BENJOLIN V2 MANUAL

Manual Revision B

HISTORY

The Benjolin is originally a ‘patch in a box’, meaning a couple of ‘modules’ patched up in a fixed way and put in a box to create a specific kind of standalone instrument. This patch is not intended to create music based on melodies, harmonies and specific rhythms, but to create ‘sound scapes’ of pure electronic sounds. Meaning it’s an ‘electronic music instrument’, an instrument to create electronic music in its most pure and abstract forms.

The first version of the Benjolin was designed as a kit in the year 2009, for the purpose to organize DIY workshops where people could build a Benjolin themselves. Every participant was taken by the hand to successfully build one, even if they had never built a piece of electronics before and/or used a soldering iron. A necessary requirement for the design was to keep it simple, it should not take more as about four hours for a complete novice to build a kit. And so the first Benjolin was fully based on the punk principle of ‘the minimum for the maximum’.

Hundreds of people all over the world have built Benjolins in these workshops and virtually everyone succeeded in finishing and go home with a properly working Benjolin. At this time the technique of circuit bending was popular, and the name Benjolin originates as ‘an electronic crossover between a banjo and a violin’ that is ‘bent by design’. The banjo being an instrument associated with popular music and the violin being associated with a bit elite music, and the built-in crazy behavior associated with circuit bending. So, an instrument for everybody, to give incredible fun while exploring its behavior. As a standalone instrument this DIY Benjolin was a good companion for guitar stompboxes and other effects units, with line level audio inputs.

Soon it became clear that the Benjolin was actually very useful in creating pure and abstract electronic music. The kind of music that the designer of the Benjolin thinks began with e.g. the soundtrack of the movie Forbidden Planet around the year 1956. Several composers and performers of electronic music and movie tracks discovered the Benjolin. And it also became the guilty pleasure of many synth and keyboard players that normally would play melodies and harmonies in proper rock songs, but also like to experiment with sounds when no one else is around, just for the fun of it.

As this first Benjolin version was a gift to the diy community the designer was always hesitant of making a Eurorack version. There has been an officially licensed Benjolin v1 Eurorack version made by Epoch Modular. The downside of this v1 was that because of the design restrictions of the original diy workshop kit many extra possibilities were not present. Signal levels were also not very compatible with Eurorack, as the original schematic had the specific property that the audio output could be used directly with stompboxes, guitar amps and living room hifi amps.

It’s now well over ten years after the first Benjolin workshops, and some time ago the Epoch version disappeared from the market. This made After Later Audio and Rob Hordijk decide to join hands, and that now was the time to make a new design specifically for Eurorack with many more features brought to the outside of the module and inputs and outputs properly specified to be used in a Eurorack setup. And so in the summer of 2020 the Eurorack Benjolin v2 was born.

DESCRIPTION

The Benjolin ‘patch’ is based on four ‘modules’, or function blocks. There are two voltage-controlled oscillators with a very wide pitch range. These two VCOs are named OSC1 and OSC2. Third is a 12dB voltage-controlled filter simply named the filter. In this text it is also named the VCF. This filter has exceptionally good ‘pinging’ characteristics, and the cutoff can be modulated deeply at the highest audio rates. The fourth block is a special ‘interference pattern generator’ function, creating voltage patterns from the signals coming from the two oscillators. The pattern generator architecture is unique enough that it is entitled to its own name and many years ago it was baptized as a Rungler. So, just like how an oscillator is oscillating, a Rungler is Rungling. In its simplest form a Rungler needs two pulse signals as inputs, and from these two pulses it can create several output signals that are basically stepped patterns of specific lengths. Patterns are either slowly changing or can be frozen in a short loop. What sets a Rungler apart from e.g. a sequencer is its property that patterns are dynamic, so they can be constantly changing. There is also a certain amount of control over when the pattern changes.

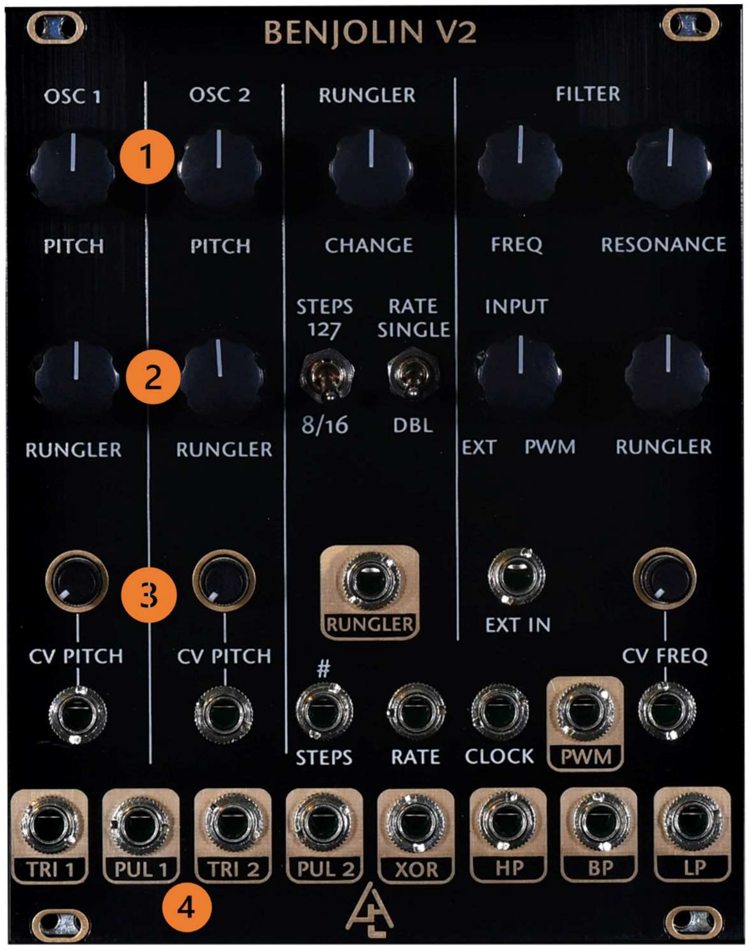
The output signals of the VCOs and the Rungler are used to cross-modulate and self-modulate themselves and the other functions. These cross-modulations and feedback-modulations together create a system that is capable of myriads of different and dynamically changing sounds. Still, all those sounds will have one specific character, and that is the ‘sound’ of the Benjolin.

To summarize, there are two VCOs, one VCF and the Rungler in the Benjolin. Each of these four blocks can be used separately as an individual module, having its own signal and modulation inputs and outputs. So, it’s no problem at all to use the VCOs as extra modulation signal oscillators in a larger patch, if you just need an extra LFO. Also the filter can be used as a separate filter, or even as a separate sinewave oscillator. The Rungler can also be used separately, its functions will be described in more detail later.

It is highly recommended to spend some time reading the signal flow and playing with the module. It should help you get a feel for how to control this complicated chaos machine.

New to the Benjolin V2:

- Reworked oscillator and filter sections
- All levels are adjusted to Eurorack standards
- Two different steps modes (8/16 and 127)
- Double and single clock rate
- Externally clockable
- External filter input with blend control
- Support for the Turing Machine expanders (with Tom’s permission)



OSCILLATORS

Oscillator 1 and 2 have identical controls and inputs/outputs.

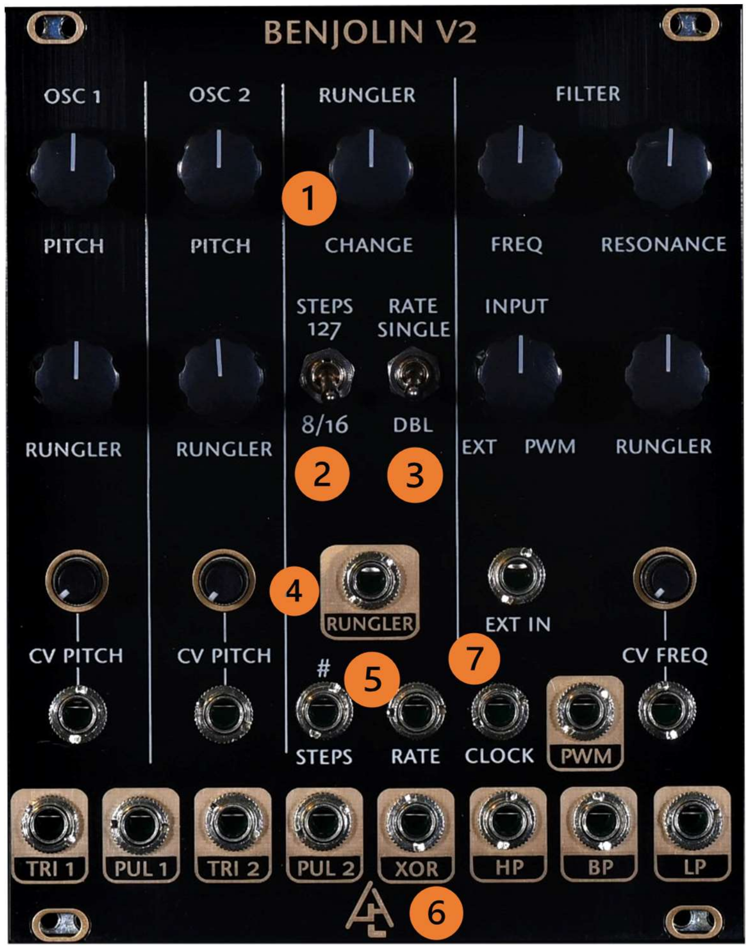
1. Pitch: Coarse pitch control to control the frequency of each oscillator.

2. Rungler: The ammount of Rungler stepped CV that is applied to each oscillator.

3. CV Pitch: CV pitch input with an attenuator to control the amount of impact on the pitch of the oscillator. The jack is normalled to the triangle output of the opposite oscillator (OSC1 CV pitch input is normalled to the OSC2 triangle wave).

4. Waveform Outputs: Triangle and Square/Pulse outputs for each oscillator.

It is important to note that the oscillators sections do **not** support v/oct. This might feel odd but once you play with the module it will become clear why this is not important.



RUNGLER

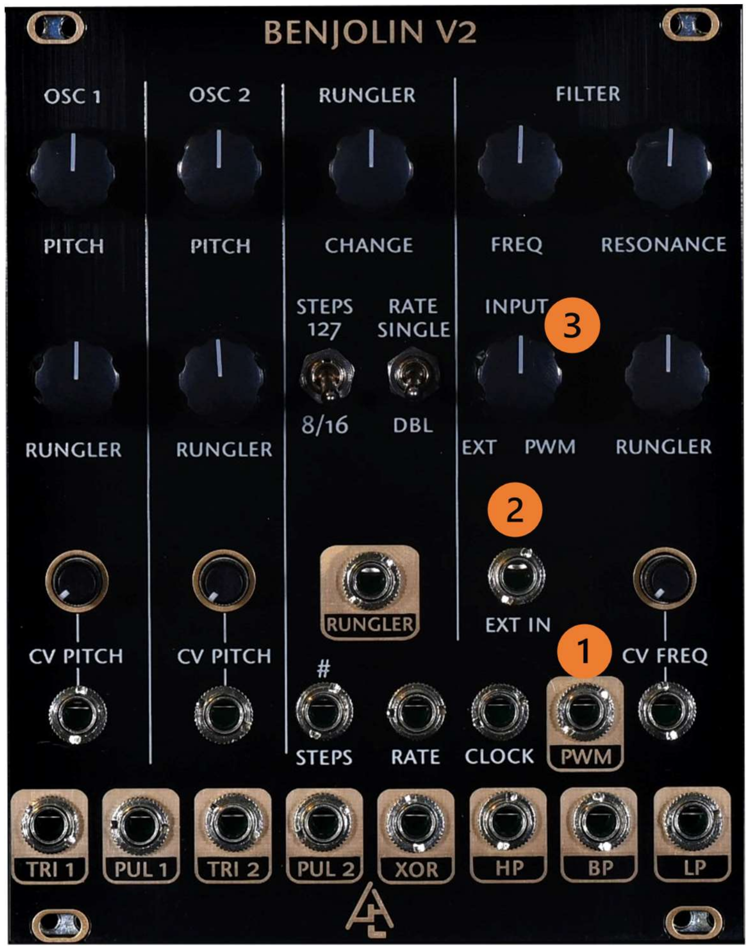
The Rungler section is centered on a shift register that uses an R2R DAC to create a stepped CV voltage. There are two inputs into the shift register, the data to sample (which comes from OSC1) and clock speed (which comes from OSC2). You can play with the speed of both of the oscillators and see how they influence the stepped CV output from the Rungler.

1 Change: Controls how much the rungler is allowed to take in new data, and therefore change the stepped CV output. Full CCW and CW does not allow new data into the shift register, and therefore locks the stepped CV loop. When the knob is at the midpoint/top, the Rungler takes in all new data and does not recirculate any data.

2 Steps: Toggle switch to control how the data in the shift register is recirculated. There are two modes of 8/16 steps and 127 steps.

3 Rate: Controls how the clock on the shift register is advanced. The single clock rate only advances on the rising edge. The double clock rate will advance on both the rising and falling edge of the clock signal.

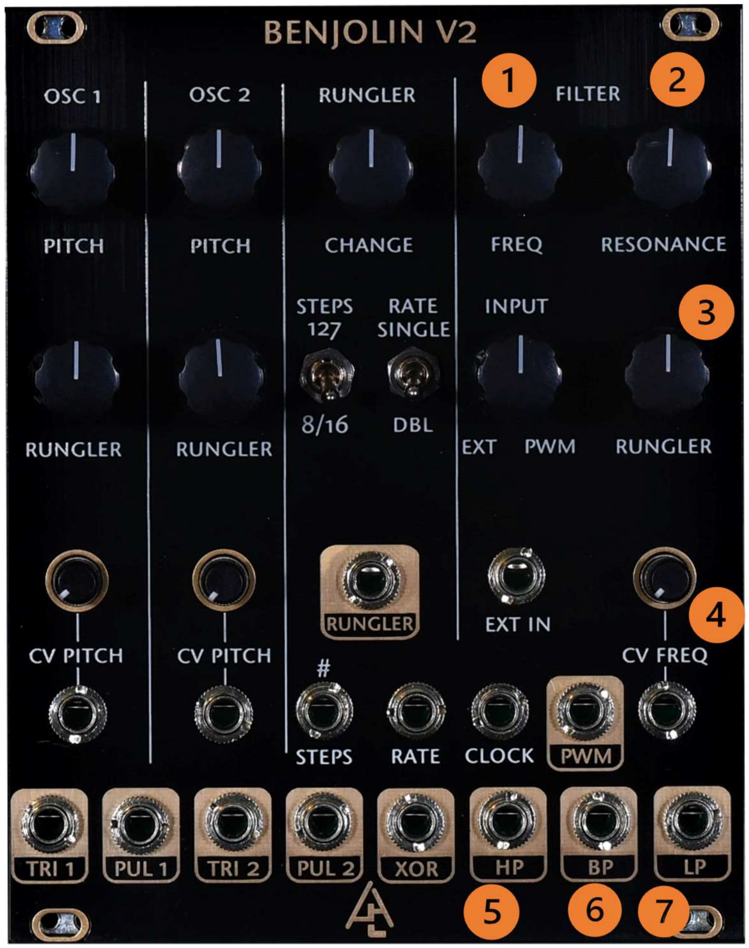
4. Rungler: The actual stepped CV output that ranges from -5V to +5V.
5. Steps/Rate CV Inputs: The switches are configured so that when the switch is up you will get the same behavior as passing a high voltage.
6. XOR: The output of one bit from the shift register resulting in a random gate output.
7. Clock: Control the clock rate of the shift register and therefore the stepped CV output of the Rungler. This jack is normalled to the frequency of OSC2.



MIXER

Controls the input into the filter section.

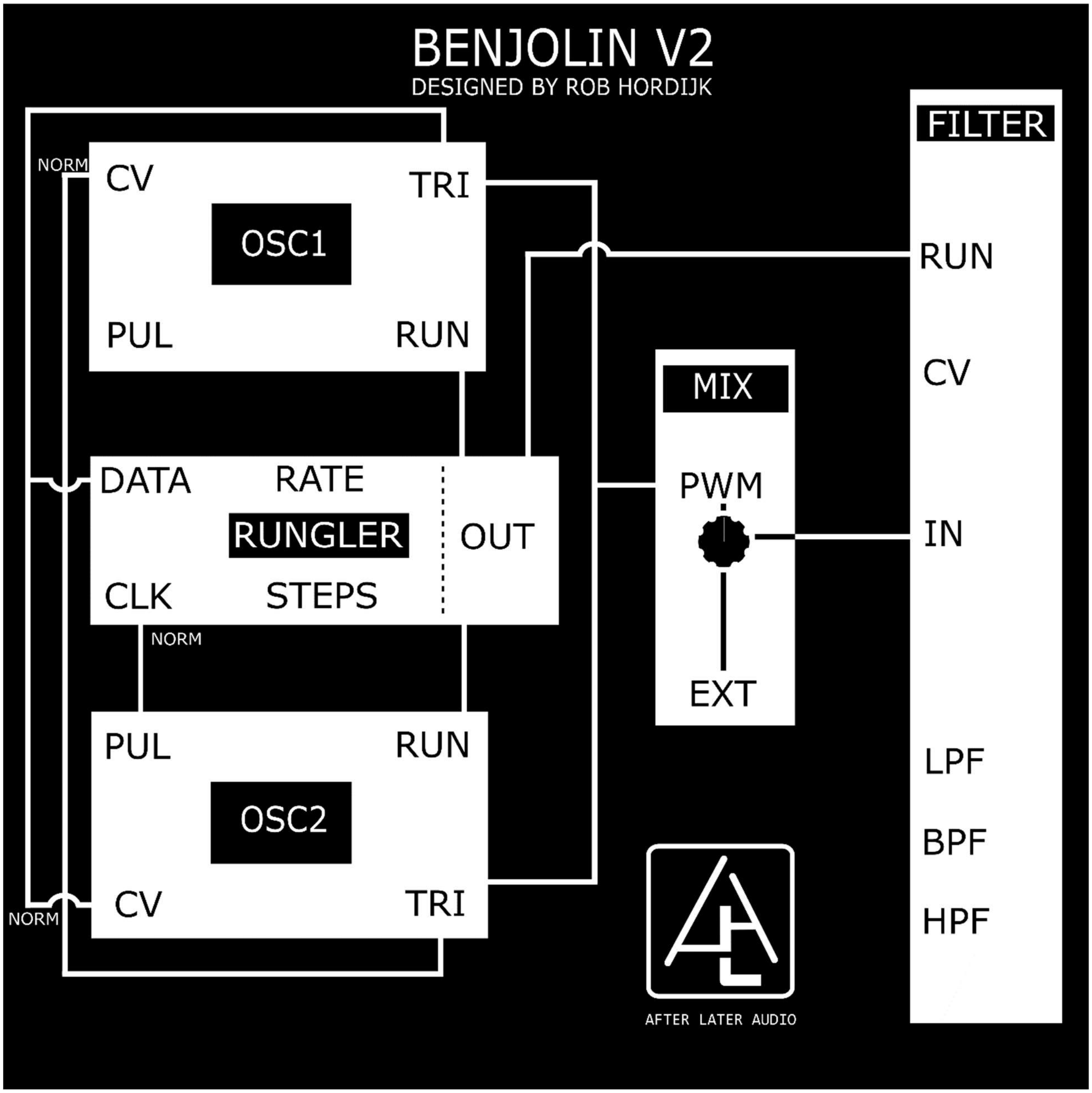
1. PWM: The output of the comparator of the triangle wave from OSC1 and OSC2 resulting in a square wave with variable width.
2. Ext In: An external audio input
3. Input: Controls the blend between PWM and Ext In that is fed to the filter input.



FILTER

1. Freq: Controls the cutoff frequency of the multimode filter
2. Resonance: Controls the resonance of the multimode filter. Delivers more wetness than a Seattle winter.
3. Rungler: The amount of Rungler stepped CV that is applied to cutoff frequency.
4. CV Freq: CV pitch input with an attenuator to control the amount of impact on the cutoff frequency.
5. HP: Highpass output of the filter.
6. BP: Bandpass output of the filter
7. LP: Lowpass output of the filter.

SIGNAL FLOW


BENJOLIN V2
DESIGNED BY ROB HORDIJK
NORM
CV
OSC1
TRI
PUL
RUN
FILTER
RUN
CV
MIX
DATA
RATE
RUNGLER
OUT
CLK
STEPS
PWM
IN
NORM
EXT
PUL
RUN
OSC2
LPF
BPF
NORM
CV
TRI
HPF
AFTER LATER AUDIO

PATCH SUGGESTIONS

1) The filter can be changed easily into a pure sinewave oscillator by feeding back the BP output to the crossfader input, setting the crossfader to the ext-in position and setting the resonance knob about ¾ open. When resonance would be fully open you will hear clipping in the sinewave. The sine signal can be taken from both the LP and the HP outputs.

2) When you would want to do FM crossmodulation with two of the Benjolin filters used as sine oscs, then you apply this BP feedback so both filters turn into sinewave oscs, listen to the LP outputs and crossconnect the HP outputs to the other filter modulation inputs.

GETTING MORE INTIMATE WITH YOU BENJOLIN

Undoubtedly you have already tried out the Benjolin V2 before reading the manual or this text. Most probably you got lots of totally crazy sounds and undoubtedly have wondered if it is at all possible to get any kind of control over the sounds. Well, for that you will have to get to know the Benjolin at a much more intimate level. Which will take some time. You will learn that it will never be possible to predict the behaviour in detail, but it is very well possible to predict the behaviour at a more global level. And that way be able to actually incorporate it in a performance or composition. Though the Benjolin will always request from you to anticipate and improvise on what you hear.

To get more familiar with your Benjolin it is a good idea to first explore the four functions one at a time. But before going into the rungler function it is a good idea to get completely familiar with the two vcos and the vcf first.

The vcos are equal in their design. Both produce a 10V pp triangle wave and a 10V pp square wave as output, available on mini-jack connectors. Both also have a mini-jack cv pitch input with an associated modulation level knob. This means that there is a ‘symmetry’ between the two vcos, each could e.g. go to a left and a right audio channel on a mixer, and then you can apply crossmodulation between the two vcos. This would give you two related drone signals, each on its own channel.

The total range of the vco pitch knob is from one cycle every 45 seconds at the ccw position to about 8kHz at the cw position. cw and ccw stand for clockwise and counterclockwise. The pitch knobs have the lfo range at the left side and the audio range at the right side. At the 12 o’clock position the pitch is roughly around 20 Hz to 40Hz, the area at the top of the lfo range and at the bottom of the audio range. There is some tolerance in the analog electronic components, meaning there may be a slight difference between the two pitches when the pitch knobs are set fully cw or ccw. But these slight differences are the charm of analog and help causing the organic quality of the analog sound.

The cv pitch curve is close to 1V/Oct, but these oscillators are not intended to play melodies in e.g. a perfectly tuned equally tempered 12 note scale. Instead they are intended to produce pitches over a very wide pitch range, of over eightteen octaves. And to be modulated over that very wide range as well, at slow rates and at very high audio rates. This is what these oscillators are very good at: to be modulated. Though at the expence of a slightly inaccurate 1V/Oct scale.

CHECK IT OUT!

Lets start with the first vco. You can connect the triangle wave output of the leftmost vco to your mixing desk, close the rungler and cv pitch knobs, set the osc1 pitch knob to about 2 o’clock and then slowly open the fader on the mixing desk. Remember that this is a hot signal, so use a mixer channel that can handle such a signal without overloading its input. You should now hear the typical ‘hollow’ sound of a triangle wave at a moderate pitch.

It is possible to do some waveshaping on this triangle wave, though this will change the pitch as well. For this you connect a short mini-jack cable between the osc1 pul1 output and the osc1 cv pitch input. Now you slowly open the cv pitch modulation level knob above the mini-jack connector. You should hear two things happening, first you hear a detuning and second you hear the character of the sound change from the typical ‘hollow’ triangle wave to a much more bright sawtooth wave.

This effect may not be very spectacular yet, but when the vco is used at lfo rates changing the waveshape this way can produce nice results.

NORMALIZATION

If there is no jack connected to a cv pitch mini-jack connector on a vco then the mini-jack connector is normalized to the trianglewave output of the other vco. This means that without jacks inserted in the cv pitch connectors osc1 is modulating osc2 and osc2 is modulating osc1. Normalization means that the circuitry uses signal switches built-in in the mini-jack connectors. This happens behind the frontpanel, so its invisible, but it basically means that if there is no jack in the connector the connector output is connected to some internal signal. And the moment when a jack is inserted in the connector the internal switch breaks the internal connection and it is the signal from the jack that takes over instead of the internal signal.

See it like this: *if no jack is connected to the osc1 cv pitch connector then osc1 will use the triangle wave of osc2 for modulation when the cv pitch knob is opened. Inserting a jack will ‘override’ this connection and osc1 will use the signal from the cable when the cv pitch knob is opened*.

So, lets listen to the triangle output of osc2 and set osc2 to a pitch in the audio range, like at 2 o’clock. Now set the pitch of osc1 into the lfo range, like at 9 o’clock, and slowly open the osc2 cv pitch knob. You will hear the triangle of osc1 sweep the pitch of osc2 up and down. Now connect a short mini-jack cable from the pul1 connector to the cv pitch input connector of osc2. Instead of a sweeping sound you will now hear a modulation between two fixed pitches, caused by the low and high voltage levels of the osc1 square wave.

If you now disconnect the short cable from the cv pitch input of osc2 and instead connect it between the PUL1 connector and the cv pitch input of osc1 and also open the osc1 cv pitch knob you hear that the modulation pattern changes from up and down sweeps of equal length into longer upsweep and shorter downsweep times.

Now you should think of every possible combination of patching only the four osc outputs and two osc inputs, while listening directly to one or more of the four outputs. Both selfmodulation and crossmodulation are possible, and all create their own specific effects.

LAWS OF FREQUENCY MODULATION

Frequency modulation of one oscillator with another oscillator can be expressed in mathematical terms and extensive calculations can be done to predict the results in terms of the harmonic content of the resulting sound spectrum. However, this math is just super complex and it needs a degree in mathematics to understand the type of functions and formulas. These kind of calculations you do not want to do. And they also do not give practical guidelines on the behaviour of frequency modulation.

Instead there is one rule of thumb that you need to remember and that is:

A low pitch can easily modulate a high pitch over a very wide range, but a high pitch can not so easily modulate a low pitch over the same range.

This means that in general the pitch of the oscillator that is modulating the other oscillator should be lower or equal to the pitch of the modulated oscillator. You can make it a bit higher and still hear some effects, but if you make it significantly higher you will hear that the frequency modulation effect disappears, no matter if you increase the modulation level or not. The sonic effect that remains is more like the signal is digitally sampled at a samplerate equal to the modulating pitch.

You can test this principle by letting osc1 modulate osc2 and listen to the osc2 triangle wave output. If you keep the cv pitch knob at the same level and tune the oscs from the lfo range into the audio range and back you hear that the lfo can easily modulate the audio pitch but an audio pitch doesn’t really do a lot on an lfo range.

There is a way to change this behaviour and get an equal modulation depth despite pitches, but this involves the addition of extra circuitry. In fact it would need a s&h circuit, which changes the mathematics from frequency modulation formulas into statistic functions. But such circuitry is not present in the Benjolin, and so you need to remember that low pitches easily modulate high pitches but high pitches hardly modulate low pitches at all.

Still, later we will see that the rungler is actually behaving like how a S&H would behave and that when using the rungler outputs the modulation mathematics follow the statistic functions and not per se e.g. the frequency modulation Bessel functions.

PWM MIXER FOR THE OSC1 and OSC2 SIGNALS

There is an inheritance from the original diy design, as the original was designed to have a little knobs as possible, just to keep things simple. To mix the signals from the two vcos before going into the filter the decision was made not to give each of them its own output level mixer knob, but instead create a fixed mix of the two vcos. However, this mix is not a sum of two vco output signals, but the ‘compare’ of two vco output signals. In fact, it are the two triangle wave signals that come from the vcos that are fed into a ‘comparator’ circuit, which outputs a low pulse if the osc1 triangle is at a momentary higher level and a high pulse if the osc2 triangle is at a momentary higher level. If one vco is running at audio rate and the other at a low lfo rate this will create a deep pwm sound, pwm meaning Pulse Width Modulation. When the pitch of the vco that is at an lfo rate is increased into the audio range the result will start to sound like ringmodulation. This pwm signal is what is fed into one of the inputs of the crossfader at the input of the vcf. If you try out this pwm sound you will instantly recognize its potential on spacey drone sounds, as the pwm has a strong ‘spacious’ character. It sounds very similar to two musical instruments playing in unison.

If both vcos are tuned in the lfo range the pwm signal sounds like pulses with a distinct ‘polyrhythm’ character. When feeding these pulses into the vcf set to maximum resonance you will create a percussive rhythm. Modulating the vcf through the cv freq from one of the vco outputs can modulate the timbre in the ‘beat’ of the rhythm.

THE FILTER

The vcf is a more or less ‘standard’ voltage controlled 12dB state-variable filter. It has a single knob ‘equal loudness’ crossfade mixer on its input to allow easy selection of either the internal pwm sound or a sound that comes in at the ext in mini-jack connector. If there is no jack inserted in this connector the crossfade mixer knob can be used as a volume control, ccw is silent and cw sends the internal pwm mixer sound signal to the filter. Note that this crossfader fades between the internal pwm signal and an external signal, and nót between the two vcos.

Of course you can also route any of the osc outputs to the crossfader external input, this way any signal can be used as input to the filter instead of the pwm signal. A crossfade mix of e.g. the pul1 connector on vco1 and the internal pwm can be used to set a subtler phasing.

The filter has three outputs: lp = lowpass, bp = bandpass and hp = highpass, as is common with 12dB state variable filter types. The advantage of a state variable filter is that it can be configured in a way that by default it is at its maximum resonanant setting. Then this resonance can be reduced by ‘damping’ the filter using the resonance knob. The Benjolin filter is set up in a way that in normal use and resonance set to fully cw it is on the brink of oscillation. If a sharp lfo pulse, e.g. the flank from a pulse wave or from a sawtooth wave is fed into the filter it will ‘ping’. Meaning a short burst of sinewave cycles is produced that dies out after a second or so. This creates a ‘percussive’ effect. If this ‘percussive ping’ is taken from the bp output the initial flank will not be present in the output signal and a clean burst of sinewave cycles is heard. This ‘ping’ can be given more sonic character by feeding e.g. an audiorate triangle wave signal into the vcf cv freq mini-jack input and slightly open its associated modulation level knob.

By mixing the lp, bp and hp outputs on an external mixer it is possible to create ‘in between’ filter curves. The phase relation between the lp, bp and hp outputs is 0 degree, 90 degree and 0 degree, meaning that the lp and hp are not in antiphase. To create a notch filter you will have to invert either the lp or the hp with an external module before mixing them to create the notch.

To use the vcf as a sinewave oscillator with a continuous sinewave output you connect the bp output to the vcf ext in connector, turn the crossfade mixer knob fully left and set the resonance knob to a 12 o'clock position. When opening the resonance knob further in the cw direction will start clipping the tops of the sinewave cycles. You can hear the sinewave on both the lp and the hp outputs. By using an external multiple you can also split the bp signal and listen to the bp signal while feeding it back to cause the oscillation.

If you listen to the lp output you can additionally connect the hp output to the cv freq input of the vcf, opening the cv freq knob will now 'morph' the sinewave to a bright sawtooth wave, though at the expense of some detuning. You can also make this hp -> cv freq connection when doing normal filtering to change the brightness of the filtered sound.

You will find out that this little vcf filter has many not so obvious extra features that are great to discover and play with. Especially when creating drones you will notice that the extra possible modulation paths in the filter can subtly change the character of the drone over wide ranges. In this case do not simply use knobs in their fully closed or fully opened positions, but turn them very slowly to discover the sonic areas and sweet spots you like most.

THE RUNGLER

The rungler circuit is based on a binary device named a shift register. This shift register is a cascaded group of one-bit memory cells (D-type flip-flops), all sharing the same ‘write’ clock pulse. On clocking each memory cell passes its stored value of either a one or a zero to the next memory cell and takes over the value of the previous memory cell. This way a pattern of bits in the memory cells is shifter one position to the right on each clock pulse, taking in a new bit from a data input at the beginnning of the cascade and dropping the last bit that gets shifted out at the end of the cascade.

This shift register circuit is found in almost all digital devices, as its most common use is to convert parallel data into a serial data stream and convert a serial data stream back into parallel data. This conversion process is at the base of e.g usb connections, Ethernet network connections, etc. But this shift register circuit can be used for many other purposes as well, e.g. sequencing, noise generation and arbitrary waveform generation. The rungler is a special use of the shift register that is somewhere half way between sequencing and noise generation.

There are several shift register chips from several different logic chip families available. The original Benjolin used a cmos logic cd4021b chip. This cd4021b has eight cascaded flipflops, a serial data input, a clock input and three outputs from the last three memory cells. In the v2 version a cd4015b is used, which is functionally compatible to the cd4021b, but features outputs for all eight memory cells. These eight bit outputs are available on one of the backside expansion connectors.

In essence a rungler circuit takes one output bit from the shift register, in general the last bit of the cascade, modifies this bit with an external modification bit and then feeds the modified result back into the serial data input of the shift register. On the next clock pulse this modified bit is fed back into the shift register. This will create a short loop of bits that form a serial bit pattern. This pattern is changed by the modification caused by the external bit. Then a few output bits are connected to a digital to analog converter to produce a stepped analog output voltage. This analog voltage changes to another value when a clock pulse is applied to the rungler circuit.

The Benjolin v2 rungler uses three bits for the DA converter, which can produce eight voltage levels at roughly -4V, -3V, -2V, -1V, 0V, +1V, +2V and +3V.

When there are eight memory cells in the shift register and three of them are used to connect to the DA then changing only one bit in the circulating pattern will influence the analog values of three steps. It is this property that actually makes its behaviour interesting.

The idea of a rungler is to use two squarewave vcos to drive the circuit, one is driving the clock input and the other provides the external modification bit for the shift register feedback loop. The simplest possible modification is a one bit multiplication, also named a logic exclusive or or xor function. What this does is, depending on the value of the external bit, either let the feedback bit pass unaltered or negate the feedback bit to its inversion. If the square wave that produces the modification bit is at a much lower rate as the oscillator that clocks the shift register then the pattern changes on every flank of the modification bit, so the moment when the modification bit goes from low to high the pattern will change and when it changes from high to low it will also change. Additionally the length of the pattern will be twice as long if the modification bit causes an inversion. So, a change in level of the modification bit will change the pattern content ánd the pattern length, doubling or halving the length on each change.

The rungler circuit is at first sight very similar to shift register based digital noise generators, but differs at some crucial points. What it shares with the noise generator circuits is that it uses feedback. But the way feedback is handled is different. The digital noise generators are set up to give a pseudo-random sequence of the maximum length possible with the amount of flip-flops in the cascade. Which for a shift register cascade length of ‘n’ is 2^n - 1. The rungler circuit produces sequences that are either n or n*2. So, while an ‘eight bit’ shift register would produce a pseudo-random sequence of length 255, where each value between 1 and 255 would appear once though in a scrambled time order, this eight bit shift register used as a rungler circuit would produce sequences of either eight or sixteen steps. But the pattern would be constantly changing at a certain rate, or be frozen in a loop. The relatively short patterns are much more useful musically compared to the longer pseudo-random sequence of a digital noise generator where patterns sound to go nowhere. An 127 step pseudo-random sequence mode is added in the v2 version rungler, which can easily turn the rungler into a white noise generator, as the modification bit can scramble the 127 steps in a way that the sequence actually becomes truely random.

The rungler circuit has two main outputs, the connector named rungler and the connector named xor. On the rungler connector is the stepped voltage with the eight possible analog output levels. The xor output is the serial stream of bits as it is clocked into the shift register. Both signals have their uses. The analog stepped signal can be used as a modulation signal to modulate pitches, filter cutoffs, etc. The one bit xor signal can be used as a gate or clock signal to trigger envelopes, sequencers, logic circuits, reset lfos, etc.

So, a basic rungler circuit has two internal inputs and at least two outputs. The two inputs are for the clock and for the modification bit, and there can be one or more stepped analog outputs and one or more digital bit outputs. If the shift register has a length of eight steps, and for each step a physical bit output is present on the chip, then there are many possibilities to connect DA converters to these bit outputs. However its best to keep things simple but effective. Instead of going for a ‘Jack of all trades but master of none’ design the Benjolin is based on the ‘minimum for the maximum’ principle. Meaning that only those output options that are the most effective are implemented. This as the trick is not really in the rungler output signal itself, but in what is done with this output signal to create ‘behaviour’ for the total of the Benjolin design.

Given the fact that a rungler circuit has two basic inputs the architecture of the Benjolin with its two wide range vcos instantly becomes clear, as these two vcos are in essence the two motors that drive the rungler circuit. The vco outputs together with the rungler outputs present us with some very interesting signals at either lfo rate or at audio rate. And to shape and modify these signals the addition of a filter is the obvious choice. Because the vcos, the vco pwm mixer and the stepped and pulsed rungler outputs all contain flanks in the waveforms the filter should have good ‘ping’ characteristics, so the flanks can create filter pings when the vcos are at slow rates.

The behaviour of the Benjolin is defined by how the rungler output signals are used to modulate the pitches of the vcos and the cutoff of the vcf. When the rungler is modulating the vcos, which drive the rungler, a complex feedback system is created.

The only thing you have to memorize is that the clock of the rungler comes from vco2 or from the clock input mini-jack connector. vco1 always creates the modification bit, but not directly from the vco1 squarewave. Instead it is made from the vco1 trianglewave. This triangle wave is fed into a comparator circuit where the momentary level of the triangle is compared to a voltage that comes from the change knob. With this knob you can influence the statistic chance for a change in the pattern. If the knob is fully ccw or fully cw the comparator output is fixed to either a zero or a one level. And will cause the modification bit to be fixed to this level and thus create no change in the pattern. This as a change is created on the moment that the modification bit changes it value form zero ot one or from one to zero. Between the nine o’clock and three o’clock position of the rungler knob changes in the pattern will take place in a rate defined by the rate of vco1. By feeding back the rungler output signal to the two vco pitch modulation points through the two rungler knobs on the vcos the pattern will start to compress and expand in time (vco2) and changes become more often or thin out (vco1). And when vco1 is at audio rate and vco2 is at lfo rate you will hear vco1 play the melody that is looping in the shift register.

There is no input connector to override the VCO1 triangle wave to the comparator that creates the modification bit. However, you can set the rungler to change a loop by an external signal by setting the change knob fully ccw or fully cw and then connect a short positive external pulse signal to the # steps input connector. This will temporarily change the mode from 8/16 to 127 and this will also change the pattern.

The single/double mode defines if the shift register is clocked on only the positive going flank of the clock signal (single) or on both the positive and the negative going flanks (double). By default the shift register is clocked from the pul2 signal, but it is also interesting to clock the rungler from the pwm output connector. When the oscs are at an lfo rate the pwm signal sounds like a polyrhythm. The double mode lets the rungler clock on each flank of the pwm signal, no matter if its going positive or negative. If the pwm signal is then used to ping the filter and the rungler signal to modulate the filter cutoff all changes in the rungler will be in sync with the flanks in the pwm signal. single and double mode can now make quite a difference in what you hear.

This synchronisation also applies when you connect the pul2 signal to the filter ext in connector, set the mixer knob fully ccw and set vco2 to a low rate. Then you can clearly hear the difference between the single and double modes.

When then the rungler signals are used to also modulate the filter cutoff, which is a feedforward modulation, an enormous amount of sonic possibilities becomes available. And all signals can be used to modulate other Eurorack modules and signals from other Eurorack modules can be used to ‘modulate the behaviour’ of the Benjolin.

There are three pitch ranges of interest, the lfo range and the audio range are obvious, but there is another range in between the lfo and the audio range where strange things can seem to happen. This is the range that is associaterd with granular synthesis, where changes in timbre and pitch take place at a rate that is not so fast that it crerates a sense of pitch, but too fast to create a sense of melody. In this range a sequence of pitches can start to sound like there is a chord playing, while the sound is monophonic. This range is more or less when the vco rate knobs are at their twelve o’clock positions. Also modulating the vcf at this range with a high resonance setting can create very nice results.

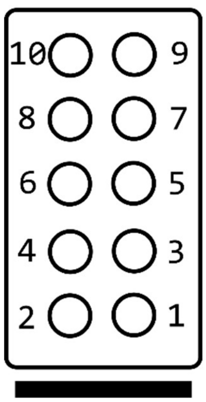
In the Benjolin V2 there are additions and expansions to the rungler circuit that were not present in the original diy-version of the Benjolin. These additions allow the Benjolin V2 to be used more easily with other Eurorack modules. ‘Digital’ inputs like the steps, rate and clock inputs do accept analog waveforms where the on/off voltage is roughly at 0.7V. So, when an external downsloping sawtooth wave is used to clock the rungler the clocking will be on the rising flank of the sawtooth, but if a upsloping sawtooth wave or a triangle wave is used the clocking seems to be slightly delayed. Because it takes a short while before the upgoing slope has reached the toggle point. Frontpanel connector outputs are all in the +5V<>-5V Eurorack range. Additionally you can use the pul1, pul2, xor and pwm outputs to directly clock e.g. a Korg SQ1 sequencer, a Moog Subharmonicon and similar kind of devices.

By now it should be clear that although at first sight the Benjolin may appear as a simple device, which it actually is. However, it is able to create an enormous variation in timbres and rhythms, unlike many other modules. You will find that each knob often has many so-called sweet spots. And that the Benjolin knobs are not meant to be just turned full cw or fully ccw, but that there is a vast sonic universe in between cw and ccw.

Rob Hordijk, the designer of the Benjolin, was often asked the question ‘How does one make electronic music?’, and his reply is invariably ‘With taste’. This as there are really no rules for making electronic music, so you can do what you want. But to make electronic music consumable for others it not a bad idea to do it with taste. Good taste or bad taste doesn’t matter, as long as it tells the narrative of the sounds with taste. And also never forget how much fun it can be to make electronic music.

EXPANSION HEADERS

CORE

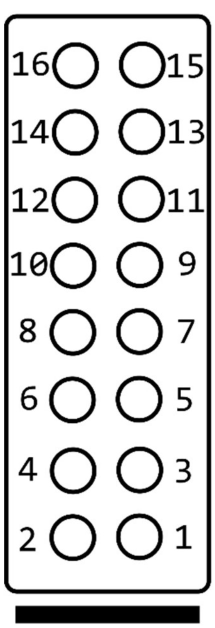


10: GND
9: rungler stepped cv output
8: hpf output
7: bpf output
6: lpf output
5: pwm output
4: oscillator 2 triangle output
3: oscillator 1 triangle output
2: oscillator 2 pulse output
1: oscillator 1 pulse output

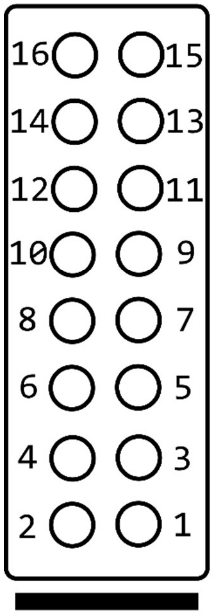
TURING MACHINE EXPANDER SUPPORT

Thanks to Tom Whitwell for making this possible

PULSES



16: +12v power rail
15: +12v power rail
14: GND
13: GND
12: -12v power rail
11: -12v power rail
10: rungler clock (only support single mode)
9: rungler clock (only supports single mode)
8: rungler bit 8 pulse
7: rungler bit 7 pulse
6: rungler bit 6 pulse
5: rungler bit 5 pulse
4: rungler bit 4 pulse
3: rungler bit 3 pulse
2: rungler bit 2 pulse
1: rungler bit 1 pulse



GATES

16: +12v power rail
15: +12v power rail
14: GND
13: GND
12: -12v power rail
11: -12v power rail
10: rungler clock (only support single mode)
9: rungler clock (only supports single mode)
8: rungler bit 8 gate
7: rungler bit 7 gate
6: rungler bit 6 gate
5: rungler bit 5 gate
4: rungler bit 4 gate
3: rungler bit 3 gate
2: rungler bit 2 gate
1: rungler bit 1 gate

MORE CONTENT

Rob Hordijk’s blog post that explains the Rungler

Video of Rob Hordijk explaining the Rungler.