ARCHAEA

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WARNING - READ THIS FIRST!

Before you plug this module into your rack and start to use it:

1. Disconnect your rack from the mains supply.
2. **MAKE SURE THE POWER CABLE CONNECTORS ARE INSERTED THE CORRECT WAY ROUND!** The red stripe on the Eurorack power cable must be orientated as indicated on your rack power supply bus. This module comes supplied with a power cable already connected and a shrouded header to prevent mis-orientation. If the power cable is changed from the supplied cable, an incorrectly assembled cable could still cause issues. If the stripe on a different cable does not match the stripe on the module when plugged in, do not power up, and use a different cable!
3. Double check the power cable orientation before switching the rack power on!

Your rack MUST have sufficient spare power available to power the module, otherwise unexpected behaviour will occur. The maximum current requirements of the module for each voltage are given in the Specifications section. The current draw of each module, for each voltage, must add up to less than the total current capability of your rack power supply.

The maximum voltage range which can be present at the input or output jack sockets is -12..12V. The warranty does not cover damage to the module from incorrectly powering the module or exceeding the jack voltage range.

Credits

Designed in Bristol, UK by Archaea.

Many thanks to Sean Costello (Isostatic) and Don Tyler (Remote Vision, Synphaera) for beta testing.

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info@archaea.co.uk

First of all, thank you for purchasing this synthesizer module from Archaea! We hope this is a useful and fun additional to your music setup.

Overview

Loki is a complete analog mono-synth in a 20HP Eurorack module. It is a subtractive synthesizer consisting of two oscillators, a filter, an amplifier and an envelope generator, all of which are voltage controlled. Loki is semi-modular, where its internal modules can be patched together in a variety of ways or even connected to external controllers and modules.

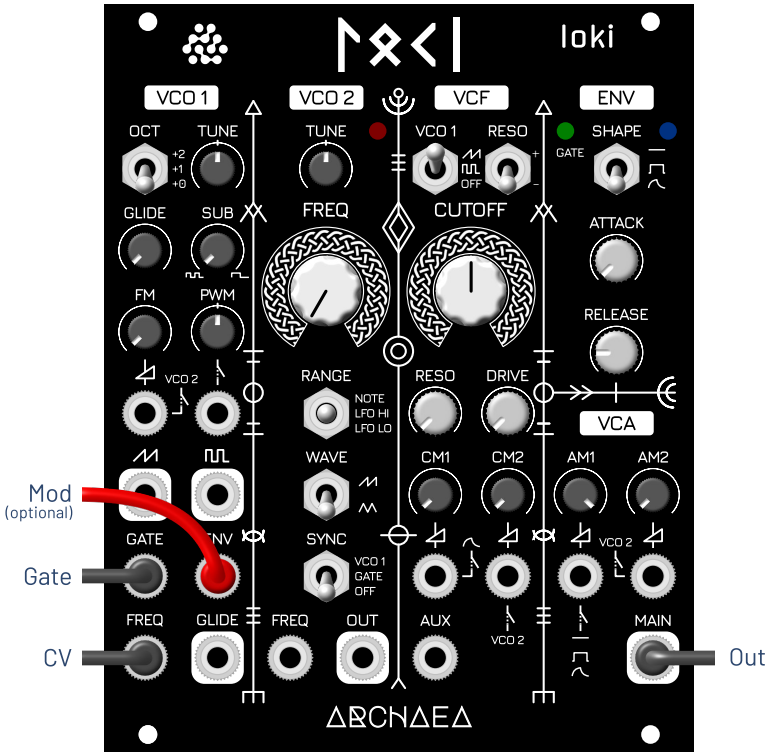
Getting Started

The synthesis architecture is shown in the Blocks and Connections section. The oscillators (VCO 1 and 2) generate the core waveforms which are then can be shaped by the low-pass filter (VCF), amplifier (VCA) and envelope generator (ENV). Each oscillator is specialised for a particular purpose. VCO 1 oscillates in the range of musical notes and outputs sawtooth and pulse waves. It can also be pulse width and frequency modulated, and includes a sub-oscillator. VCO 2 outputs saw and triangle waveforms, and oscillates in both the note range and low-frequencies so can be used as a sound source and low-frequency oscillator (LFO) for use as a modulation source. It can also be synchronised to the start of a note and to VCO 1. The controls and their function are described in the Front Panel - Oscillators and Front Panel - Processing sections.

The synthesis architecture is designed so that, by default, VCO 1 generates a note, VCO 2 provides an LFO for modulation, and the VCF and VCA shape the waveform. VCO 2 and ENV are connected to both the VCF and VCA, with attenuators to control the amount of modulation. The common performance controls, the VCO 2 frequency and VCF cutoff frequency, are provided through larger knobs to make them easier to access during playing. For example, the centre cutoff frequency can be swept by hand, while changing the filter modulation rate from a triangle wave from VCO 2. This default architecture can be modified by patching different connections between blocks. Through patching, the oscillator outputs can be routed to different inputs and both VCO 2 and the VCF can be used as note range oscillators. This can be seen in some of the example patches.

Essential Patch Connections

Loki is voltage controlled, so to play notes with it you need to connect it to a CV-gate source, such as a controller keyboard, sequencer or MIDI to CV-gate interface. These connections are shown below along with the settings needed to achieve an initial basic sound.



The note Control Voltage (CV) source connects to VCO 1 FREQ and the gate to GATE. The main audio output is provided from VCA MAIN. The CV is an analog signal that determines the pitch of the oscillator from the note that is pressed.

The gate is a digital signal that is high when a note is held down and low otherwise.

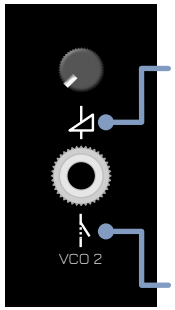
TIP: Optionally, a modulation source can control the envelope 'size' (amplitude) by connecting it to ENV. For example, if your CV-gate source has a modulation source that can output a voltage proportional to note velocity then the velocity can be used to control the loudness or filtering envelope of each note.

Connection Properties

The patch connections are all standard Eurorack 3.5mm mono jack sockets. The voltage ranges expected at all the inputs and present at the outputs are shown in the Block Diagram and Connections section. The input voltage ranges may be safely exceeded up to a maximum of -12..12V, but in general will have no effect beyond the stated range. Typically, all envelope and control signals range from 0..5V, oscillator frequencies from 0..10V and all other waveform signals from -5..5V. These ranges are adopted by many other Eurorack modules.

NOTE: The main audio output voltage range is -5..5V to allow the output to be processed by other Eurorack modules without the need for signal amplification. This is significantly higher than standard line levels used by amplifiers and other audio equipment. If you are connecting directly to an amplifier, mixer, audio interface or other audio equipment you will need to turn down the input on your audio equipment to prevent clipping.

The front panel is labelled to denote 'attenuated' and 'normalled' patch inputs. An example of this is shown below.



Jack Input Attenuator
The 'volume' symbol denotes that the knob acts as an attenuator for the input. The attenuator can be used to adjust the gain of the input signal from 0% to 100%, i.e. changes the waveform amplitude (size) from no signal to the original full-sized signal.

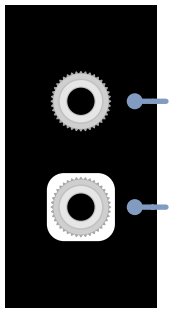
Jack Normal Input
The 'switch' symbol denotes what is connected internally to the input when no jack is connected. In this case, the output of VCO 2 will be connected to the input until a jack is inserted, at which point the signal provided in the jack cable will be switched to be the input.

There are 5 inputs with attenuators, shown in the table below.

Sub-module	Description	Label	Normalled Input
VCF	Cut-off modulation 1	CM1	Envelope: attack-release
VCF	Cut-off modulation 2	CM2	VCO 2
VCA	Amplitude modulation 1	AM1	Envelope: continuous, window or attack-release
VCA	Amplitude modulation 2	AM2	VCO 2
VCO 1	Frequency modulation	FM	VCO 2

TIP: A good starting point for setting up a sound is to turn all the attenuators down, apart from AM1, by turning them all counter-clockwise all the way. AM1 controls the VCA output connected to the MAIN output according to the note envelope. Without AM1 turned up, no sound will pass from the filter to the output when a note is played.

The front panel is labelled to denote which jacks are inputs and which jacks are outputs as shown below. No harm will be caused if inputs are accidentally connected together or if outputs are connected together. However doing this will have no effect.



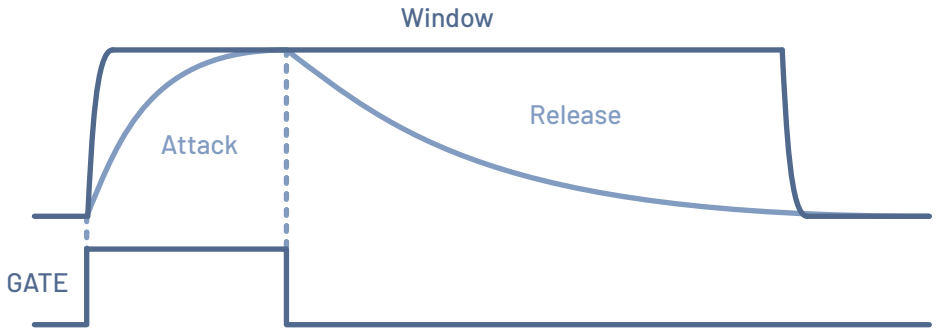
Input Jack
A plain jack denotes an input jack.

Output Jack
A jack with a box surround denotes an output jack.

Envelope Shapes

The ENV sub-module has three shape modes, continuous, window and attack-release. These three modes are internally routed to the VCA, whereas the VCF only has the attack-release shape routed to it (see the Block Diagram and Connections section). The additional modes available to the VCA allow the attack-release modulation of the VCF cutoff to be used without attenuation occurring from the VCA.

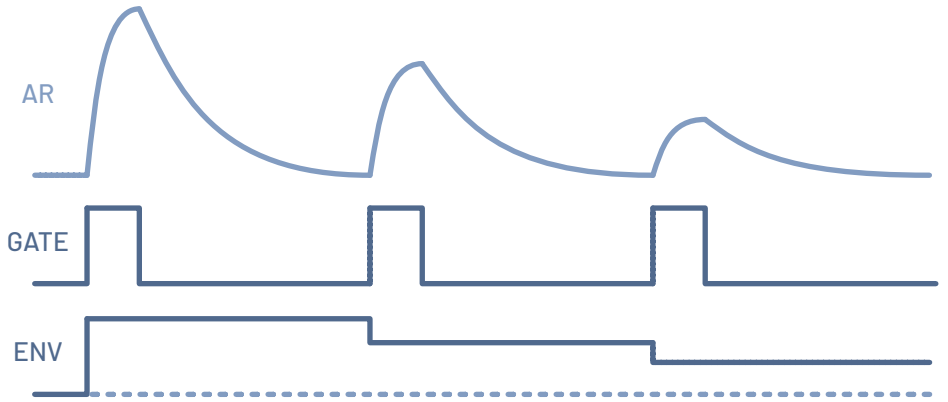
In the continuous mode, the ENV sub-module output is always high which can be used to create drone sounds or hold the VCA on continuously during note sequences so the gate input has no effect on the signal amplitude. The window mode is high when the attack-release envelope is above a level close to zero. The window goes high at the start of the attack and stays high until the end of the release as shown below:



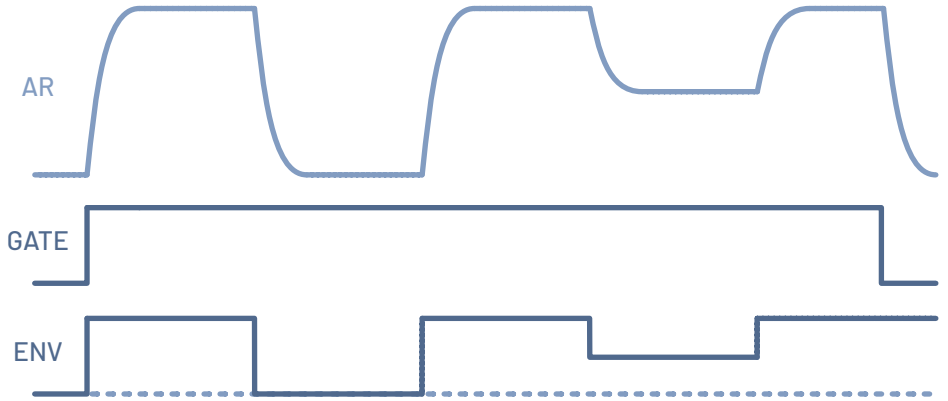
The window mode allows the envelope to shape the sound by sweeping the VCF cutoff during both the attack and release phases without the VCA decreasing the amplitude during the release phase. When the filter cutoff becomes low it naturally reduces the amplitude of the signal due to the low-pass filtering.

External Envelope Modulation

The attack-release envelope can be modulated from an external source using the ENV input. As mentioned previously as an example, this can be used to control the envelope size using note velocity, as shown in the following figure.

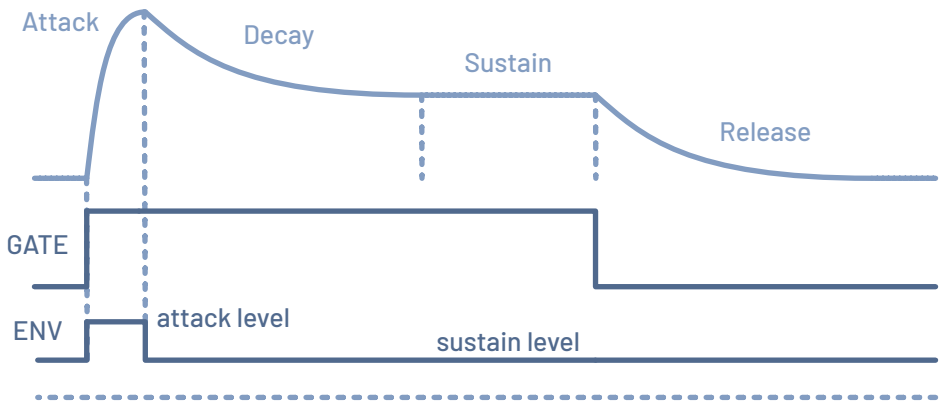


When the gate is high, the envelope sub-module will track to the ENV input level. When the gate is low, it will track to zero. When ENV is disconnected, the ENV input level is set to the maximum level. In the note velocity case above, the ENV level remains constant until a new note occurs and the velocity is measured once more. More complex envelope modulation is possible by changing the ENV input level while the gate is high, as shown below.



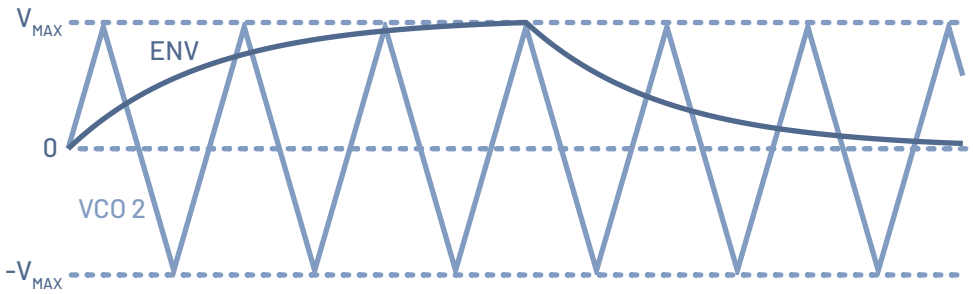
If the ENV input level changes while the gate is high, the envelope will track to the new level according to the set attack and release rates. If the ENV input level increases, the envelope will track at the attack rate. If it decreases, the envelope will track at the release rate. When the gate goes low, the envelope will track to zero at the release rate.

TIP: a type of 'ADSR' envelope can be achieved using a sequencer as follows: 1) Set the ENV input high at the note start when the gate goes high (see diagram below). This gives the attack level. 2) Set the ENV input to a lower level when the envelope gets the top of the attack. The envelope will then fall to lower ENV input level, the 'decay' phase. The ENV input gives the 'sustain' level. 3) The release phase starts when the note is off, i.e. the gate goes low. This can be useful for 'acid' style sequences where there is an 'accented' type of attack and a sustained level which can be then used to glide between successive notes. The only limitation with this is that decay and release times will be the same and cannot be independent.

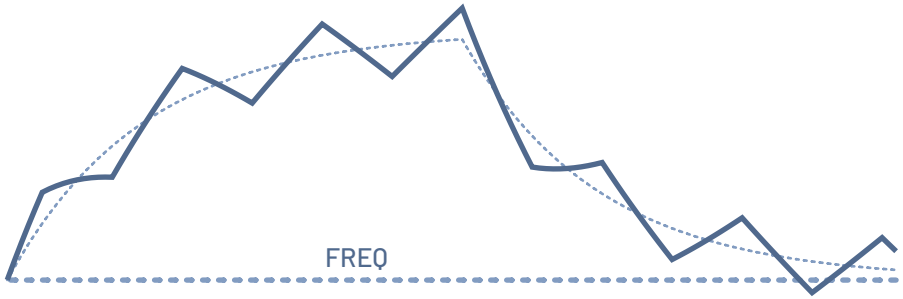


Modulation Summing

This section describes how the modulation sources CM1, CM2, AM1 and AM2 are summed together to give the overall modulation to their sub-modules. The VCF modulation summing can be illustrated with an example. The figure below shows the ENV and VCO 2 sub-module outputs which will be used as the modulation sources. The maximum control voltage V_{MAX} = 5V, where the ENV output has the range 0 to V_{MAX} and VCO 2 the range $-V_{MAX}$ to V_{MAX}.



The modulation sources are summed along with FREQ. More attenuation is applied to CM2 to make its amplitude smaller relative to CM1. In this situation, the VCF cutoff will be modulated as shown below.



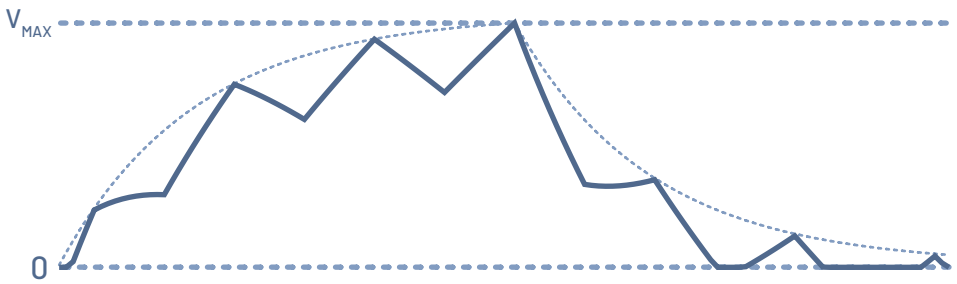
The solid line represents the overall VCF cutoff modulation. The bold dashed line is the FREQ control, i.e. the modulation base level. The fine dashed line is the AR envelope, where the overall modulation goes above and below this envelope with the oscillation of VCO 2. Note the overall modulation will 'saturate', i.e. reach the limit and not go any further, at the top and bottom of the VCF control range. The figure above shows the overall modulation within the limits of the control range.

For reference, the function of the VCF modulation summing is:

$$VCF_{cutoff} = FREQ + 2 \times a_{CM1} \times CM1 + a_{CM2} \times CM2$$

The attenuator control settings are represented by a_{CM1} and a_{CM2}, where they take values between 0 and 1. Note the VCF also adds the setting of the cutoff frequency control FREQ to the CM1 and CM2 modulation inputs. This way, FREQ determines the 'base level' at which the modulation is applied. The CM1 source is doubled, which is allows sources that are only positive to be scaled over the cutoff range, such as the AR envelope.

Using the same example as for the VCF previously, the VCA amplitude will be modulated as shown below.



The solid line represents the overall VCA amplitude modulation, and the fine dashed line the AR envelope. The bold dashed lines represent the limits of the VCA control range, which are 0 and V_{MAX}. As the amplitude relates to the loudness of the ENV audio signal output, then it can only take on a positive value. For this reason, the overall modulation will saturate at V_{MAX} and 0. As shown above, the effect on the overall modulation due to VCO 2 will reach 0 towards the end of the AR envelope but will not go any further. At this point the VCA will be completely shut off.

For reference, the function of the VCA modulation summing is:

$$VCA_{amp} = a_{AM1} \times AM1 \; + \; a_{AM2} \times (AM2 \; - \; V_{MAX})$$

The attenuator control settings are represented by a_{AM1} and a_{AM2}, with values between 0 and 1. An offset of $-V_{MAX}$ is applied to the AM2 modulation source. This offset ensures that AM1 will determine the overall envelope which will be below the limit of V_{MAX}, provided that AM2 stays within the limits of $-V_{MAX}$ and V_{MAX}.

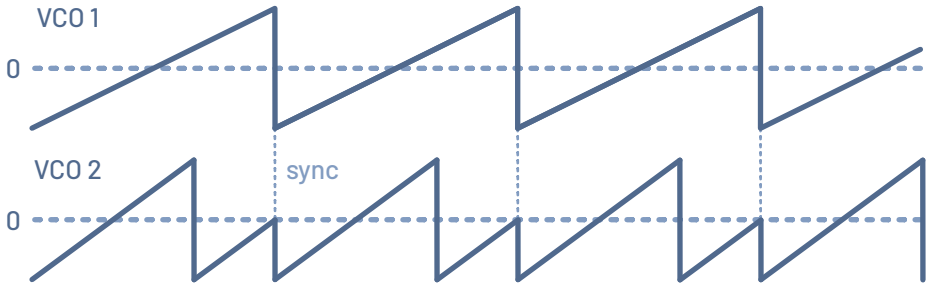
Glide Output

VCO 1 features a glide circuit that will ramp between jumps in voltage in the CV (see Front Panel - Oscillators). The ramped voltage is fed into the VCO 1 oscillator circuit. This ramping will only occur when the gate remains high during the jump in CV. Otherwise, VCO 1 will receive the instantaneous jump in CV. The connected keyboard or sequencer will need to keep gate high during note transitions, typically achieved by 'legato' playing where a note is held for a short time just after the next note starts. The glide circuit output is duplicated at the GLIDE jack so it can be patched into other inputs, for example to achieve the glide effect on VCO 2 by connecting it to VCO 2 FREQ.

VCO 2 Sync

VCO 2 can be synchronised to either the gate or VCO 1. The sync feature 'resets' the VCO 2 waveform to its most negative level at the instance a sync event occurs. In the case of SYNC being set to GATE, VCO 2 will be synced when the gate transitions from off to on, i.e. at the start of a note. For example, when using VCO 2 as an LFO modulation source it will reset the modulation and make it aligned with each note played.

When SYNC is set to VCO 1, VCO 2 will be synced for every cycle of VCO 1 giving a 'hard-sync' effect. VCO 2 is reset when VCO 1 is reset, i.e. when the VCO 1 saw and square waves fall from high to low. This allows more complex waveforms to be generated with VCO 2 when VCO 1 and 2 are set to different frequencies by the voltages at their FREQ inputs, by their TUNE controls and VCO 2's FREQ control. This effect is shown below where the frequency of VCO 2 is greater than VCO 1 and VCO 2 is set to output a saw wave.



In this case, VCO 1 determines the fundamental frequency of the oscillations and VCO 2 the wave shape and therefore the degree of inharmonic overtones. The VCO 2 FREQ control can be used to easily control the wave shape during a performance by determining the number of cycles of VCO 2 for every cycle of VCO 1. When VCO 2 is set to output a triangle wave, it will be reset in the same way to the most negative level with each sync event.

The filter is the main sound shaping component of the Loki synthesizer. It is a resonant low-pass filter with a roll off of 24 dB/oct at high frequencies. The filter has three main controls: cutoff frequency, resonance and drive.

The cutoff frequency essentially controls the frequency beyond which frequencies components of the oscillators will be removed. The resonance controls the amount the frequencies around the cutoff frequency are boosted relative to other frequencies. The drive controls the amount the filter output is driven into soft-clipping overdrive. There is a fourth control, the resonance mode which is described below.

Filter Resonance Modes

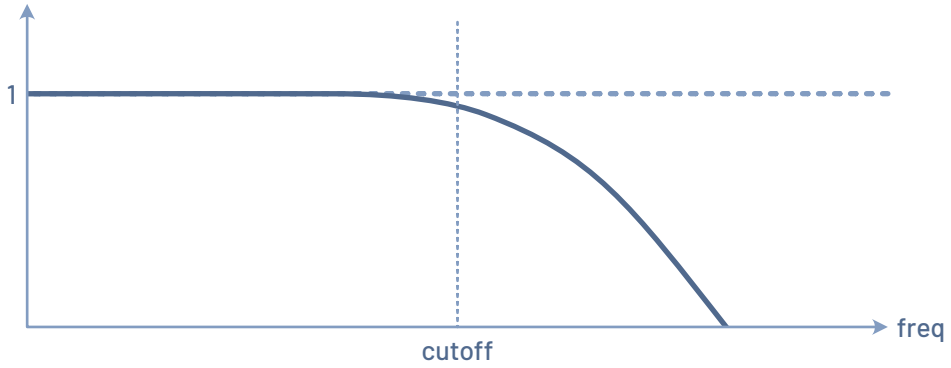
The figure top-right shows the response of the filter without any resonance applied. The x-axis of the graph represents frequency, and the y-axis gain. A gain of 1 is applied at low frequencies, i.e. unchanged, where high frequencies are progressively removed beyond the cutoff frequency. There are two modes in which resonance is applied, the 'negative' (-) mode and 'positive' (+) mode.

Negative Resonance Mode

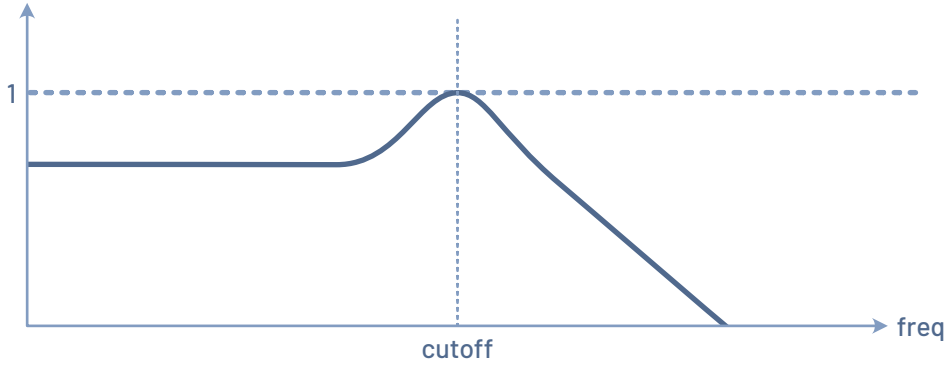
In the negative resonance mode, the low-pass frequency response is *subtracted* from the resonant peak level, shown in the middle-right figure. This mode keeps the signal peaks within the same range as the response without resonance. This will give the minimum amount of drive at the filter output as the peaks will not exceed the overdrive limit, giving the purest resonant tone similar to the sound of classic 'ladder' filter designs. However the bass response of the filter will be reduced as the resonance is increased.

Positive Resonance Mode

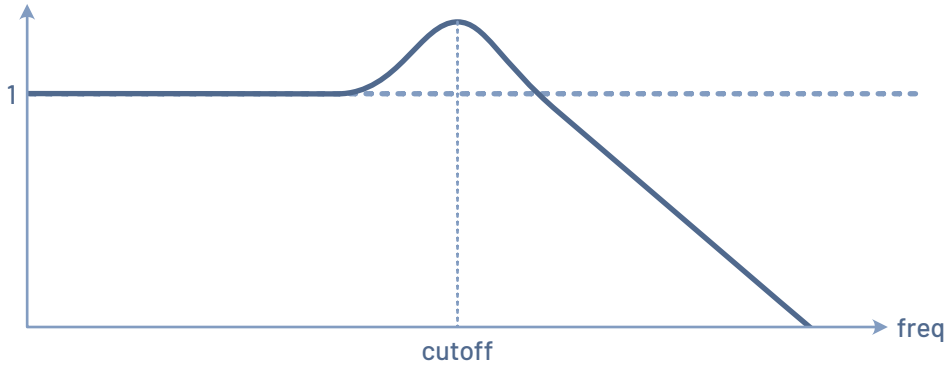
In the positive resonance mode, the resonant peak is *added* to the low-pass response, shown in the bottom-right figure. This mode maintains the bass response of the filter, and pushes the resonant peak into the output overdrive, which increases the harmonics of the resonance oscillation. This gives a thick resonant, full-bass sound.



Low-pass Filter Response without Resonance

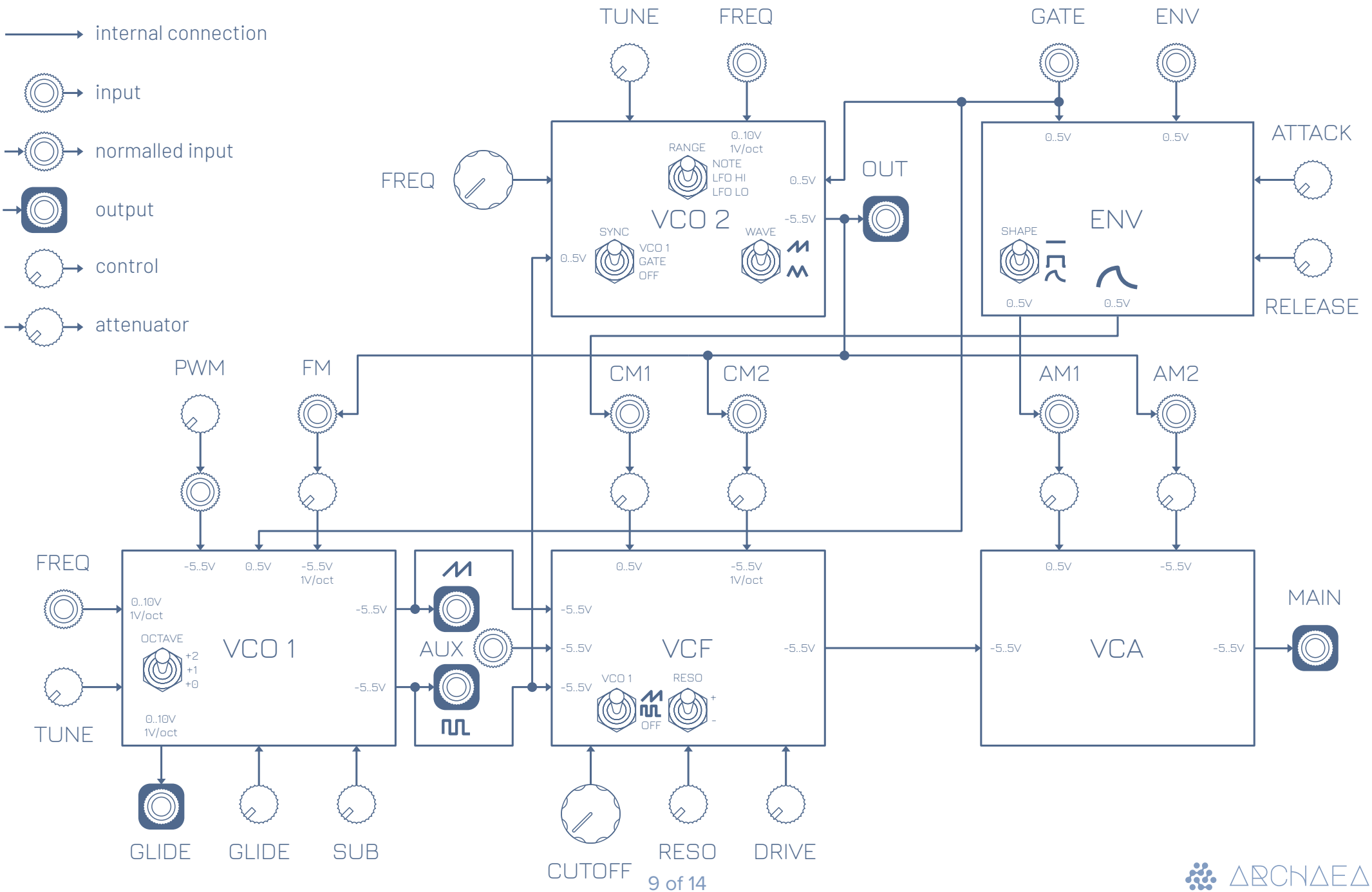


Low-pass Filter Response with Negative Resonance

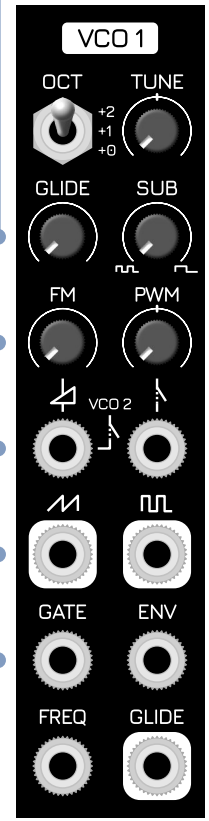


Low-pass Filter Response with Positive Resonance

Block Diagram and Connections



Voltage Controlled Oscillator 1



Octave Selection
Transposes the oscillator frequency up by 0, 1 or 2 octaves.v

Tuning
Fine tunes the oscillator by approx. +/-1.5 semi-tones. Zeroed when pointing up.

Glide Time
Sets the time to glide the frequency of a note to the next. A note will glide when the next note is pressed before the previous is released.

Sub-oscillator Mix
Sets the mix between the oscillator and sub oscillator. The sub oscillator is a square wave.
Full left: 100% osc. 0% sub
Full right: 0% osc. 100% sub

Frequency Modulation
Attenuates the FM amount applied to the oscillator from the FM source. The FM type is exponential.

Pulse-width Modulation
Sets the pulse width of the pulse wave output.
Full left: 90% hi, 10% low
Full right: 10% high, 90% low
Up: square wave

FM Source Input (-5..5V)
The FM source is either the input when a jack is connected, otherwise the VCO 2 output.

PWM Source Input (-5..5V)
The PWM source is either the input when a jack is connected, otherwise the PWM knob.

Saw Wave Output (-5..5V)
Allows the saw wave to be externally processed.

Pulse Wave Output (-5..5V)
Allows the pulse wave to be externally processed.

Gate Input (0..5V)
The gate input source. The start of a gate pulse triggers the envelope, provides a sync. for VCO2 and activates the note glide.

Envelope (CV) Input (0..5V)
When the gate is high, the envelope tracks to the level of the input signal when a jack is connected, otherwise tracks to the maximum level. The envelope tracks up by the attack rate and down by the release rate.

Frequency (CV) Input (0..10V 1V/oct)
The frequency input source. The source is either the input when a jack is connected, otherwise approx. a constant 2.75V.

Glide Output (0..10V)
The glide output is the frequency input processed to include frequency glides between notes. This can be connected to the VCO 2 frequency input to provide note control with glide for VCO 2.

Voltage Controlled Oscillator 2

Tuning
Fine tunes the oscillator by approx. +/-1.5 semi-tones. Zeroed when pointing up.

LED
Indicates the frequency of the oscillator by illuminating when the oscillator output is high.

Frequency
Sets the base frequency of the oscillator. The output frequency of the oscillator is the sum of the base frequency setting and the frequency input source.

Range
Sets the oscillator frequency range. The NOTE range, with FREQ full left, gives the same range as VCO 1 with OCT +0. LFO HI and LFO LO set the oscillator to be a high and low frequency LFO respectively.

Waveform
Sets the output waveform of the oscillator to a saw wave or triangle wave.

Sync
Sets the oscillator hard-sync source. When set to off, the oscillator will not be sync'd and will free run. Otherwise it will be sync'd to either the GATE input switching on (i.e. a note start) or to VCO 1.

Frequency (CV) Input (0..10V 1V/oct)
The frequency input source. The source is either the input when a jack is connected, otherwise the input is disconnected.

VCO 2 Output (-5..5V)
The oscillator output. VCO 2 can be mixed with VCO 1 by connecting the output to the AUX input of the VCF.

Voltage Controlled Filter

VCO 1 Source Select
Selects the VCO 1 output waveform, either saw or pulse waves, as an input to the filter. When OFF is selected, no VCO 1 output is used.

Resonance Mode
Sets the resonance mode of the filter. This affects the filter frequency response:
subtract (-) mode, low-pass response subtracted from the resonance peak
add (+) mode, resonance peak added to low-pass response

Cut-off Frequency
Sets the base low-pass cut-off frequency of the filter. The cut-off frequency applied to the filter is sum of the base frequency setting, cut-off modulation 1 and cut-off modulation 2.

Resonance
Sets the resonance level of the filter. When turned fully right the filter will self oscillate.

Drive
Sets the amount of drive applied to the filter output. Increasing drive will push the filter into soft clipping.

Cut-off Modulation 1
Attenuates the CM amount applied to the filter from the CM 1 source.

Cut-off Modulation 2
Attenuates the CM amount applied to the filter from the CM 2 source.

CM 1 Source Input (0..5V)
The CM 1 source is either the input when a jack is connected, otherwise the attack-release output of the envelope generator.

CM 2 Source Input (-5..5V)
The CM 2 source is either the input when a jack is connected, otherwise the VCO 2 output.

Auxiliary Input (-5..5V)
The auxiliary filter signal input allows an external source to be connected to the filter. The filter input is a mix of the VCO 1 source and the auxiliary source.

Envelope Generator & Voltage Controlled Amplifier

Shape
Selects the shape mode of the envelope between continuous, window and attack-release.

Gate LED
Indicates when a gate signal is received by illuminating.

Envelope LED
Indicates the envelope output level, the higher the envelope the brighter it is illuminated.

Attack
Sets the attack time of the envelope generator.

Release
Sets the release time of the envelope generator.

Amplitude Modulation 1
Attenuates the AM amount applied to the amplifier from the AM 1 source.

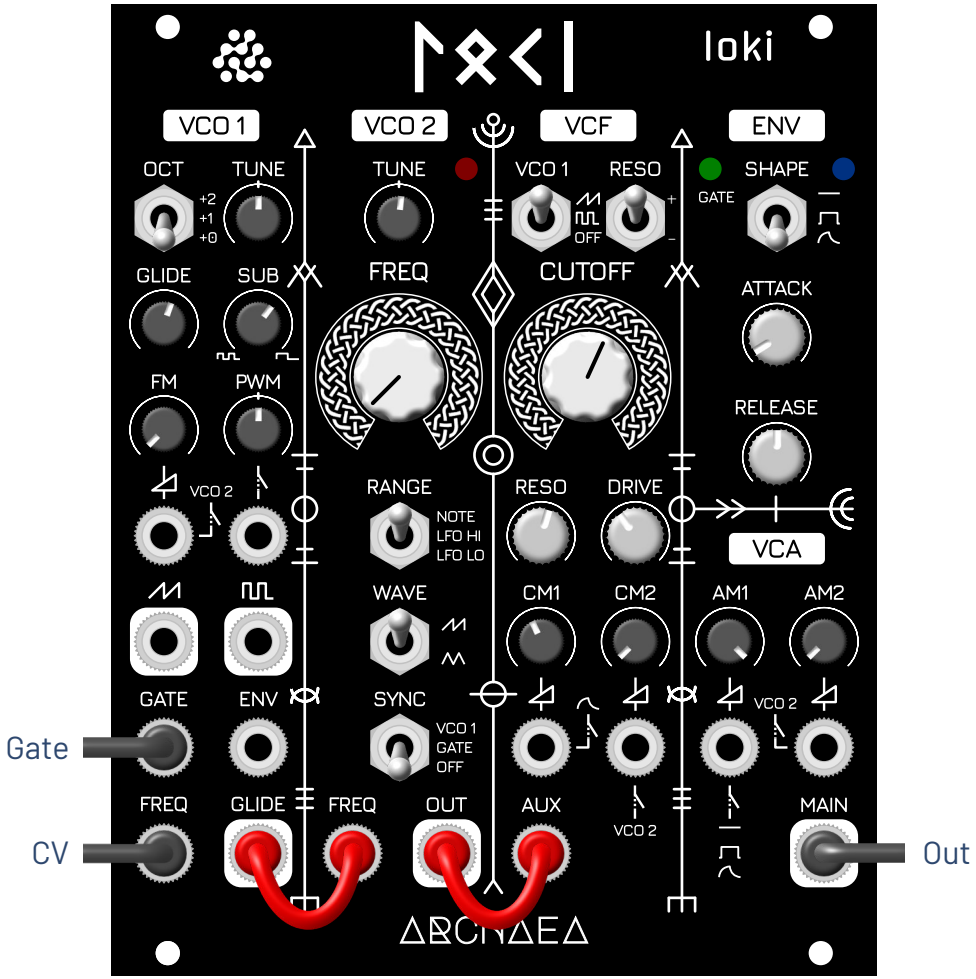
Amplitude Modulation 2
Attenuates the AM amount applied to the amplifier from the AM 2 source.

AM 1 Source Input (0..5V)
The AM 1 source is either the input when a jack is connected, otherwise the selected shape output of the envelope generator.

AM 2 Source Input (-5..5V)
The AM 2 source is either the input when a jack is connected, otherwise the VCO 2 output.

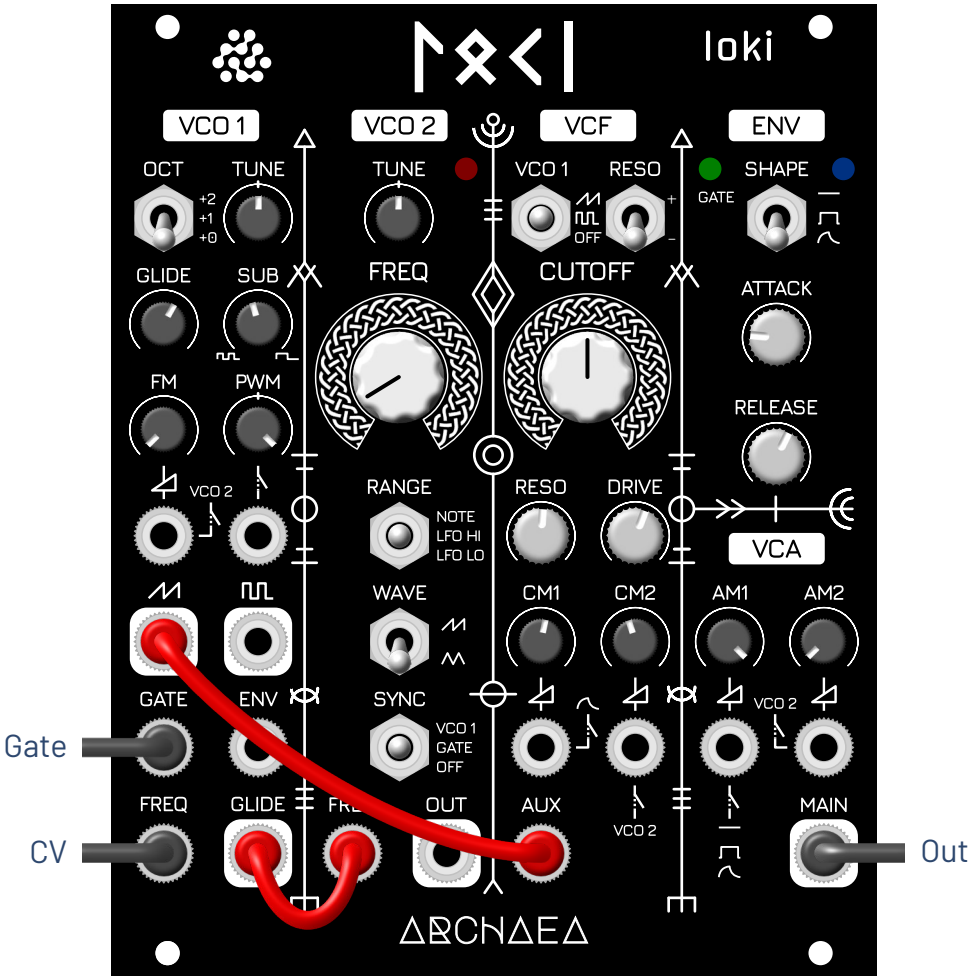
Main Output (-5..5V)
The main audio output. This is the output from the VCA.

Twin Saw



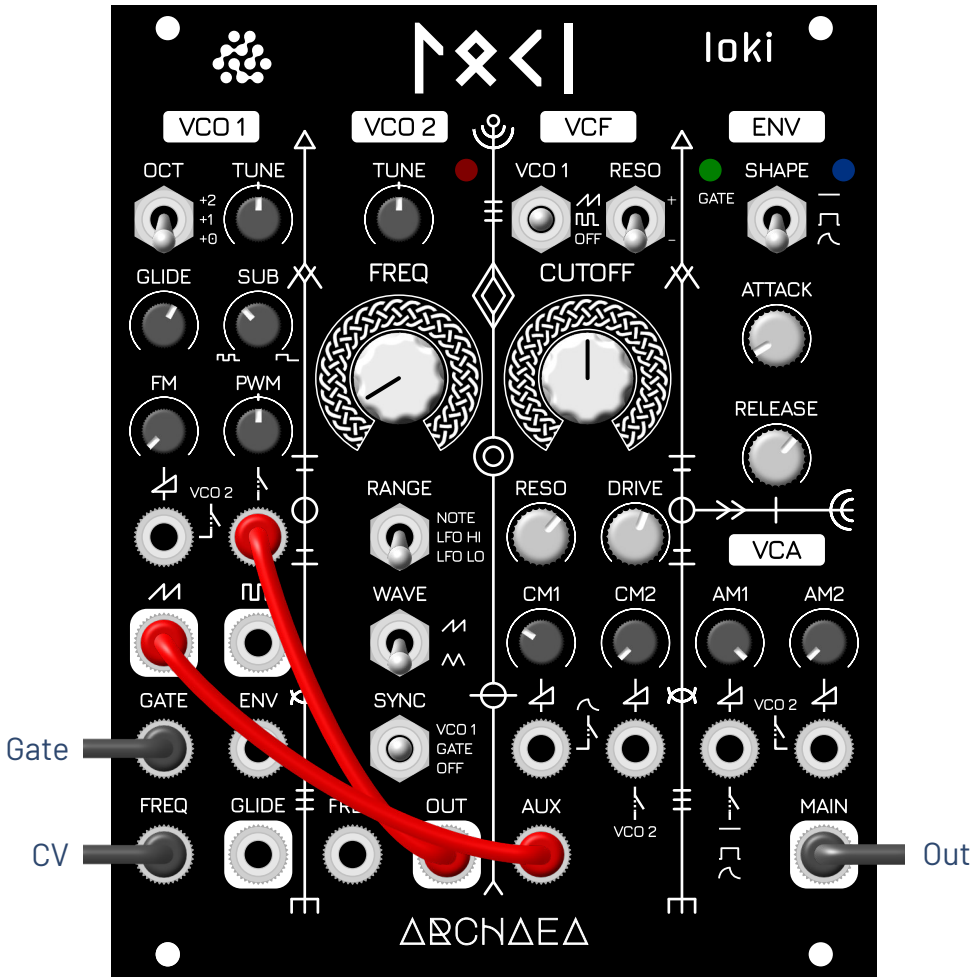
The CV frequency input can be routed to both VCO 1 and 2 by patching the glide output to the frequency input of VCO 2. The output of VCO 2 can then be mixed with VCO 1 by patching its output to the VCF AUX input. With VCO 2 set to note range and VCO 1 and VCO 2 slightly detuned, a thicker twin saw wave sound can be created.

Pitch Controlled LFO



By default, VCO 2 is connected to CM 2 if no jack is inserted into the CM 2 input. When set to an LFO range, VCO 2 will modulate the cut-off frequency when the CM 2 attenuator is turned up. The LFO rate will increase with the note pitch as glide is patched to VCO 2 frequency.

Slow Phasing PWM



VCO 2 can modulate the pulse width of VCO 1 by patching the output of VCO 2 to the PWM input. By setting the VCO 2 range to LFO LO, a slow phasing effect is achieved. This patch also shows mixing the VCO 1 saw wave in with the modulating pulse wave using the VCF AUX input.

Sine Oscillator

The filter can be used as a sine oscillator by turning the resonance to full and patching the V/oct modulation input (CM 2) to the glide output. Note: the cut-off needs to be carefully adjusted to tune the filter to the desired note for a given CV input.

Features

- Oscillator one: saw, and pulse outputs, glide, PWM, FM, sub-oscillator
- Oscillator two: saw and triangle outputs, LFO, hard-sync, sync to gate
- Filter: SSI2144 based design, two modulation inputs, aux input, drive
- Envelope generator: drone, window and attack-release, level input
- Amplifier: two modulation inputs
- Default signal path and 16 patch connections

Measurements

Width	20HP (101.6mm)
Height	3U (128.5mm)
Depth requirement for skiff/rack	32mm (including power header)
Current requirement	12V: 93mA, -12V: 79mA, 5V: 6.4mA