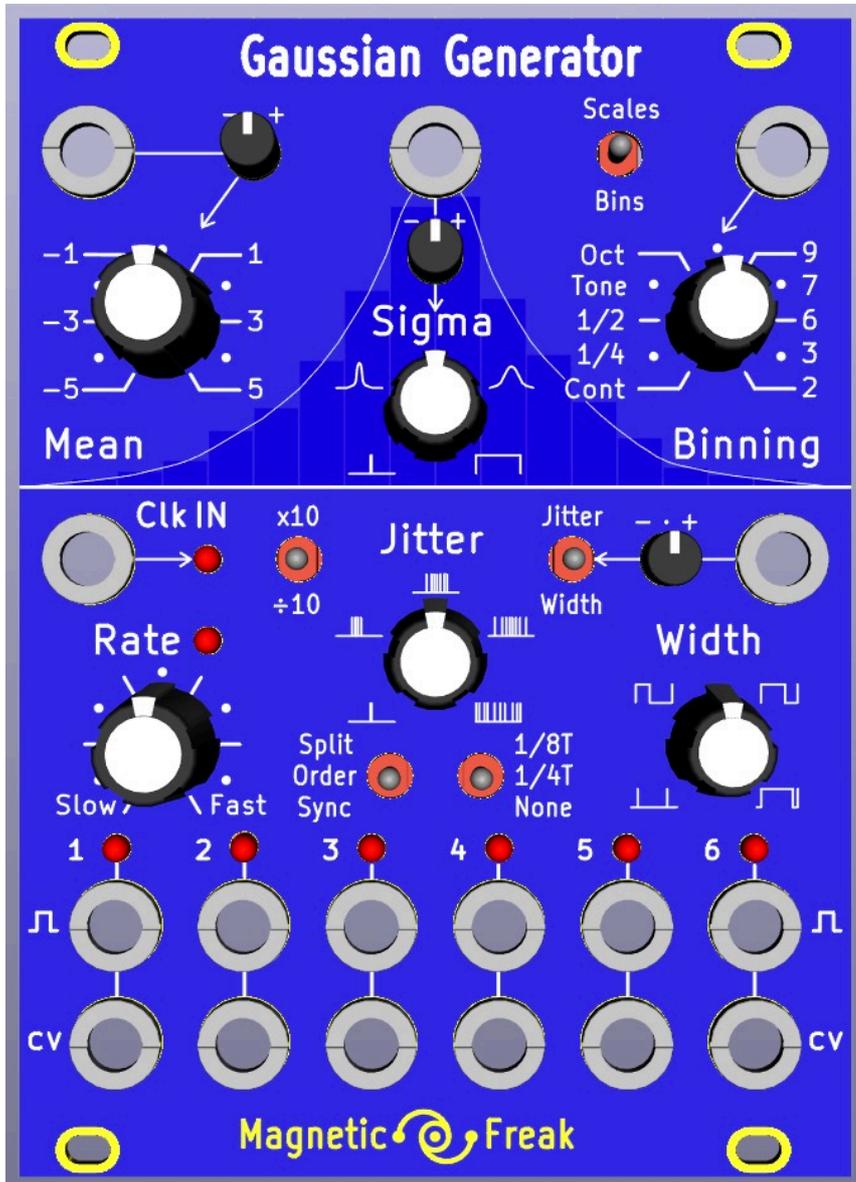# Gaussian Generator

User Guide
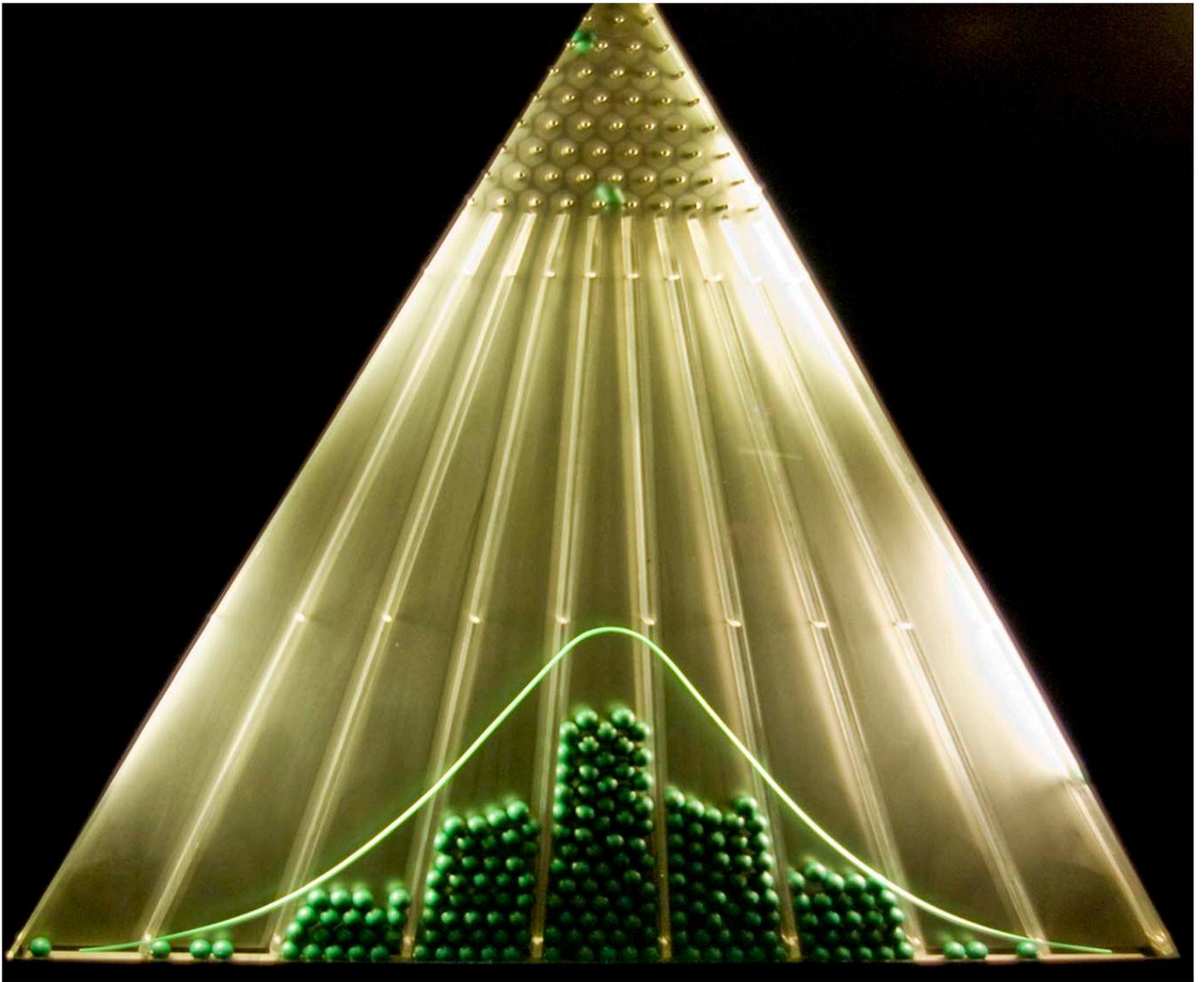
Dr. Robert Kieffer *Last Updated June 2022*

Specs

- Power supply consumption +12V 200mA and -12V 50mA
- CV output range [-5V to 5V]
- CV IN range [-5V to 5V]
- GATE output 10V pulses are emitted
- Corresponding GATE LED helps to visualise their respective timing.
- Clk IN is a Clock input [5 to 12V] pulses are accepted.
- Panel 18HP Total panel width 5.08x18 = 91.44mm
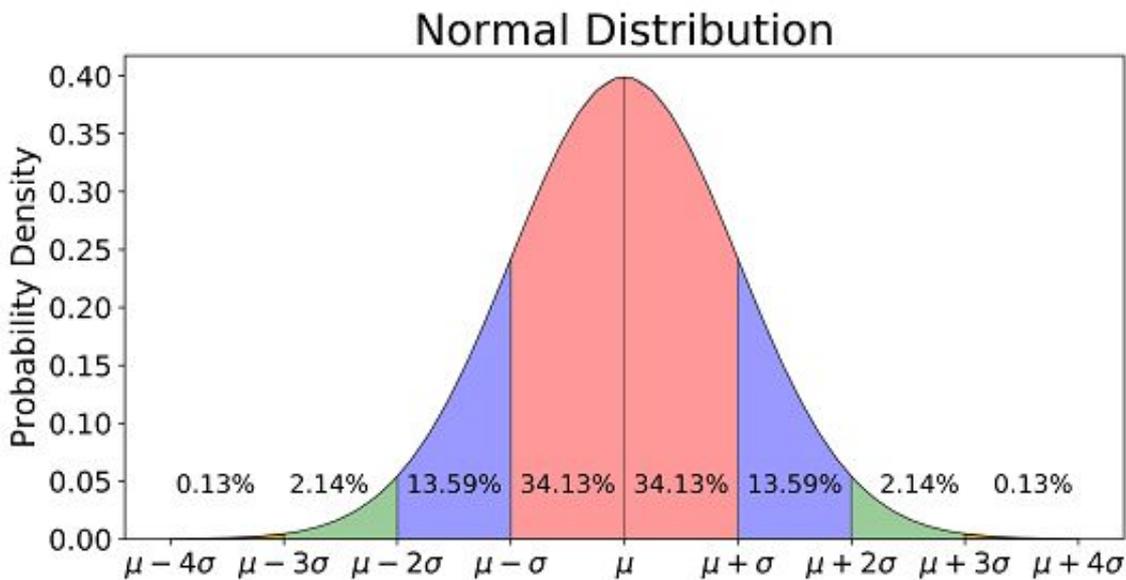- Sloted fixation holes diam 3.2mm

Why the Gaussians are so exciting ?

The Gaussian Distribution is a bell-shaped graph which encompasses two basic terms: mean (mu) and standard deviation (sigma). It is a symmetrical arrangement of a data set in which most values cluster in the mean and the rest taper off symmetrically towards either extreme.

The most visual way to represent the gaussian distribution as the result of a series of statistical process (left/right decision), is the Galman Box also named "bean machine". In this simple experiment, balls are falling from a central position onto obstacles that they need to pass left or right, but in average after 8 stages most of the trajectories end up in the center. Only in rare occasions a ball bounce 8 times in a raw to the right side in order to reach the extremum bins. The result shows the most probable ending place statistically testing all paths to go through the 8 stages of obstacles using numerous balls.

Because the normal distribution approximates many natural phenomena so well, it has developed into a standard of reference for many probability problems. This bell shaped distribution is defined by only two parameters, the mean value (Mu) and the standard deviation or width (Sigma).

Normal Distribution

0.13% 2.14% 13.59% 34.13% 34.13% 13.59% 2.14% 0.13%

$\mu - 4\sigma$ $\mu - 3\sigma$ $\mu - 2\sigma$ $\mu - \sigma$ μ $\mu + \sigma$ $\mu + 2\sigma$ $\mu + 3\sigma$ $\mu + 4\sigma$

Normal distribution arise when you distribute the height of the population data into a binned histogram. The curve you obtain have a typical gaussian shape whith mean value corresponding to the average Human size (1.80), and the width showing into wich range this height could mostly vary. The normal distribution simply feels natural. Indeed you would not expect to see a population of 1m to 3m tall peoples present in equal quantity as a flat distribution would do. But only find such over-sized peoples in rare cases with respect to the mean height of the human kind.

Any physical process, is subject to these rules and the music and generation of sound is just another opportunity to take advantages of these natural sounding statistical distributions.
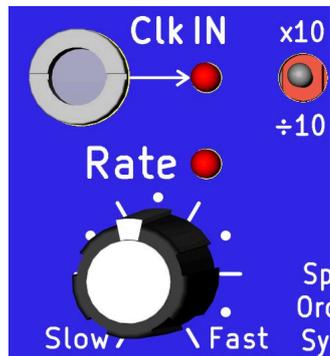
If you would measure the tune of 100 metalic vibraphone blades tuned by ear one by one when fabricated to a A 440Hz of a piano. You will discover that none of the blades are exactly 440.00Hz, but they all have a pitch slighly lower or higher (0.01Hz etc..). The mean value is 440.00Hz and the width of the distribution tells you how well they have been tuned. But a contrario you might want to control 6 oscillators in a slighly natural detuned way has a natural instrument ensemble would have performed. Using the Gaussian module, you can get a small detuning control following a gaussian distribution and apply it to broden the spectra of the 6 oscillators when sumed together.

The Gaussian Monte Carlo module's algorithm make use of two gaussian distributions: one acting on time the other on control voltage. Every clock cycle these two distributions are used to perform random sampling on them, this process is also named Monte Carlo sampling method. One of the gaussian distributions is used to determine the level of the CV outputs. The second gaussian distribution is used in the time domain to generate a controlable jitter delay for the six Gates outputs. For each of the six channels the Gate and CV output values are synchroneously updated together.

This module can be used both in the time domaine and as CV level generator, to control multiple sound generators, effects, or spatialisation modules. The controllability of this random source make it very usefull to create a randomness which can be "played" in a controlled way.
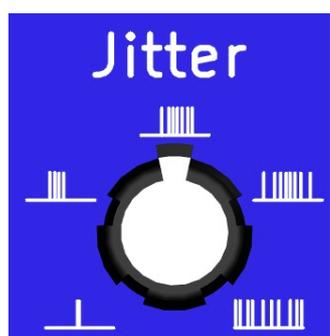
Timing aspect of the module

The timing aspects of the Gaussian Generator are handeled at the bottom part of the module.

The **Rate** controls the period of the internal clock generator of the module. It works together with the multiplicator switch [x10 x1 /10] to reach a wide range of periods from 10ms to 20s. The associated **Rate LED** helps to monitor the actual rate.

In case a jack is plugged into the **Clk IN** the internal clock is bypassed and the external clock drives the module instead (up to 400Hz clk rate accepted). In that case the **Rate** knob act as a clock divider, and the multiplicator switch is not used anymore. Turning this knob from **Slow** to **Fast** allow to do the following time division to the input clocks [1/32 1/8 1/6 1/4 1/2 1]. To keep an eye on this you can monitor the difference of beating between the **Clk IN LED** and the **Rate LED**. The pulse amplitude needed to trigger the **Clk IN** ranges from [3V to 12V]. This clock input is also protected against negative voltages swings.
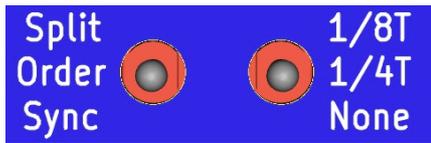
From this main driving clock common to all six GATES outputs, a complementary time delay jitter might be added.

The **Jitter knob** adds a time offset (time delay) to each of the six **Gate output** with respect to the main clock (external or internal). This jitter could be generated both before/after relative to the main clock tick. At each input clk edge the alogithm compute the next coming clock jitter combinaison to be applied. So always expect 1 clock cycle delay to get the result of the variation of a module parameter.

The jitter time delay value is randomly generated following the MonteCarlo principle using a gaussian distribution. The set amount of **Jitter** corresponds to the width of the time delay distribution. From no jitter at

all when the taper is to the left to the fully randomly spaced gates when at maximum. The whole center area let you play a lot with the main time distance between the six **Gate output**.
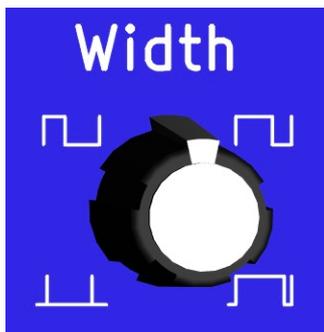

On top of that, different sorting algorithms can be added to distribute the time jitters of each of the six gates outputs.
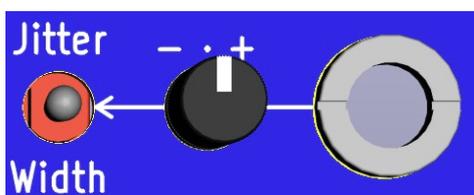
- The **SYNC** position apply a jitter globally with respect to the internal clock. So the same jitter applies to all six gates and they all rise and fall synchroneously.
- The **SPLIT** position each of the six Gates will get a different jitter delay with respect to the internal clock.
- The **ORDER** position again the six gates will get a different jitter delay, but these delays are ordered in a way that it will always be channel 1 output first and channel 6 output last (i.e. from left to right).

The time delay jitter can also be quantised using the second switch in order to perform rytmical variations:

- **NONE** means no time quantisation, all durations are possible within the range [-ClockCycle to +ClockCycle], following the gaussian time distribution introduced earlier.
- **1/4T** means that the jitter delay is quantised and can only change by entire steps of (ClockCycle/4), usefull for creating rytmic variations, with magnitude controlled by the jitter potentiometer.
- **1/8T** is the same with (ClockCycle/8), to allow finer rytmical variations.

The **Width knob** controls the duration (duty-cycle) of the generated Gate Pulses. It is set in percentage of the main clock cycle. So when the clock rate changes the pulse width will follow accordingly. The smallest Gate width is 1% of the duty cycle,the maximum width is 99%.
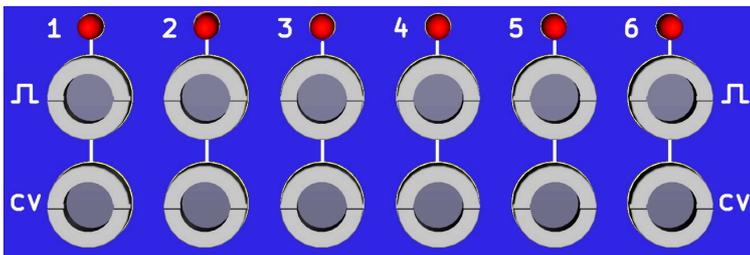

Just on top of the **Width knob** there is a control voltage CV input directed to an **attenuverter** and going into
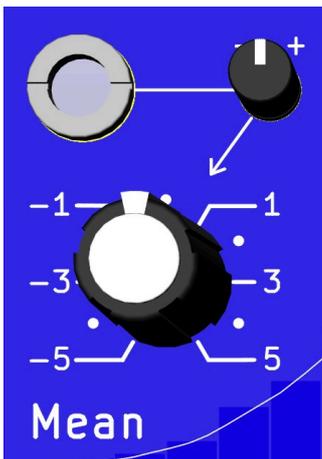
a 3 positions switch :

- Position **Width** use the CV signal to shift the value set by the **Width knob**.
- Position **Jitter** use the CV signal to shift the value set by the **Jitter knob**.
- The center switch position connect the CV to both the **Width knob** and **Jitter knob**.

If there is no jack connected, the **CV input** is normalised to the **CV 3 output** in case you want to have a chaotic self evolution. So keep in mind that when the **CV attenuverter** is out of it's center detent point the mean value will be modified constantly by this internal source.
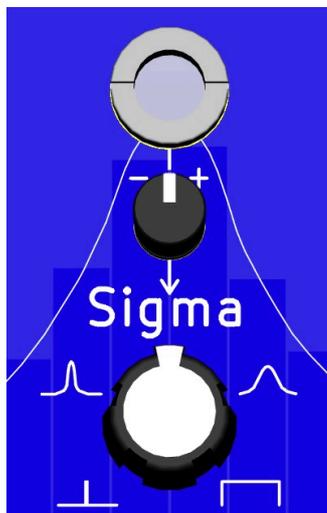
Control Voltage generator

For each of the six **GATES Outputs**, there is a corresponding control voltage **CV Output**. The CV levels are changing synchroneously to the corresponding gates rising edges. The algorithm used to generate these control voltages is using a gaussian distribution controlled by the knobs sitting on the top of the module pannel. The gate LEDs let you monitor the pulses width and/or when the CV value is being updated.

The **Mean knob** setting corespond to the mean value of the distribution of outgoing CV levels. It can be interpreted as a global offset of the six **CV outputs** level around which gaussian voltage variations will be added.

There is a **CV input** jack and a **CV attenuverter** to eventually shift the **Mean knob** setting by using any external control voltage source of your choice. The **CV attenuverter** let you adjust the multiplication level from -1 to 1. Center detent position leads to no CV modulation.

If there is no jack connected the **CV input** is normalised to the **CV 1 output** in case you want to have a chaotic self evolution. So keep in mind that when the **CV attenuverter** is out of it's center detent point the mean value will be modified constantly by this internal source.

The **Sigma knob** adjusts the width parameter of the Gaussian distribution.

- For a small sigma the generated CV level will mainly fall close to the mean value introduced earlier.
- Larger the sigma, larger the width of the distribution and therfore the range of values in reach to be generated on the **CV outputs**.

There is also a **CV input** jack and a **CV attenuverter** to eventually shift the **Sigma knob** setting by using an external control voltage source.

If there is no jack connected the **CV input** is normalised to the **CV 2 output**. So again keep in mind that when the **CV attenuverter** is out of it's center detent point the sigma value will be modified constantly by this internal source.

There is a **switch** with two states **Bins** and **Scales**, it allow to adress the type of quantisation of the **CV outputs**, it works together with **Binning knob**.

First we will introduce the **Bins** (binning) mode, and then the **Scales** mode wich is a set of scales encoded in the 1V/oct format.

With the switch set to **Bins**, the **Binning knob** indicates the number of possible CV levels that could be generated at the outputs. It corresponds to the binning of the CV dynamic range [-5 to +5V]. You can go for a head-and-tail configuration of two states, up to the full dynamic range of the CV outputs (65000 possible values - 0.15mV steps). Binning into 1/V octave is present and also division coresponding to Tone half-tone and quartertone are present.

Binning	CV levels (Volt)	Delta (Volt)
2	-5 ; 5	10
3	-5 ; 0 ; 5	5
6	-5 ;-3 ; -1 ; 1 ; 3 ; 5	2
7	-5 ; -3.3 ; -1.6 ; 0 ; 1.6 ; 3.3 ; 5	1.6
9	-5 ; -3.75 ; -2.5 ; -1.25 ; 0 ; 1.25 ; 2.5 ; 3.75 ; 5	1.25
1.2V/Octave	-4.8 ; -3.6 ; -2.4 ; -1.2 ; 0 ; 1.2 ; 2.4 ; 3.6 ; 4.8	1.2
1V/Octave	-5 ; -4 ; -3 ; -2 ; -1 ; 0 ; 1 ; 2 ; 3 ; 4 ; 5	1
Tone	61Steps of (1/6) Volts	0.166
1/2 Tone	221 Steps of (1/12) Volts	0.083
1/4 Tone	241 Steps of (1/24) Volts	0.041
Continuous	65000 values	0.00015

Using the binning set to 3 for example the CV level will oscillate between 3 CV levels (-5, 0 and 5V)depending how the mean value and the sigma are set, you can control the probablility of falling into one bin or the neighbouring ones.

If you use the Gaussian module to regullary trigger a bass drum for example, you could select how often an excursion to a different pitch is happening.

Now with the switch set to **Scales**, the **Binning knob** is used to select one of the 12 following Scales, in that case the **Mean knob** position is used to jog along the scale's notes and the **Mean CV input** with the attenuverter set to max could be used to perform 1V/oct pitch shifting of the used scale. The result is a bit like an arpegiator would do but you can control the spread of allowed notes and move along the scale's notes with the Mean value giving a lot of playability.

Scale #	Name	Notes
1	Blues Minor	D1 F1 G1 G#1 A1 C#2 D2 F2 G2 G#2 A2 C#3
2	Iwato	D1 D#1 G1 G#1 C2 D2 D#2 G2 G#2 C3 D3 D#3
3	Sakura	D1 D#1 G1 A1 A#1 D2 D#2 G2 A2 A#2 D3 D#3
4	Javanese	D1 D#1 F1 G#1 A1 D2 D#2 F2 G#2 A2 D3 D#3
5	Strange	D1 G1 A1 F1 G1 D2 G2 A2 B2 D3 G3 A2 B3
6	Gipsy	D1 D#1 G1 G#1 A#1 B1 C2 D2 D#2 G2 G#2 A#2
7	Hungarian	D1 E1 F1 G#1 A1 A#1 C#2 D2 E2 F2 G#2 A2
8	Romanian	D1 E1 F1 G#1 A1 B1 C2 D2 E2 F2 G#2 A2
9	Oriental	D1 D#1 F#1 G1 G#1 B1 C2 D2 D#2 F#2 G2 G#2
10	Messiaen	D1 D#1 F#1 G1 A#1 B1 D2 D#2 F#2 G2 A#2 B2
11	Magam	D1 D#1 F#1 G1 A1 A#1 C2 C#2 D2 D#2 F#2 G2

The CV input signal that can be fed on top right of the panel will add to the **Binning knob** position. No attenuator on that one! Signals from -5 to 5V are accepted. Just remember that a 1 Volt step make you reach the next setting. That's it there is no normalised value on this jack when disconected.

Application examples

This module is mainly meant to be a CV level and Gate generator. By setting the gaussian distribution and playing with the time you can get a variety of evolving pattern to control your sound sources and other modules.

Historical studies from pioneers

Using the Gaussian module you could typically perform the Tarantella study from Peter Zinovieff (EMS synth designer) . The piece was based on a more-or-less constant pulse (small time jitter) and a narrow timbral range (narrow sigma for the CV gaussian). In this piece created in the 70's, the specific pitches that are heard at any given moment were determined by probability-weighted randomness, and the loudness set randomly between two limits ([see reference](#)).
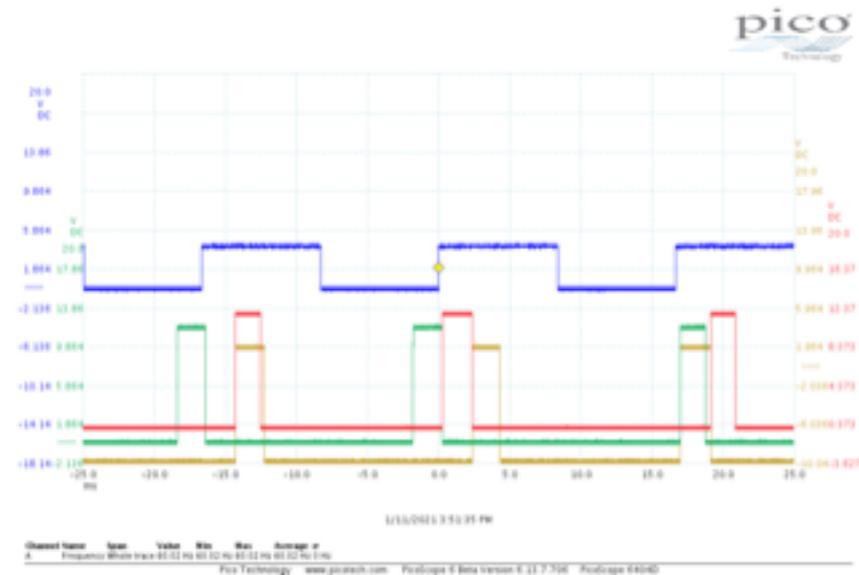
Rythmic patterns

Playing with the **Jitter knob** and the Time quantisation switch, you can create beats always evolving. Using

the six ouput and eventually combining them into a set of logical function you can control the generation of very nice rythmic pattern using your favorite drum sound oscillators.

The Blue trace being the injected clock input signal.

With the quantisation set to 1/8T here is what you get on three of the six gates with a small amount of jitter.
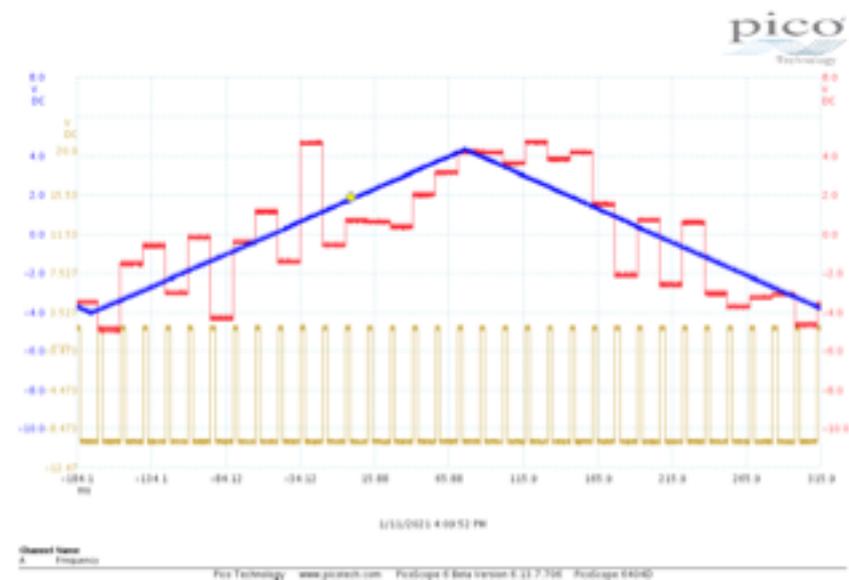

With the quantisation set to 1/4T here is what you get with the same amount of jitter.

Tracking

Though the **CV input** like the one controling the **Mean** can also be used to process CV input signals and duplicate/change them. It would allow you to generate a cloud of levels on the six **CV output** channels that will be tracking the input CV waveform at the desired clock rate.

The next two oscillograms are illustrating the idea. In blue the signal injected to the **Mean CV input**, yellow the **Gate output**, red the **CV output**. First waveform with a small sigma give a small dispertion. Second waveform with a larger sigma allowing larger excursion.

Clock divider

The module can be used as a clock divider (up to 400Hz) just by inserting a signal on **Clk IN**, and using the **Rate** knob to select the division factor. To get six nicely synchroneously divided clocks on the **Gates outputs**, you want to reduce the **Jitter** pot to the minimum. But opening the Jitter slightly can quickly bring a bit of imperfection and human feel to the controlled devices.

Sample and Hold behaviour

Triggering the **Clk IN** with a gate from any of your modules (or your favourite keyboard). With the **Jitter** set

to minimum you will generate 6 CV levels each time a gate is received. A bit like a good old Sample And Hold would do, but in our case we have strong possibilities to adjust the diversity of the CV levels produced by setting the Gaussian width, mean, and bininng. If you start to add a litle bit of **Jitter** on top, the change of the 6 CV levels will occur just following your keyboard gate with a different delay for each output.

Always evolving

Don't forget, each time a **small attenuverter** is out of is central detent point and no jack is plugged you need to remember that the jack normalization is done to one of the six main **CV output**. Thanks to this internal normalization the module can create pseudo-random patterns with even more complex structures always evolving.

References

Gaussian or Normal distribution

Monte Carlo method

Bean machine

Gaton Box