CubuSynth

Engine V2

Dual Complex VCO with wave shaping and modulation features

Manual

SMD-PCB V1.1 Jul 2023

Written and Illustrated by Ruben Sponar

Contents

Limited Warranty:

CubuSynth guarantees this product to be without defects in materials and workmanship for a period of one year from the date of purchase (proof of purchase/invoice needed).

Malfunctions due to improper supply voltages, incorrect or reversed Eurorack power cable connection, misuse of the product, removal of knobs, changing faceplates, or other causes determined by CubuSynth are the user's responsibility and are not covered by this warranty.
During the warranty period, all defective products will be repaired or replaced, in the CubuSynth workshop with the customer paying the shipping costs to us.

CubuSynth takes no responsibility for any damage to persons or equipment caused by the operation of this product.
Please contact cubusynth@gmail.com with any questions, authorization for return to manufacturer or any needs and comments.

1. Introduction

The CubuSynth Engine is a dual analog VCO with wave shaping functions, internal modulations and a chaos generator. It is based around the 3340 chip and features 4 Waveforms + Wavefolder per VCO and 4 Modulated Outputs, all simultaneously.
The CubuSynth Engine can work as 2 independent VCOs, or as one complex FM oscillator. With its inernal "Chaos Engine" it creates semi-random voltages, generated by the 2 oscillator cores. This signal is then normalized to the CV inputs for Pulse width modulation and exponential FM.
Each of the 2 VCOs offers a switch to select one of the 4 waveshapes to be used by the wavefolders, and the linear FM input normalisations.

2. Specifications

- Size: 24HP / 121mm
- Depth: 35mm (measured from the front panel)
- Current Draw:
  +12V: +87mA
  -12V: -74mA
  +5V: +15mA

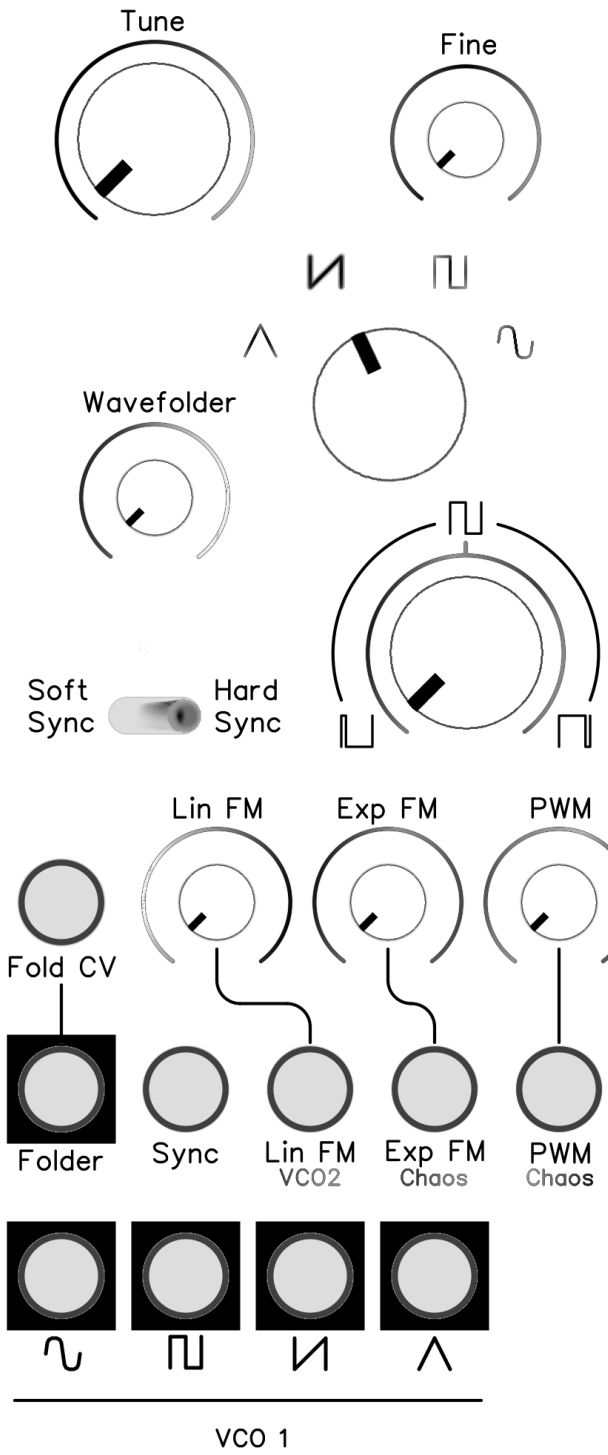
3.1 Key features

- 2 VCO cores (voices)
- 4 simultaneous wave forms per voice + 4 Modulation Outputs
- Wavefolder per voice
- Pulse Width modulation
- Linear and exponential FM inputs
- 1 V/oct tracking stable over up to 10 octaves
- Chaos generator with external clock input
- Complex internal normalised modulations

3.2. V2 Updates

- Improved Pitch stability (Separate Voltage reference for each VCO)
- Old XOR ring modulation circuit replaced by diode ring modulation
- Improved Wavefolder circuit
- New AM circuit based on a N-Channel RF Amplifier
- Replaced Sine shaper circuit with extra Trimmers for Symmetry and Roundness
- SMD technology used to save an extra PCB, resulting in less weight and depth
- Noise filtering capacitors on outputs 1vs2, Chaos and Wavefolders

4.1 VCO Features



Tune
sets the frequency of the VCO, ranging from ~10hz to ~20khz.

Fine
Fine tunes the frequency in ± 2 semitones

Waveform Selector
Select one of four wavefoms used by the wavefolder and internal modulations

Wavefolder
Set the amount of wave folding on the selected wave form. It also has additional CV input.

Pulse Width Modulation
Sets the pulse width for the Pulse Output. It also features a CV input with attenuation.

Sync Switch
Select between hard and soft sync modes.

Lin FM / Exp FM
Linear and Exponential FM inputs with attenuation

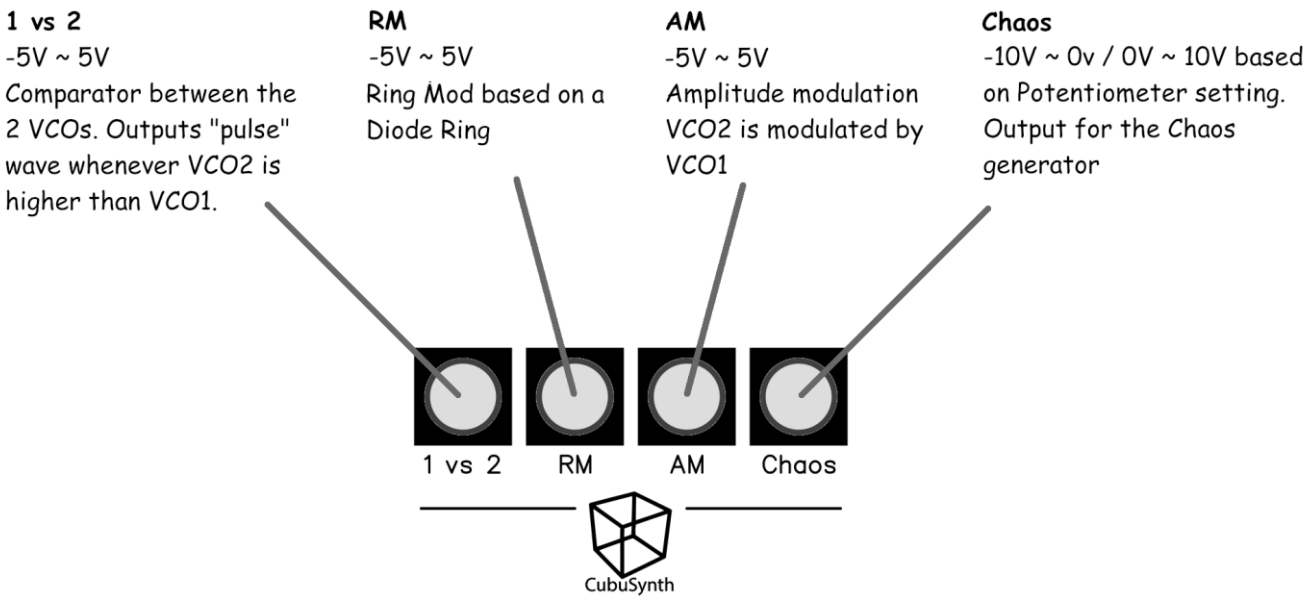
1 V/O Input
1 Volt per Octave stable over up to 10 octaves. Can be linked to VCO2

4 Waveform Outputs
Sine, Pulse, Ramp, Triangle
-5V ~ +5V

4.2 Modulation Outputs

The CubuSynth Engine features 4 simultaneous modulation outputs.

In the 1vs2, RM and AM outputs the selected waveform of each VCO is used to form the modulation.
"Chaos" is the output of the internal chaos generator. It is designed as a CV signal, but might be audible, when the VCOs work in higher frequencies. Keep in mind, that the level of this output depends on the setting of the chaos knob (attenuverter).



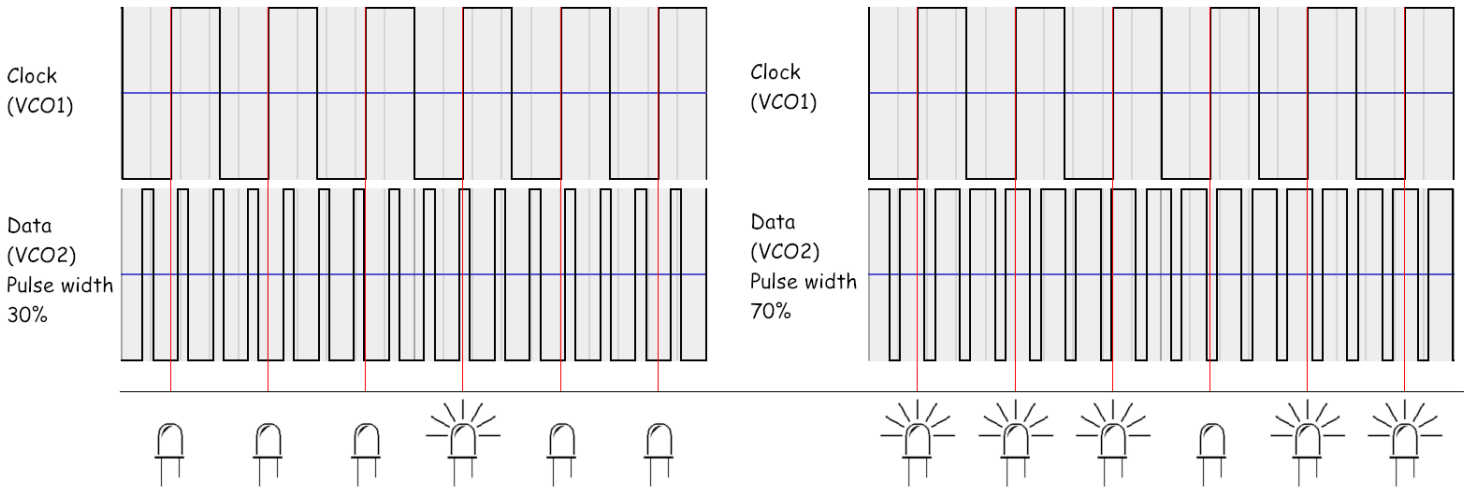
4.3 Chaos generator

The "Chaos engine" is based on a shift register, well known from Rob Hordijk's Benjolin or Music Thing Modular's Turing Machine.
In this module, it is clocked from VCO1 square wave (through normalized Clock Input) and reads data from VCO2 square output.

That means, that for each cycle of VCO1, the Shift register checks the voltage on VCO2. If the Voltage is "high" it lights up a LED. When the next cycle starts, it will "shift" down the light to the next LED and reads VCO2 again. If the voltage is "low" the LED stays off. On the next cycle it will shift down the LEDs status to the next, read VCO2 and so on. This creates the rotation of the light on the front of the module.

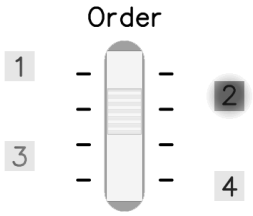
So the Pulse width on VCO2 sets the Probability for the voltage to be "high" in the moment, the Shift register is clocked.

Below you can see 2 examples with same frequencies but different Pulse width settings on VCO2. The six LED symbols represent the light around the Chaos knob.

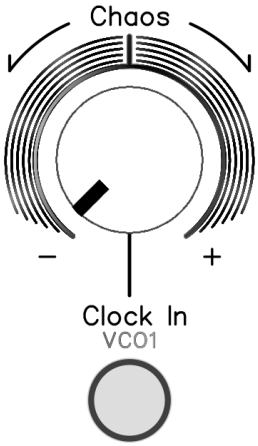


The voltages from the 8 LEDs are then mixed together with different strengths, to create semi-random stepped Voltages. With the Order switch, you can select which part of the LEDs has the strongest influence. This gives different patterns of the voltages generated.

4.4 Chaos generator features overview



Order
Select which part/color of the LED-circle has the most influence on the chaos signal.
1 means red has most influence, as 2 for purple, 3 for green and 4 for yellow



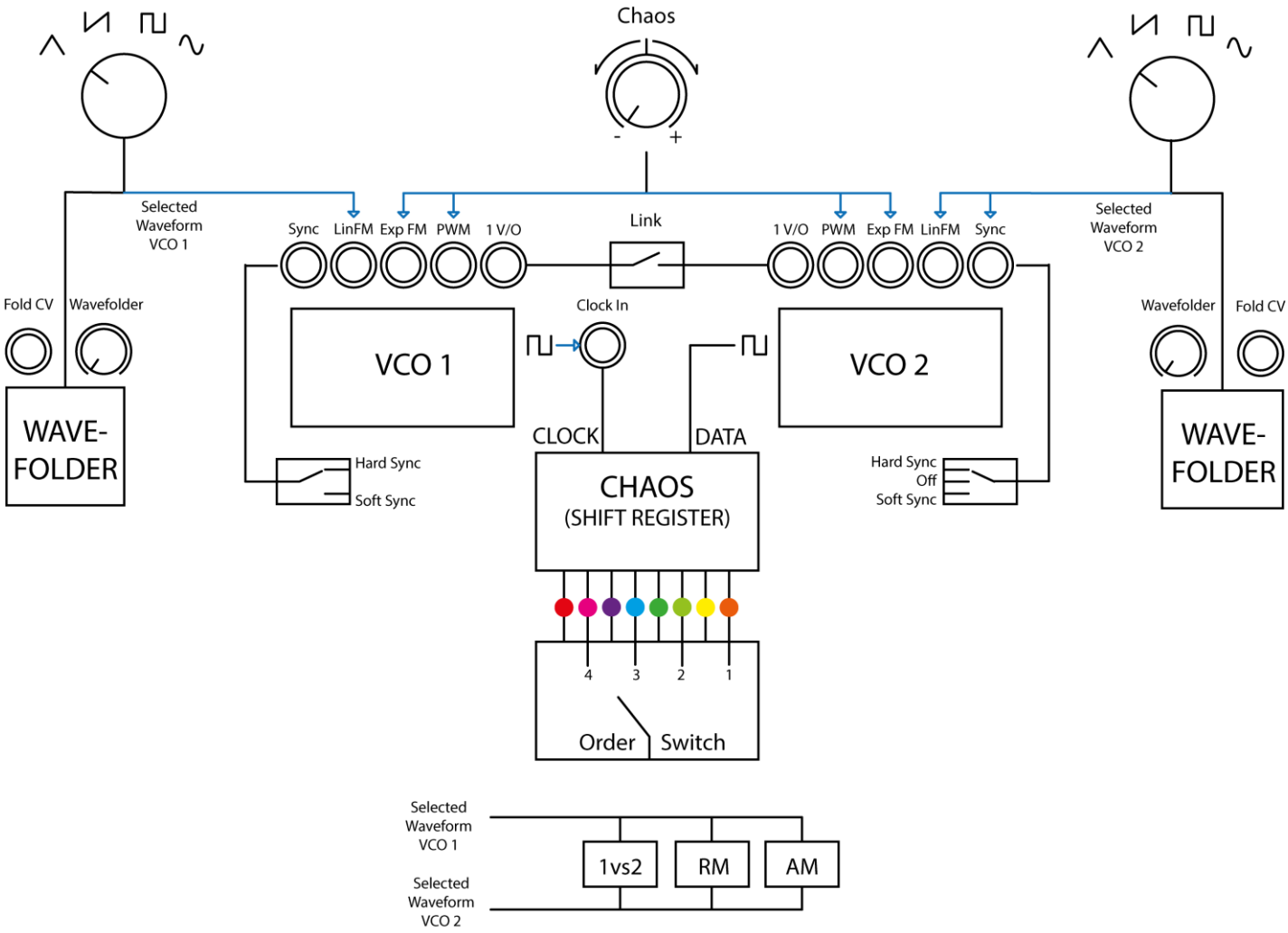
Chaos attenuverter
Sets the overall voltage range of the chaos signal ranging from -10V < 0V to 0V < 10V

Clock In
External clock input for the chaos generator.
Normalized from VCO1 square wave, this input sets the speed of the LEDs rotation

5. Routing Map

Here is an overview for the internal routing path of the signals. With the waveform selector switch, you can choose, which one of the waveforms will be used in the Wavefolder, the modulation outputs and and the normalisations. On the Engine Frontpanel you can see the normalized signals on inputs written in silver.

The arrows in blue represent the normalisations, the colored dots represent the LEDs around the chaos knob.



6. Tips & Tricks

There is many ways to create very interesting and complex sounds, only with the Engine Module.

You can plug any of the outputs to any of the inputs of the module itself. For example the VCO1 waveform outputs to the input of the second Fold CV. Or the Wavefolder output of one, to the FM inputs of the other VCO. You could also use the chaos signal for the Wavefolder CV.

When turning down VCO1 to very low frequencies, the chaos generator will create "Sample&Hold style" stepped random voltages.

By sending the chaos signal to a quantizer and back to the 1V/oct input, you can create very musical randomness. Sometimes it will lock itself on a loop/sequence.

The chaos CV signal can also be used to create random triggers (for example for a gate of an envelope generator), depending on the Chaos knob setting and the voltage, the gate input needs to trigger the module. With the Pulse width control of VCO2 you can then control the probability (enough voltage to trigger). This also works great with an AND logic gate, combined with your clock signal.

For the Wavefold CV input it is recommended to use an external Attenuator to have control of the CV modulation amount. When the Fold CV (in combination with the wavefolder knob) reaches negative voltages, it will also control the volume of the VCO, so it can also act like a VCA with wavefolding.

7. Callibration

In case the Module should get out of tune, you need to calibrate the trimmers on the back.

To do so, plug in the 16pin Eurorack Power cable correctly to your Bus board and the Module while your rack is powered OFF! Make sure orientation is correct. (Red stripe to the -12V side).

Sine Wave

Plug the VCO1 sine wave into an oscilloscope.

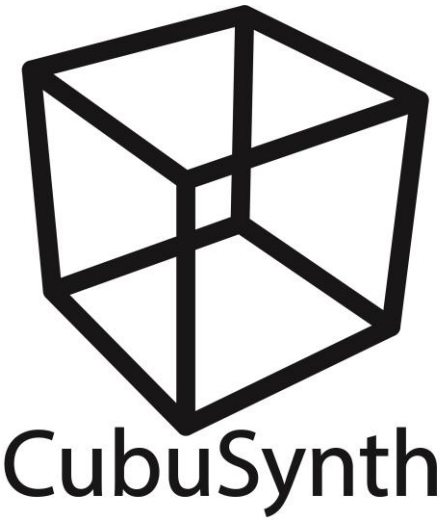
Adjust the "Sine Symmetry" Trimmer so the wave looks the same on top and bottom ends, and swing around 0V.
Then adjust the sine roundness, until you reach the desired sine shape. You can also check on a frequency spectrum (EQ) to adjust for the least overtones possible.
Then repeat for VCO2.

1V/octave

To adjust the V/oct tuning, plug a Keyboard/Sequencer or MIDI-interface, that produces 1V/oct signals to the 1V/O input of VCO1.
Play the lowest C and tune VCO1 to play a C. Then press the C1 on your keyboard (one octave higher) and adjust the trimmer (without detuning on the Front) so the tuning is exactly note C, one octave above. Repeat those steps until the VCO always plays a C when you play a C on the keyboard, and up to 10 octaves higher.
Repeat for VCO2.

If you prefer, you can also let a sequencer play through 4 octaves in 4 steps (C1, C2, C3, C4) and turn the trimmer, until the tuner always shows the same note in different octaves.
If you don't have a tuning device, but a frequency counter (on the oscilloscope), you can replace the notes with Hz. Tune down to exactly 100hz, the next octave should always double the frequency to 200hz, then 400hz, 800hz, 1600hz and so on.

The HF trim might need to be adjusted. If by playing in higher frequencies (higher octaves) the V/O tracking is not exact, turn up or down the trimmer, until the high octaves are also stable in pitch.



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The CubuSynth Engine was designed by Ruben Sponar, from the first prototype in September 2021 to the finished module in May 2022. The V2 is an improvement based on customers feedback and was released in 2023.
A few honorable mentions:
The Chaos generator was inspired by Rob Hordijk's Benjolin and Music Thing Modular's Turing Machine.
The Wavefolder is based on schematics by Eddy Bergmann and adds CV input, based on Tom Wiltshire's Vintage VCA.
The Sine wave shaper is based on schematics by Thomas Henry.