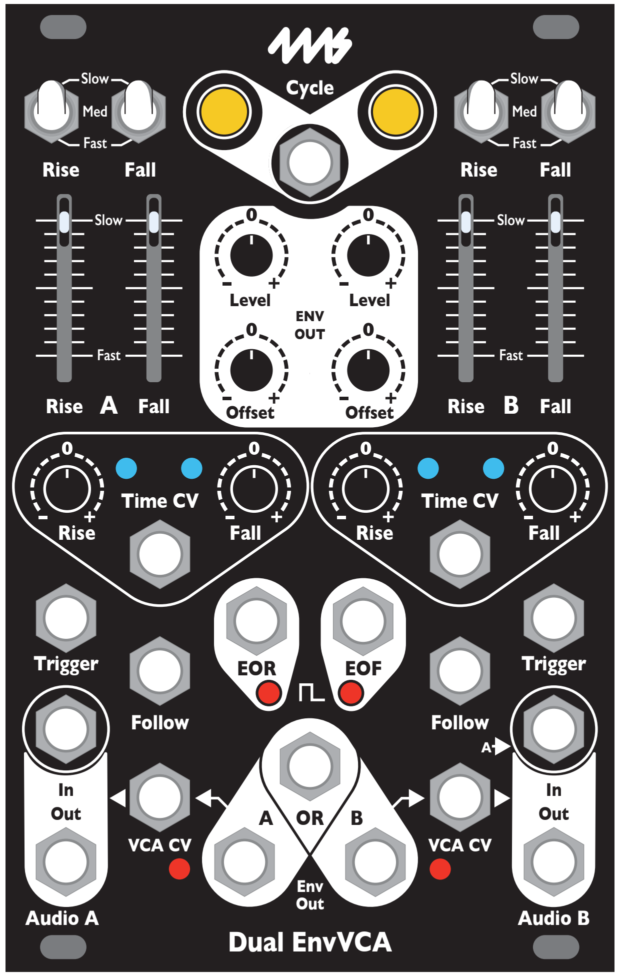
Dual EnvVCA
4ms Company
User Manual 1.0 – October 31, 2022



The **Dual EnvVCA** is a dual analog envelope generator, slew limiter, and VCA. Each of the two channels are identical and can be used separately or together.

Dual EnvVCA features:

- Versatile linear envelope generator/LFO
- Low-noise, low-distortion, DC-coupled exponential VCAs
- 100% analog
- Sliders and Range switches control Rise and Fall times from ~1.25ms (800Hz) to > 2 min.
  - **Time CV** jack extends time range: ~125μs (8kHz) to ~10 min.
  - Independent attenuverters for **Rise** and **Fall** time
  - Blue/Red LEDs indicate strength and polarity
- **Cycle** buttons for looping envelopes (LFO)
- **Trigger** input jacks fire a one-shot envelope
- **Cycle** gate input jack toggles cycling for both channels
- **EOR/F** (End of Rise/Fall) gate outputs can be used to chain and sequence events
- **Env Level** and **Offset** knobs scale and shift **Env Out** without changing VCA volume
- **Audio In** and **Out** jacks for passing audio or CV through the VCA
- **VCA CV** inputs to use VCAs independently from the envelopes
  - VCA gain internally connected to envelope output when **VCA CV** jack is left unpatched
- **Follow** input jacks allow for slew limiting, sustain (ASR), and exotic filtering effects
- Re-trig jumpers allow for re-triggering during rise phase

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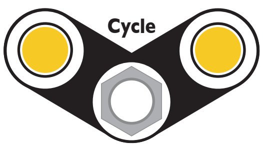
Setting up your Dual EnvVCA

1. Power off your Eurorack system.
2. On the back of the **Dual EnvVCA** you will see a 10-pin header. The 10-pin header connects to a Eurorack power header using the included power cable. Connect the 16-pin end of the power cable to a 16-pin Eurorack power header on your power supply distribution board and the 10-pin end to the **Dual EnvVCA** with the red stripe on the power cable oriented towards the bottom of the module.
3. Using the included screws, securely attach the **Dual EnvVCA** to the rails of your case.
4. Power on your Eurorack system.

*Note: The **Dual EnvVCA** is reverse-polarity protected, but incorrectly connecting any module in any system can damage other modules on the power bus.*

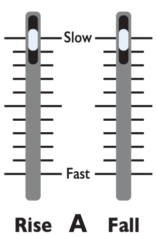
Controls and Jacks



Cycle Buttons and Cycle Jack

The **Cycle** buttons toggle the cycling state for each channel. When cycling, the **Dual EnvVCA** behaves like an LFO, with an output waveform that continuously rises and falls. Each button illuminates orange to indicate the module is cycling. Note that pressing this button does not reset or alter an envelope that's already rising or falling.

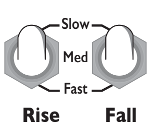
The **Cycle** jack toggles the cycle state of both channels. If a **Cycle** button is off, a gate signal will turn the button on and make the channel cycle for as long as the gate is held high. If a **Cycle** button is on, then a gate signal will turn the button off and cease any cycling for as long as the gate is held high. See Cycle Button/Jack on page 13 for more information.



Rise/Fall Sliders

The **Rise** and **Fall** sliders control the rise and fall times of the envelope. Shifting a slider up makes the rise or fall portion slower, shifting down makes it faster.

Each slider has a white light that indicates the current stage and output voltage of the envelope. When the envelope is in the rise stage, the **Rise** slider light will increase in brightness until the envelope hits its maximum. Once the peak is reached, the **Rise** light will turn off and the **Fall** light will turn on, decreasing in brightness as the envelope falls.



Rise/Fall Switches

The **Rise/Fall** switches select the overall range of the sliders. Each slider has its own switch with three positions: **Fast, Med, Slow.**

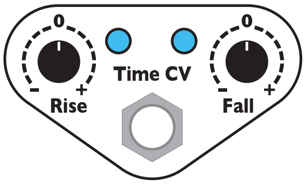
When the switch is flipped to **Fast**, the envelopes go well into the audio range, allowing for classic AM, FM, and other fast modulation effects.

The middle position (**Med**) is designed for typical musical tempos, and can be useful when using the VCA to make notes at common BPMs.

The **Slow** position is geared for gradual fades and other slow LFO-style modulations.

See the Rise and Fall Time Ranges chart on page 6 for more information.

Time CV Jack and Rise/Fall CV Knobs



The **Time CV** jack modulates the **Rise** and **Fall** times of the envelope. The jack feeds two knobs: **Rise CV**, and **Fall CV**. Each of these knobs is an attenuverter (short for “attenuating inverter”) and controls how much the control voltage on the **Time CV** jack will affect either the rise or the fall time.

Turning an attenuverter knob to the right of center means that a positive voltage on the **Time CV** jack will *lengthen* the rise/fall time and a negative voltage will *shorten* the rise/fall time.

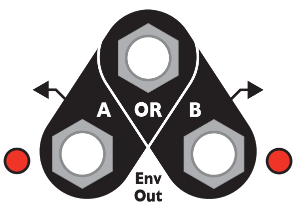
Turning a knob to the left of center gives the opposite effect, meaning that a positive voltage on the **Time CV** jack will *shorten* the the rise/fall time, while a negative voltage will *lengthen* these durations.

The farther you turn the knob from center in either direction, the more effect incoming CV will have. When the knob is centered, the signal on the **Time CV** jack will have no effect on the rise or fall time.

Next to each knob is a light which indicates the strength and polarity of the modulation. The light will turn blue when the rise or fall time is being lengthened by CV, and red when the time is being shortened. The brighter the light, the more of an effect the CV is having. When the light is off, the **Time CV** jack has no effect on the envelope time.

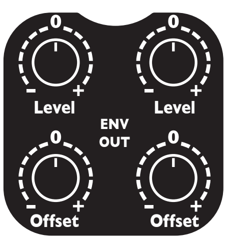
When nothing is plugged into the **Time CV** jack, the knobs act as fine-tuning controls for the **Rise** and **Fall** times.

Env Out Jacks, OR Jack, and LEDs



The **Env Out A** and **B** jacks output the envelopes for each channel. DC offset and vertical scale of each channel’s envelope are determined by the positions of the **Level** and **Offset** knobs. The **OR** jack compares both **Env Out** signals and outputs the highest voltage value between the two at any given moment. The lights near each jack indicate the amplitude and polarity of each envelope. When the envelope is somewhere between 0V and 10V, its respective light will shine blue. When the envelope is somewhere between -10V and 0V the light will shine red. The brightness of each light indicates the amplitude of the outgoing signal, so when the light is off, this means the signal is outputting at or around 0v.

Level and Offset Knobs



The **Level** knob attenuates and inverts (attenuverts) the envelope output on each **Env Out** jack. When **Offset** is centered, turning **Level** fully clockwise will output a positive envelope, with a maximum peak of about 10V. Turning the knob counter-clockwise inverts the envelope. When **Level** is fully counter-clockwise, the output will peak at about -10V.

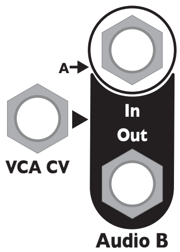
Turning the **Offset** knobs clockwise will add a positive offset between 0V and 10V to the envelope, while turning the knobs counter-clockwise will add a negative offset between 0V and -10V. See Using Level and Offset on page 18 for more details.

Note that neither the **Level** pots nor the **Offset** pots affect the envelope going to the internal VCAs. For example, if the **Env Out** jack is patched to a modulation input on an external module while audio is running through the VCA, **Level** and **Offset** can be used to control the amount of modulation without changing the audio level.

EOR and EOF Output Jack

The **EOR** (End of Rise) jack is specific to Channel A. It outputs a gate that goes high when the rise stage ends and the fall stage begins. It remains high as long as the envelope is falling, and goes low when the envelope completes. When the envelope is not running, the **EOR** jack will stay low. The **EOR** light will shine whenever the output is high.

The **EOF** (End of Fall) jack is specific to Channel B. It outputs a gate that goes high when the fall stage ends, and remains high until the envelope begins rising. Said another way, the gate at the **EOF** jack only goes low during the rise stage. The **EOF** light will shine orange when the **EOF** output is high.



Audio In, Audio Out, and VCA CV Jacks

The **Audio In** and **Out** jacks are the input and output of the VCA. The envelope output (pre-level and offset pots) is internally routed to the **VCA CV** input. When the envelope is stopped or at 0V, the **Out** jack will output silence. As the envelope rises, the signal will get louder until it becomes as loud as the input signal at the peak of the envelope. As the envelope falls, the signal will fade back to silence. **Audio In B** is normalized to **Audio In A**, as indicated by the graphics on the faceplate. So when **Audio In B** is unpatched, the **Audio In A** signal will be sent to both channels. Patching into **Audio In B** will break this connection so that both channels are operating independently.

When patched, the **VCA CV** jacks break the internal connection between envelope and VCA, allowing for independent use of the VCA. The **VCA CV** input has a range of 0 to 5V, which translates to about -90dB (silence) to 0dB (unity gain).

Trigger Jacks

Each **Trigger** jack requires a trigger of at least 2V to start an envelope. If there is no envelope in progress, then a trigger will initiate a single complete envelope. If the envelope is rising when a trigger is received, then the trigger is ignored (unless the **RETRIG** jumper is installed, see below). If the envelope is falling when a trigger is received, it will begin rising from its current voltage.

On the back of the module is a **RETRIG** jumper for each channel. When this jumper is installed, the envelope will immediately jump to 0V and start rising any time a trigger is received. This can cause a click on the VCA output, so the jumper is not installed at the factory.

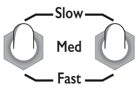
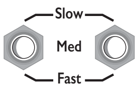
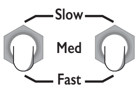
Follow Jack

The **Follow** jack is the input of a slew limiter, and can also be used for complex envelope generation, exotic audio filtering, and envelope following.

Whenever the internal envelope is not triggered or cycling, the envelope output will rise or fall in order to match the voltage level present on the **Follow** jack. However, the rate of rise and fall times is limited by the positions of the **Rise**/**Fall** sliders and the CV amounts. That is, the envelope output will try to “follow” the signal present on the **Follow** jack, but it can only rise and fall as fast as the envelope would rise/fall if it were to be triggered. Since “slew” is the rate of change, we call this “slew limiting”.

Slew limiting can be used to create complex envelopes (ASR, ADSR, etc) by timing the signal on the **Follow** and **Trigger** jacks. See Fundamentals of the Follow Jack on page 14 for more information.

Rise and Fall Time Ranges

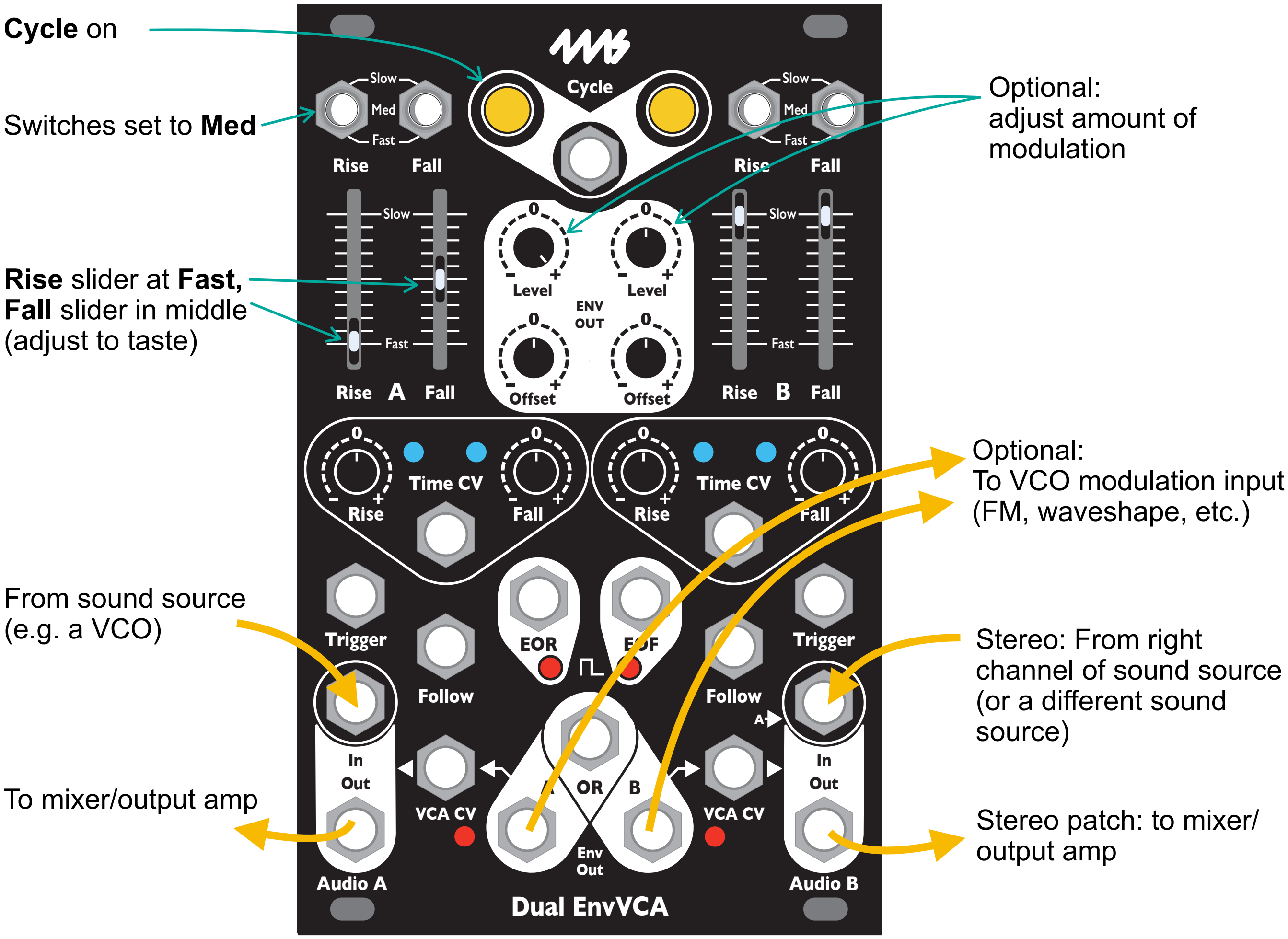
Switch Position	Slider Range (total env. time)	Max Range with CV (total env. time)	Use Cases
 **Slow**	*5 min. to 1.5 sec.*	*~30 min. to 300Hz*	Gradual, slow fades or modulation changes occurring over the course of a long time.
 **Med**	*20 sec. to 18Hz*	*~9 min. to 1kHz*	Generally suited for typical musical tempos. Useful for making notes, from snappy percussive sounds to long decays. The slower slider settings approach LFO ranges.
 **Fast**	*2.5Hz to 800Hz*	*~8 min. to 8kHz*	Good for FM, AM or other audio-rate modulation. Snappy attacks and sharp decays.

Note that the switch positions have little effect on the range obtained by using CV. This is intentional, to allow external modules control over the full range.

Because of its analog nature, the maximum and minimum rise and fall times vary from unit to unit. The table above shows typical values.

The rise and fall times will not necessarily be equal when the sliders are in the same position. For precisely equal rise and fall times, manual adjustment is usually needed. When applying CV to make very slow envelopes (greater than 10 minutes), the fall time can be made much slower than the rise time. Typically the rise time is limited to about five minutes, while the fall time can go up to 20 minutes or up to an hour on some units.

Patch: Making Notes



Making Notes (Basic)

Patch a sound source into the **Audio In A** jack, and patch the **Audio Out A** jack to your mixer or amp so you can hear it on speakers or headphones. When choosing the sound source, try to find something that makes a continuous tone or drone, such as a VCO like the **Ensemble Oscillator**.

When the left **Cycle** button is on (button is shining orange), you should hear notes being played at a steady tempo. The notes should have a sharp attack (quick fade-in) and longer decay (slower fade-out).

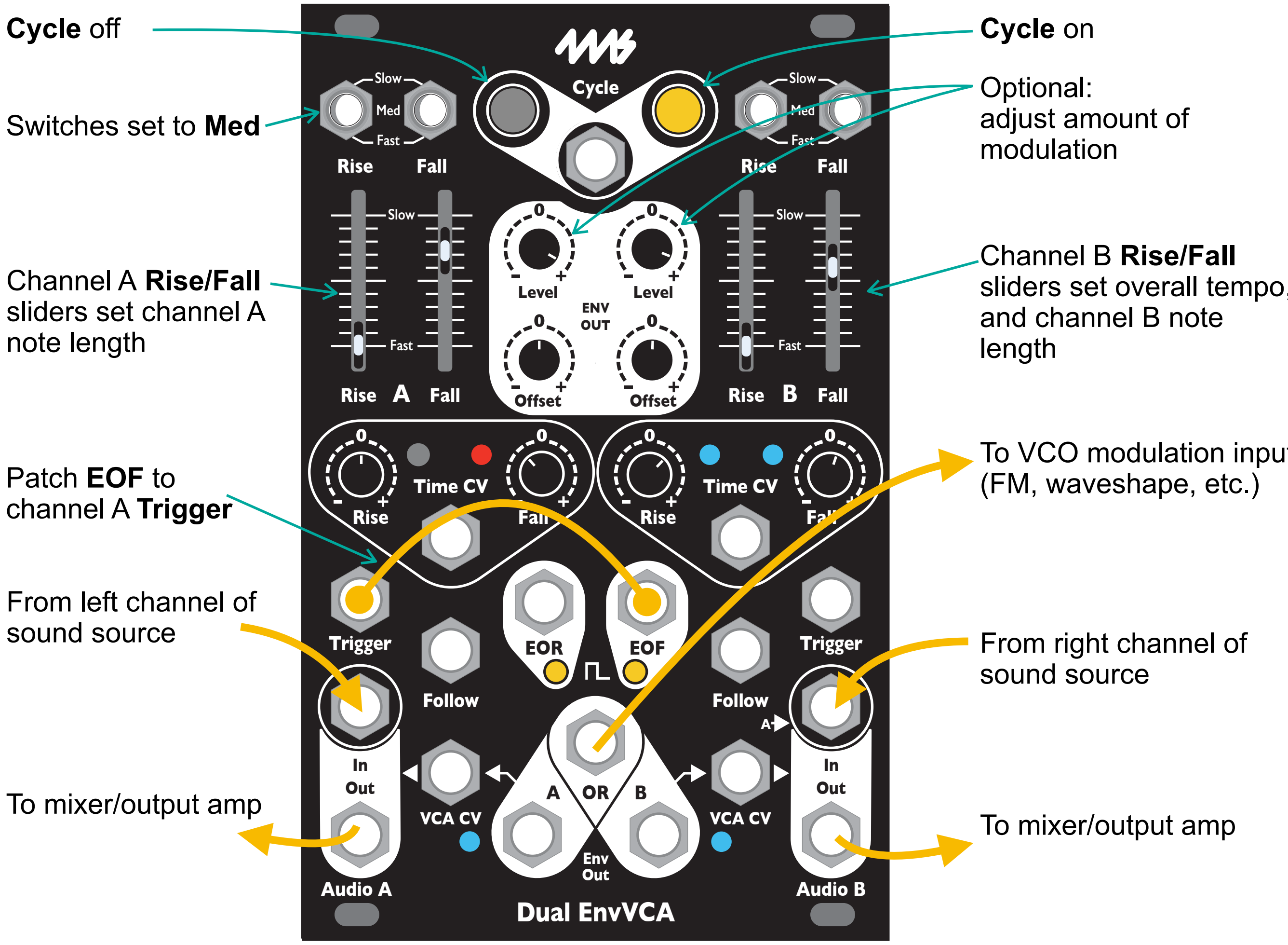
Try moving the **Rise** slider up and listen to how the sound fades in more slowly. Then move the **Fall** slider down and hear how the fade-out gets faster. Continue to experiment with the slider positions, listening to how the sound and tempo change. Try flipping the switches to **Fast** and hear how much faster the envelope gets.

Next, patch the **Env Out** jack to a modulation input on the sound source. For example, if you're using the **Ensemble Oscillator**, try patching it to the **Warp** jack. For other VCOs, try a PWM or wave-shaper input. Adjust the **Level** and **Offset** knobs to control the amount of modulation. When both knobs are centered, you should hear no modulation.

Making Notes in Stereo

So far we've just used Channel A, but this patch can be duplicated on Channel B to process two sound sources or a single stereo sound source. Try doing this now, by patching the second output of the **Ensemble Oscillator** or some other sound source into the **Audio In B** jack. If you don't have another sound source, you could leave **Audio In B** unpatched and the signal from **In A** will be routed there automatically, but using a stereo sound source (or two mono sound sources) has a nicer effect.

Patch the **Audio Out B** jack to the mixer (adjust the panning if your mixer supports that). Turn channel B **Cycle** on. Adjust the **Rise** and **Fall** sliders and set the switches to center. You should hear both sound sources playing at different tempos.



Synchronizing Channels: Making Notes Using Triggers

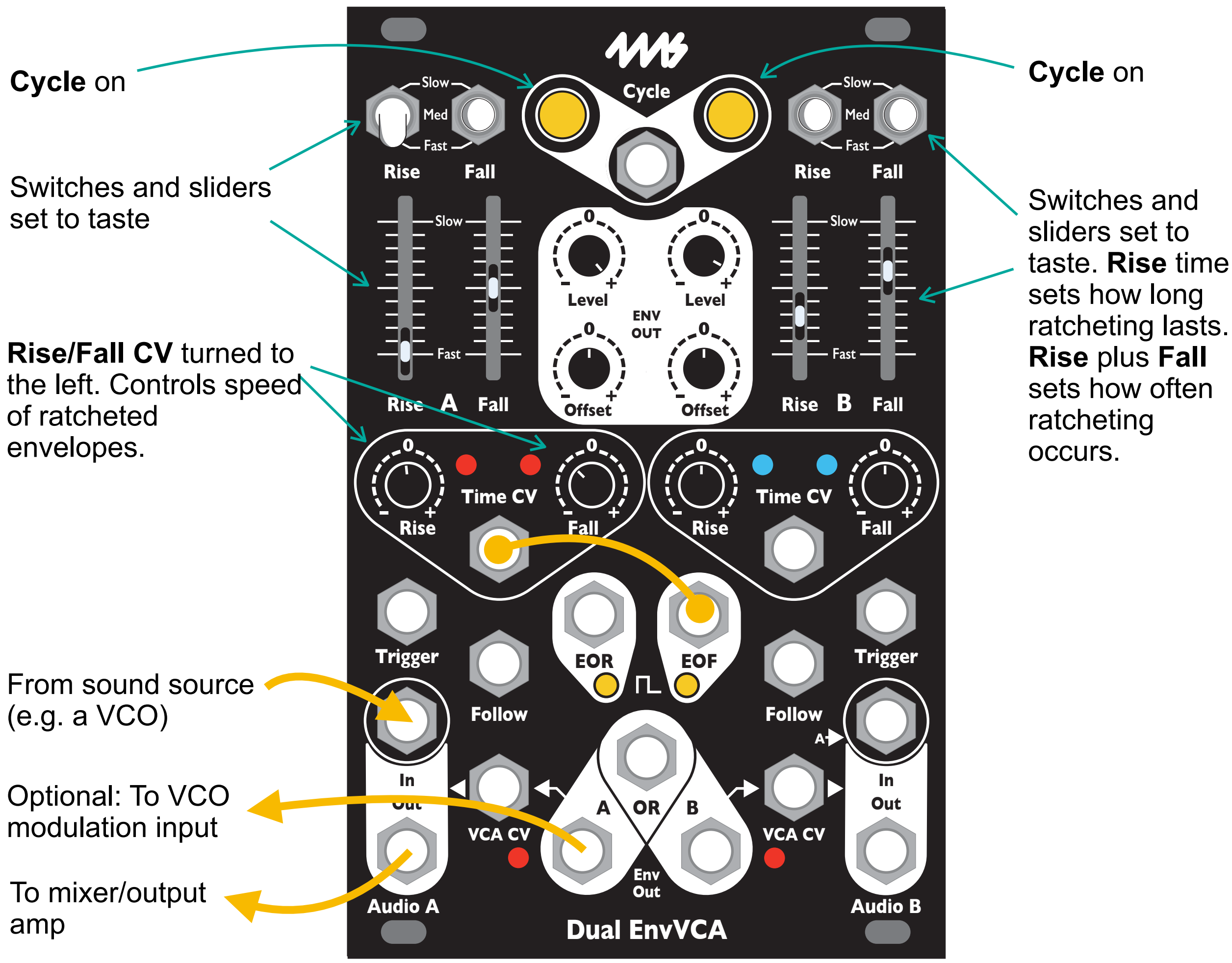
With the previous patch, the tempo of each channel is linked to the rise and fall times of the envelopes. It's not possible, for example, to have quick, short notes at a slow tempo. It's also nearly impossible to adjust the sliders so both channels are going at the exact same tempo.

By turning channel A's **Cycle** off and patching the **EOF** trigger from channel B to channel A's **Trigger** jack, we can synchronize the channels and separate channel A's envelope length from its tempo. Try doing this now.
Every time channel B ends an envelope and begins a new one, an EOF pulse fires, causing channel A to start an envelope. Channel A's **Rise/Fall** sliders control the envelope length without changing the tempo. Channel B's sliders control the tempo for both channels as well as the envelope for channel B. If you want to decouple channel B's envelope length from its tempo, you could turn off **Cycle** and patch an external clock or LFO into channel B's **Trigger** jack. Now the external clock controls the tempo and each channel's sliders independently control the envelopes.

Adding Chaos

You can create some inter-related pattens by patching Channel A's **EOR** jack into Channel B's **Trigger** jack, leaving **EOF** patched to Channel A's **Trigger** jack, and turning off both **Cycle** buttons. Now both channels trigger each other. For some extra chaos, patch the **Env Out OR** jack to one of the **Time CV** jacks, and patch the **EOR** jack into the **Cycle** jack instead of channel B's **Trigger** jack. Press one of the **Cycle** buttons to start the chain of events, then play with the sliders, the **Rise/Fall CV** knobs, and the **Level** and **Offset** knobs until you find sweet spots where random patterns emerge.

Patch: Ratcheting



Self-Patched Ratcheting

In this patch we'll make a ratcheting effect where the notes play at a steady tempo for a while, and then periodically speed up in a rapid burst. Start with the Making Notes patch on Channel A, with **Cycle** on and the **Audio In/Out** jacks patched to a sound source and mixer. With the **Time CV** knobs centered, you should be hearing notes at a steady tempo.

Turn on **Cycle** for Channel B. Adjust the **Rise** and **Fall** sliders of Channel B so that it's going at least four times as slowly as Channel A. Patch the **EOF** output of Channel B to the **Time CV** input of Channel A. Turn Channel A's **Rise CV** and **Fall CV** attenuverters slightly to the left, so that when the the **EOF** jack fires a pulse, the notes play at a faster rate.

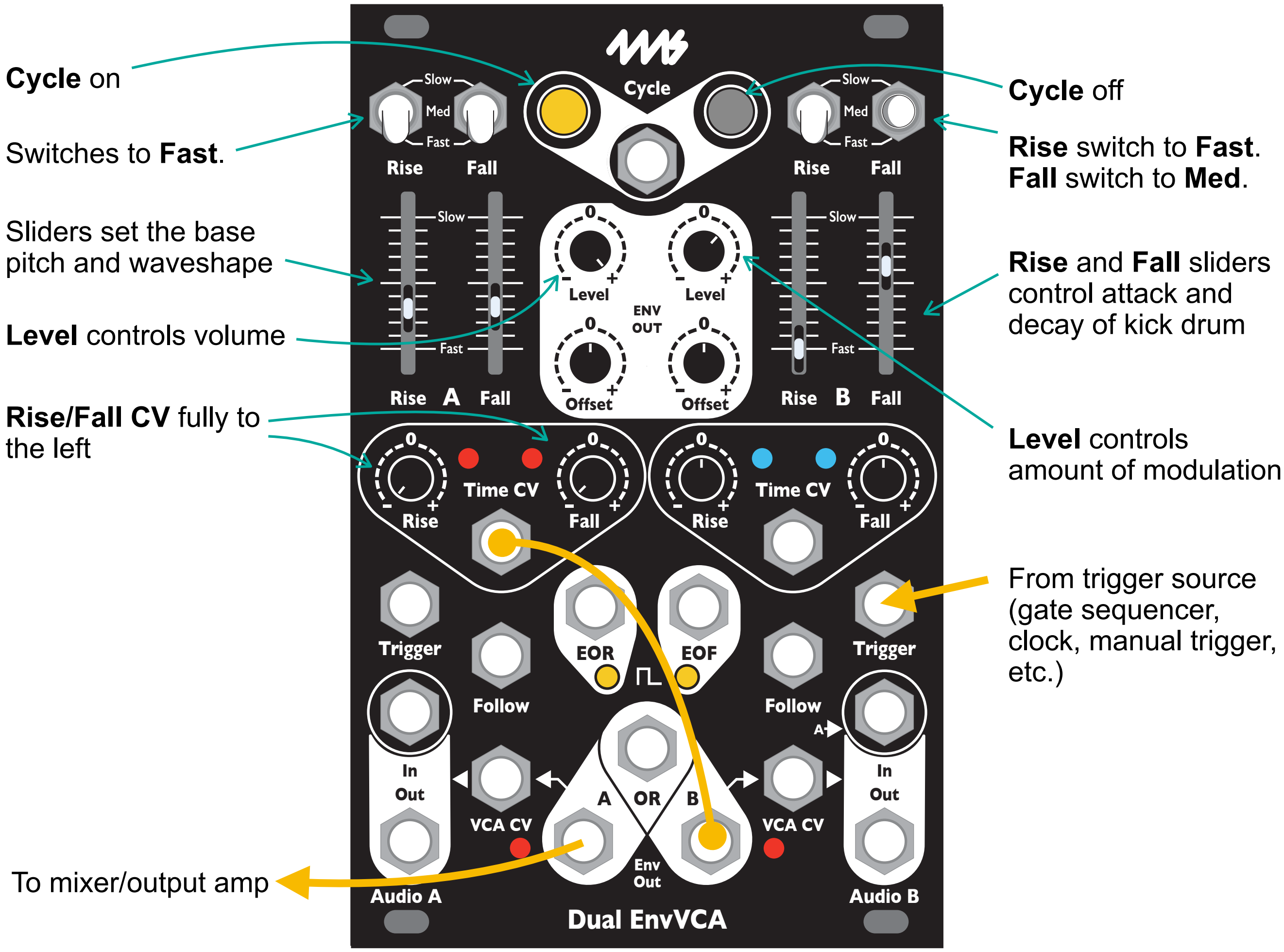
Adjusting the **Rise** time of Channel B will change the pulse width of the **EOF** pulse, thus controlling the duration of the rapid bursts. The sum of the **Rise** and **Fall** times on Channel B controls how often the ratcheting occurs. Try adjusting these parameters slightly to hear the effect it has on Channel A.

Ratcheting With a Clock Divider

With the previous patch, it's hard to specify the exact relationship between the base tempo of Channel A and Channel B. Using a clock divider module such as the **RCD** or **QCD** can give us more control.

Unpatch the cable from **EOF** to **Time CV**. Turn off Channel A's **Cycle** and patch the clock divider's undivided output to Channel A's **Trigger** jack. Adjust the speed of the clock divider to set the base tempo. Next, patch a divided output from the clock divider (say, /8) to the **Cycle** jack and Channel A's **Time CV** jack. Adjusting the pulse width of the divided clock controls the duration of the rapid bursts. Adjusting the amount of clock division controls how often the bursts happen.

Patch: Making an Oscillator and Synth Drums



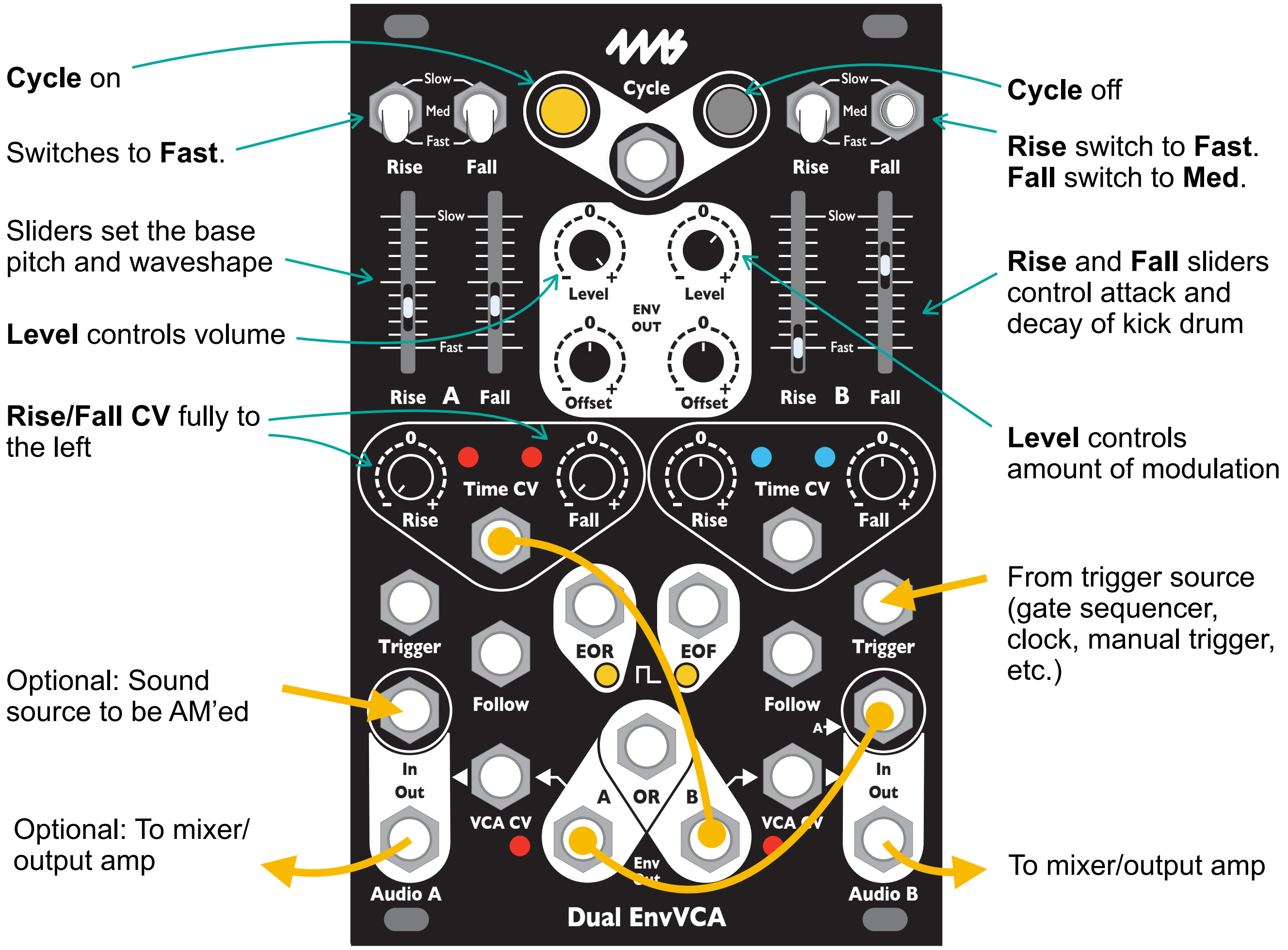
Making an Oscillator

In this patch we'll use Channel A of the **Dual EnvVCA** as an oscillator and Channel B as the modulator to create a kick drum sound.
To make the oscillator, flip the **Rise** and **Fall** switches of Channel A to **Fast**. Patch the **Env Out A** jack to a mixer. Engage the **Cycle** button to begin oscillation. You can change the pitch by adjusting the sliders. If both sliders are approximately at the same position, you'll get a triangle wave output. If one is substantially higher or lower than the other, the output will resemble a ramp or saw wave. For pulse wave shapes, you can take the signal from the **EOR** jack instead of **Env Out A**. In this case, adjusting the sliders separately will change the pulse width.

Making a Kick Drum

To make a kick drum sound, first use the sliders to set the pitch of Channel A low enough so that you can't hear sound. Set the sliders to equal positions. Now we will modulate the pitch by patching the **Env Out B** jack to Channel A's **Time CV** jack. Set Channel A's **Rise** and **Fall CV** attenuverters to be fully CCW. Fire triggers into Channel B's **Trigger** jack to hear the pitch of Channel A modulate. Adjusting the **Level** knob on Channel B will change the amount the pitch rises: typically for a classic analog kick sound the knob should be around 1 or 2 o'clock. The **Rise** and **Fall** sliders of Channel B will adjust the attack and decay. A typical drum will have a sharp attack and slower decay, so start with the **Rise** slider and switch at **Fast,** and the **Fall** slider and switch in the middle positions.

An exponential modulation curve makes a more extreme kick drum sound. To create this, split the signal coming out of **Env Out B** to also go to Channel B **Time CV.** Adjust Channel B's **Fall CV** knob to left of center (try at about 10:00), and keep the **Rise CV** knob at center. If you adjust Channel B's **Level** knob, you also will need to adjust Channel A's **Rise** and **Fall CV** knobs to set the amount of pitch modulation.



Making Other Synth Drum Sounds

In the Making an Oscillator patch, we created a kick drum which decays to an inaudible tone below the range of human hearing. To create a higher-pitched drum, such as a tom-tom, we will need a VCA to cut off the audio after the drum decays.
Raise the pitch of Channel A using the sliders or Channel B's **Offset** knob. You should hear a steady tone between Channel B firing. Now we'll route this sound through Channel B's VCA. Unpatch the cable going to the mixer and patch it into **Audio Out B** instead. Patch a cable from **Env Out A** to **Audio In B.** Now you should hear a similar drum sound, but it will be silent between hits. If you are using the exponential modification in the previous patch, you probably will want to dial it back because the VCA itself has an exponential response.

To add some noise to the sound, you can patch an external oscillator into **Audio In A.** Then move the patch cable going from **Env Out A** to **Audio In B** so that it goes from **Audio Out A** to **Audio In B**. The external oscillator will be amplitude modulated (AM) with the synth drum sound, and this resulting sound will be VCA'ed with Channel B's envelope. Play with Channel A's sliders and **Rise/Fall CV** knobs to hear the range of possible sounds. Next use any of the **Env Out** jacks to modulate the external oscillator in time with the synth sound.

Try adding slight modulation to the **Time CV** of Channel B to create organic, naturally changing drum sounds. A slow LFO or a CV sequencer will work nicely.

Self-patching ideas

Frequency Modulation (FM)

Turn both channels' **Cycle** on, and switches to **Fast**. Start with all sliders in the center position. Use Channel B to modulate the frequency of Channel A by patching **Env Out B** into Channel A's **Time CV** jack. Adjust both **Rise** and **Fall CV** knobs to around 9:00. Turn both **Level** knobs fully clockwise and center **Offset** knobs. Listen to the output on **Env Out A**, or for a mix of both oscillators, use **Env Out OR** jack. Slowly adjust Channel B's sliders and listen to how the sound changes. Then slowly adjust Channel A's sliders and **Rise** and **Fall CV** knobs to hear the effect.

The **Rise** and **Fall** sliders of Channel B control the modulation frequency, and Channel A's **Time CV** knobs control the modulation amount. Channel A's sliders control the base frequency, also known as the carrier frequency.

Chaotic FM

For chaos, start with the FM patch above, and then use Channel A to modulate Channel B by patching **Env Out A** into Channel B's **Time CV**. Start with Channel B's **Rise** and **Fall CV** knobs set to about 10:00. Take the output from **Env Out OR.** To find interesting chaotic sounds, you probably will need to move the sliders to a slower position and the **Rise/Fall CV** knobs more towards center than in the FM patch.

Utility Patches

Attenuator

Patch a signal that you want to attenuate into **Audio In** (either channel), and take the output from **Audio Out**. Patch **Env Out** to **VCA CV**. Use **Offset** to adjust the attenuation amount (typically between 12:00 and 2:00 is a good setting). If you are using the envelope portion of the channel (**Cycle** is on or you are triggering the channel), set **Level** to center or else the envelope will bleed into the attenuator output.

Trigger Delay With Pulse Width Control

Turn Channel A's **Cycle** off. Send a trigger into Channel A's **Trigger** jack. Take the output from **EOR**. Adjust the **Rise** slider and switch to set the trigger delay time (rising edge of incoming trigger to rising edge of outgoing trigger). Set the **Fall** slider and switch to control the width of the outgoing trigger.

Inverted Trigger Delay (With Pulse Width Control)

Same as the previous patch, but use Channel B's **Trigger** jack and **EOF**. **Rise** controls the amount of delay (rising edge of incoming trigger to falling edge of outgoing inverted trigger) and **Fall** controls the width of the inverted trigger.

DC generator (Manual CV)

When a channel is not running, the **Offset** knob will produce a steady DC voltage on the **Env Out** jack. If the channel is running, set **Level** to center.

Ducking (Sidechaining)

A ducking effect reduces the volume of a sound at the same time a secondary sound plays. If the secondary sound is generated by triggers in your patch, you can easily create this on the **Dual EnvVCA** by generating an inverted envelope and patching it into the VCA.
To achieve this effect, split the trigger that's triggering the secondary sound and patch it into the **Trigger** jack of one channel. Turn **Cycle** off. Adjust **Rise** and **Fall** to create the envelope you want (typically the rise will be shorter than the fall). Patch an audio signal into **Audio In** and take the output from **Audio Out**. You should hear your sound play every time the trigger fires. In order to create the inverse behavior (get more quiet when the trigger fires), patch **Env Out** to **VCA CV** and turn **Level** to about 9:00 and **Offset** to about 3:00.

If the secondary sound source is not generated by triggers in your patch (perhaps because it's an audio track), see Sidechaining (Envelope Following) on page 17.

Creating Envelopes (Trigger, Cycle, Follow)

There are four ways to generate an envelope with the **Dual EnvVCA:** using the **Trigger** jack, the **Cycle** button, the **Cycle** jack, or the **Follow** jack.

The **Trigger** jack starts an envelope when it receives a trigger. It only responds to rising edges, that is, when the voltage rises through 2V. Figure 1 shows how a long or short pulse will cause identical envelopes since the pulse width and falling edge of the signal are ignored.

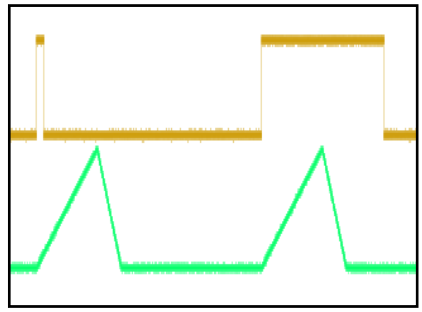


Figure 1: Trigger jack pulse width does not change Env output.

Triggering with RETRIG Jumper Off (Factory Default)

If the envelope is already rising when a trigger is received, then the trigger is ignored (unless the **RETRIG** jumper is installed). If the envelope is falling when a trigger is received, it will begin rising from its current voltage. Figure 2 demonstrates this: the fifth and seventh triggers occur while the envelope is falling and cause it to begin rising mid-fall. The rest of the triggers either occur while the envelope is rising and are ignored, or while the envelope is not running, causing it to start.

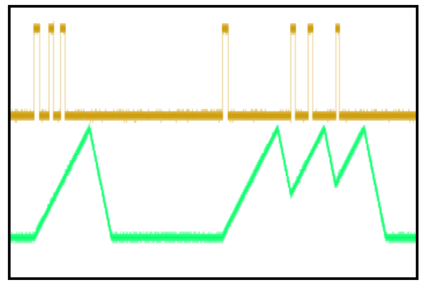


Figure 2: RETRIG jumper off. Triggers on rise stage have no effect. Triggers on fall stage switch to rising.

Triggering with RETRIG Jumper On

Figure 3 shows how the **RETRIG** jumper changes the behavior. With the jumper installed, a trigger will always reset the envelope to zero and begin rising, regardless the stage of the envelope. This sharp transition to 0V can cause a click when used with audio, so the jumper is not installed by default.

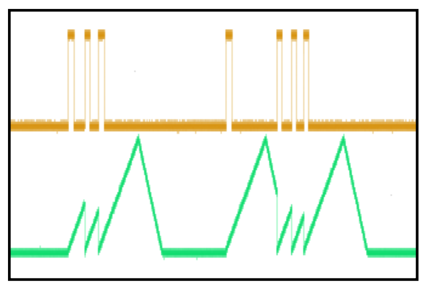


Figure 3: RETRIG jumper installed. Triggers always restart the envelope.

Cycle Button/Jack

The **Cycle** button is a simple way to initiate an envelope. When the button is on, envelopes will cycle continuously. The button is latching, so pressing it once will make the module output envelopes until you press the button again. Once an envelope begins, pressing the **Cycle** button again will not immediately stop the envelope. Instead, the envelope will stop after finishing its fall stage.

The **Cycle** jack toggles the cycling state of both channels when a gate is received. It's utilized in tandem with the **Cycle** buttons. If a channel's button is initially off, a gate signal at the **Cycle** jack will toggle it on. If the button is initially on, a gate at the jack will toggle it off. The **Cycle** button will shine orange whenever the combination of the **Cycle** jack and **Cycle** button causes the envelopes to cycle.

In Figure 4, the **Cycle** button is initially off, and the incoming gate signal on the **Cycle** jack causes the envelope to cycle for as long as the gate is high. In this case, as the pulse width of the gate signal gets wider, the **Dual EnvVCA** outputs more cycles.

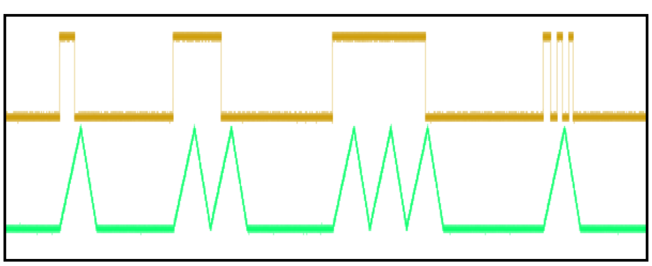


Figure 4: When Cycle button is off, high gate on Cycle jack makes envelope run.

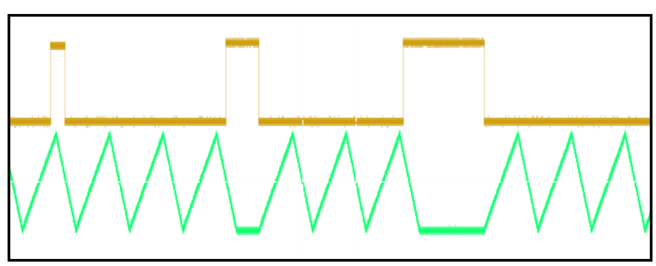


Figure 5: When Cycle button is on, high gate on Cycle jack makes envelope stop.

Figure 5 shows the opposite state; the **Cycle** button is initially on, so the incoming gate signal stops the cycling for as long as the gate is high. In this case, as the pulse width of the gate signal gets wider, there are longer pauses between groups of envelopes.

Note that the first pulse in Figure 5 does not stop the envelopes, and the three rapid pulses in Figure 4 only cause one envelope. This illustrates an important aspect of the **Dual EnvVCA**: the state of the **Cycle** jack and button only matter when the envelope is stopped (at 0V). Any combination of gates and button presses while the envelope is running have no effect; it's only when the envelope finishes running that the **Cycle** jack or button can make it cycle again.

Follow Jack With Gates

Figure 6 illustrates the use of gates on the **Follow** jack. A gate signal will cause the envelope to rise as long as the gate is high. When the gate goes low, the envelope will fall.

The fourth gate in Figure 6 shows that if the gate is held high while the envelope reaches its maximum, the envelope will hold (sustain) until the gate is released. This is an easy way to create an ASR envelope (Attack Sustain Release).

The short burst of pulses at the end illustrates how the **Follow** jack can be utilized to create complex envelope shapes using only a sequence of gates.

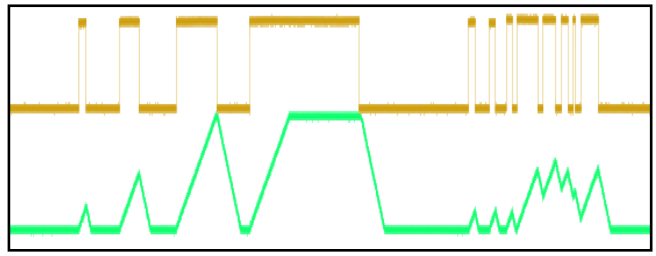


Figure 6: Sending gates into the Follow jack. When the input gate goes high, the envelope rises; when the input goes low, the envelope falls.

The **Follow** jack can be used with more than gates, see the next section for a detailed discussion.

Fundamentals of the Follow Jack

The **Follow** jack causes the envelope to rise or fall in order to "follow" the signal on the jack. Sending a high voltage (5V) into the Follow jack will cause the envelope to rise. Sending a low voltage (0V) will cause it to fall. This can be seen in Figure 6 of the previous section.
Sending voltages between 0V and 5V, such as a waveform from an LFO, or an audio signal will have more complex effects.

There are two basic rules that govern this jack:

> *Rule 1:* If the voltage on the **Follow** jack is greater than the envelope voltage, the envelope will rise; if the voltage on the **Follow** jack is less than the envelope voltage, the envelope will fall.

That is, the envelope will always "seek" the **Follow** signal: it will go up if the **Follow** signal is higher, and it will go down if the **Follow** signal is lower. This is where the term "follow" originates.

> *Rule 2*: The envelope can only rise and fall at the speed set by the **Rise/Fall** controls and CV.

This means that if the **Follow** jack suddenly jumps up (for example, when a gate is applied), the envelope will try to follow that jump by rising, but it can only rise as fast as the controls allow it. The rate of change, or slew, is limited, thus we call the **Follow** circuit a "slew limiter".

Note that the term "envelope voltage" in Rule 1 refers to the internal envelope voltage, before the **Level** and **Offset** knobs and **Env Out** jack output driver. Internally, the envelope has a maximum of 5V and minimum of 0V, which is why the **Follow** jack only responds to voltages from 0V to 5V. The **Env Out** jack's output driver doubles the internal voltage, so a 5V internal envelope corresponds to approximately 10V envelope on the jack.

Armed with these two basic rules, we can now showcase some advanced uses for the **Follow** jack in the following sections.

Sidechaining (Envelope Following)
The **Follow** jack can be used to create an envelope that follows an audio signal's envelope. This envelope can be inverted and used to control a VCA, creating a "ducking" effect on another sound. This technique is called sidechaining.

A common application is to use a kick drum to duck another sound source, for example, a background drone. Patch an audio source that's making a kick drum sound into the **Follow** jack of Channel B. Make sure **Cycle** is off. Start with the switches at **Med**, the **Rise** slider all the way down, and the **Fall** slider in the center. If you turn **Level** up, the **Env Out B** jack will be outputting an envelope that roughly follows the kick drum's envelope. Adjusting **Rise** and **Fall** will control the attack and release of the envelope, that is, how quickly the envelope responds to the attack and release of the kick drum.

For this example we want to invert the envelope, so turn **Level** all the way counter-clockwise, and turn **Offset** to around 2:00. **Env Out B** will now be outputting an inverted envelope that rests at about 5V and then ducks down when the kick drum plays. Patch this inverted envelope into Channel A's **VCA CV** jack. Run the audio that you want to be ducked (e.g. a drone sound) into Channel A's **Audio In**, and listen to the output on **Audio Out**. You should hear the drone play at normal volume, and then briefly get more quiet whenever the kick drum fires. Try listening to the drone and the kick drum simultaneously to get the full effect.

Adjust Channel B's **Rise** and **Fall** sliders to control how quickly the envelope responds. If the sliders are set too fast, the envelope will trace the individual peaks of the sound wave, not the overall envelope, and the result will be like a subtle AM effect. If the sliders are set too slow, the volume won't change much when the kick drum fires.

You can also adjust Channel B's **Offset** and **Level** knobs to control the dynamic range of the ducking. If you want less ducking, turn **Level** towards center to reduce the amplitude of the envelope. On the other hand, if the kick drum is quiet you may need to turn **Level** towards the extreme counter-clockwise position to generate an envelope with enough amplitude to get the amount of ducking you want. **Offset** almost always needs to be between 1:00 and 3:00. If it's too low, the output will be too quiet, and if it's too high, the output will be at maximum volume with very little ducking.

Audio Filter
The **Follow** jack can be used as an exotic audio low-pass filter by taking advantage of its slew-limiting properties. First, the audio signal must be shifted up such that it's within the range of 0V to 5V. Typically a level shifter can be used to add the required DC offset. You may also need to attenuate the audio so that it's no more than 5V. Any signal outside this range will be clipped, resulting in harsh distortion.

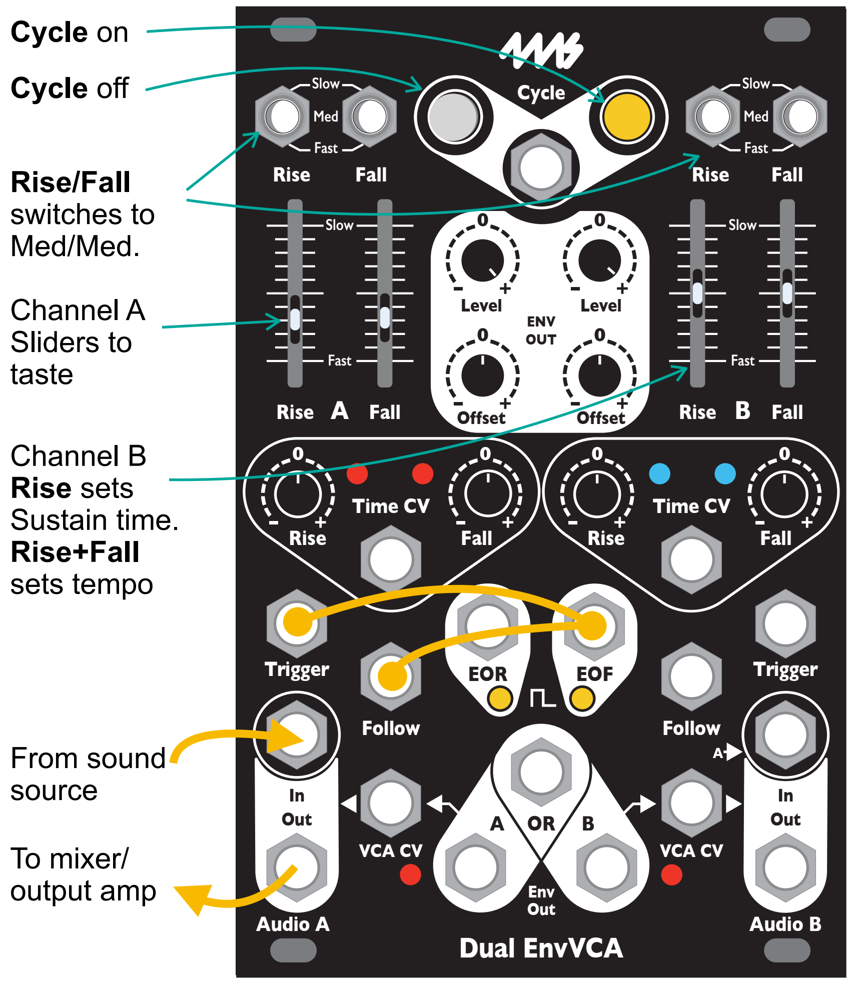
Patch this adjusted audio into the **Follow** jack. Patch the **Env Out** jack to your mixer/amp. Turn **Level** all the way up and turn **Offset** to center. To start, set the **Rise**/**Fall** sliders and switches to the fastest positions. Send a steady positive voltage into the **Time CV** jack and turn the **Rise CV** and **Fall CV** knobs all the way down.
At this point you should be hearing an audio signal that is similar to the original signal.
Now make the rise and fall times slower by adjusting the **Rise/Fall CV** knobs and sliders, or by adjusting the CV patched into the **Time CV** jack. As you do this, you should hear the audio get more muffled, as the slew becomes limited and higher frequencies can no longer pass.
To make more exotic sounds, try just adjusting the rise or the fall time. This will let the rising portions and falling portions of higher frequencies pass differently, creating some unique harmonics.

Waveshaper
By limiting the slew, wave shapes with sharper transitions can be altered to have smoother transitions. For instance, feeding a square wave into the **Follow** jack will produce a trapezoidal or triangular wave on the **Env Out** jack. Adjust the **Rise/Fall** sliders and switches to get a maximum amplitude output waveform while still performing the desired amount of waveshaping. These controls will need to be re-adjusted if the frequency of the waveform changes. You may be able to use the **Time CV** jack and **Rise/Fall CV** knobs to track the frequency and create a somewhat consistent variable-frequency wave shaper.

Portamento/Glide
The output of a CV/Gate keyboard or a sequencer is often a step-wave, meaning that the voltage jumps (or "steps") from one voltage to the next as the notes are played. When this is patched into a VCO, the result is a sequence of notes that jump from one pitch to the next. Adding in some slew causes the

notes to “glide” from one pitch to the next. This effect is known as portamento or glissando. The **Dual EnvVCA** can perform this effect by patching the step-wave into the **Follow** jack and taking the output from the **Env Out** jack. The amount of glide effect is controlled by the rise and fall times. If you’re patched into the pitch input of a VCO, you can adjust the tuning with the **Level** and **Offset** pots. Keep in mind that the **Dual EnvVCA** is not designed to be a precision portamento effect, so tuning will not be accurate over a wide range.

Creating ASR and ADSR Envelopes



ASR Envelope

An ASR (attack-sustain-release) envelope is trapezoidal, with a rising slope (attack), a flat plateau (sustain), and a falling slope (release). See Figure 7. The width of the sustain stage is controlled by the width of the gate input: holding the gate high longer results in more sustain. This is in contrast to an AR (attack-release) envelope, which is the triangular shape that results from patching into the **Trigger** jack or using the **Cycle** button.

One channel of the **Dual EnvVCA** can be used to generate a variable pulse width, and the other generates an ASR envelope. Turn Channel B Cycle on and patch the EOF output to the **Follow** jack and the **Trigger** jack, using a mult or stacking cable. Patch an audio sound source into the **Audio In** jack, and run the **Audio Out** jack to a mixer or amp.

Make sure Channel A’s **Cycle** is off. Set all four **Rise/Fall** switches to Med. Adjust the sliders so that Channel A’s sliders are lower (faster) than Channel B’s. Now adjust Channel B’s **Rise** and **Fall** sliders to control the overall tempo, and the **Rise** slider alone to control the length of the Sustain portion.

Alternatively, you can use a keyboard instead of Channel B’s **EOF** jack. Patch the gate output into Channel A's **Trigger** and **Follow** jacks. Tapping a key quickly will result in a staccato note, while holding the key down longer will result in a longer note. Keep in mind that the minimum note length will always be determined by Channel A’s rise and fall time parameters, no matter how short the gate input is. Another alternative instead of the **EOF** jack or a keyboard, is to use the gate output of a sequencer that has control over the gate length (pulse width). Setting longer gate lengths for certain notes will emphasize or accent them in the sequence. If you don’t have pulse width control on your sequencer, you could patch it into Channel B’s **Trigger** jack and turn off **Cycle**.

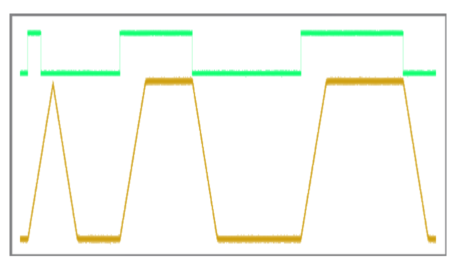
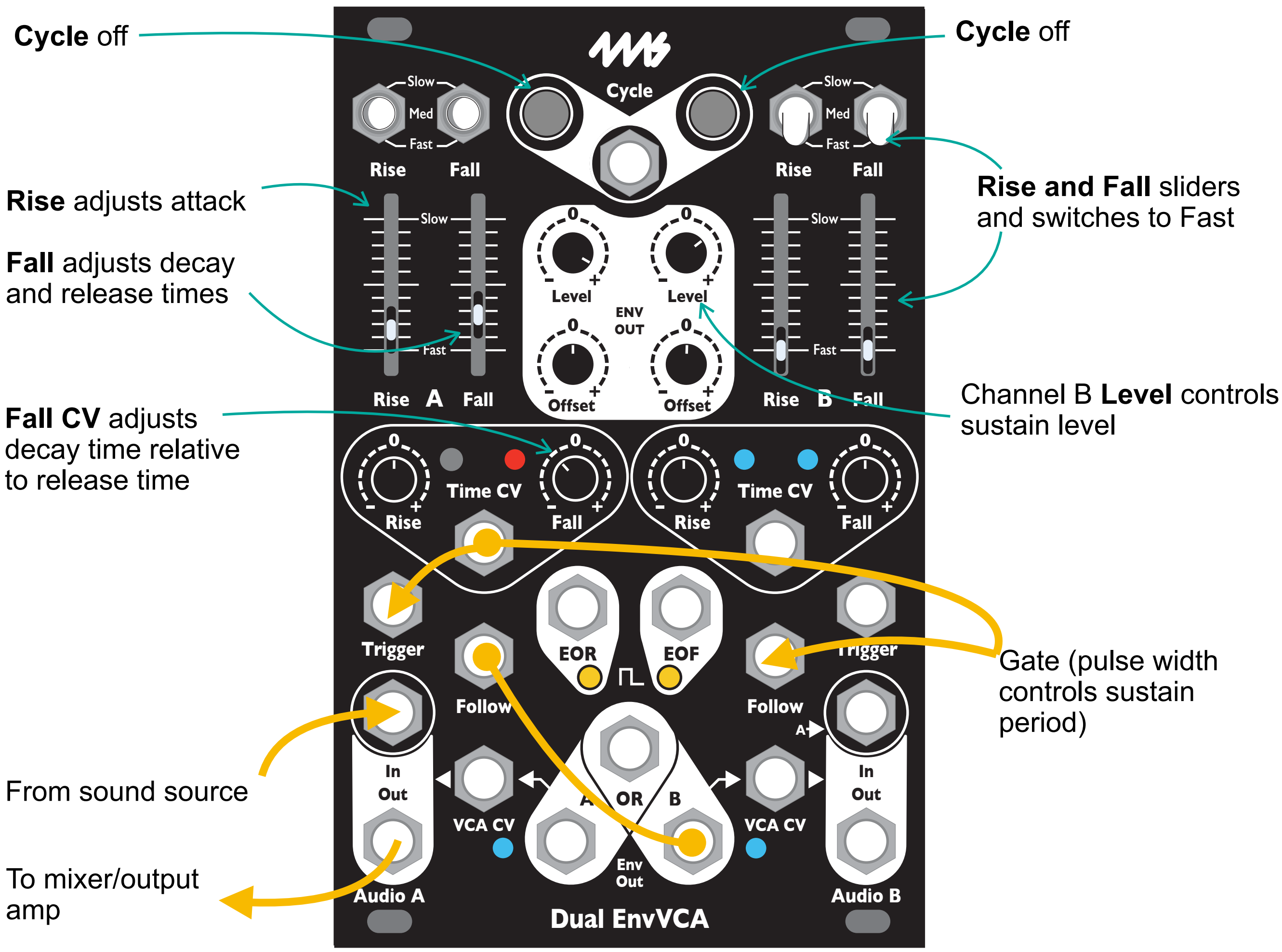


Figure 7: ASR patch: Gate length controls sustain length

This patch works because we patched the gate into both the **Trigger** and **Follow** jacks. The **Trigger** jack ensures a complete envelope will output even if the gate width is very short. The **Follow** jack produces the sustain. If we had just patched a gate into the **Trigger** jack, the envelope would start to fall once the peak is reached and we would have no sustain. However, if the gate at the **Follow** input is still high, the envelope will remain high, creating the sustain portion of the envelope. On the other hand, if we had only patched into the **Follow** jack, then a short gate width would only produce a complete envelope if the rise time parameter was very fast. Gates that are more shorter than the rise time will result in an envelope that doesn't reach the peak, as seen in Figure 6 of the previous section. However, by patching the gate into both the **Trigger** and **Follow** jacks, we get complete envelopes regardless of the settings, as seen in Figure 7. Notice the width of the pulses and how they correlate to the sustain of the envelope output. The first pulse is not wide enough to produce any sustain because its width is lesser than the time it takes for the envelope to rise.



ADSR Envelope

An ADSR (attack-decay-sustain-release) envelope is like an ASR envelope, except that it adds a fourth stage known as "decay" after the attack stage. After hitting the peak, an ADSR envelope "decays" to a sustain level less than the peak level. See Figure 8.This sustain level and the speed at which the envelope decays are controllable.

We can generate an ADSR envelope with the **Dual EnvVCA** by feeding a gate into **Follow**. The gate should be generated by an external module such as a keyboard or sequencer that lets you control the pulse width. The pulse width determines the length of the sustain, that is, the ADSR envelope will do the attack and decay segments and then hold at the sustain level until the gate goes low. At that point it'll do the release segment.

Use a mult or stackable cable to patch the gate signal into Channel A's **Trigger** jack and Channel B's **Follow** jack. (The diagram above shows it also going to **Time CV**, but ignore that for now). Patch **Env Out B** to Channel A's **Follow** jack. Both **Cycle** buttons should be off. You can take the ADSR envelope out from Channel A's **Env Out** jack, and/or you can run audio through Channel A's **Audio In/Out** jacks.

Set Channel A's switches to **Med** and set sliders two or three marks above **Fast**. **Rise** will control the attack time, and **Fall** will control both the release and decay times. Channel B is configured as a follower with fast rise and fall times, which essentially makes it pass the incoming gate out of the **Env Out** jack. We can control the amplitude of the gate output using the **Level** knob. We then feed this variable-amplitude gate into Channel A's **Follow.** As we'll see below, its amplitude sets the sustain level. Note that the **Level** knob is sensitive and the patch only works if it's between 12:00 and 3:00.

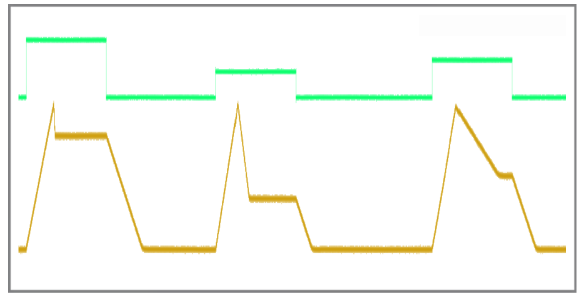


Figure 8: ADSR. Offset knob turned down in 2nd envelope to lower sustain level. Fall CV turned up in 3rd envelope to make decay slower.

Firing a gate will generate an envelope as shown in Figure 8. The rising edge of the gate will trigger Channel A because it's patched into the **Trigger** jack. This causes the envelope to rise to its peak and then begin to fall for the decay stage. When it reaches the level on Channel A's **Follow** jack, it will hold for the sustain segment. The level on the **Follow** jack is controlled by Channel B's **Level** knob, thus the **Level** knob controls the sustain level. After the gate on the **Follow** jack goes low, the envelope will fall back to zero during the release stage, at a rate determined by Channel A's **Fall** slider and switch.

We now have control over the attack or rise speed (**Rise** slider/switch), sustain length (gate pulse width), and sustain level (**Level** knob). However, the decay time and the release time will always be the same, set by the **Fall** slider/switch.

To make this a true ADSR envelope, patch a cable from the mult or stacking cables on the gate output of the keyboard or sequencer to the **Time CV** jack. Make sure the keyboard/sequencer gate output still goes to Channel A's **Trigger** jack and Channel B's **Follow** jack. Now you can use the **Fall CV** knob to set the decay time relative to the release time. Turning it to the left of center will make the decay time faster than the release time, and vice-versa. The reason this works is that the decay stage occurs while the gate is high, and the release stage occurs when the gate is low. Since the gate is patched into the **Time CV** jack, the position of the **Fall CV** knob only has an effect on the time when the gate is high, which is the decay stage. Note that adjusting the **Fall** slider or switch will change both the decay and release times.

For some exotic envelope shapes, try flipping Channel B's switches to **Med** and adjusting the sliders to slow down Channel B's **Rise** and **Fall** times.

Generating Exponential and Logarithmic Envelopes

The **Dual EnvVCA** can be used to generate exponential and logarithmic shapes by patching **Env Out** back into the **Time CV** jack. The **Rise CV** and **Fall CV** knobs can be used to independently control the shape of the rise and fall portions. Turning the knob to the left of center will make the shape more exponential, and turning it right will make it more logarithmic. Notice that the rise and fall times change dramatically when using this technique, especially if the Rise CV or Fall CV knob is set higher than 3:00. The waveforms in Figure 9 were generated using this technique (and by setting the Rise/Fall sliders differently for each envelope).

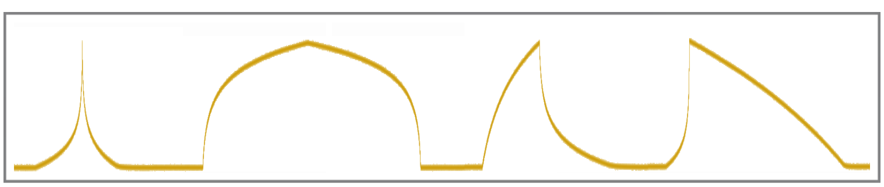


Figure 9: Log and expo shapes generated by patching Env into Time CV and adjusting Rise/Fall CV knobs

The **Shaped Dual EnvVCA** module from 4ms Company is the bigger cousin of the **Dual EnvVCA**. This module has an exponential and logarithmic wave shaper, which can alter the wave shapes without changing the envelope timing.

Using Offset and Level Knobs

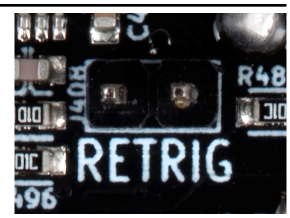
The **Level** and **Offset** knobs control the amplitude and DC level of the signal output from the **Env Out** jacks. They do not effect the VCA or the audio signal (unless you patch **Env Out** to **VCA CV**). Being independent of the VCA allows you to modulate something with **Env Out** and control the modulation with **Level** and **Offset** without disrupting the VCA.

The **Level** knob controls the amplitude of the envelope. When the knob is centered, no envelope will be output. Turning it to the right of center makes the envelope rise upward in voltage and fall downward (this is the most common setting for an envelope). If you turn **Level** left of center, the envelope will be inverted: it will rise downward and fall upward. The farther from center (in either direction) that you turn **Level**, the greater the amplitude. At fully clockwise or counter-clockwise, the amplitude will be about 10V.

The **Offset** knob shifts the envelope output up and down. With the **Offset** knob in the center, the envelope will rest at 0V and then rise to the voltage set by the **Level** knob (at most +10V if **Level** is fully clockwise, or -10V if **Level** is fully counter-clockwise). If **Offset** is turned left of center, the envelope will rest at a negative voltage. When **Offset** is fully counter-clockwise, it will rest at -10V. Going the other way, if **Offset** is turned to the right of center, the envelope will rest at a positive voltage, with +10V being the maximum.

The **Env Out** jacks clip at about -10V and +10V. Using **Level** and **Offset** at their extremes, you can easily cause clipping which results in a steady -10V or +10V output (and is not typically very interesting in a patch). If you're ever unsure where to set **Level** and **Offset**, a good starting place is to set **Offset** to the center, and **Level** to around 3:00 or higher.

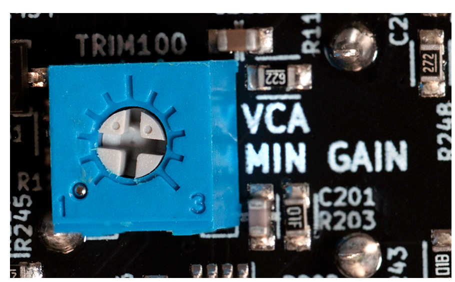
RETRIG Jumper



The **RETRIG** jumper on the back of the module changes the **Dual EnvVCA's** behavior when it receives a trigger while an envelope is already running. When the jumper is not installed (factory default), triggers received as the envelope is rising will be ignored, and triggers received while the envelope is falling will make it begin rising again from its current voltage.
When the jumper is installed, the **Dual EnvVCA** will immediately restart the envelope when it receives a trigger, regardless of whether the envelope is rising or falling. When this happens, the envelope will immediately fall to 0V and begin to rise again. This sharp transition to 0V can cause clicking when used with the audio VCA section.

See the Creating Envelopes section on page 13 for more details.

VCA Min Gain Trim pot



On the back of the module is a trimpot that can adjust the minimum VCA gain. Typically, you will want to set this so that you do not hear any audio bleeding through when the envelope is not running. However, setting the minimum gain too quiet means that when the **Dual EnvVCA** is cycling, there are longer gaps between notes. That is, there is more time between envelope peaks where the sound is inaudible or barely audible.

At fully counter-clockwise, the VCA will provide -90dB of attenuation when the envelope is not cycling. This is the maximum amount of silence between notes when cycling and minimum amount of bleed. In the middle position (factory default), there is -80dB of attenuation. It provides a short amount of silence between envelope cycles, and low amount of bleed. Turning the trim pot all the way clockwise provides -30dB of attenuation when the envelope is stopped. This may be useful if you wants less silence between cycles, and don't mind hearing some audio when the envelope is not cycling.

Electrical and Mechanical Specifications

- **Dual EnvVCA**
  - 16HP Eurorack format module
  - 0.95” (24mm) maximum depth (includes power cable)
  - 10-pin Eurorack power header
- **Power consumption**
  - +12V: 156mA max
  - -12V: 131mA max
- **Audio/VCA**
  - 100k input impedance, 1k output impedance, DC-coupled
  - VCA gain range: -90dB to +0.9dB
  - DC to 20kHz, +/-0.1dB
- **Envelope Times**
  - Minimum rise or fall time: ~62.5us (8kHz max frequency)
  - Maximum rise time: > 10 minutes (typically > 13 minutes)
  - Maximum fall time: > 20 minutes (typically > 40 minutes)
- **Jacks:**
  - Env jack: Min = -10.2V, Max = 10.1V
    - Envelope: Max amplitude = 9.3Vpp
  - Trigger jack: rising edge threshold = 2.5V
  - Cycle jack: rising edge threshold = 2.5V
  - Follow jack: active range = 0V to +5V
  - EO* jacks
    - EOR (channel A): <80mV low to >4.50V high gate output
    - EOF (channel B): <80mV low to >4.95V high gate output
    - Minimum stable pulse width: 1ms. Shorter than this may produce extra 50μs pulses
  - Audio In/Out jacks: <-10.0V to >+10.0V maximum range without clipping