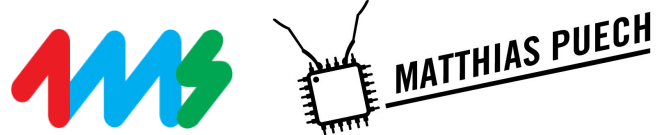
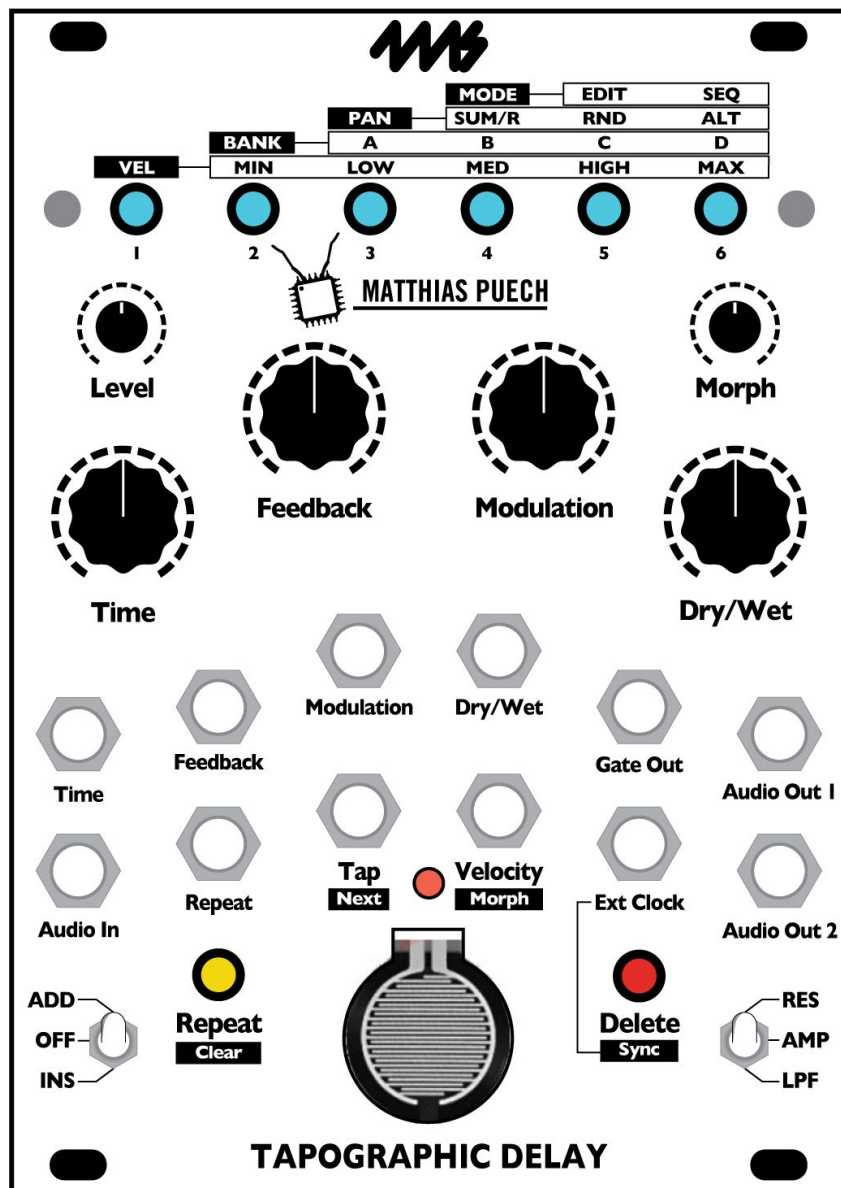


# Tapographic Delay

from 4ms Company and Matthias Puech



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for firmware v1.0



## Table of Contents

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<b>Introduction</b>	<b>3</b>
<b>Background</b>	<b>4</b>
What's a multi-tap delay?	4
What's a tapography?	6
<b>Installation</b>	<b>6</b>
<b>Getting started: Your first TD patch</b>	<b>7</b>
Create a new Tapography	7
Editing your Tapography	8
Saving your Work	8
Explore the Knobs	8
Explore the Switches	8
Explore the Buttons	9
Sequencer Mode	9
<b>Controls</b>	<b>9</b>
<b>Signal path</b>	<b>12</b>
<b>Editing tapographies</b>	<b>13</b>
Entering Taps	13
ADD/OFF/INS Switch	13
RES/AMP/LPF Switch	14
Upper Button Row	14
<b>Settings Menu</b>	<b>14</b>
<b>Navigating tapographies</b>	<b>16</b>
Loading a tapography	16
Saving a tapography	16
<b>Sequencer mode</b>	<b>17</b>
<b>Advanced features</b>	<b>17</b>
Velocity normalization jumper	17
Firmware update	18
Calibration	19
<b>Factory tapographies</b>	<b>19</b>
Banks A - D	19
Reset a bank to factory default	21
<b>Acknowledgments</b>	<b>21</b>

## Introduction

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The Tapographic Delay is a complex multi-tap delay in the Eurorack format with a unique interface designed for live performance. It excels at transforming the simplest audio (a drone, a percussive sound) into complex rhythmic structures, meshes of organic textures, lush harmonic mille-feuilles, liquid and resonant effects... plus everything we have not explored yet!

Have you ever got tired of the monotonous repetitions that your standard delay pedal/module produced? Have you ever wished for a more complex rhythmic structure than just decaying repetition? If yes, you have come to the right place: the Tapographic Delay is an advanced effect that lets you handle repetition in a completely novel way. It is in a way to a traditional delay what a full rhythmic sequencer (with pattern recall, velocity control, tactile input) is to a simple clock. With the TD, you interactively define the rhythm that the repetitions will follow: a velocity-sensitive sensor allows you to record, edit, modify, and sequence your own arrangements of delays. In a sense, the TD is the converse of the classic Frippertronics sound-on-sound setup popularized by Robert Fripp in the 70's: you don't play the guitar, you play the tape loop!

The Tapographic Delay is an expressive experimental instrument meant to be played in real-time, rather than a set-and-forget end-of-chain effect. Interact with it! Experiment! Push it to its limits!

- Velocity-sensitive force sensor to tap the delay configurations (*tapographies*)
- Up to 32 taps, each with its own delay time, amplitude/filter and panning
- Low-pass filter or resonant (pingable) band-pass filter on each tap
- Morphing between delay configurations, with adjustable morph time
- Two different feedback paths: a Repeat toggle and a Feedback knob
- Save and recall up to 24 delay configurations (4 banks of 6 slots each)
- Tapography sequencer with forward, random walk or random directions
- Synchronization to an external clock, with clock divider/multiplier
- Gate output that plays the current rhythm of delays
- Maximum delay time of 174 seconds (almost 3 minutes)
- 16 bits/48kHz with 32 bits floating-point internal processing, 1.3ms software latency
- Mono-in, stereo-out operation
- 18HP Eurorack module
- Current consumption: 125mA of +12V; 32mA of -12V. (10-to-16pin cable included)
- 0.98" (25mm) maximum depth with power cable
- Dry frequency response: 20Hz - 5kHz: +/-0.1dB. @10kHz: -2.3dB. @20kHz: -7.8dB
- Audio inputs max 22Vpp. Audio outputs soft-limit at max 17Vpp
- Trigger/clock inputs: +2V minimum, +12V maximum
- Gate (trigger) output: +8V, 4ms pulse width

## Background

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### What's a multi-tap delay?

The best way to understand the concepts underlying the Tapographic Delay is to remember the experimentations with reel-to-reel tape decks. Imagine a setup with two tape recorders and a strip of tape going from one to the other. The first tape recorder is set to record your input audio continuously; the second is set to play what's on the tape to your speakers. As the tape passes through the write-head and then read-head of the two machines, a delay is introduced between input and output: a particular signal will appear at the output of the system some time after it went into the system. This delay is proportional to the distance between the two machines (and the tape speed, which we consider constant here). If you use a mixer to sum the "dry" input and the "wet" output, you will hear a repetition: the original signal, then its delayed copy some time after.

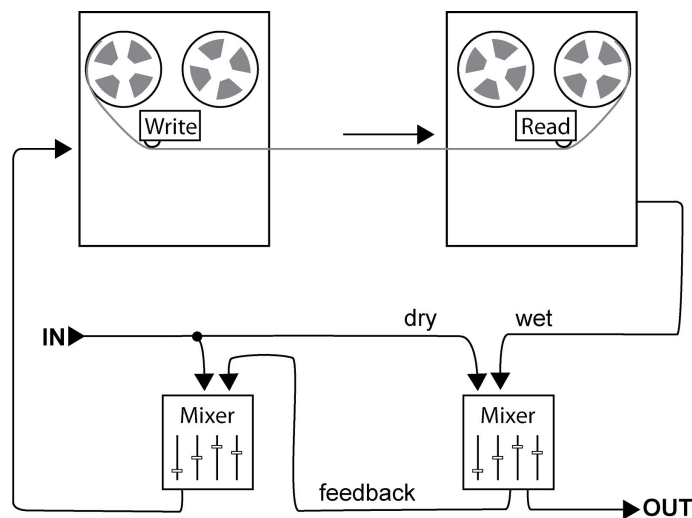
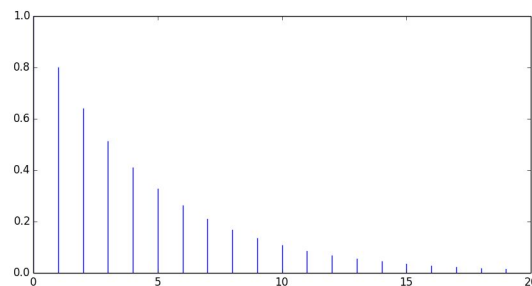


Figure 1: Classic delay system

If now you reinject the output of the system back into its input, material will be played back, then rewritten on tape, then played back again, and so on... It will repeat at regular intervals indefinitely, until it dies out due to signal attenuation and/or distortion. This is *feedback*.



This situation and its two controls, feedback amount and dry/wet, describe the workings of typical delays, whether they use actual analog tape or memory chips.

Now, let's make the topology a bit more complicated by introducing more than one read head on the path of the tape. Each of these read heads is called a *tap*: it is where you tap

into the tape signal. Our traditional delay configuration above is just the particular case of a 1-tap delay (one read head); but if you place  $n$  taps, and sum them all together with the input, you will now hear  $n+1$  repetitions (the dry signal, then the  $n$  repetitions).

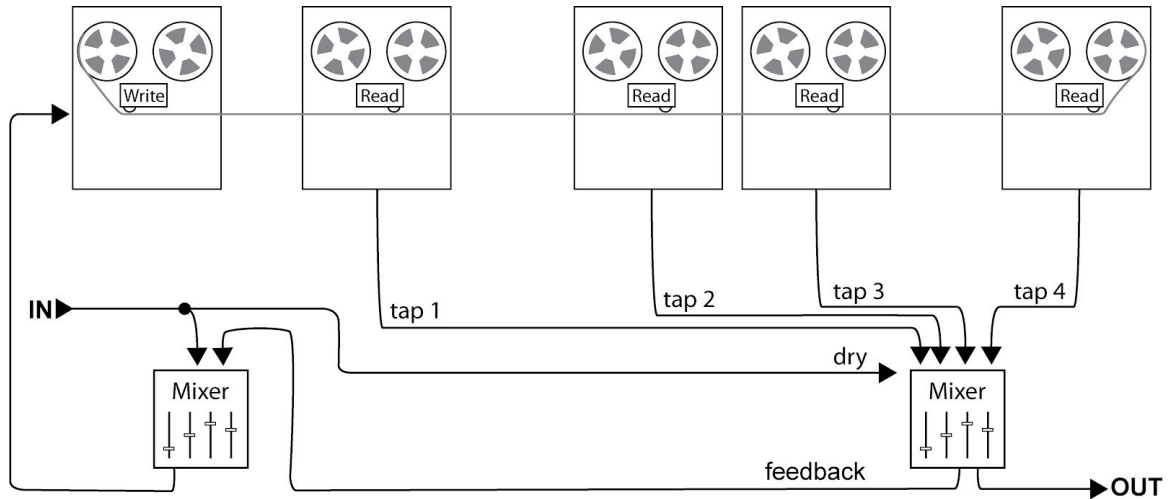
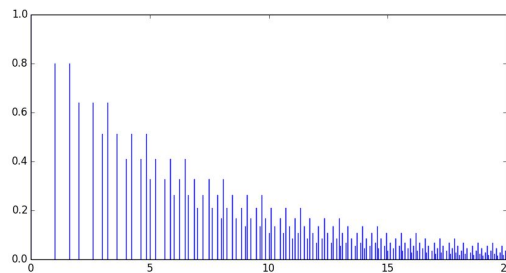
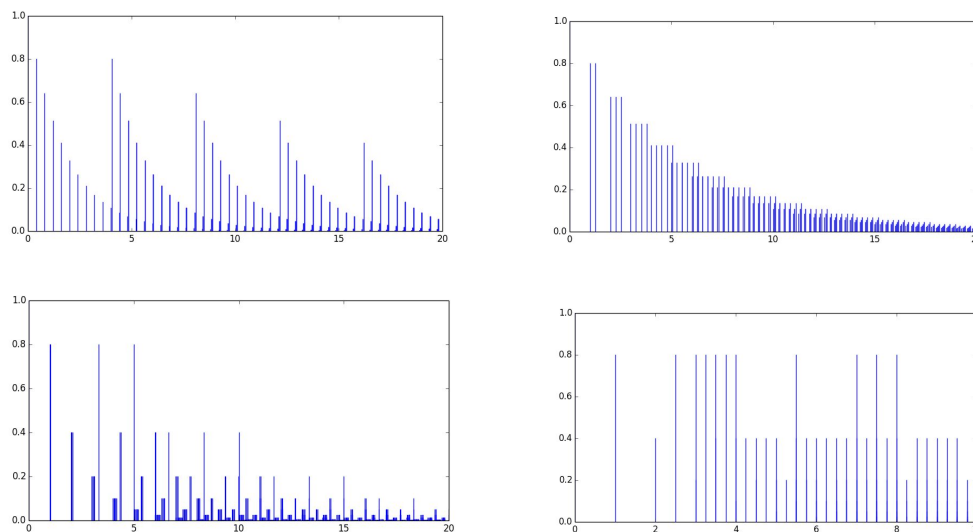


Figure 2: Classic multi-tap delay

More interestingly, the interval between each repetition will vary with the distance between each read head (tap) on the tape! Even more interestingly, if you now feed the sum of all taps back into the input, the “rhythm” gets more and more complex as time passes. For instance, with two taps placed at 1 and 1.618 seconds from the write head, we get this:



A multi-tap delay is therefore conceptually a small step from the usual single-tap delay, but can give more complex sonic results, depending on the relative delay times (distances) of the taps, their amplitudes, the amount of feedback, the modulation of the delay times...



Since multi-tap delays are about timing and rhythm, why not let you enter these parameters yourself, by tapping the rhythmic pattern on a sensor. Welcome to a world of *tapographies*!

### What's a tapography?

It's a word we invented. A tapography is the particular configuration of a multi-tap delay including the timing and the relative intensity of each tap. A signals engineer would probably call it an *impulse response* (like on a convolution reverb, only discrete), but a tapography contains a bit more information. Precisely, a tapography is a collection of taps, where each tap has the following information:

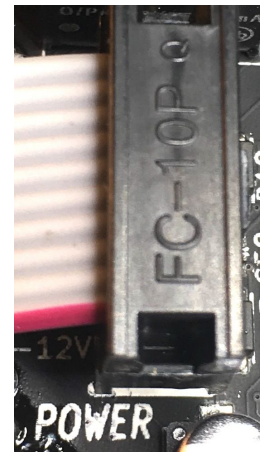
- Time, i.e. the distance in seconds separating it from the write head
- Velocity (intensity)
- A parameter the velocity is mapped to (amplitude, low-pass cutoff, or band-pass frequency)
- Panning in the stereo field

The Tapographic Delay allows you to record, edit, sequence, save and recall these tapographies, and of course, hear them in action.

### Installation

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1. Remove the Tapographic Delay (TD) from the box and anti-static bag. The RAM chip on the TD may be damaged by static electricity; take care not to touch the circuit board.
2. Connect the free end of the power cable to a Eurorack power header on your power supply distribution system, with the red stripe towards to the -12V. The other end of the power cable is a 10-pin connector which should already be connected to the TD. The red stripe on the power cable should be oriented towards the bottom of the module (the bottom is marked by a white stripe and the word "POWER"). Note: The TD is reverse-polarity protected, but if a module is incorrectly connected, it could damage something else on the power bus.
3. Securely screw the TD to the rails of your case.
4. Power the system on. You will see a colored animation on the upper buttons.



### Getting started: Your first TD patch

---

*Create a new Tapography*

1. For your first patch with the Tapographic Delay, prepare a simple sound source. A short melodic sequence of percussive sound (envelope with very short attack and ~0.5s exponential decay) is a good choice. Make sure to clock it relatively slow, perhaps one note every two or three seconds. Now, patch this sound source to the **Audio In** of the TD and monitor both **Audio Out** jacks in stereo.

2. Put the controls in these default positions:
  - **Level** at 70% (adjust downward if you hear clipping)
  - **Time** at 50%
  - **Feedback** at 0%
  - **Modulation** at 0%
  - **Dry/Wet** at 50%
  - **Morph** at 50%
  - Bottom left switch flipped up to **ADD**
  - Bottom right switch flipped center to **AMP**
  
3. Take a look at the top row of buttons: if most of the buttons are red, you are in **SEQ** (sequencer) mode. We'll discuss **SEQ** mode later, but for now let's go into **EDIT** mode: hold button 4 (**MODE**) and then press button 5 (**EDIT**). When the top row of buttons are no longer red, you're ready for the next step.
  
4. Hold the **Repeat/Clear** button for 0.5 sec to clear any existing tapography. You should now only hear your dry input.
  
5. Tap several times (say, 5 times) on the sensor, in a rhythm of your choosing. Watch and listen carefully to what happens.
  - On the first tap, the red **Tap LED** located above the sensor lights up, indicating that the module is now recording a tapography.
  - Each subsequent tap makes the row of buttons flash in white, indicating that a new tap has been entered. The more buttons light up, the stronger its velocity is.
  - Each input sound is now repeated, according to the rhythm you tapped on the sensor. For instance, if you did "tap... taptap... tap" on the sensor and the input audio goes "pling", you will hear "pling... plingpling... pling". The velocity of the taps determines the volume of the "plings".

Congratulations, you recorded your first tapography!

### *Editing your Tapography*

You can clear it by holding down the **Repeat/Clear** button for half a second, then record a new one by tapping some more on the sensor (or via CV).

*Careful:* if you forget to clear and tap the sensor once more, you will add a new tap to the existing tapography, only far, far away from the rhythm you first entered! Since then, maybe 70 seconds have elapsed so your resulting tapography will sound like:

*"tap... taptap... tap... [70 seconds of silence]... tap".*

If you enter more than the maximum of 32 taps, the upper row of buttons will start pulsing purple instead of white, indicating that older taps are starting to disappear to make room for the new ones.

If you made a mistake, you can delete the last tap entered by pressing the **Delete** button.

Notice that the **Delete** button flashes to reflect the pattern you tapped in. Each time the button flashes, the **Gate Out** emits a short trigger. Use this output to trigger events somewhere else in your system.

### *Saving your Work*

When you are satisfied with your tapography, you can save it to an empty slot. Bank D is empty when the module leaves the factory. Go to this bank by holding the second button (marked **BANK**) and quickly pressing the sixth button (marked **D**). Now, save your tapography into slot 1: hold Button 1 until it blinks red, release it and quickly press it again to confirm. You have saved the tapography! The button lights up green to indicate that this first slot is loaded. To load another slot, just press its corresponding button.

### *Explore the Knobs*

Now, explore the effect of the knobs: Turn **Level** up and down to hear how the level of the input changes. Now turn **Time**. This knob scales the delay times of all the taps, making your whole tapography shorter or longer, maintaining the time ratios between taps. The pitch will shift temporarily whenever this knob moves, like on a tape delay. **Feedback** feeds the sum of all taps back into the input. Turn this knob with care: it can very easily bloom to very high levels and damage your ears, or worse, your speakers. **Modulation** sets the amplitude and frequency of the LFOs which modulate each tap time, independently. Turn it all the way down to disable it; now turn it slowly up and listen for bendy, wow-and-flutter sounds that increase in amplitude and decrease in speed as you turn it up. As usual, **Dry/Wet** controls the mix of your input and output signal.

Each change in the active tapography can be instant or gradual. The **Morph** knob sets the time it takes for a tap to fade in or out when you insert/delete it, or when you load a new tapography. Try turning **Morph** up and then press a button on the top row to select a new tapography. See how the new tapography's button flashes green for a while? That indicates you are "morphing" from the current tapography to the new one.

### *Explore the Switches*

The two switches at the bottom of the faceplate determine what happens when each new tap is entered. For a detailed description of these, see the *Entering taps* section below. Briefly, the leftmost switch (**ADD/OFF/INS**) determines what happens when you tap the sensor (or fire a trigger into the **Tap** jack). When it's set to **ADD**, more time is added to the tapography. In the tape machine analogy, this is akin to splicing more tape to the end of the existing tape. **ADD** mode is great for creating your initial tapography, but if you leave the switch set here for a while and then add more taps, you'll get some very long silences. Often, once you've created a tapography you will want to add more taps inside the "tape loop" without extending the time (or adding "more tape"). To do that, flip the switch to **INS**. In this mode, new taps are **INS**erted **INS**ide the tapography, without making the tapography longer. The center position, **OFF**, simply disables the sensor and the **Tap** trigger jack: no new taps can be added.

The rightmost switch (**RES/AMP/LPF**) selects what kind of tap is inserted. **RES** means the tap is run through a resonant band-pass filter with the velocity controlling the frequency. **LPF** means the tap is run through a low-pass filter, with the velocity controlling the cut-off. **AMP** means the tap is attenuated based on the velocity. Try adding different types of taps



to a tapography. Keep in mind, the **VEL** setting in the menu changes how the velocity of your taps changes the filters: try different values as you experiment (see *Settings Menu*).

### Explore the Buttons


**Repeat** will make the input repeat indefinitely, accumulating on top of older material. Turn it on and listen how input material builds up quickly! Hold the **Delete/Sync** button for a second, it will turn red to indicate *Sync mode*. In this mode, the total length of the tapography (from the first to the last tap) is scaled to the clock input in **Ext Clock**. Try this out: patch your master clock to the **Ext Clock** jack, and enter a rhythmic tapography (one where tap times are all multiples of a common tempo). Now enable **Sync** and listen how the tapography syncs; **Time** then becomes a multiplier/divider for this clock.

### Sequencer Mode

Remember when we checked to make sure we weren't in **SEQ** mode at the beginning of this tutorial? Let's explore what **SEQ** mode is. On the top row of buttons, hold down the 4th button (**MODE**) and press the 6th button (**SEQ**) shortly. Release the buttons and you'll enter Sequencer mode. You know you're in sequencer mode because the top lights have a red "background". In this mode, tapping the sensor will not enter new taps; instead it will select the next tapography saved in the current bank. Notice that the position of **Morph** is honored, as well as the velocity of your taps: the stronger you tap on the sensor, the faster the morphing will be between slots. The leftmost switch also changes meaning in this mode, and determines the direction of this sequencer: **OFF** means forward, **INS** means random walk, and **ADD** means random. To exit Sequencer mode, hold the 4th button (**MODE**) and press the 5th button (**EDIT**).

## Controls

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 **Tap Buttons 1 to 6:** load and save tapographies (see *Navigating tapographies*); display and modify the settings (see *The Settings Menu*).



**Level**

**Level knob:** sets the level of the signal going into the delay (does not include the dry path, only the wet path). From 0% (no signal going into the delay) to 300% amplification.



**Time**

**Time knob:** scales all the tap times in the current tapography by a factor from about 0.1 to about 4 (middle position is 1). It effectively compresses or expands the current tapography in time. While the knob is moving, pitch shifting will occur. This factor also affects where newly entered taps will be placed, and it also affects the visual and gate output. When **Sync** is engaged, **Time** selects the multiplication/division of the incoming clock on **Ext Clock**. The divisions/multiplications available are: 1/8, 1/7, 1/6, 1/5, 1/4, 1/3, 1/2, 1, 2, 3, 4, 5, 6, 7, 8, 16. The middle position corresponds to 1 (no division/multiplication of the input clock).



**Feedback**

**Feedback** knob: Amount of the sum of all taps that is injected back into the input. From 0% to 120%. Careful: in some settings, the effect of this knob can be *wild*.



**Modulation**

**Modulation** knob: Amount and frequency of the internal LFOs modulating each tap time. Each tap has an independent random LFO whose shape is close to a sine wave. With enough modulations, the delayed material will be pitched up/down, just like wow and flutter on a tape recorder. Fully counter-clockwise, frequency is high (around 50Hz) but the amount of modulation is so small that there is no effect. Fully clockwise, amount is maximum (+/- 0.5 sec) but frequency is so small that the LFOs are stalled on a particular position. Positions in between minimum and maximum give intermediate amplitudes and frequencies for the LFOs. *Tip*: Adding a bit of modulation can help avoid harsh buildups when using Feedback.



**Dry/Wet**

**Dry/Wet** knob: crossfades between the unaffected input signal and the sum of all taps.



**Morph**

**Morph** knob: amount of time it takes to transition from one tapography configuration to the next, from 0 seconds to about 12 seconds. Any time the tapography changes, Morph dictates the transition time. This includes adding a tap, removing a tap, clearing the entire tapography, en/disabling Repeat, and recalling a tapography from a memory slot.



**Time**



**Feedback**

### **Time, Feedback, Modulation, Dry/Wet CV**

Bipolar CV inputs for the respective parameters (-5V to 5V). Sending a positive voltage adds to the knob's value; sending a negative voltage subtracts from the knob's value.



**Modulation Dry/Wet**



**Gate Out**

**Gate Out**: emits a trigger pattern in a loop, according to the current tapography and the current **Time** setting. Can be used to turn the TD into a recordable trigger sequencer. Triggers are +8V, with 4 millisecond pulse width.



**Audio Out 1**



**Audio Out 2**

**Audio Out 1 & 2**: stereo audio outputs. By default, taps are assigned alternatively to each output. See *Panning Setting* for more details. In some panning settings, **Audio Out 1** is considered the main output for mono use.



**Audio In**

**Audio In** (audio input). Accepts full range of modular level signals (+/-11V)



**Repeat**

**Repeat jack** (trigger input): toggles the current setting of the Repeat button when a trigger is received on this jack.



**Tap  
Next**

**Tap/Next** (trigger input): when a trigger is received, has the same effect as tapping the sensor with a velocity read from the **Velocity** CV jack. In **SEQ** (sequencer) mode, it initiates a transition to the next tapography slot.



**Tap LED**: lights up when a tapography is being recorded (i.e. when the internal stopwatch is rolling, see *Entering taps* below); it is off when the stopwatch has stopped. The LED flashes when the stopwatch resets/loops.



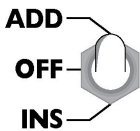
**Velocity  
Morph**

**Velocity/Morph** (CV input): the voltage on this input is sampled every time a trigger is received on the **Tap** jack. Valid range is 0V to +8V. When used to set cutoff frequency of taps (**RES** or **LPF** setting), this input tracks 1V/Oct on a few octaves. In **SEQ** mode, this controls the **Morph** amount when a trigger appears on the **Tap/Next** jack. Higher voltage = slower transition.



**Ext Clock**

**Ext Clock** (clock input): When **Sync** is engaged, the current tapography's length will be synced to the clock input, multiplied or divided by a factor set by the **Time** knob.



**ADD/OFF/INS** switch: selects *where* newly entered taps will be inserted in the current tapography. **ADD** means after the current tapography, **INS** means *inside* its bounds, **OFF** means that it will *not* be inserted (useful to inhibit recording, e.g. during performance or to disable the **Tap** jack). See the *Entering taps* section for more details.



**Repeat  
Clear**

**Repeat/Clear** button: short press toggles **Repeat**. When enabled, an additional tap at the very end of the tapography is fed back into the input at unity gain, effectively repeating the audio indefinitely. The loop size is fixed when **Repeat** is activated and will not be scaled with the **Time** knob. Holding this button down for half a second clears the current tapography by deleting all taps at once (*Warning*: there is no undo!). Both functions are subject to **Morph**: taps will fade in/out in a time determined by the **Morph** knob.

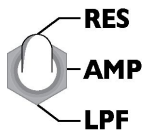


**Tap sensor**: the force-sensing resistor (FSR) that records the velocity-sensitive tap information. Used for entering taps and advancing the sequencer.



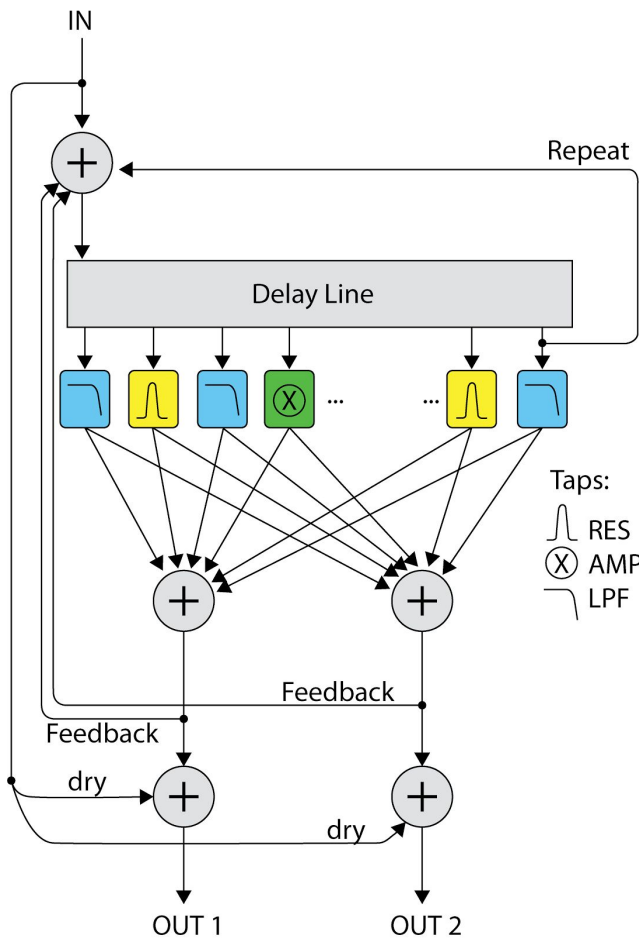
**Delete  
Sync**

**Delete/Sync** button: short press deletes the last entered tap (subject to **Morph** time); long press toggles Sync. The button flashes white each time a trigger is emitted to **Gate Out**; lights up red when Sync is engaged.



**RES/AMP/LPF** switch: selects how newly entered taps will be affected by their velocity. **RES** means the tap's output will go through a resonant band-pass filter with the velocity mapped to the center frequency. **AMP** means the tap's velocity is mapped to the volume. **LPF** means the tap's output will go through a non-resonant low pass filter with the velocity mapped to the roll-off frequency. See *Entering taps* section for more details.

## Signal path



There are two independent feedback paths:

The **Repeat** feedback path re-injects the tap with the longest time back into the input of the delay line. It does this without alteration, that is, at unity gain with no filtering. If the tapography is 5 seconds long and **Repeat** is on, the input signal 5 seconds ago is continually being re-injected into the input. Since re-injection is at unity gain, the signal never weakens. One use for the **Repeat** feature is to send a one-shot sound (perhaps a single percussive sound) into the TD. With **Repeat** on, the one-shot sound will continue to loop, and you can play with the tapography without having to fire the one-shot sound again.

The **Feedback** path re-injects the sum of all taps. This means their delay times and filtering/amplitude effects will all be fed back into the start of the delay line. If taps are not “aligned”, i.e. if their time are

not multiples of a base tempo, then **Feedback** will gradually create more and more complex repetitions, until it fills the sonic space with a smooth “tail”. Just like in a room with a microphone and a PA, **Feedback** is not straightforward to control: depending on the number of active taps, it might be too weak to build up and quickly dilute into silence, or too strong and rapidly build up harsh tones. We did our best to make the range of the **Feedback** knob as useful as possible depending on the number of active taps.

*Note:* A soft saturation is applied to the output and to the feedback path. Therefore, as layers of sound accumulate, clipping will be analog-like and pleasant to the ear.

## Editing tapographies

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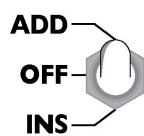
### Entering Taps

When you tap on the sensor (or input a trigger), you add taps on the delay line so that the tap times mimic the rhythm that you tap. Let us see how this works in a bit more detail. Keep in mind this section only applies to **EDIT** mode (see the *Settings Menu* section).

When you first tap the sensor after a **Clear**, the red **Tap LED** lights up to indicate that the TD is ready to record new taps. The velocity of this first tap is not taken into account: it just tells the TD to *start recording*. Imagine that a stopwatch starts counting time when the **Tap LED** lights up. Each subsequent tap on the sensor will place a new tap on the delay line at the time indicated by the imaginary stopwatch.

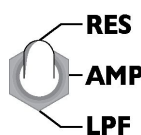
### ADD/OFF/INS Switch

Once the **Tap LED** is on, the leftmost switch controls what happens when you add a tap:

- 
- **ADD** means that new taps are appended to the end the tapography. Each tap you add in **ADD** mode makes the total time of the tapography longer. The imaginary stopwatch simply counts upwards, indefinitely.  
*Example:* if you tap in a few taps in **ADD** mode, then wait 10 seconds, then tap once more, it will add a new tap 10 seconds after the previous one. **ADD** mode is how you *add* time to a tapography. The maximum time your tapography can be is about 3 minutes.
  - **INS** means that new taps are inserted *inside* the boundaries of the current tapography. The total time length of the tapography will not change. When you're in **INS** mode, the imaginary stopwatch counts from 0 to the last tap, and then loops back to 0. New taps will be inserted wherever they fall in this "loop". The top buttons shows the taps and can help you visualize where the new tap will be inserted when you tap the sensor.  
*Example:* let's say you already entered a few taps for a total of 3 seconds in **ADD** mode. If you switch to **INS** mode and tap a new tap, it will be inserted somewhere within those 3 seconds.
  - **OFF** means that tapping the sensor and the **Tap** jack will have no effect. This can be used to protect a tapography from accidental taps and unwanted gates.

### RES/AMP/LPF Switch

When adding a tap, the rightmost switch sets what parameter the velocity is mapped to. The **VEL** menu setting determines *how much* velocity is mapped (See *Settings Menu: VEL* section).

- 
- **AMP:** The tap's output is attenuated by an amount determined by the tap's velocity.
  - **RES:** The tap's output passes through a resonant band-pass filter. The velocity of the tap is mapped to the center frequency of the filter: the stronger you tap, the higher the pitch.

- **LPF:** The tap's output passes through a low-pass filter. The velocity of the tap is mapped to the cutoff frequency of the filter: the stronger you tap, the higher the cutoff.

Notice that the **Tap LED** flashes each time the stopwatch goes through 0. The tempo of this flashing is the tapography's period (total time).

Also, the **Tap LED** turns off whenever taps are not being recorded: when the tapography is **Cleared** and when the switch is set to **OFF**.

### Upper Button Row

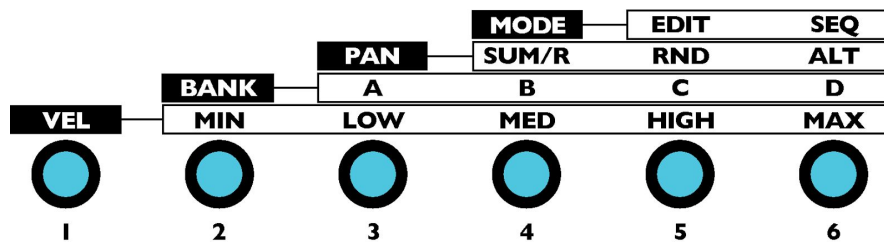
The upper row of buttons pulse in different colors to indicate various events. The lights flicker like a bar graph to indicate velocity: more lights = more velocity.

- *White pulse* when a tap is **ADDED**
- *Yellow pulse* when a tap is **INS**erted (added inside the current tapography)
- *Purple pulse* when a tap is added or inserted but you exhausted the maximum 32 taps. In this case the oldest tap starts to fade out to make room for the new one. (The **Morph** parameter sets the fade-out rate)
- *Blue pulse* when a tap is crossed, that is when the stopwatch indicates the time of a currently active tap.

Note that in **ADD** mode, only the new taps will be displayed (white pulses only). In **INS** and **OFF** modes, the current tapography will be displayed.

### Settings Menu

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The settings menu lets you change some aspects of the behavior of the module. There are four settings you can change. Each one is marked with a word on a black background: **VEL**, **BANK**, **PAN**, and **SEQ**.

Take a look at the menu graphic now to make sense of it. Each horizontal line corresponds to a setting. For instance, **VEL** has five possible values: **MIN**, **LOW**, **MED**, **HIGH**, and **MAX**; You change the **VEL** setting using Button 1. To change a setting, hold its button down while quickly pressing one of the buttons on its right to select a value. For instance, to switch to Bank B, hold the **BANK** button (button 2) while quickly pressing **B** (button 4), then release both buttons. The button lights will change color to indicate the new setting and its value: *Purple* indicates the setting being changed, *Turquoise* indicates its value.

*TIP:* Don't hold the first button too long, or the TD will think that you want to save a new tapography! If that happens, the light will flash red. Just release all buttons and let it stop blinking.

- **VEL** changes the way velocity is assigned to its destination. Higher **VEL** values (towards **MAX**) make the overall output louder. This translates to different behaviors for the different types of taps:
  - For **LPF** and **AMP** taps, **VEL** sets how much the velocity of the tap influences its amplitude or roll-off. At the lowest value (**VEL = MIN**), the sensitivity is full, so the amplitude/roll-off fully depends on velocity. At the highest value (**VEL = MAX**), sensitivity is zero and amplitude is always maximum (no roll-off).
  - For **RES** taps, **VEL** sets the resonance (Q) of the band-pass filter, from 1 to 20. The **VEL** setting works differently than the **LPF** and **AMP** in that with **VEL = MIN**, there is minimum response to velocity (less resonant), and with **VEL = MAX** there is maximum response (more resonant).
- **BANK** changes the currently active bank of load/save slots. There are four banks labelled **A**, **B**, **C**, and **D**. All slots of all banks are writeable. See *Factory Tapographies* section. Bank D is empty when the TD is purchased new.
- **PAN** sets how the stereo field is managed:
  - **ALT** means that new taps will be **AL**Ternatively panned left, then right, then left etc. as they are entered.
  - **RND** means that new taps are panned randomly. They can be panned anywhere in the stereo field from 100% left to center to 100% right.
  - **SUM/R** stands for "Sum/Repeat". This mode sets the module in mono. The main output is **Audio Out 1**, which is the sum of the left and right taps. **Audio Out 2** outputs the Repeat tap only. The Repeat tap is the last tap in the delay line, at unity gain without any filtering.
  - Choosing a new stereo assignment will also re-pan all existing taps, so if you have previously entered taps in **ALT** or **RND** mode, selecting **RND** again will choose new random panning for all taps. You can repeat the process until you are happy with the resulting stereo image. Remember that the panning of all taps is saved within a tapography, so once you find a result you like, you can save it.
- **MODE** selects edit mode or sequencer mode:
  - **EDIT** is the default mode where you can create new tapographies, add or remove taps, clear a tapography, etc.
  - **SEQ** mode does not allow editing tapographies, but instead lets you sequence between them using the sensor pad and/or an external trigger or clock. See the *Sequencer* section for more details.

*Warning:* settings should not be altered during performance: doing so occasionally causes audible clicks or glitches. They are meant to be set and forgotten, not played live.

*Note:* All settings are saved and restored across power cycles.

## Navigating tapographies

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### Loading a Tapography

To load a saved tapography, simply tap one of the six buttons on the top row. Each button corresponds to a slot within the current bank. When you press and release the button, it will blink green while the TD morphs to this new tapography. Then it will turn solid green to indicate the new tapography is loaded. Keep in mind that the **Morph** knob sets the morph time, so if the knob is down, you might not see any flashing. As soon as you start editing a saved tapography, the green light will turn off. To revert all your changes and reload the saved tapography, just tap the slot button again (or a new slot, if you like).

*Note:* On start up, the last tapography slot used is loaded. Careful: parameters are only saved when entering the settings menu, so to save the current tapography for next start up, long-press one of the menu buttons until the menu is displayed.

### Saving a Tapography

Once you are satisfied with a tapography you created or edited, you can save it to one of six slots in one of four banks (A, B, C, D). To save the currently active tapography to a slot:

- Make sure you are in the bank you want to save into (see *Settings Menu* section)
- Hold down the corresponding slot button (1-6) for about a second until it blinks red. (when using buttons corresponding to menus, the menu will first appear, but just keep holding down).
- Release the button and it will continue blinking red.
- Press it again immediately to confirm the save.
- If you change your mind about saving, just let go of the button when you see it flashing red and don't press it again. In a moment the red flashing will stop and saving will be aborted.

What is saved exactly in a tapography? This information, no more no less:

- The number of active taps, and for each of these:
  - its delay time
  - its velocity
  - the mapping of this velocity (AMP, RES, or LPF)
  - its panning

*Note:* A tapography is not a preset! Neither the position of the knobs nor the settings are saved or restored; only the items above. Use this at your advantage!

### Sequencer mode

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Sequencer mode is a special mode of the module that allows to switch tapographies within a bank programmatically, via a tap or a trigger instead of via a button press. Sequencer mode is enabled and disabled via the settings menu (See *Settings Menu*). In Sequencer



mode, the upper LEDs all turn red, except for the currently loaded tapography which lights up green, as usual.

In this mode, editing of tapographies is disabled; instead, each tap on the sensor or trigger in the **Tap/Next** input will start transition to the “next” tapography in the current bank.

Which tapography is “next” is determined by the position of the leftmost switch:

- In the center position (**OFF**), the tapographies are in order from 1 to 6 (and it wraps around from 6 back to 1). This is like a standard sequencer running “forward”.
- In the upper position (**ADD**), it picks a random slot in the current bank.
- In the lower position (**INS**), it randomly picks the next slot immediately to the left or to right (random walk).

As in the normal mode of operation, the **Morph** knob determines the transition time between two tapographies. This transition time is increased by one of two things:

- The tap velocity when the pad is hit (the harder you tap, the faster the transition).
- The voltage in **Velocity/Morph** CV jack when a trigger is received in **Tap/Next** jack (the higher the voltage, the longer the transition)
  - In Sequencer mode, **Velocity/Morph** jack is normalled to zero volts when the **VEL NORM** jumper on the rear of the PCB is set to **HIGH**. This means sending a trigger with nothing plugged into the **Velocity/Morph CV** jack will result in a fast morph time.

Note that if you advance the sequencer by hitting the pad, the **Velocity/Morph CV** will be ignored. Likewise if you advance the sequencer by sending a trigger into **Tap/Next**, any pressure on the pad will be ignored.

## Advanced features

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### Velocity normalization jumper

When a trigger is received in the **Tap/Next** input, a new tap is inserted, with a velocity determined by the voltage read on the **Velocity/Morph** input. When no cable is inserted in **Velocity/Morph**, what is the “default” velocity? Or in other words, what is **Velocity/Morph** normalled to?

Normalization of **Velocity/Morph** is determined by the Velocity normalization (**VEL NORM**) jumper on the back of the module. It has two positions:

- In the **HIGH** position, it is normalled to its maximum value, so all taps entered with a trigger will have maximum velocity (see note about *Sequencer Mode* in the section above)
- In the **TAP** position, it is normalled to the **Tap/Next** input. This means that the taps entered with a trigger in **Tap/Next** will have a velocity depending on the amplitude of the trigger. Here is one way to use this: pass your trigger source through a VCA, and plug a random source (0-8V) in its CV input. On the rising edge of the trigger, its amplitude will be random; the added tap will have a random velocity.

## Firmware Update

Your TD is flashed at the factory with the latest firmware version. If a new version is published, it will be available at <http://4mscompany.com/td.php> . The firmware is distributed as a .wav file that you play into your module after entering bootloader mode. *Careful:* the content of the .wav file must be played back without interruption or alteration, and without volume change. Make sure to disable any EQ or system notification on the player before starting, and set your levels beforehand. If you interrupt the playback, the module will be left in an inconsistent state, and you will have to redo the procedure from the beginning.

The update procedure is as follows:

- Turn your case off, and unplug all cables from/to the TD
- Plug a mono cable (ideally a patch cable) from your computer, tablet or phone to the **Audio In** jack
- Turn your case on while holding the **Repeat** button. The **Delete** and **Repeat** LEDs now blink red.
- The **Level** knob will set the input level. Typically start with the knob at about 2:00 (70%).
- Play the .wav file into **Audio In** at full volume. The upper row of LED buttons will display the input level.
- Adjust the **Level** knob so that the yellow LED is lit, but not the last two red ones.
- If an error occurs (level was too low/high at some point during playback, or the file or playback was altered), all LEDs will blink red.
  - Rewind the .wav file to the beginning
  - Press **Repeat** to tell the TD you're going to re-try
  - Start playing the audio file again
- If the file is played through correctly and the update succeeds, the module will directly boot up with the new firmware. Follow the calibration procedure after each update (see above section).

An update either succeeds or fails, there is no in between! In particular, there is no need to re-install more than once if you suspect an erratic behavior. Please contact us at [4ms@4mscompany.com](mailto:4ms@4mscompany.com) for support.

## Calibration

All modules are calibrated at the factory. The calibration procedure centers the 0V position of all CV inputs. May you encounter problems of shifted knob positions, or knob not reaching their maximum/minimum value after a firmware update, try calibration:

- turn off your case, and remove all cables from/to the TD;
- turn it on again while holding the Delete button;
- all LEDs will blink yellow, to indicate successful calibration.

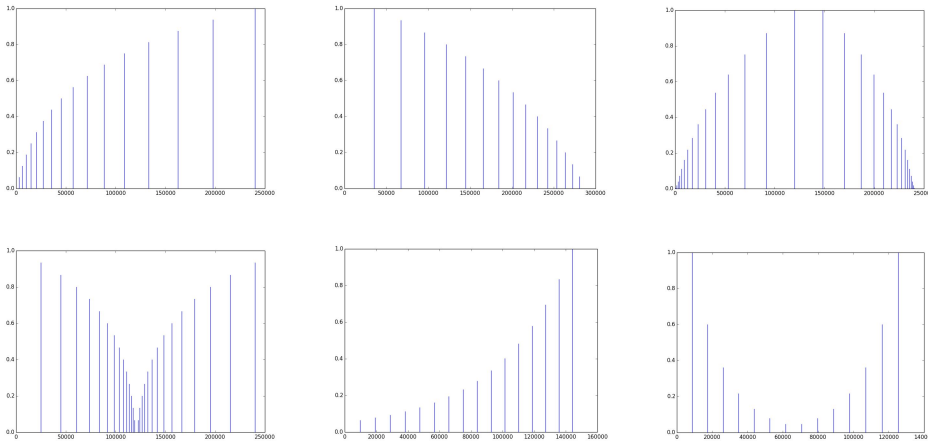
## Factory Tapographies

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This section briefly describes the example tapographies that are shipped with the TD in banks A, B and C. Bank D is empty, for your own use. These are only examples: you can of course overwrite any of them. Nonetheless, a special procedure described below allows to restore a bank to its factory default.

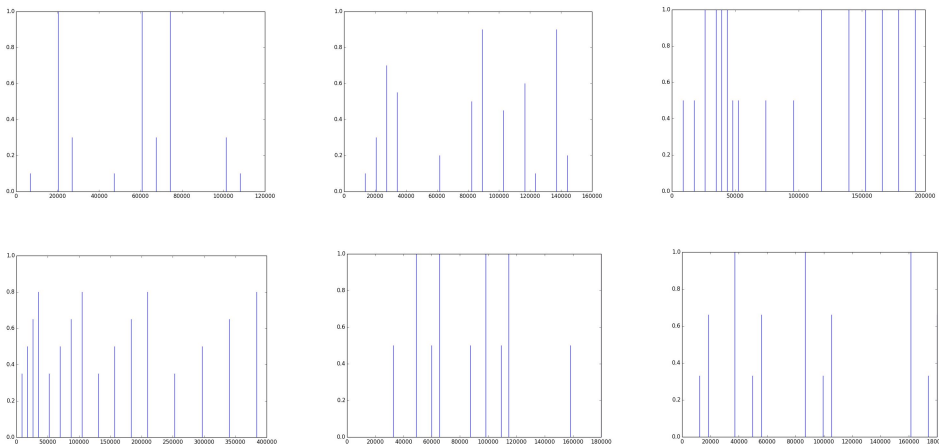
### Bank A

This bank contains tapographies that simulate physical bounces and oscillations. It contains exponentially decelerating and accelerating movements.



### Bank B

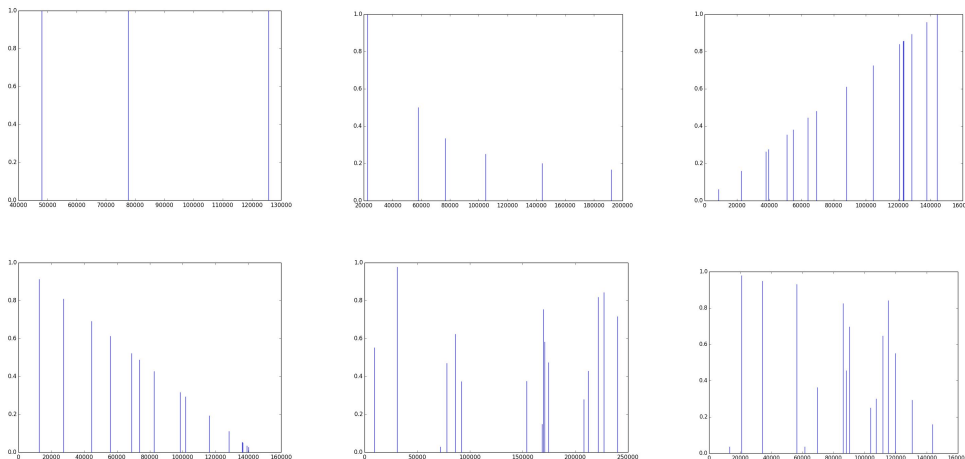
The tapographies in this bank are rhythmic: all delay times are multiples of a base tempo, and their tap times describe a rhythm. Feed a short stab of audio to the input: it will repeat rhythmically. Increasing the feedback, the repeated impulses will always align to the tempo.



### Bank C

In this bank you will find tapographies that were especially designed to produce a dense response after a short period of time when increasing Feedback. When the tap times are not multiples of a common tempo, but are for instance irrational (in the mathematical sense, like  $\pi$  or  $e$ ), feedback will never be align to previous impulses, and the sound will eventually melt into a continuous tone, much like a reverb tail (in fact, you will find that they sound

similar to proto-reverbs from the 70s and 80s). This bank is therefore the exact opposite of Bank B: the delay times are chosen on purpose to be as non-rhythmic as possible.



Slot 1 has three taps, whose times are related by the golden ratio. Being an “especially irrational” number, the golden ratio is said in the DSP literature to produce dense impulse responses. We have not found a mathematical proof of this fact, but we are willing to believe them.

Slot 2 has six taps, which times are calculated to produce the most echo density when some **Feedback** is applied. They were found by simulating computationally the interaction between taps.

#### *Bank D*

This bank is empty for you to store your own tapographies.

#### *Resetting a Bank to Factory Default*

To reset one of the four banks to its default tapographies, follow this procedure:

- Select the bank you wish to erase from the settings menu.
- While the LEDs still indicate the selected bank, quickly press **Repeat** and **Delete** at the same time.
- All LEDs in the upper row will blink red, indicating a successful reset.

*Warning:* this cannot be undone; the tapographies you saved in this bank will be lost forever.

## **Acknowledgments**

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