

Reaktor Synth

My task to complete was to create a software instrument. To create the synth, I used Reaktor to build it from scratch. *'It's a sandbox for sound creation – a limitless platform for experimenting and diving into new sound directions. Simply put, REAKTOR lets you build instruments to replicate the sounds in your head – in a way that existing instruments can't.'*

My approach to creating the instrument was to be able create a program which would allow me to mix desired oscillators with the function of being able to fine tune, transpose and change waveforms. I have taken some inspiration from VST's such as Minimog. With the idea of creating a program subtractive synthesis we must consider what other features we will need to create to have the synth to replicate in some form of a hardware synthesizer. Not only do we need oscillators with the ability to change the pitch and the waveform we need to create envelope shapers and filters so that we can really create interesting sounds. In my instrument I created three oscillators. An oscillator allows you to create a waveform whether it be a sine, saw, triangle or square waves. A sine wave has no harmonics so the only thing you can modify is the pitch and the level. A square or triangle wave contain a series of some harmonic content, yet the triangle wave has lower harmonics than the square wave does. From both of those waves a slightly 'Reedy or hollow' tone is produced yet there is a brighter sound to the square wave. The sawtooth wave has a series of even harmonic content which can be used to create pad sounds as well as strings and brass.

After that I needed to be able to implement a gain so that I could change the volume of the overall synth. With now having the very basic needs of a synth I wanted to go a step further by being able to change the pitch of the synth which I could do in a couple of different ways. The first part of this was that I added in a pitch switch so that on each oscillator I could transpose the signal up to two octaves higher and lower. I then decided to that I would like the synth to be able to be transposed in smaller increments so that's where I created fine tuning so that I could pitch up the signal by tiny amounts. A production technique that you could use with fine tuning would be that you could slightly detune an oscillator that allows the phase of one oscillator to produce a natural chorus which can make the synth sound bigger, this is widely used in electronic music such as trance and techno. The reason for creating this synth with more than one oscillator is because when combining two or more oscillators a very dynamic and rich sound. So, with having three oscillators this will allow the user to create very complex sounds with some very rich sounding patches that can be created using this synth. If I could go an extra step further, I'd build a function so that the two or more of the oscillators could sync as this would be able to create an aggressive but dynamic sound which can be very distinctive, this is seen widely with analogue synthesizers. How this works is by one of the oscillators is the designated master and the other is the slave, the oscillators can be tuned to the same frequency or to a desired interval. The slave oscillator waveform restarts when a cycle of the master's oscillator finishes and resulting in the slave to run at the frequency of the masters nearest harmonic.

To maximise the use from the oscillators I also added in a mixer section which allows you to dial in a level amount of each oscillator to be able to give the synth different tones and loudness of each waveform to reach the specific sound that the user is after.

To create movement and to carve the sounds of the oscillators I built an ADSR envelope function. ADSR stands for Attack, Decay, Sustain and Release. This allows the synth to have the ability to control the loudness and shape of a sound. An envelope means the evolution of sound in a piece of music. An ADSR envelope are fed through envelope generators which tells the synth when and how the sound is going to change. What the envelope does is it defines the trajectory and the modulation of the sound whereas the envelope generator controls the behaviour of the envelope. The attack is

the initial start to the sound and determines how quickly the sound takes to reach its highest amplitude with it then going into the decay section. The decay part of the ADSR means how long it takes for the sound to drop from the highest point of the amplitude to the sustained level of a sound. The sustained phase means how long at full volume of the sound will hold for between the decay and the release. The release means the speed of at which a sound ends from the moment a key is released. For some context to all this, an example ADSR of strings would be that it would have a long attack and a long release.

A synthesizer I have taken inspiration from that I have attempted to replicate at a basic level would be the Moog. The Moog was created by Bob Moog and was first unveiled in 1964. This instrument alone changed the course of modern music. By the end of the 1960's the synth was being used by some of the biggest names such as The Beatles, The Doors and The Monkees. The Moog came from an idea from a man named Herb Deutsch. He requested to Bob Moog that he wanted complex and experimental sounds and tones that can't be easily found in other instruments. The envelope module which allows the fading in and out of individual notes was modelled after the doorbell. When looking at designing the filter, Herb and Moog looked at the Wah-Wah pedals for inspiration. The Moog became so popular due to its infinite possibilities in combinations of tones especially compared to other instruments on the market at the time. The use of modules gave the synth more complexity as each module had a function, yet many users used these in alternate ways, or they would misuse them however would find different and new uses for the modules creating more variations whilst using the synth. Due to this some of the modules were direct results of challenges set out by the Moog, because of this now it has grown a legendary status and still holds that today. It is now a traditional benchmark for analog synthesis and not just for it sonically, yet visually and historically. The synth has had such a massive impact on music today without it bands like Kraftwerk, Daft Punk and many more wouldn't have been able to achieve some of the sound design in their works.

Due to the Moog being analog, it would be extremely difficult to exactly replicate this into a VST and some of the emulations like Mini V3 haven't completely cracked the warmth from the analog sound that the Moog gives out, yet it's very close. Knowing that I wouldn't be able to do this myself, I certainly took a lot of inspiration from it and took some of the same features whilst building my synth in Reaktor. The reason I chose to use Reaktor was that I have previously used it for a small project and since it is fairly user friendly with lots of content available online that I could use to research whilst building the synth. I had other options to use Max/MSP yet I have used it before and found it very complicated and not user friendly at all in my personal opinion.

A function I implemented into the synth was the ladder filter which is based off the Moog. This would allow the user to be able to modify the pitch cut off and the resonance of the filter to further shape the sounds from the three oscillators. The cut-off filter can be used to block certain frequencies from the sound. In this instance for the synth, I created a low pass filter which had two different poles which would make the filter tighter (Low pass 2, Low pass 4), this determines how sharp the filter cuts off the frequencies. For next time I would implement a high pass filter and a band pass filter so that I could switch the three to make it more versatile for the user. I also added in the resonance knob so that the notch of the filter can be amplified. This can be used as an effect, especially if the desired outcome is to emulate a sound like the TB-303 and create an 'acid' like sound having the resonance very high and the cut off filter automated to move forwards and backwards.

I would also look at creating a Low Frequency Oscillator (LFO) to the synth for next time. An LFO is another oscillator which occurs at a very low frequency that you can't hear and operating below

20hz. This is used for manipulating other parameters, they have a rate control function which is the speed at how fast it oscillates. It also has a depth control for each parameter chosen on the synth to manipulate. The LFO can be set to oscillate in certain amounts whether it be in a positive or negative direction. A popular effect used with the LFO affects the pitch, volume or cut off filter which creates a vibrato like effect or a wobble. This is very popular in genres such as dubstep and melodic techno.

I have taken inspiration from Arturia's Mini V3 which is an emulation of the Moog synthesizer. Similarly, to the Mini V3 the synth I have created has the same number of oscillators and has a few of the same functions such as a low pass filter, cutoff and resonance and also the fine tuning; as well as the semitones. I would look at adding in noise oscillator as this is missing from the synth in Reaktor. The emphasis knob on the mini v3 would also be a feature I'd look to add. This is a global feedback path where the gain is controlled using the emphasis knob. When the emphasis knob is all the way down then the cutoff filter is solely responsible for the actual cutoff of the filter. Once the emphasis knob is turned up then resonance is introduced into the sound and becomes progressively more noticeable. As well as that the cutoff filter will decrease and slowly increase to the point where the filter goes into self-oscillation. Self-oscillation is the generation and maintenance of a periodic motion by a source of power that lacks a corresponding periodicity. The reason for this to be a feature is so that richer and a more complex sound can be achieved by using the emphasis knob as more musical features are given out by the filter.

I would also include features such as adding in a reverb and a delay so that the user wouldn't need to step outside of the synth to reach any desired effects that they would need in sound design. Within the reverb you would be able to change the size of the space as well as the pre delay and the overall dry/wet signal of the reverb can be altered to taste. For the decay I would have the functions of changing the delay times e.g., 1/1, 1/2, 1/4 etc. I would also add in a link where they can be snapped to create different delay effects on the left and right channels or have the delays even and if left off a ping pong delay effect can be created if needed. On top of that I would have the dry/wet overall delay signal that can be altered.

When it came to using Reaktor to build the synth I had to do some research to find out what goes into a synth for it to work and look at building it piece by piece to break it down. I started in the panel with the output terminal so that when I have completed the synth, I can route it to the out terminal for the signal to be heard when a note is played. Firstly, I created a macro which is a self-contained unit which was for the oscillator section. Before I went into the macro and started to create the oscillators, I had to find a way for the synth to listen to information being inputted to produce a sound. In this case as we are using a DAW, using MIDI would be the way to do this. This would include a note pitch and a gate module. To connect the Midi section to the oscillator macro and then to the output I had to create a terminal within the oscillator section for it to communicate with the rest of the modules. Within the Oscillator macro, I added in the waveform modules including Sawtooth, Sine, Square and Triangle. The 'in' terminals would allow the waveform to oscillator as they would allow it to create the amplitude and the pitch. After that I connected the MIDI note pitch to the pitch in the Osc (Oscillator) section and the MIDI gate to the amplitude in the Osc section too.

For the user to be able to choose which type of waveform they want I had to create a switch module within the oscillator macro. The number of ports in the switch means the number of options you want to allow to switch between, so in this case as we have 4 different waveforms, I chose 4 ports on the switch and then connected each waveform to the switch. After this I renamed each port to the waveform that it was connected to as this would be what the user would see when the synth is

displayed. I wanted the user to be able to vary the width of the pulse wave so I created a control knob so that it would be more flexible for the user.

The next step was to then allow the user to be able to change the pitch of the desired sound, I used another switch to then set the number of ports to 5 as I wanted 5 options. The middle port on the switch would be the default note that is being played and so would be 0. The top two switches would make the signal transpose up by 12 semitones (one octave) and then 24 semitones 2 octaves). The bottom two ports on the switch would transpose the signal by 1 and two octaves. I did this because it would mean that when the user was creating a patch using the synth, they could have more flexibility and create a sound with larger harmonic content. For this to then work the Pitch terminal settings had to be altered. An add module was attached to the pitch and a constant value (12/24) would be created to tell the synth how many semitones it would be changing when the selected switch would be selected. As we wanted to transpose down too, I did the same thing again yet this time with a subtract module and followed the same procedure. I wanted to have a semi tone knob as well so that you could transpose the signal by semitones in increments of one. To do that I created a knob and then changed the values to 12 so you can transpose up by a whole octave and then change the lower value to -12 so that we can transpose down up to a whole octave too. As a personal choice, I like to detune some of my oscillators to get a big and wide detuned effect so I wanted to take the synth a step further with the pitch by adding in another knob for fine tuning which would allow you to change the pitch between one semitone either up or down.

Rather than changing the volume of the synth in a DAW, I wanted to put in an amp/mixer module so that the overall volume output on the synth could be changed within the synth. This was done by connecting the amp/mixer module from the oscillator macro to the output terminal.

To be able to shape the sound with an ADSR envelope, I created another macro so that it could be connected to the oscillator macro which would give feed the envelope signal to the oscillator, allowing the user to further shape the sound they want. Inside the ADSR macro, again a in port and out port terminal would be created to allow the macro to communicate with other macros. I then added in the ADSR module and the in port would be connected to the gate point on the ADSR module. As I was taking inspiration from the Moog, I didn't want the attack, decay, sustain or release to be faders so I changed the setting to a knob.

I then wanted to create a mixer section so you can feed in different amounts of each oscillator. I created another macro which would be placed after the Osc macro. Each oscillator would be needed to connect to the mixer so I created one mixer modules and changed the number of ports from one to three and named them Osc 1,2 and 3 so that when I came out of the macro, I could correctly link up each port to the right oscillator.

With now having all the oscillators working and the synth able to communicate with the DAW correctly, I was now missing a filter function. As the Moog has a ladder filter I added in another macro and within that macro, I inserted a ladder filter module. The filter was able to change the cutoff pitch and the resonance of the filter to further shape any sounds from the three oscillators. I wanted to have the ability to change the type of pole on the filter, so I created another switch with two ports as to connect to the low pass 2 and the low pass 4 poles before going to the out terminal. I then was able to change the display of the switch on the filter to a drop-down box which was to my own taste. The filter macro would then be connected from the Oscillator to the mixer macros. To take the filter a step further I wanted to add in another ADSR function for the filter. As I had already created an ADSR, Reaktor allows you to copy and paste modules or macros so I duplicated the ADSR and then renamed it to the Filter ADSR. The only difference being between the two ADSR macros

now is how they're connected to the other macros within the synth. I had to create another out terminal in the first ADSR macro so that the gate could communicate with the filter ADSR and then had to create another in port terminal in the filter so that I could connect the in and out ports to the rest of the synth. I then had the problem where the filter ADSR wouldn't work as I needed to change the way the audio was communicating with the data on the in port terminal of the filter. I added in a converter called A to E which stands for audio to event. This would be fed into the pitch which would allow the ADSR to control the pitch. I had to work out the value of the cutoff and multiply it by a value between 0 and 1 which acts like a fader. I added in a multiply module and connected it to the cutoff filter and then connected the A/E module to the multiply module before connecting the multiply module to the pitch on the filter module. The cutoff filter values were too short so I went into the function settings and changed -up the values to a higher number to allow it to work at a better rate. For the last touches, I wanted to clean up the way the synth looked, so I spent time moving different macros on the layout section in Reaktor to make it look neater but also to place sections in a way that made sense due to the signal flow.

With now completing the synth I sent the patch to a few peers of mine to get some feedback. Most of this feedback included for next time to add more functions like an LFO section and effects such as delay and reverb. Other than some of the missing functions my peers were able to use the synth to make some interesting sounds and some have taken it a step further and gone to use them within their own productions.

To conclude, with initially feeling this task was going to be very complex, I believe I created the synth to a decent level. For next time I would follow up on the feedback advice and add in some other elements to give the user more flexibility whilst using the synth instead of having to use external plugins and effects to achieve their desired sound. I was taken by surprise that I ended up really enjoying this challenge and would certainly look at spending more time on this patch and taking it to a higher standard.

Ed Hannon

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