Jacobi[17] SurfBox Synth

A Synth for LMMS

The synth is a design combining varied spectral content generation methods, and simple subtractive state variable filters to cut out higher harmonics. Features are built in which simplify the interface.

- There is only a ramp waveshape to the oscillators
- Each oscillator is a phase modulated chain feed
- The final oscillator feeds back to the first
- Oscillators have mod (in) and ratio controls only
- The post oscillator filters have frequency and resonance controls only

The above scheme makes for four independent controls per oscillator. They control the tuning ratio (or interval), the modulation from the previous oscillator (or the last in case of the first), and an output filter frequency cutoff and resonance of a 2 pole low-pass filter. There is no envelope control, as this is done via the LMMC synth builtin envelope generator.

All oscillators share a common base waveform. This is just the DCO counter and is a sawtooth wave. This simplifies things considerably. Less harmonics can be made by the filter on each DCO. The decision to use three DCO, and rational ratios only, leads to a large number of base timbres. Automation can be used for dynamic control of the timbre.

The post filter output of the last DCO is fed into a wave shaper. The wave shaper is perhaps more complex to understand, as the wave shape curve is mathematically derived. The net result is a dynamic wave shape controlled by quite a few controls.

- Slide – alters the responsiveness of the controls, like a timbre portamento
- Drive – the applied drive to the shaper, like a kind of timbral volume
- PQ – the mix between the timbral pair, varies depending on other controls
- Tort – the complexity index, generally makes the timbre more harmonic
- Generator – the nature of the generation group, steps through the generators
- Bank – the preset switching of the other five shaper controls

This makes for 18 controls in total. A complex enough synth for generating many timbres. The output of the shaper is not filtered, and high values of tort and drive will cause likely loud and high pitched harmonics. You are advised to post filter the synth using the instrument FX to band limit such harmonics. Bank and slide are added to the oscillators too, just for fun.

That's enough of an operational specification, playing is the acid test as it were.

Simon Jackson, KRT Instruments

Extra Optional Controls

Due to the note rendering process in LMMS, it is not possible to place effects units not the instrument before the LFO and envelope which are effectively applied post instrument. This is a limitation of efficient polyphonic rendering, of not running an effect on each note, but only on the full instrument (with LFO and envelope) output.

The extra controls added to the Jacobi allow extra expressional control, and are banked in the usual bank rows. This places effects local to an oscillator, and there is a post shaping filter. Considering the timbral effect of each oscillator, the controls are customized to each row, and its general effect on timbral quality.

1st Spreading	SPRD	Fade Harmonic Content (Exponential)	Gaussian Noise Modulation
2nd Harmonic	HRMC	Fade Harmonic Content (Exponential)	Rasp Dither Frequency (Hi-Lo PWM-ish)
3rd Fundamental	FUND	Walsh Sub Octave	Sub Sub Octave

The FHC allows an effect similar to a very simple envelope generator, there is no attack, just a release rate controlled by the fade. In the centre position there is no fade. Lower positions increase the fading speed, and higher positions are use an inverted and offset decay to make ever slower increasing harmonic content.

GNM allows Gaussian noise to added into the modulation (after the MOD pot), to give some random character to the DCO. RDF on the other hand plays for each two cycles of the waveform, one sped up and one slowed down for the same timing over two waveforms. The range is from no effect to a 0.5:1.5 effect.

WSO and SSO are designed to invert every second waveform (or two contiguous out of every four for SSO), and take these extra two waveforms, gain them, and put them through the DCO filter along with the main DCO wave. This has the effect of generating harmonic sub octaves.

The reasoning behind which DCO has which effects was complex, and based somewhat on the internal model in my head of the sounds from a DX7 (from experience). Keeping the synth simple yet at the same time not hiding some of the best tweaks was the optimizing concern. Big fat base from the sub octaves, wide harmonic content from the RDF, natural harmonic spreading from the GNM, and some simple modulation style envelope effects from the FHC.

For actual real chaos noise the MOD on SPRD should be turned up high, along with high CUT values starting from the top, along with low REZ values. This is mainly due to the filter implementation using a constant maximum level algorithm, where high REZ values make the filter into band-pass mode instead of low-pass with resonant peak.

Extra Plugin Development Ideas

- A twist on the Peak Controller (Project FEEDBACK)
- Some kind of nuts delay (Project SQUIRAL)
- A spectral compressor (Project EARS)
- A four track audio in and tape transport (part of Project FEEDBACK?)

Implementation Plan

In the analysis the wave shaper is the most complex part of the synth. For polyphonic operation, each voice needs a wave table. To avoid excessive note playing triggering 'to much sound', this is set to a fixed static allocation per machine instance. A suitable polyphony for chord with overlap use is sixteen. Using symmetry and Nyquist with relation to the TRT maximum, a simple cubic interpolation to 'complete' the wave table on dynamic audio changes is required.

The feature of SLD represents a moving accumulation via a time constant from the current value, to any new value which is input. Representation of an inner value of a control, which eventually via a moving average becomes equal to the control face value. TRT and GEN are special in this regard. PQ can be effectively implemented using a doubling of the waveshape memory needed (as it has to hold both P and Q wave halves, and PQ can average to an inner value.

The SLD effect on the wave table is to drift the table which is in direct use, toward the value contained in the 'control requested' wave table built from TRT and GEN. The sequencing of what to move average and when, is in many senses like a fixed frequency LFO. A double buffering of the control requested wave table prevents glitching on rapid TRT and GEN changes. The memory saved, and the cache thrashing relieved along with modern fast arithmetic, makes interpolation feasible.

A memory reduction on the triple index, (TRT, GEN and table input value DRV'd range) of a pre-calculated arrays (to save complex series evaluation time costs, one of each for P and Q [quicker than a quad index, and of course two smaller arrays for PQ symmetry indication]), can be achieved by pre-calculating fewer points and taking advantage of 3D interpolation. This leads to a much faster response time for TRT and GEN, by being able to calculate the half P and half Q half wave table pair for building the shaper output to feed into the final filter.

The SLD and BNK controls must have some or no effect involving an inner control value. First consider interpolating BNK from some fixed setting points. Very good for twisting BNK, but not so good for refilling the fixed setting point memories. The problem comes from 'automating' the fade 'overriding' user input aswell. The decision then is to have discreet BNK program increments, which automate on a 'change of bank' crossing spaced around the rotation of BNK. The SLD related complexities are from the questions, does it self slide and does the slide refer to a change out, or a bring in?

The consequence of self slide would be a long slide pattern would switch to a short slide pattern longly getting shorter, and a short slide pattern would switch to a long one quick. That is to say a change out indication, where as not having self slide would lead to a bring in indication. No long slide latch up, and no long slide avoid, on a parameter change. Fade in rights prevail, and there is no inner control average on SLD or BNK controls.

The CUT and REZ control a state variable filters. An interpolated cutoff curve is used to for control, and another for the resonance 'linearity' mapping. All the filters are key base and offset frequency tracking. This completes the implementation plan, sets the conceived bounds of the Jacobi synth.

An Open Source Software Implementation