the (right-hand) CLK input jack, the comb size will follow the period of the clock signal, multiplied by the CLK DIV value. In this situation the COMB SIZE potentiometer, the SIZE input, and the 1V/OCT inputs will have no effect.

When *COMB SIZE* is selected, the comb size will be set by the sum of the 1V/OCT input, the SIZE input and the COMB SIZE potentiometer setting. In this mode the comb size is affected by the CLK DIV setting, where doubling the CLK DIV value will double the comb size. This is useful in setting the overall range for the comb size controls.

When *Encoder* is selected, then the comb size can only be changed by turning the rotary encoder, while in the SIZE display mode (see below). In this situation the comb CLK, SIZE, and 1V/OCT inputs, the COMB SIZE potentiometer, and the CLK DIV setting will not have any effect.

Note that the COMB SIZE control voltage signal has some low level noise, which can cause small random jumps in the comb size, resulting in audible glitches in some situations, particularly when using large comb sizes. In these cases you should set the COMB SIZE to Encoder unless you really need to have the voltage control over the comb size.

When *DLY CLK/T* is selected the comb size will follow the rhythm delay time. This is useful for synchronizing the comb and rhythm delay effects.

- **CLK DIV** Displays the clock source, the current comb size in milliseconds, and the comb clock division factor (highlighted). Turning the rotary encoder will change the CLK DIV (clock division factor) value. Possible DIV settings are /1, /2, /3, /4, /6, /8, /12, /16, /24, /32, /48, /64, /96, /128, /192, /256.
- **SIZE** Displays the clock source, the current comb size (highlighted), and the clock division factor. The comb size is the delay time of the 64th tap in the comb. This tap has the longest delay time, so the comb size gives the overall delay of the comb. The comb size is determined in one of three different ways, which are selected by the CLK SRC setting (see above). The first way is to use the rotary encoder to directly specify the comb size in milliseconds. This is enabled when CLK SRC is set to “Encoder”. This is useful when you want to dial in a precise, fixed, comb size value. When CLK SRC is set to “COMB CLK” the comb size is determined by the period of the clock signal present at the (right-hand) CLK input, multiplied by the current CLK DIV setting. This mode is useful for syncing to an external LFO or MIDI clock signal, for example. When CLK SRC is set to “COMB SIZE”, then the comb size value is determined by the sum of the 1V/OCT, SIZE, and COMB SIZE potentiometer voltages and by the CLK DIV setting. When the module is properly calibrated (done at the factory), the comb size will be cut in half for every 1 volt increase in the 1V/OCT input signal. This mode is used when you want tuned resonances, for example when using the comb for Karplus-Strong string synthesis. The SIZE input and the COMB SIZE potentiometer provide linear offsets to the 1V/OCT signal (much like the Transpose control on a VCO).
- **FX ON** Switches the comb effect on or off. When the effect is on the red LED to the right of the button will be constantly lit up. When the effect is off, the LED will also be turned off. When the effect is turned off the comb section input signal is passed to the comb output. That is, the FX ON button acts as a *bypass* switch.
- **MUTE** Mutes/un-mutes the comb section. When the comb effect is muted, the red LED in between the FX ON and MUTE buttons will flash on and off. The muting effect is on the input to the comb, and when muted the comb input will be set to zero. The output will continue to regenerate if the comb feedback is turned up.
- **COMB SIZE** When CLK SRC is set to COMB SIZE, this potentiometer is added to the 1V/OCT and SIZE control voltage inputs and together determine the size of the comb (i.e. the delay time of the 64th tap).
- **COMB FEEDBACK** This potentiometer adjusts the amount of signal fed back from the last (64th) tap in the comb to be mixed with the input. The potentiometer voltage is added to the FEEDBACK control voltage.

This section includes three potentiometers and three buttons.

- TEMPO** The big white button is a TAP-TEMPO input. Press the button with a regular repetitive rhythm will set the delay time (beat time) to the average interval between the last 3 button presses. If more than 10 seconds elapse between button presses the previous taps are ignored and 3 more taps are needed to specify the tempo. If an active clock signal is input to the CLK jack in the DELAY section, the tap tempo setting will be overridden by the clock. The yellow LED beneath the TEMPO button flashes with a period equal to the delay time.
- MIX** The module's audio output (OUTL and OUTF) is obtained by mixing the input to the module (IN L and IN R) with the effects' outputs (the precise source of the effect output depends on the module's routing configuration - see section 9 of the manual). The mixing is done in the analog domain, not digitally. The relative mixture of the input and effect output is controlled by the MIX potentiometer. When turned counter-clockwise, more of the module's input signal is passed to the module's output jacks ("DRY"), while when the potentiometer is turned clockwise, more of the effect output is passed to the module's output jacks ("WET").
- MOD A & MOD B** The MOD A and MOD B potentiometers and control voltage inputs provide a way to control parameters that do not have their own dedicated controls. Each control can adjust the value of one parameter at a time. Pressing the white buttons to the right of the MOD A and B potentiometers will display the MOD destinations (i.e. the parameters which are being controlled by the MOD signals). Turning the rotary encoder will change the selection of the destinations. However, the parameter to be controlled will not actually be selected until the rotary encoder is pushed. A "?" at the end of the line in the display indicates that the choice has not yet been selected. When the rotary encoder is pushed, then the "?" will disappear. The list of parameters that can be chosen is given in the following table.

MOD Destination	Description
None	No parameters are controlled by the MOD signal.
Tap Filter cut	The filter cutoff frequencies for all of the taps are offset by the MOD signal. Positive voltages will increase the frequencies while negative voltages will lower the frequencies.
Tap 3 Cut	The filter cutoff frequencies for only tap #3 is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
Tap 4 Cut	The filter cutoff frequencies for only tap #4 is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
Tap Balance	The balance/pan setting for all of the taps are offset by the MOD signal.
Tap Filter Q	The filter Q setting for all of the taps are offset by the MOD signal.

MOD Destination	Description
Grain Size	The grain size for the granular pitch shifter is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
FB Detune L	The detune amount for the left feedback channel is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
FB Detune R	The detune amount for the right feedback channel is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
FB Detune L&R	The detune amounts for both the left and right feedback channels are controlled by the MOD signal. This is not an offset, but directly overrides the current settings. In this case both channels will have the same detune.
FB Pitch L	The pitch shift amount for the left feedback channel is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
FB Pitch R	The pitch shift amount for the right feedback channel is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
FB Pitch L&R	The pitch shift amounts for both the left and right feedback channels are controlled by the MOD signal. This is not an offset, but directly overrides the current settings. In this case both channels will have the same detune.
FB Tap# L	The number of the tap whose output is fed back in the left feedback channel is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
FB Tap# R	The number of the tap whose output is fed back in the right feedback channel is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
FB Tap# L&R	The number of the tap whose output is fed back in both the left and right feedback channels are controlled by the MOD signal. This is not an offset, but directly overrides the current settings. In this case both channels will have the same detune.
Delay Mod Wave	The waveform selection for the rhythm delay modulation lfo is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
Delay Mod Level	The amplitude of the rhythm delay modulation lfo output is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
Delay Mod Rate	The oscillation rate of the rhythm delay modulation lfo is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
Groove Type	The selection of the rhythm delay's groove type is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.

MOD Destination	Description
<b>Groove Amount</b>	The selection of the rhythm delay's groove type is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
<b>Delay Wet/Dry</b>	The selection of the rhythm delay's wet/dry mix is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
<b>Comb Density</b>	The selection of the number of taps used by the comb resonator (aka the <i>comb density</i> ) is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
<b>Comb Pattern</b>	The selection of the comb resonator's pattern of tap spacings is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
<b>Comb Mod Wave</b>	The waveform selection for the comb size modulation lfo is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
<b>Comb Mod Level</b>	The amplitude of the comb size modulation lfo output is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
<b>Comb Mod Rate</b>	The oscillation rate of the comb size modulation lfo is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
<b>Stereo Spread</b>	Spreads the pan values of adjacent taps between left and right. This directly overrides the current settings.
<b>Preset #</b>	Sets the number of preset to load. Use this in conjunction with the preset load trigger function. This is not an offset, but directly overrides the current setting.
<b>All Tap Pitch</b>	Sets the per-tap pitch shift applied to all taps (all taps will have the same pitch shift value). This is not an offset, but directly overrides the current setting.
<b>Grid</b>	The GRID setting for the rhythm delay is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.
<b>Delay CLK DIV</b>	The DIV setting for the rhythm delay is controlled by the MOD signal. This is not an offset, but directly overrides the current setting.

## Utility Operations

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The red buttons on the upper right hand side of the module provide utility operations which determine the overall functioning of the module, as well as managing the storage of parameter values into presets.

- ROUTING+CONFIG** Pressing this button first brings up the routing display. Turning the rotary encoder selects between four different routings of the rhythm delay and comb effects. These routings are:
  - DLY > CMB** In this configuration the module's audio input is fed into the rhythm delay and the output of the delay is fed into the comb resonator. The module's audio output is taken from the comb output.
  - CMB > DLY** In this configuration the module's audio input is fed into the comb resonator and the output of the comb is fed into the rhythm delay. The module's audio output is taken from the delay output.
  - DLY + CMB** In this configuration the module's audio input is sent in parallel to both the rhythm delay and the comb resonator. The outputs of the delay and comb are summed and sent to the module's audio output.
  - L: DLY R: CMB** In this configuration the module's left channel audio input is sent to the rhythm delay's left input, and the delay's right input is set to zero. The module's right channel audio input is sent to the comb resonator's right input, and the comb's left input is set to zero. The delay's left channel output is sent to the module's left audio output and the comb's right channel output is sent to the module's right audio output.
- Pressing the ROUTING+CONFIG button a second time highlights the input mode. There are three different input modes available:
  - STEREO** In this configuration the left audio input signal is passed to the left channel of the delay/comb effects, and the right audio input signal is passed to the right channel of the delay/comb effects.
  - MONO L+R** In this configuration the two input channels, INL and INR, are summed and the sum is sent to both the Left and Right channels of the delay/comb effects.
  - MONO L** In this configuration the left input channel is sent to both the Left and Right channels of the delay/comb effects. In this situation the INR signal is ignored. A similar arrangement can also be had by using the STEREO input mode and leaving the INR jack unconnected. In that case the INL signal is normaled (directly connected) to the INR signal. The two situations are not exactly the same, since the right channel analog to digital converter is not used in the MONO L configuration, while it is in the STEREO case. Thus in the stereo case there may be slight differences between the left and right channels.
- Pressing the ROUTING+CONFIG button yet a third time displays the TRIGGER MODE display page. This page displays the operation that is controlled by the TRIGGER button and/or the TRIG external input. The Trigger operation is highlighted, and turning the rotary encoder selects the active trigger operation from the list of possible operations. The current state of the Freeze and Reverse operations (ON or OFF) is also displayed, but these are not changeable here. The list of possible Trigger operations is given in the table below.

Trigger Operation	Description
<b>Freeze</b>	When a trigger is received, the freeze state will toggle (if ON, it will turn OFF, and if OFF, it will turn ON). At the moment the freeze state is turned ON the read pointer for the rhythm delay will step back in time by an amount equal to the current Feedback Tap delay time. Playback will then read forward in time to the point at which the Freeze was turned on, and then loop back again. This continually repeats until the Freeze is turned off (by another Trigger event). Note that when Freeze is turned on the feedback has no effect, since the delay is now insensitive to the input. It is just playing back material that has already been recorded. However, any active taps will continue to sound, so echoes can be produced on the sound in the frozen buffer. The Feedback Tap delay time can be altered while Freeze is turned on, and the looping period will change accordingly. This can be used for interesting effects when the Feedback Tap is set to COMB SIZE, since the 1V/OCT and COMB SIZE control voltages can then be used to change the loop period.
<b>Reverse</b>	When a trigger is received the state of the Reverse effect will be toggled (if ON, it will turn OFF, and if OFF, it will turn ON). See section 3 of the manual for a description of the Reverse effect.
<b>Randomize</b>	When a trigger is received a Randomization event will occur. The parameters that are randomized by this event is determined by the randomization destination setting (see section 3 of the manual for details on this).
<b>Delay Mute</b>	When a trigger is received, the mute state of the rhythm delay will be toggled (if ON, it will turn OFF, and if OFF, it will turn ON).
<b>Comb Mute</b>	When a trigger is received, the mute state of the comb will be toggled (if ON, it will turn OFF, and if OFF, it will turn ON).
<b>All Mute</b>	When a trigger is received, the mute state of both the comb and delay will be toggled (if ON, it will turn OFF, and if OFF, it will turn ON). However, if the effect is already muted via pressing the front panel FX ON button, then the trigger will have no effect.
<b>Delay Bypass</b>	When a trigger is received, the bypass state of the rhythm delay will be toggled (if ON, it will turn OFF, and if OFF, it will turn ON).
<b>Comb Bypass</b>	When a trigger is received, the bypass state of the comb will be toggled (if ON, it will turn OFF, and if OFF, it will turn ON).
<b>All Bypass</b>	When a trigger is received, the bypass state of both the comb and delay will be toggled (if ON, it will turn OFF, and if OFF, it will turn ON). However, if the effect is already bypassed via pressing the front panel FX ON button, then the trigger will have no effect.

Trigger Operation	Description
<b>Ping Input</b>	When a trigger is received a short burst of noise (“ping”) will be added to the module’s input signal. This can be used to excite the resonator, for example to “pluck” a Karplus-Strong string.
<b>Shaped Pulse</b>	When a trigger is received a short smooth pulse will be added to the module’s input signal. This can also be used to excite the resonator, but produces a softer, less bright, sound than the noise ping.
<b>Toggle PingPong</b>	When a trigger is received, the PingPong state will toggle (if ON, it will turn OFF, and if OFF, it will turn ON). See section 3 for a description of the PingPong effect.
<b>Gated Freeze</b>	When the trigger input is high (or the trigger button is pressed) the rhythm delay will be frozen (see the “Freeze” trigger mode).
<b>Gated Reverse</b>	When the trigger input is high (or the trigger button is pressed) the rhythm delay will play in reverse (see the “Reverse” trigger mode).
<b>Preset Load</b>	When a trigger is received the currently selected preset is loaded.
<b>Clear Buffer</b>	When a trigger is received, the comb and delay memory will be cleared.

- **METERS+GAIN** Pressing this button brings up a display of the stereo signal levels at eight different points in the module, and also displays the overall gain applied to the outputs of the Rhythm Delay (DLY) and Comb (CMB). Pressing the METERS+GAIN button will toggle between the DLY gain and the CMB gain. Turning the rotary encoder will adjust the gain setting for the currently highlighted effect. Setting the gains is VERY IMPORTANT to avoid distortion. As more taps are activated in the rhythm delay, the DLY gain will need to be reduced. For one or two active taps a gain of 8 to 10 is typically, but if all sixteen taps are active a lower gain may be needed. If the per-tap filters are used, the DLY gain may have to be increased. Similarly, with the comb resonator, the CMB gain should be set to avoid distortion. Normally it will be around 8 to 10, but higher or lower levels may be appropriate depending on the level of the signal being fed in, or the amount of feedback being used.

The points in the system whose levels are shown in the eight meters are:

- ◇ **IN** The outputs of the Analog to Digital converters. This is the point where the analog input signals, INL and INR, are converted to digital form, and it is crucial that these levels be kept away from the maximum value, otherwise objectionable distortion may occur (unless you like that sort of thing). These levels can be adjusted by using the attenuator controls located directly above the INL and INR jacks. **For typical Eurorack signal levels, the attenuators will be set to the 12 o’clock position.** The attenuators can be turned further clockwise if lower level input signals are used.
- ◇ **OUT** The inputs to the Digital to Analog converters. This is the point where the digital outputs from the internal rhythm delay and comb resonator blocks are converted back to the analog domain. The analog outputs of the Digital to Analog converters are mixed with the analog inputs and sent to the OUTL and OUTR output jacks.

- ◇ **DLY : IN** This point is the input to the rhythm delay line memory, and is also the output of the mixer that combines the delay input with the delay feedback.
- ◇ **DLY : FBK** This point is the tap off of the rhythm delay line memory which is being fed back to the delay input. This level is controlled by the DELAY FEEDBACK amount.
- ◇ **DLY : OUT** This point is the sum of all 16 of the rhythm delay taps, and forms the output of the rhythm delay, which is then sent either to the comb resonator input, or directly to the module output, depending on the current module configuration. This level is controlled by the DLY GAIN (the number on the left of the top line of the display).
- ◇ **CMB : IN** This point is the input to the comb resonator delay line, and is also the output of the mixer that combines the comb input with the comb feedback.
- ◇ **CMB : FBK** This point is the output of tap number 64 of the comb resonator delay line that is being fed back to the delay input. This level is controlled by the COMB FEEDBACK amount.
- ◇ **CMB : OUT** This point is the output of tap number 64 of the comb resonator delay line, and forms the output of the comb, which is then sent either to the rhythm delay input, or directly to the module output, depending on the current module configuration. This level is controlled by the CMB GAIN (the number on the right of the top line of the display).
- **SAVE** This edit page allows the current module parameters and front panel knob positions to be stored in a non-volatile memory (i.e. the memory is retained even when the power is turned off). When the SAVE button is first pressed, the rotary encoder can be used to select which of the 128 different memory slots will be written to. Keep in mind that whatever was previously stored in this memory slot will be over-written. The preset number and preset name are displayed on the second line of the display. Note that the preset name will initially be that of the last preset that was loaded (preset #1 is always loaded on power up). If you want to change the preset name, press the SAVE button once more. Now, the rotary encoder will change the first character of the preset name. Scroll through the list until you reach the symbol that you wish to use. Then, press the SAVE button again. The rotary encoder will then change the second character, and so on. The preset name can have up to 10 characters. When you have entered the desired name, and are ready to save the preset, PUSH on the rotary encoder (ENC). The display will indicate a successful save operation by displaying an exuberant “Saved!” message.
- **LOAD** This edit page allows the contents of one of the preset memory slots to be loaded. This will overwrite the current module parameters with the stored values. It will also load in temporary values for the front panel knobs (i.e. the potentiometers with knobs, but not the attenuators). These temporary values will hold their level until the associated knob is moved by a certain amount from its current position. This means that right after loading a preset the visual appearance of the knob’s position may not match its actual value. The advantage is that knob positions can be stored in the preset, so for example if you had found a sweet spot with the pitch shift knob or the comb feedback level, this could be immortalized in a preset. Turn the rotary encoder to select which of the 128 presets you wish to load. The name of the preset will change along with the preset number, to match the name that was stored with the preset. To actually load the preset memory contents once you have scrolled to the desired preset number, PUSH on the rotary encoder (ENC). The display will indicate a successful load operation by displaying the “Loaded!” message. If the LOAD button is held down when the rotary encoder is pushed, just the parameters of the active effect (in the preset) will be loaded. This means, for example, if you saved a preset with the COMB effect turned off, then its parameters would not be loaded, and the previous parameter values would remain. This is useful when you want to combine the delay parameters from one preset with the comb parameters of another.

- **MIDI TRANSFER of PRESETS** If you press *BOTH* the SAVE and the LOAD buttons at the same time the PRESET MODE edit page will be displayed. This mode allows you to read from, or write to, the preset memory from an external computer or MIDI-capable patch storage device. When first entering this display mode, the display will show the “Connect USB ^” message. This refers to the USB micro connector on the top of the display board at the rear of the module. You will have to remove the module from the case to connect a USB cable to it. The power should still be connected, however. Connect a USB cable to your midi storage device (typically a computer). Once successfully connected (your computer may have to install the proper drivers first), the display will change to read “USB connected Waiting for SysEx”. SysEx is short for “System Exclusive”, which is a special type of MIDI message used to transfer patch data (among other things). You will need software on your computer that is able to send and receive patch using SysEx data transfers. There are many freeware software packages that can do the job. On PC compatible computers the program MIDI-OX is good for this.

The MIDI SysEx command strings for sending and receiving MIDI preset data are as follows:

To **download** one preset (from the Rainmaker module to the computer):

**0xF0, 0x00, 0x02, 0x14, 0x01, 0xNN, 0xF7** (where NN is the preset number in hex)

The response from the Rainmaker module will be a sysex stream which is in the form of an upload preset command (see below), so that it can be replayed back to a module to upload the preset.

To **download** all 128 presets at once:

**0xF0, 0x00, 0x02, 0x14, 0x02, 0xF7**

There will be a series of 128 responses as when downloading a single preset.

To **upload** a single preset (from the computer to the Rainmaker module):

**0xF0, 0x00, 0x02, 0x14, 0x00, 0xNN, 0xDD ... 0xCC 0xF7**

where 0xDD ... are the data bytes containing the preset parameter values.

## INSTALLATION

The Rainmaker module must be installed in a Eurorack standard (3U height) enclosure and fastened to the enclosure using appropriately sized screws through the front panel mounting holes. Please consult the specifications of your enclosure to determine the type of screws that are needed. These vary depending on the manufacturer of the enclosure, but are typically either M3x6 or 4-40 screws.

Before fastening the module into the enclosure, attach the power cable to the module and to the enclosure's power supply connector. The enclosure must have a power supply with Doepfer standard power connectors, and must provide +12V and -12V (a +5V supply is not needed by the Rainmaker module). The Rainmaker module draws nearly 300 mA of current from the +12V supply, so you must ensure that your enclosure's power supply has sufficient excess current capacity to handle this load. Connect the ribbon power cable to the Rainmaker module's power connector on the back of the module, with the red stripe on the ribbon cable at the bottom, as shown in the figure below. Also, ensure that the power cable to the FPGA board is connected properly (this should be installed at the factory, but may have come loose during shipping). The connector should be oriented so that the red wire is at the bottom, as shown in the figure below.

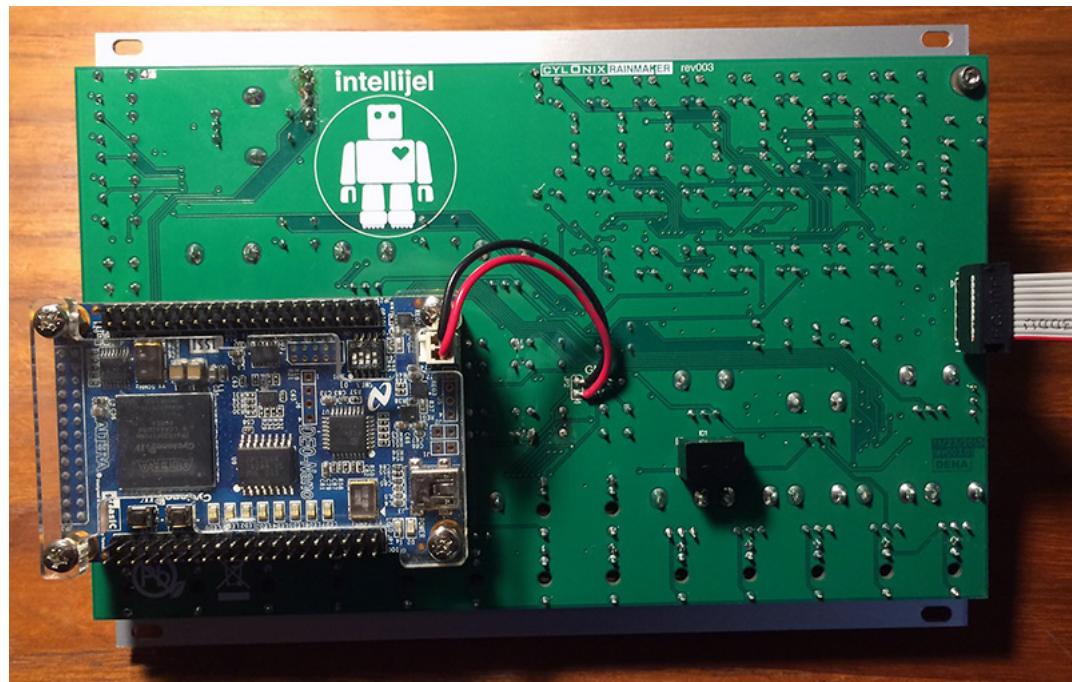


Figure 10. The rear view of the Rainmaker module, showing the FPGA board (lower left) and the power supply connector (at the middle right edge), with the red stripe of the power cable at the bottom.



### WARNING! ACHTUNG! CAUTION!

Do not connect the power connector to the eurorack's power supply backwards or offset in the socket. Damage to the module or to the power supply may result. Do not spill caustic fluids onto the module. Take care to not overly antagonize your band's drummer with the rock-solid beats generated by the Rainmaker.

## FACTORY PRESETS

There are 128 non-volatile memory slots into which you can store sets of parameter values. These can be recalled at any time by pressing the LOAD button, turning the rotary encoder to select the desired memory slot and then pressing the rotary encoder to execute the loading operation. Although these memory slots can be overwritten by the user, they come pre-filled from the factory with interesting preset configurations. These factory presets are listed and briefly described below. Presets 82 to 128 were created by Richard Devine.

- 1 - **1-Tap** : Basic single tap (tap #4) delay with no filtering or pitch shifting, 120bpm
- 2 - **Ping-Pong** : Basic two-tap ping-pong delay (taps #2 and #4)
- 3 - **BouncyPng** : Bouncy ping-pong delay
- 4 - **4NoteSwing** : 4-note swing delay
- 5 - **Slap-Back** : A very short slapback delay, good for vocals or drums
- 6 - **Panner** : Produces a set of echoes that pan across the stereo field
- 7 - **2 Swells** : Echoes that rise then fall in amplitude, then rise and fall again
- 8 - **16tap Beat** : 16 echoes with a beat that falls in amplitude as well as in filter cutoff
- 9 - **16tap Swell** : 16 echoes that rise in amplitude
- 10 - **16tapDecay** : 16 echoes that fall in amplitude as well as in filter cutoff
- 11 - **Up Chirp** : Delayed 160 msec up chirp, (MODA adjusts CUT, MODB adjusts Q).
- 12 - **Spectrm Up** : 80 msec spectral delay up chirp, (MODA adjusts CUT, MODB adjusts Q).
- 13 - **Spectr Dwn** : 80 msec spectral delay down chirp (MOD adjusts mod level and rate).
- 14 - **Descender** : Slow 2.8 sec spectral decay (MODA adjusts CUT, MODB adjusts Q).
- 15 - **Rand Reflx** : Echoes with random delay times (MODA adjusts CUT, MODB adjusts Q).
- 16 - **VocalThick** : Vocal thickener with two short slightly panned delays.
- 17 - **Krellverb** : Irregular echoes for alien reverbish effects
- 18 - **Rev Swell** : Reverse double swell delay
- 19 - **Triller** : Trill
- 20 - **Takeoff** : UFO takeoff rising pitch
- 21 - **Fanfare** : 5 note fanfare delay
- 22 - **Devo Octav** : Devo ring modulated octave repeats
- 23 - **II-V-I** : II-V-I chord progression using 4 piles of pitch-shifted taps to form chords
- 24 - **2Tap Res** : Two-tap resonant lowpasses (MODA and MODB adjust filter cutoff frequencies).
- 25 - **TechnoLoop** : Techno beat looper
- 26 - **Waltz Loop** : Waltz beat looper
- 27 - **FrmntChoir** : Formant choir, using 4 piles with 3 high-Q bandpass filters each
- 28 - **Chorus** : Thick chorus
- 29 - **FilterBank** : Four-filter filterbank rhythm
- 30 - **Up Gliss** : Upsweeper (change the feedback pitchshift amount to get different effects)
- 31 - **Down Gliss** : Downward sweeping pitch shifts
- 32 - **Sub Octave** : Adds a delayed suboctave to the input
- 33 - **Flanger** : Flanger (MODA adjusts the depth, and MODB adjusts the rate)



34 - **Resonator** : 63-tap comb resonator and delay  
35 - **Woodwind** : Another type of comb resonator sound  
36 - **Chorus Res** : Chorus resonator  
37 - **Wobblebug** : Wiggly wobbly comb resonator  
38 - **KarplusStr** : Karplus-Strong String (use 1v/oct, full wet, ping with TRIGGER)  
39 - **40tap Res** : Slow 40-tap resonator beat  
40 - **Bouncy Res** : Bouncy comb resonator  
41 - **Washboard** : Washboard comb  
42 - **1-Tap** : Whalesong reverb  
43 - **Overdrive** : Overdriven delay and resonator  
44 - **Dreamy Res** : Ethereal, dreamy resonator  
45 - **WahVerb** : Wah-wah reverb  
46 - **Pass Cars** : Passing cars doppler shift  
47 - **Bubble Png** : Bubbling pingpong delay and resonator  
48 - **Dual L/R** : Delay on the left, comb on the right  
49 - **Steel Drum** : A rattling steel drum delay  
50 - **Insects** : Insect swarm  
51 - **Roar Surf** : Roar of the surf  
52 - **NewAgeDrone** : New age drone  
53 - **ResoBeat** : Resonant beat loop  
54 - **Phantom Op** : Phantom of the opera  
55 - **Psycho Rpt** : Psycho repeats  
56 - **Tinny Beat** : Tinny beat  
57 - **Funky Drum** : Funky Drummer  
58 - **Psychedelc** : Psychedelic beat  
59 - **Film Noir** : Film noir soundtrack  
60 - **Very Slow** : Very slow swell  
61 - **Vibration** : Vibration  
62 - **ParaleVerb** : Parallel reverb  
63 - **LongReverb** : Long resonating reverb  
64 - **Symphony** : Symphony warmup  
65 - **Ping Arp** : Trigger to ping a rising arpeggio. MODA shifts the frequencies.  
66 - **Modal Ring** : Modal synthesis. Use with no input, TRIGGER causes pinging. Play with the MOD A to change the pitch.  
67 - **AllTapz** : MODA selects different rhythm grooves  
68 - **Delay\*Size** : Feedback time is set by COMB SIZE, use the encoder to change  
69 - **Xmod Echo** : Modulated delay. MODA controls mod level, MODB the mod rate.  
70-81 - **( empty )** : blank slots for you to fill with your masterpieces  
82 - **Alienizer** : Trigger randomizes tap mutes (i.e. randomly selects taps to hear)  
83 - **Berserker** : Trigger randomizes the delay parameters.  
84 - **ShortWave** : Trigger randomizes all comb and delay parameters.  
85 - **PitchFrac** : Trigger randomizes the tap pitch shifts.  
86 - **Transform** : Randomized tap pitch shifts.

87 - **RandomMute** : Trigger randomizes mutes. MODA changes grain size.  
88 - **Electrik** : Modulated comb.  
89 - **Mod Maker** : MODB controls the comb modulation waveform  
90 - **BrokenPins** : Pinged pitch shifted delay and comb  
91 - **GlitchFeed** : Trigger randomizes comb parameters after a long delay  
92 - **MachineCut** : Trigger to ping delay/comb to give a breathy sound  
93 - **WormHole** : Slow chaos, randomization of comb  
94 - **Plextrig** : Trigger randomizes all the rhythm delay parameters  
95 - **Spectras** : Vibrating ping, with filter bank frequencies adjusted by MODB  
96 - **Spreader** : Spectral spreading delay  
97 - **Spirals** : Nightmarish spiraling pitch shifts  
98 - **Tick Tock** : Noisy grains with downshifted feedback  
99 - **Waves** : 16 repeats, giving waves of sound  
100 - **SpineTaps** : Filtered echos, rising in frequency  
101 - **Chasers** : MODB adjusts feedback pitch shift  
102 - **VocosDecay** : Four downshifted piles of vocal repeats  
103 - **GettinAway** : Upwardly mobile pitch shifts  
104 - **Imperial** : Five repeats with upward pitch shifted feedback  
105 - **KingKarp** : Another pingable Karplus-Strong, with Sitar nonlinearity  
106 - **CombCutter** : Pingable elektronik resonator  
107 - **CombRipple** : Trigger a ping to generate Geiger counter ticks  
108 - **DroneChord** : Haunting drone creator  
109 - **Weaver** : Subtle pitch shifted repeats  
110 - **CombDriper** : Juicy ticking comb  
111 - **SnareRolls** : Comb resonator for multiplying snare hits  
112 - **RandomFlux** : Random comb repeats  
113 - **Complexor** : Two piles of long filtered pitch shifted echoes  
114 - **ModCluster** : Modulated comb  
115 - **AlienMurk** : Murky burbles, moving MODA makes bubbles.  
116 - **CanyonLand** : Land of the canyons  
117 - **Tectonic** : Whistling plates sliding past, MODA makes ticklets  
118 - **CombGeos** : Bright expressive reverb  
119 - **1V/Ripper** : Tunable resonator  
120 - **Steper Verb** : Pingable cymbalism  
121 - **GlitchComb** : Hairy repeats stuck in the comb  
122 - **SmearSmash** : Smear shifted delay  
123 - **CombDeform** : Filtered-Shifted-Deformed  
124 - **Karp&Scuff** : Many repeats into a high feedback comb - watch the levels!  
125 - **Vertex** : Two filterbank piles, MODA shifts filter cutoff, MODB makes clicks  
126 - **Fade2Metal** : Tunable heavy metal digeridoo  
127 - **InvertComb** : Fuzzy ping  
128 - **Skip&Fold** : 20th century symphonic dancing pitches

# SPECIFICATIONS

## Dimensions

Height	3U eurorack standard height
Width	36 HP
Depth	44 mm/ 1.75 in (from rear of front panel to top of fpga board power connector)

## Power Consumption

+12V	270 mA.
-12V	24 mA.
+5V	0 (not connected)

## Voltage Levels

INL, INR, OUTL, OTR	- 5 to +5 Volts
CLK (in and out)	0 to +5 volts
CV inputs	0 to +10 volts

# CHANGE LOG

## Version 1.09:

ADDED: Mod B Only Destination for Rhythm Delay Time (with range set by CLK DIV - repeats every 4 levels of CLK DIV) (Mod A can still be set to Delay Clock Div)  
ADDED: Reduce MOD LEVEL amplitude by a factor of 8 when the encoder is pressed while the mod pages are displayed. This is to give more subtle modulations.

CHANGE: The preset load/save changed so that now the last preset to be saved or loaded is loaded on power up

FIXED: Routing was not loaded all the time from preset  
FIXED: Preset Loading Screen flashes to boot screen and hangs  
FIXED: Randomizer on some list based values was giving out of range values

## Version 1.05:

ADDED: an additional mode, called "Random", has been added to the RANDOMIZE function. This selects a randomize mode at random from the other 15 modes.  
ADDED: an entry labelled *DLY CLK/T* has been added to the comb CLK SRC list.  
ADDED: five new values have been added to the list of MOD A/B destinations.  
ADDED: Automatic Gain Control (AGC) circuits have been added to the rhythm delay feedback, comb feedback, and overall output pathways. This prevents runaway feedback and the resulting distortion.

CHANGED: by popular demand the word "PILE", present on the original front panel design, has been replaced by the word "STACK". The functionality has not been changed.  
CHANGED: now when you hold down the LOAD button when pressing the rotary encoder while loading a preset, just the parameters of the active effects (as stored in the preset) will be loaded. This was the default behaviour before, now the default behaviour is to load all parameters.

IMPROVED: The interpolation used in the rhythm delay and comb modulation LFOs has been improved, reducing clicks and artifacts when modulating the delay lines.

CORRECTION: the value 671 msec has been added to the list of GRAIN SIZE values. This was left out in the previous version of the manual.



Burnaby, British Columbia, CANADA  
info@intellijel.com • www.intellijel.com