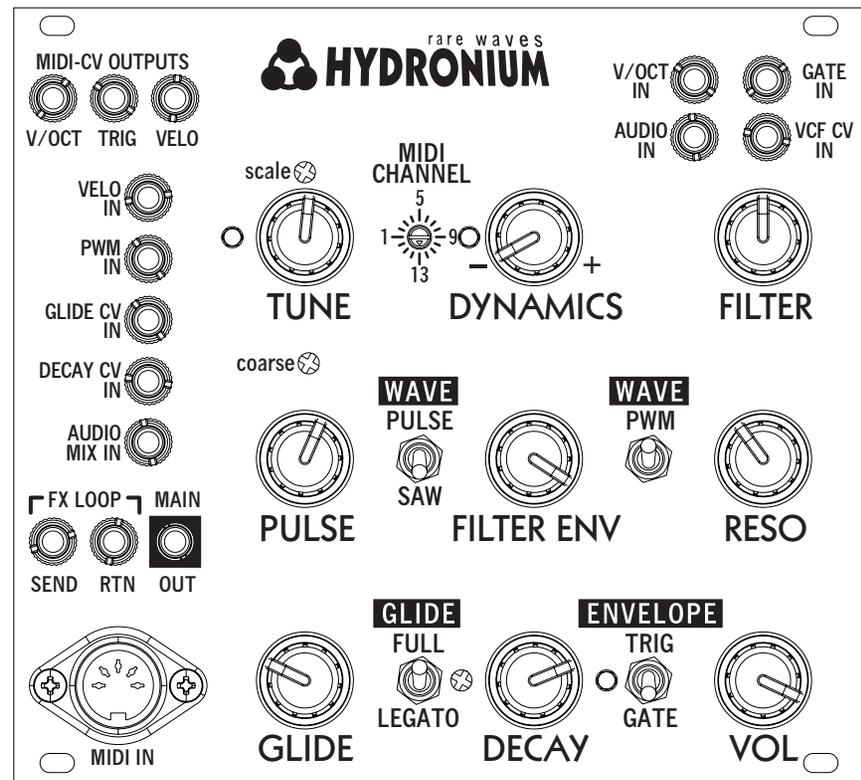


Tabletop



Eurorack



What is it?

The Rare Waves Hydronium is a semi-modular synthesizer with unmistakable true analog tone. Its rich array of CV patch points can interconnect with other analog synthesizers to inspire your music deeper and further in the creative zone.

While it is designed to fulfill the role of a TB-303 inspired acid synth, Hydronium is not a clone circuit. Instead it is an all-new design with its functions re-imagined and extended a little beyond what you might expect from the clone genre.

Its tone is based on a single VCO, a resonant low-pass filter, and a simple decay envelope. And as you'd anticipate of any acid synth, it has programmable glide (pitch slide) and dynamic accents for individual notes.

Hydronium's classic tone is a natural choice for sequenced basslines. Switch the envelope to gate mode, and it also serves as a lead synthesizer when you need a bright, clean sawtooth or pulse waveform in the mix.

It can be played either by MIDI control or CV-Gate. In addition, its built-in MIDI-to-CV converter with post-glide v/oct output lets you use it as a bridge between your MIDI controller and other analog synthesizers.

Hydronium features an audio effects loop that is positioned between its filter and VCA. This is a good place for distortion effects, phaser, and certain other effects that tend to increase the noise floor when patched to a synth's line out. The pre-VCA effect return silences the self-noise from the effect, preserving full dynamic range even when you bend its tone with a high-gain fuzz pedal, for example.

Hydronium is available in Eurorack and Tabletop formats. This manual describes both versions, which are equivalent in almost every regard.

Specifications

Polyphony

- Monophonic (1 voice)

Oscillator Waveforms

- Sawtooth, Square, Pulse, PWM

Filter

- Voltage-controlled 12dB/oct state-variable low pass filter with variable Q and self-oscillation capability

Envelope Generator

- Velocity-sensitive decay envelope. Triggered (decay) or gated (hold-release).

Dynamic Accent

- Bipolar accent control (+6 dB boost, -infinity dB cut)

Glide (Pitch Slide)

- Legato glide, full glide.

MIDI

- MIDI Input x 1 (DIN-5 jack)

CV-Gate Inputs (1 volt per octave)

- V/oct In x 1 (100k Ω impedance), Gate In (20k Ω impedance)

MIDI-CV Outputs

- V/oct Out (post-glide), Trigger Out (5ms @ +5V), Velocity Out (0..+5V)

Other CV Inputs

- Filter V/oct In, Velocity In, PWM In, Decay CV In, Glide CV In

Audio Inputs

- Audio In (VCO cancel), Audio Mix In. Both are pre - filter.

Audio Line Output

- 1/4" mono unbalanced (Hydronium Tabletop)
- 3.5 mm mono unbalanced (Hydronium Eurorack)

Dimensions

- Eurorack: Width = 28 HP (5.6", 142 mm), Depth behind rails = 1.0" (26 mm)
- Tabletop: W x D x H = 4.8 x 6.0 x 2.2" (122 x 152 x 56 mm)

Power Supply Requirements

Hydronium Tabletop

The unit is powered by AC adapter.



DC 12V
200 mA

Tip = Positive (+)
2.1 mm center pin

* Hydronium will operate with a 9VDC power supply, but the sound quality may be reduced

Grounding

★ For best sound quality, the audio system should include one or more grounded AC power plugs (3-prong outlets). Typically, the speaker amplifier and / or mixing console will have 3-prong AC plugs. This is important because it creates a path for electrical noise to dissipate away through.

On the other hand, if the entire audio system is running on 2-prong AC adapters and/or batteries, it is in a “floating” condition. It is likely that your audio quality will be contaminated noise and interference caused by the AC adapters.

Therefore, if you will use Hydronium with a laptop computer, you should pay close attention to how electrical grounding affects your signal integrity. The laptop power supply may or may not have a 3-prong AC plug.

If you are using a DI box to connect Hydronium to a PA system, we suggest setting its Ground Lift switch to OFF.

Any time you move to a new production setup, be prepared to listen critically to the audio noise floor and make changes to the electrical grounding situation when needed. Clean audio is more inspiring...

Hydronium Eurorack

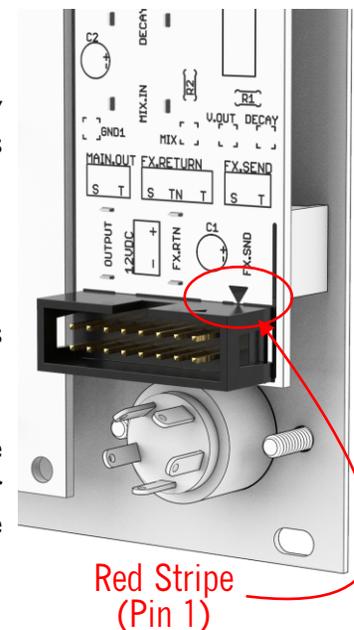
The module requires +/-12 VDC from the rack power supply bus. Use a standard ribbon cable to connect it to your rack's power supply distribution board.

+12V @ 50 mA
-12V @ 5 mA

The module's power connector is a 16-pin shrouded header. It is located on the back of the expander PCB.

Align the red stripe on the ribbon cable to match the triangle printed by the module's power connector. The module's power connector is keyed to ensure correct alignment. There should be no physical way to insert the plug backwards.

* It is OK to power Hydronium from a +/-15 VDC supply.



Hookup Diagram : Tabletop MIDI Control

**Distortion Pedal
Chorus, Phaser,
Multi-FX Unit**
(optional)

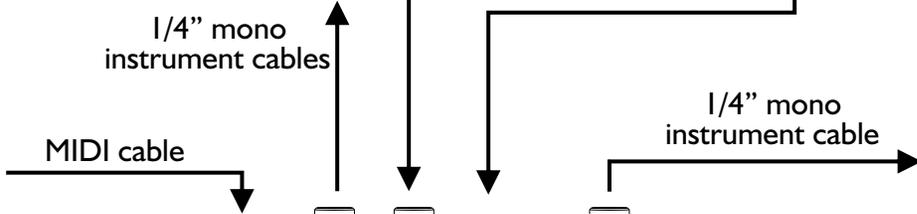
LINE IN LINE OUT

**Wall-mount
AC Adapter**

12 VDC
Output

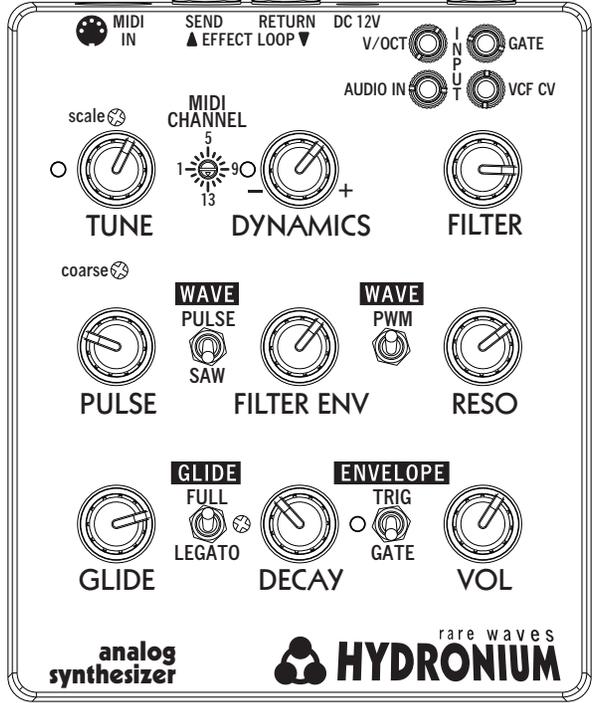
**MIDI Keyboard
MIDI Controller
MIDI Sequencer
DAW, etc.**

MIDI OUT

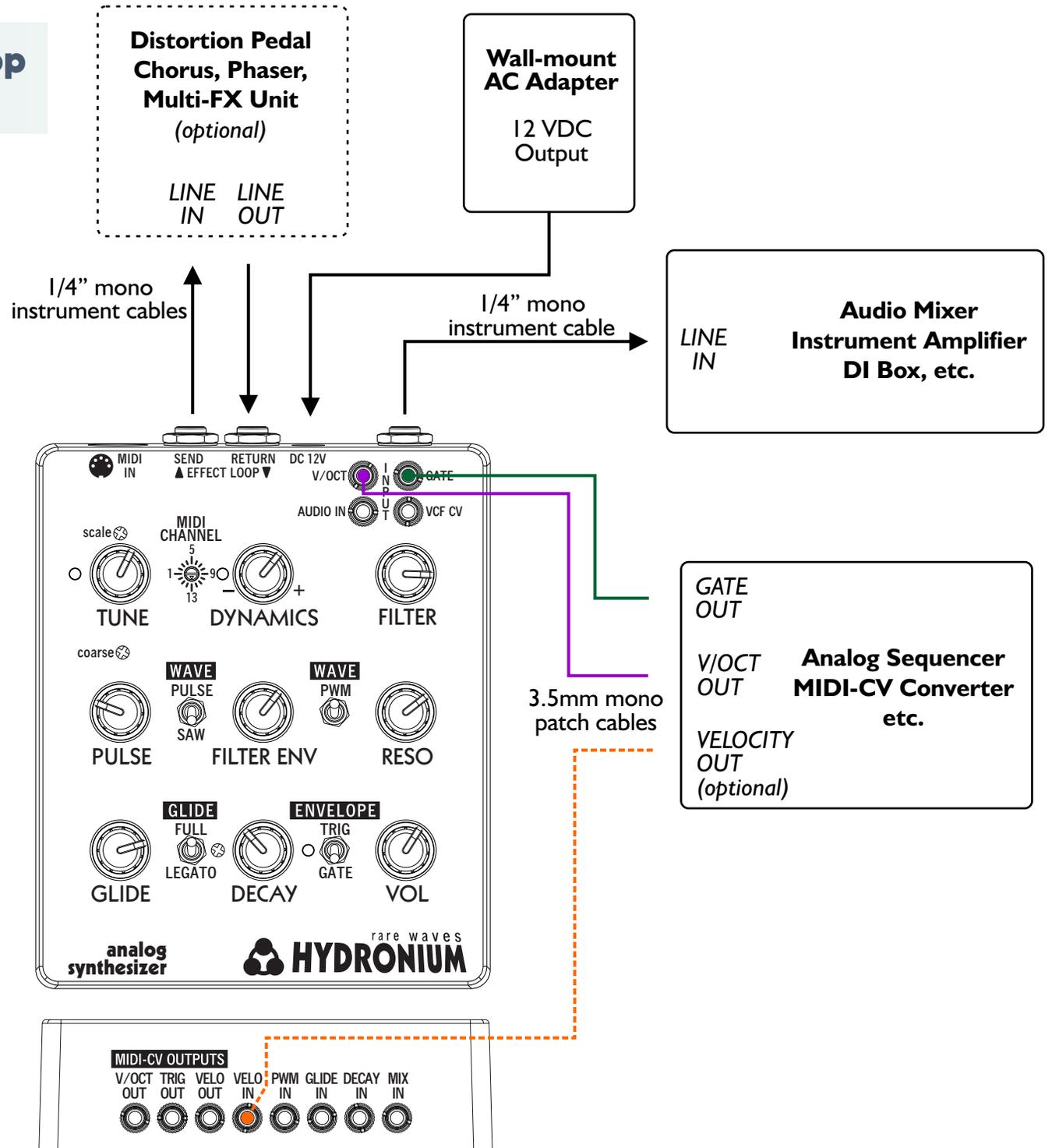


**Audio Mixer
Powered Monitors
Instrument Amplifier
PA System, etc.**

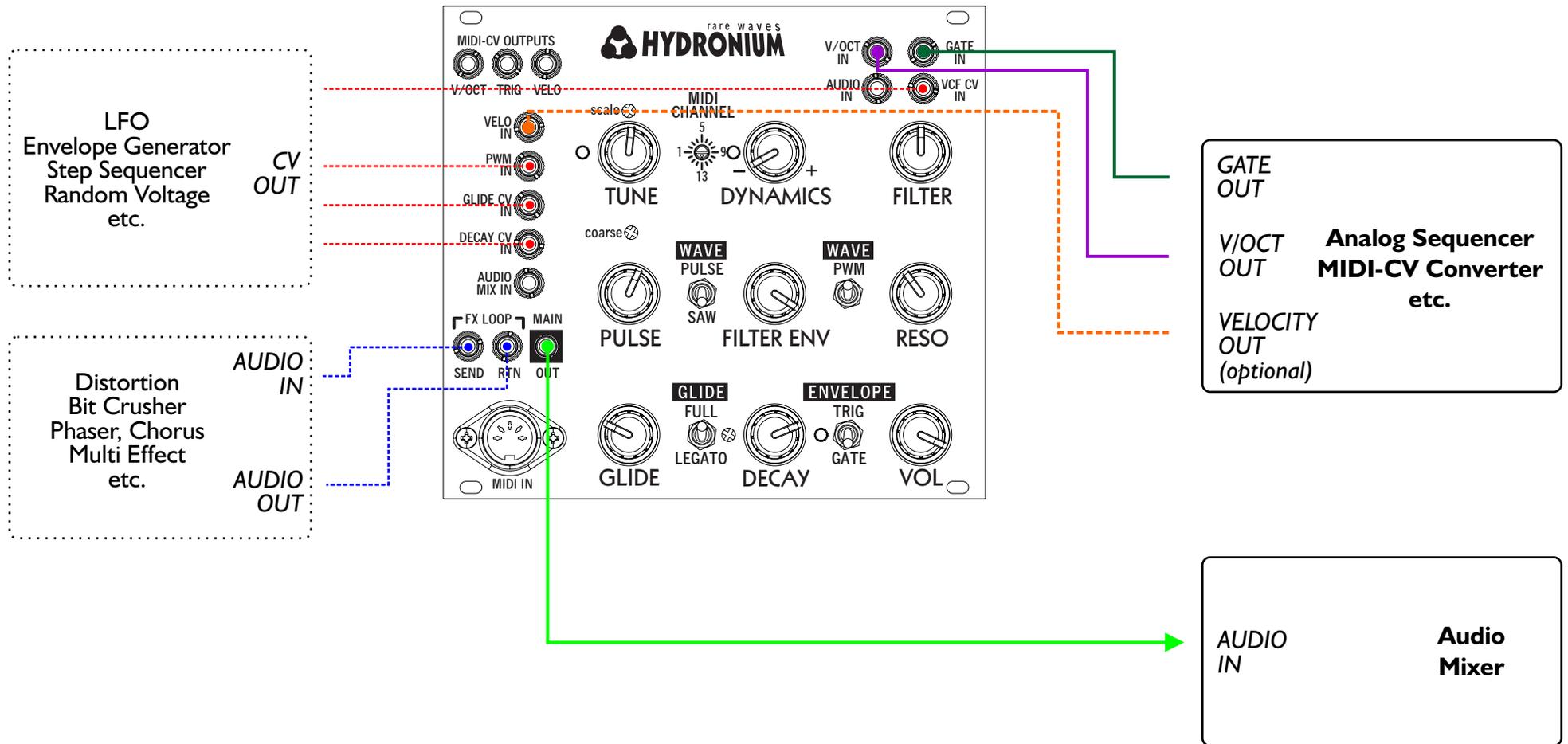
LINE IN



Hookup Diagram : Tabletop CV-Gate Control

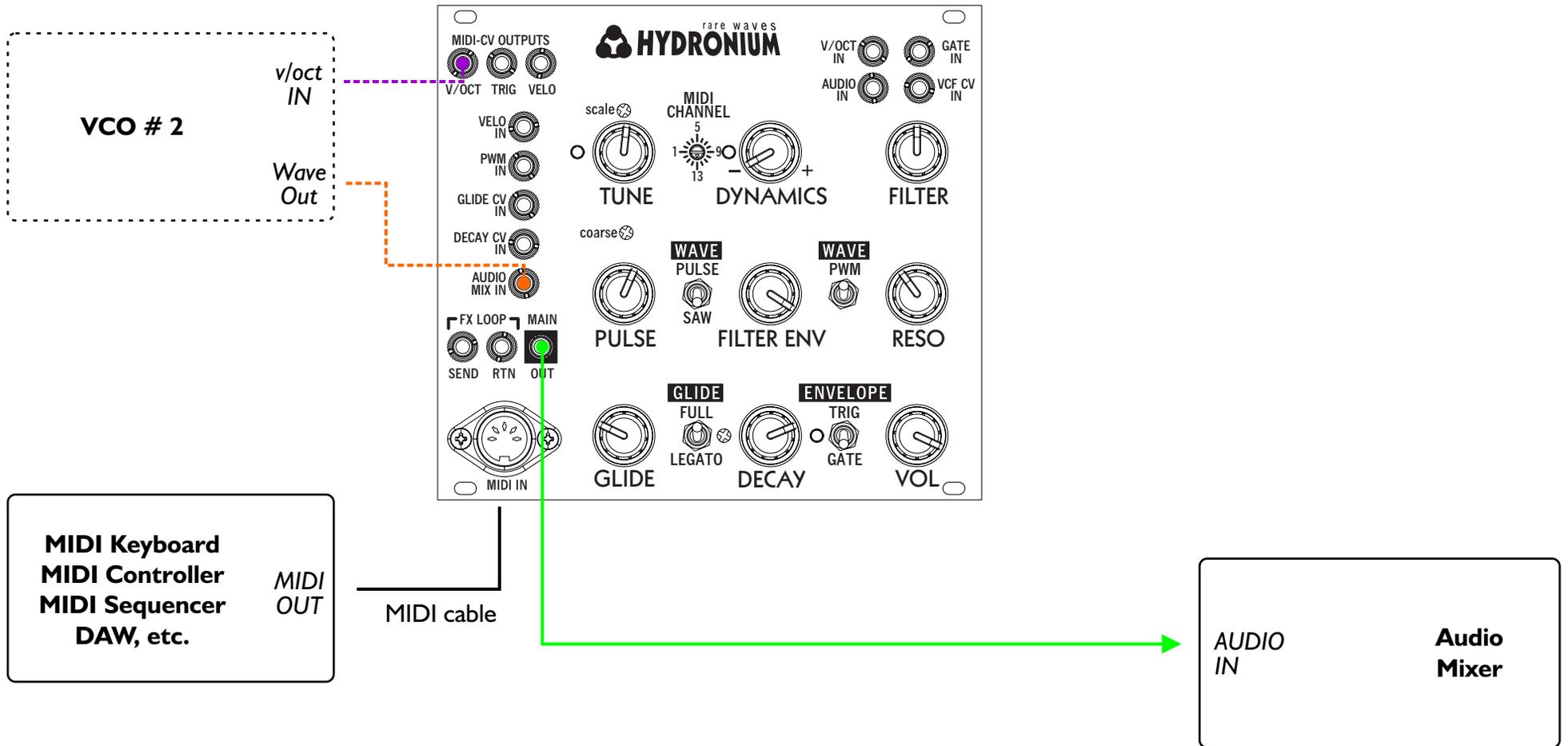


Hookup Diagram : Eurorack CV-Gate Control



All connections : use 3.5mm mono patch cables

Hookup Diagram : Eurorack MIDI Control



Setting the MIDI Channel

Set the MIDI receive channel with the rotary switch. It is located between the Tune and Dynamics knobs.

Look closely at the rotary switch. It has a triangle on its surface. The tip of the triangle is pointing to the current MIDI channel. Read the channel number from the legend printed on the panel.

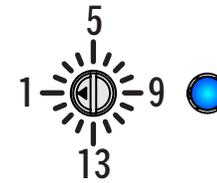
Use a 1/8" flat-blade screwdriver to turn the switch.

The MIDI activity indicator LED is next to the switch. Whenever MIDI note messages are detected on the selected channel, the LED will blink.

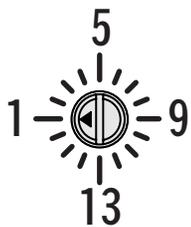
If you are unsure what channel your controller is sending, you can rotate the switch one click at a time while playing the controller. When the MIDI activity LED blinks in rhythm with your playing on the controller, you have found the channel.



MIDI CHANNEL



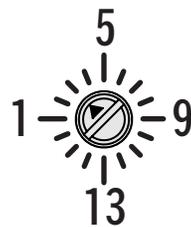
MIDI activity LED



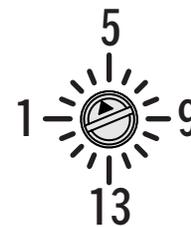
Ch. 1



Ch. 2



Ch. 3



Ch. 4

...



Ch. 16

Tuning

The TUNE knob on the control panel has a range of +/- 2.5 semitones. It is used to fine tune the synthesizer.

The Coarse Tuning trimmer has a wider range. It is accessed with a screwdriver tool, through the port under the TUNE knob. Its range is approximately 3 octaves

If you find that the pitch intervals sound out of tune, the Scale trimmer should be calibrated. See the Calibration page in this manual for additional detail.

Tuning for MIDI control

When Hydronium is under MIDI control it is designed to play the precise pitch according to MIDI standard. But if the Coarse tune trimmer is out of adjustment, then the TUNE knob won't have enough range to compensate.

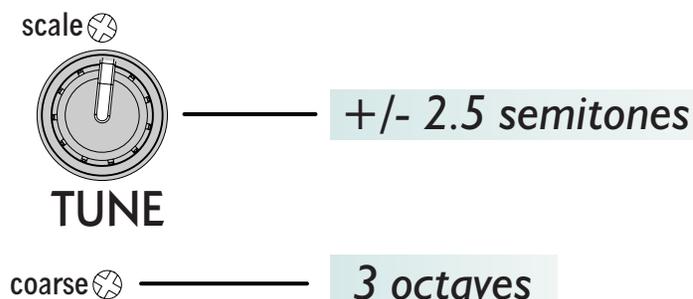
The quick tuning procedure is summarized in the sidebar on this page.

Once you have set the Coarse tune trimmer accurately, you shouldn't need to adjust it again as long as you continue to use MIDI control.

Tuning for CV-Gate control

When Hydronium is used with CV-Gate control, you may find it necessary to use the Coarse Tuning trimmer to shift the pitch range of the unit appropriately to the CV source it is connected to.

★ You can use the MIDI input and CV-Gate control simultaneously. The MIDI input transposes the CV-Gate sequence. You can use MIDI to set the tuning range of the V/oct input, instead of adjusting the Coarse Tuning trimmer.



Simple steps to tune Hydronium to MIDI standard pitch

- Start by setting the TUNE knob to 12 o'clock position.
- Set the ENVELOPE switch to GATE position.
- Sound the note "A" in a middle octave on another accurately tuned MIDI instrument.
- At the same time, hold the same A note on the MIDI controller that is connected to Hydronium.
- Use a screwdriver to adjust the Coarse tuning trimmer until the two pitches are very close.
- Finally, give the TUNE knob a touch-up adjustment so Hydronium's pitch matches the external reference pitch.

It is even simpler if the reference instrument and Hydronium are on the same MIDI channel. If you have a MIDI keyboard synth, you may patch its MIDI Out to Hydronium. Set Hydronium's MIDI Channel to receive the keyboard's messages. Then play any key on the MIDI controller and both instruments will sound simultaneously. Listen to both synthesizers while adjusting the Coarse tune trimmer so the pitches are in unison.

Dynamic Accent

The DYNAMICS knob lets you alter the volume of the accented notes in your MIDI sequences.

MIDI Velocity 0 - 100 : Accent Off
MIDI Velocity 101 - 127 : Accent On

DYNAMICS has a bipolar control range. It can make the accented notes louder or quieter. You can even erase the accented notes completely from the sequence, giving you a live control for pattern variations.

MIDI notes with velocity less than 100 are not affected by the DYNAMICS knob. The volume of these notes is controlled only by MIDI Velocity.



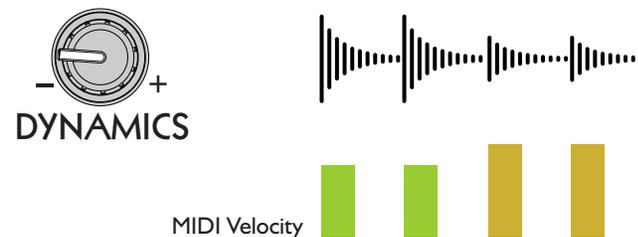
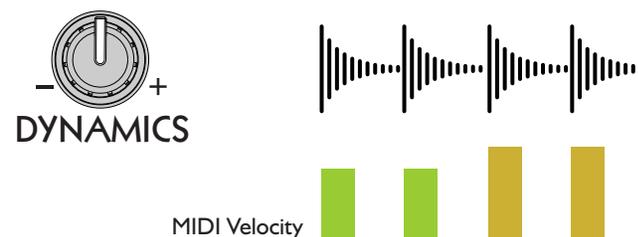
The DYNAMICS knob is intended for use with MIDI control.

CV-Gate Control : Every note is treated as an accented note. Whenever there is activity at Gate In jack, it is interpreted the same as MIDI Velocity = 120.

With CV-Gate control, the DYNAMICS knob basically acts like a second volume knob. In general, you may leave the DYNAMICS knob set to maximum while you are using CV-Gate control.

★ To control the volume of each note independently, patch a CV sequencer to the VELO IN jack. This accepts a variable voltage in the range 0 to +5 volts.

If your CV sequencer has ACC GATE output, you will need a voltage processor module (attenuate and offset) to translate it into Velocity CV for Hydronium.



Pitch Glide (Slide)

Pitch Glide effect creates a smooth pitch transition from one note to the next. The speed of the transition is controlled with the GLIDE knob.

Rotating the glide knob fully to the left (counterclockwise) will disable the effect regardless of the Glide switch setting.

The GLIDE IN jack can also be used to vary the effect. This CV input and the knob are summed together. When patching to GLIDE IN, you should experiment with setting the Glide knob to fine tune the effect as you need it.

★ The results of the Glide effect are sent to the V/oct CV output. This provides a convenient way to 'slave' an external VCO for 2-oscillator tones.

* The tabletop model's V/OCT OUT voltage range is +0.85 .. 8.1 V (MIDI Note C#2 .. E9). MIDI Notes below C#2 will not appear correctly at V/OCT OUT on the tabletop version of Hydronium.

** Long glide time settings may cause a slight detuning effect of the oscillator.

Full Glide

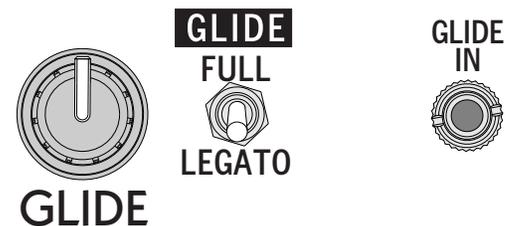
In Full Glide mode, the Glide effect is applied to all notes.

Legato Glide

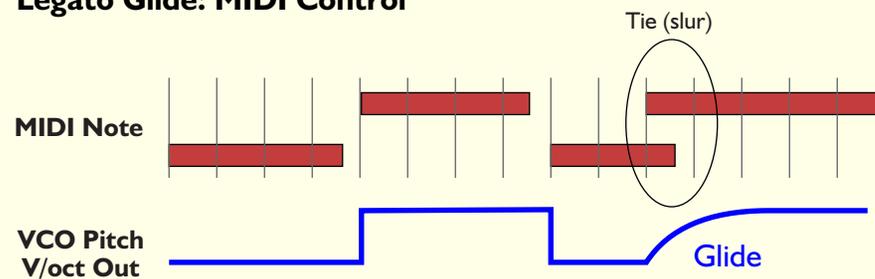
In Legato Glide mode, the Glide effect is only applied to notes that are tied (slurred).

MIDI Legato : When the end of one note overlaps the beginning of the next, the Glide effect will be activated.

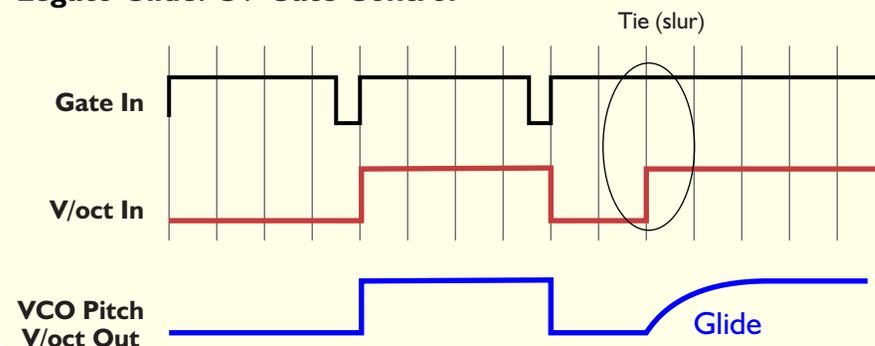
CV-Gate Legato : The first note when Gate In is activated will not have glide effect. Changing the V/oct CV voltage while Gate In is already active will cause a glide.



Legato Glide: MIDI Control



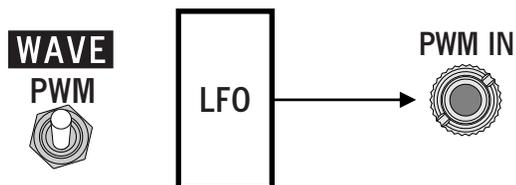
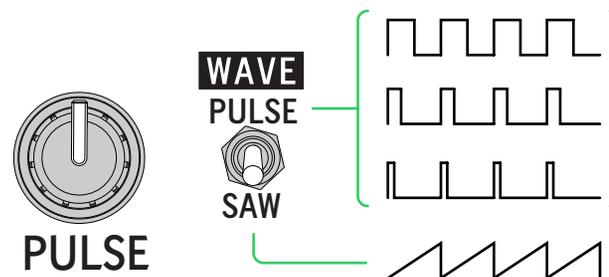
Legato Glide: CV-Gate Control



Voltage-Controlled Oscillator

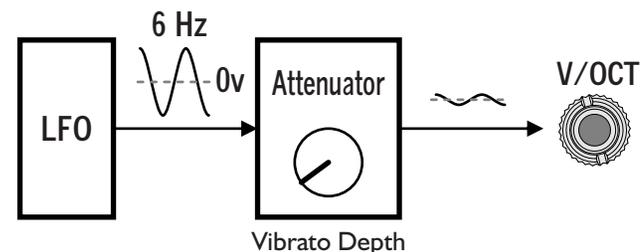
The Hydronium VCO is a sawtooth-core type with 1 volt per octave response. It also offers a pulse waveform which can be varied with the PULSE knob from square wave to vanishingly thin pulses.

Pulse width modulation (PWM) is also available. The only built-in PWM source is the decay envelope. When the WAVE-PWM switch is up, the pulse width is linked to the envelope generator.



Patch an LFO to the PWM CV input for a classic de-tuned sound. The jack and the PULSE knob are summed together, so you should experiment with setting the PULSE knob to vary the effect of the PWM CV input. If your LFO does not have variable output amplitude, an attenuator module will be useful to control the intensity of the PWM effect.

For vibrato effects, you will need an LFO and a voltage attenuator to reduce the vibrato width. Your LFO voltage should be centered at zero volts. If you connect an LFO which ranges from 0.. +5 volts, the VCO pitch will be offset upwards, which is inconvenient.



** The Hydronium VCO is not designed for FM synthesis.

Pitch Control: MIDI vs. CV-Gate ... or both!

The pitch of the VCO can be controlled by MIDI note or by the V/oct CV input.

If you want to use both the V/oct and MIDI to control pitch simultaneously, it is OK.

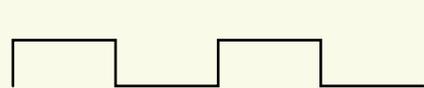
★ For a nice example, you can send a melody sequence to Hydronium's MIDI input, and patch your analog sequencer to the V/oct input to create key changes and transpositions.

Or do it the other way around... send a melody sequence to the CV-Gate inputs from your analog sequencer, while using Hydronium's MIDI input to transpose it for key changes. This gives you a powerful way to get melodic variations from inflexible analog sequencers.

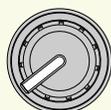
Voltage-Controlled Filter

The Hydronium has an OTA-tuned state-variable filter. It is a low pass filter with a slope of -12dB/octave. The FILTER knob adjusts the cutoff frequency. The filter cutoff frequency automatically tracks the VCO frequency.

The resonance (Q - factor) is adjustable with the RESO knob. Resonance can range from zero to almost infinite self-oscillation.



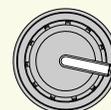
unfiltered VCO waveform



RESO



No resonance



RESO



High resonance



VCF CV

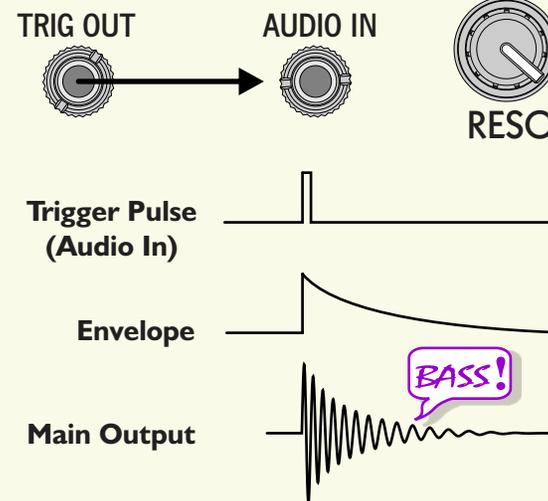
You can also vary the cutoff frequency by patching to the VCF CV input. Try connecting it to an external LFO, analog sequencer, envelope generator, random voltage source, etc. Its response is approximately 1 volt per octave.

- ★ When the resonance is turned up to maximum, the filter can be used for damped sine wave percussion synthesis.

Patch the TRIG OUT jack to AUDIO IN. This cancels the internal VCO and hits the filter input with a trigger pulse to excite its self-oscillation. Now set the RESO pot to maximum. The filter will self-oscillate with a sine wave tone.

Use the Filter Envelope control to vary the pitch sweep. You can create tuned bass drums, zaps, and other minimal electronic percussion sounds without relying on a sampler.

* There is no trimmer to adjust the filter's scale. Therefore, the intervals may be slightly out of tune when using it for sine wave synthesis of melodic pitched percussion.



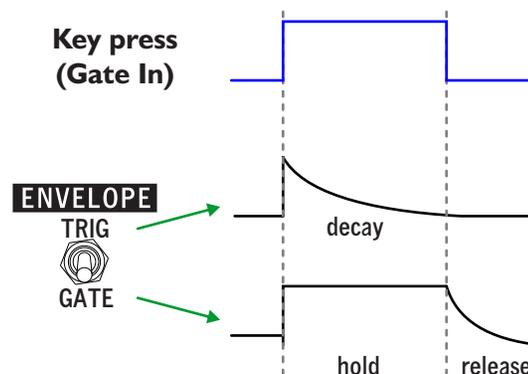
The Hydronium filter is derived from a reference design published by National Semiconductor in the LM13700 OTA datasheet. It also contains improvements compiled from various articles published in the Electronotes journal several decades ago.

Envelope Generator

Hydronium's envelope generator has two modes: Decay and Hold-Release. Use the Envelope switch to choose between Triggered or Gated operation.

In TRIG mode, the decay phase begins immediately when the note is cued by either a MIDI Note or activity at the Gate In jack. This mode is typically used for basslines, and any time a staccato percussive sound is required.

In GATE mode, the envelope is held open as long as a note is sustained. The release phase begins immediately upon releasing the key. This mode is typically used for lead playing.



FILTER ENV

Use the FILTER ENV knob to modulate the filter cutoff frequency with the envelope generator.

The original idea behind filter envelope is that the sound of many acoustic instruments has decreasing harmonics as a note fades away. When this idea was translated into electronic form, and supercharged with a resonant filter, the acid sound was born...

Use the DECAY knob to vary the length of the fade out.

Decay time can be controlled by patching to the DECAY IN jack. It is summed with the knob. Experiment with varying the knob setting to see how it interacts with the CV jack.



DECAY



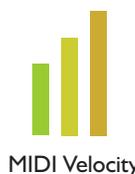
DECAY IN



MIDI Mod Wheel also affects decay time. More mod wheel = longer decay time.

The envelope generator is hard wired to the unit's VCA (voltage-controlled amplifier), so it always controls the volume envelope of the main output.

The envelope is velocity-sensitive. MIDI Note Velocity controls the loudness of the notes. You can also patch to the VELO IN jack to control it from an external analog sequencer, LFO, etc. This will allow you to create accented notes when using CV-Gate control. Hydronium's VELO IN requires a variable voltage in the range 0 to +5 volts.

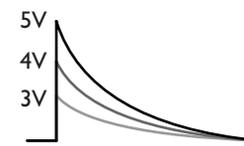


MIDI Velocity



VELO IN

0 ..+5V only



Envelope Re-trigger

When using MIDI control, the envelope generator can be re-triggered when legato (tied) notes are played. Set the Envelope switch to TRIG position. MIDI note velocity controls the re-trigger status of each note.

ENVELOPE



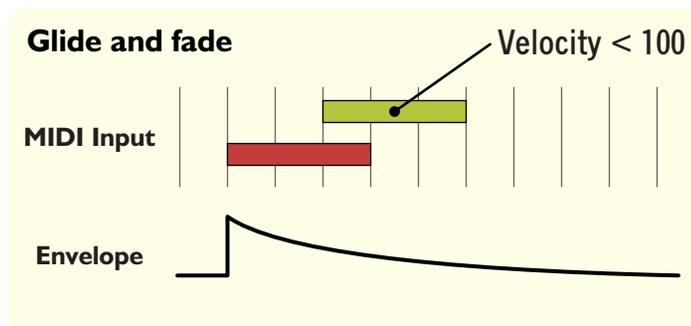
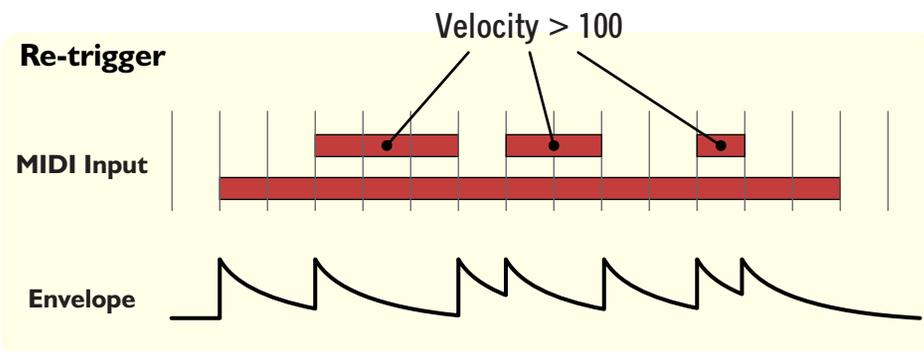
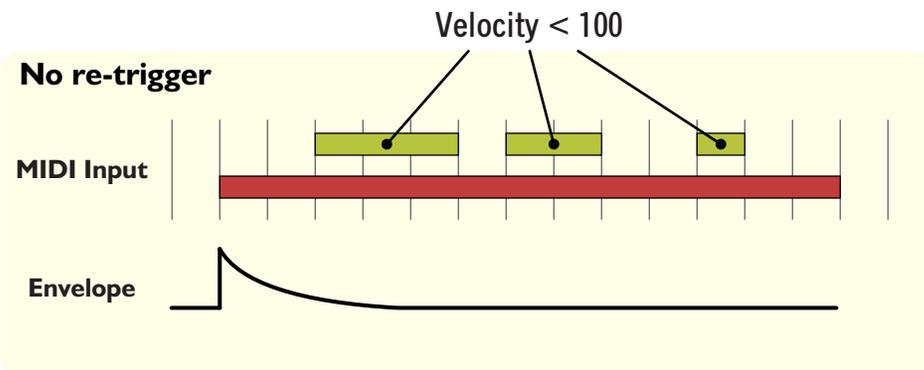
Note Velocity < 100 : No re-trigger
Note Velocity > 100 : Re-trigger

No re-trigger means the envelope generator only resets on the first note of a phrase.

Re-triggering means the envelope generator resets every time a new note is played.

If your MIDI controller has velocity sensitive keys, you can easily understand the difference. Press a key on the MIDI controller and hold it; then tap another key rapidly. You'll see that when you hit the second key hard, the envelope generator re-triggers. Or, if you play it with a light touch, the envelope fades to silence even while the new notes are playing.

★ To make a note glide while it fades out, play a legato phrase with the second note's velocity less than 100. Adjust the Decay knob so the duration of the fade is long enough to let you hear both notes. Set the Glide knob high enough so you hear the pitch bend.



Effects Loop

The Effects Loop gives you an alternative way to connect effects pedals and processors, besides simply patching them after the synth's main output.

The effects loop breaks the connection between the filter and the VCA. This lets the VCA work like a noise gate. It will erase any self-noise generated by the effects chain.

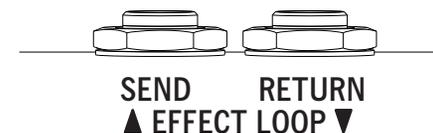
Hydronium's effects loop is a sweet spot for high-gain type effects, such as distortion, fuzz, and overdrive. That's because if you patch these effects after the main output of a synthesizer, they increase the noise floor and exaggerate all of the unwanted background sounds like clock contamination.

Its also a good place for effects with low dynamic range, because the audio level from Hydronium's effect send is constant. Set the effect's input gain once, and you shouldn't have to worry about it clipping at some unexpected moment.

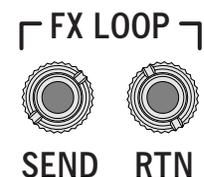
When using the effects loop for high-gain tones, note that adding distortion to a square wave simply gives you back the same square wave! For example, when the filter is wide open and resonance is off, a distortion effect won't change the tone very much.

Hydronium's effects loop may not be your best place for ambience effects like echo or reverb. That's because the VCA will gate out the results of any time-delay based effect. Regardless, experimentation is worthwhile because you can get interesting slapback delay and gated reverb effects this way.

Tabletop: 1/4" mono



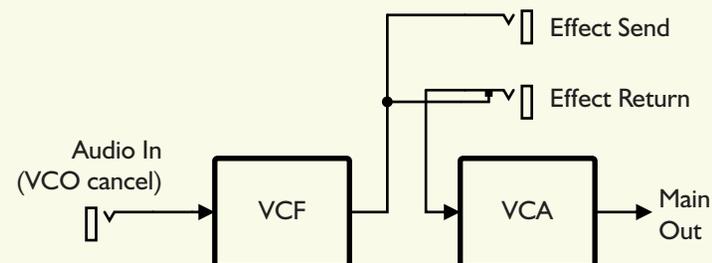
Eurorack: 3.5 mm mono



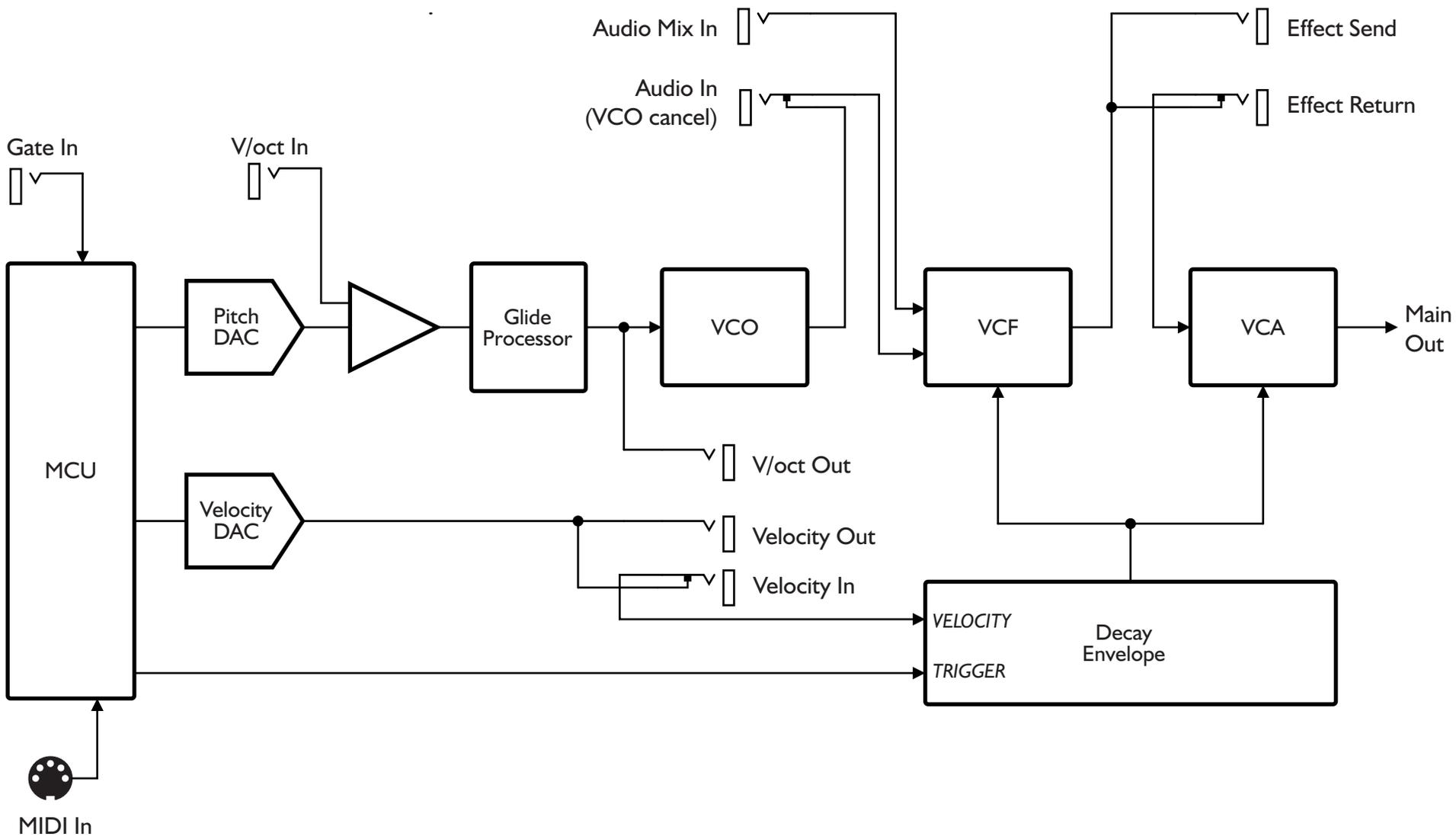
★ How to isolate Hydronium's filter and VCA sections for processing external audio:

To process external audio through the Hydronium VCF only, patch it to **Audio In** and use **Effect Send** as the filter output.

To process external audio through the Hydronium VCA only, patch it to **Effect Return**, and use **Main Out** as the VCA output.



Block Diagram



Voltage Control Specifications

CV-GATE INPUTS

V/OCT In

- 1 volt per octave (100 k Ω impedance)

GATE In

- +5V = Gate On, 0V = Gate Off, (20 k Ω impedance)

MIDI-CV OUTPUTS

V/OCT Out

- 1 volt per octave. (220 Ω impedance)
- TABLETOP: Range +0.85.. +8.1 V (MIDI Note range C#2 to E9)
- EURORACK: Range -2 .. +8.1 V (MIDI Note range C-1 to E9)

TRIG Out

- Positive pulse, +5V amplitude, 5ms duration. (1 k Ω impedance)

VELO Out

- MIDI Velocity Output, range 0 .. +5V. (1 k Ω impedance)

OTHER CV INPUTS

VCF CV In

- 1 volt per octave (100 k Ω impedance)

VELO In

- Range 0 .. +5V. (20 k Ω impedance)

PWM In

- Range -2.5 .. +5V. (6 k Ω impedance)

Glide In

- Range -2.5 .. +5V. (20 k Ω impedance)

Decay In

- Range -2.5 .. +5V. (20 k Ω impedance)

AUDIO CONNECTIONS

AUDIO In

- -10dBV nominal (150 k Ω impedance)

MIX In

- -10dBV nominal (200 k Ω impedance)

EFFECT SEND

- -10dBV nominal (390 Ω impedance)

EFFECT RETURN

- -10dBV nominal (20 k Ω impedance)

MAIN OUT

- -10dBV nominal (impedance depends on VOL knob setting)

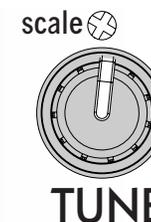
Calibration

A screwdriver is required: flat or Philips, size 1/8" or 2.5mm
Adjust the trimmers by inserting the screwdriver through the hole in the control panel
All of the trimmers are single-turn type.

Scale trim

How to set up the internal VCO to play correct pitch intervals:

- Connect a MIDI controller keyboard.
- Listen critically while playing low-middle notes that are separated by octaves. Or use an arpeggiator to play an octave sequence in the low-to-middle pitch range.
- If the octave intervals don't sound true, use a small screwdriver to adjust the Scale trimmer.
- If the intervals sound flat, turn Scale trimmer clockwise (right). If the intervals sound sharp, turn Scale trimmer counterclockwise (left).



Coarse Tune trim

How to tune the synthesizer so it plays the correct MIDI note pitches:

- Start by setting the TUNE knob to 12 o'clock position.
- Set the ENVELOPE switch to GATE position.
- Sound the note "A" in a middle octave on another accurately tuned instrument.
- At the same time, hold the same A note on the MIDI controller that is connected to Hydronium.
- Use a screwdriver to adjust the Coarse tuning trimmer until the two pitches are very close.
- Finally, give the TUNE knob a touch-up adjustment so Hydronium's pitch matches the external reference pitch.

coarse 

It is even simpler if the reference instrument and Hydronium are on the same MIDI channel. For instance, if you have a MIDI keyboard synth, you may patch its MIDI Out to Hydronium. Be sure Hydronium's MIDI channel matches the keyboard's settings. Then play any key on the MIDI controller and both instruments will sound simultaneously. Listen to both synthesizers while adjusting the Coarse tune trimmer so the pitches are in unison.

VCA Balance trim (located next to the DECAY knob)

How to minimize bleed-through of the envelope generator into the audio output:

- Dead-patch the Audio In jack. This mutes the internal VCO.
- Turn RESO to minimum, and FILTER to maximum
- Turn FILTER ENV to minimum
- Set the ENVELOPE switch to TRIG
- Play notes on your MIDI controller or with the Gate In jack while listening critically. You will hear a subtle "pop" sound at the attack of each note, and silence after that.
- Turn the VCA trimmer and try to hear the difference it makes in the popping sound. Leave it set where it is the quietest. This is not a critical adjustment.



V/oct Out trim (located on the back of Hydronium's Expander PCB)

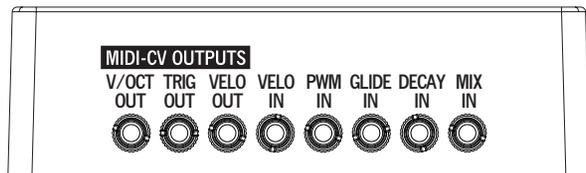
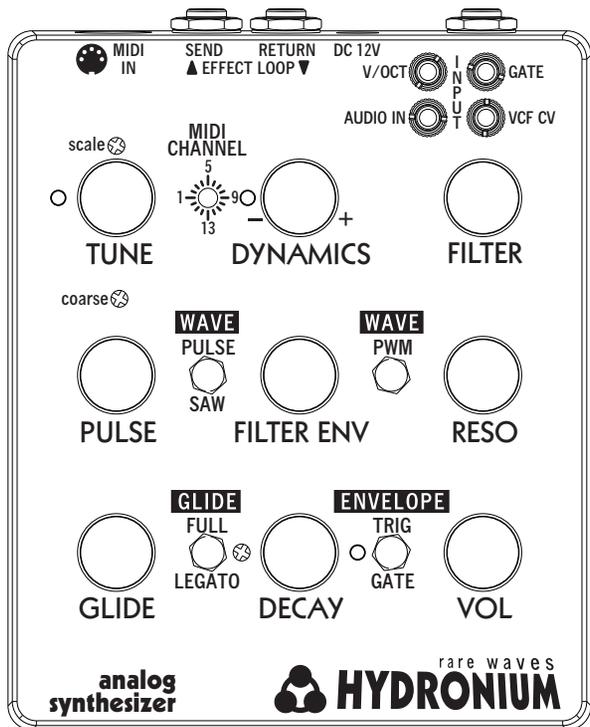
How to set up the V/oct Out jack to send correct intervals to an external VCO:

- First, be sure you have the Scale trim adjusted properly so Hydronium's internal VCO is playing in tune.
- Connect an external VCO to Hydronium's V/oct Out jack. The external VCO must also be properly calibrated before doing this.
- Connect a MIDI controller to Hydronium.
- Mute Hydronium's audio output, and listen to your external VCO. Play an octave sequence while listening critically.
- Adjust the trimmer on the back of Hydronium's Expander PCB until you hear correct intervals from your external VCO.
- Now un-mute Hydronium's audio output. Listen to both VCOs together and make further adjustments until they play in unison.

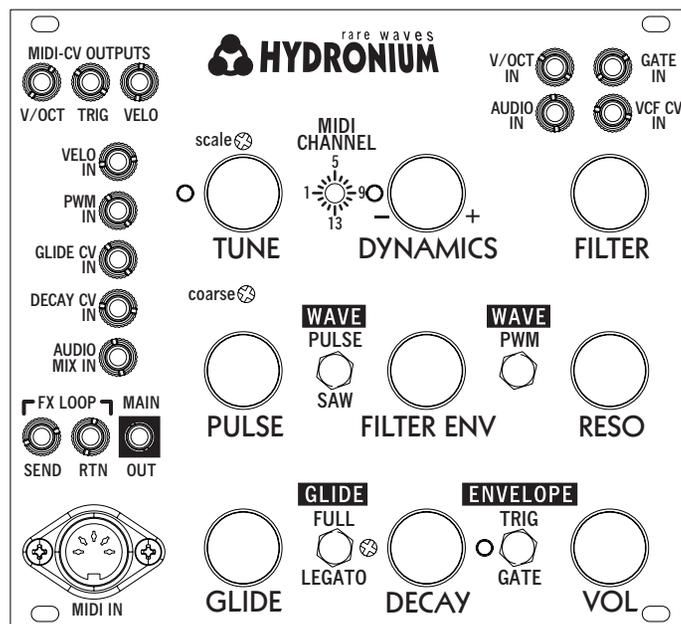
Its simpler with a digital multimeter:

- Patch your DMM to V/oct Out.
- Set the DMM to read DC Volts
- Play octaves on the MIDI controller
- Tweak **V/oct Out trim** so the voltage difference between octaves is 1.000V

Patch Name _____



Patch Name _____



MIDI Implementation

| FUNCTION | RECOGNIZED | REMARKS |
|-------------------------------------------------------|-------------|----------------------------------------|
| Channel | 1 - 16 | |
| Note Number | 0 - 127 | |
| Velocity | 0 - 127 | Velocity 101 - 127 : Dynamic Accent On |
| After Touch | x | |
| Pitch Bender | x | |
| Mod Wheel | ○ | Decay time control |
| Continuous Controller | x | |
| Program Change | x | |
| System Exclusive | x | |
| System Common Song Position Song Select Tune | x x x | |
| System Real-Time Beat Clock | x | |
| Aux Messages All Notes Off | ○ | |

x = not recognized

○ = recognized

Hydronium is created and supported by Eric Archer of Rare Waves®

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