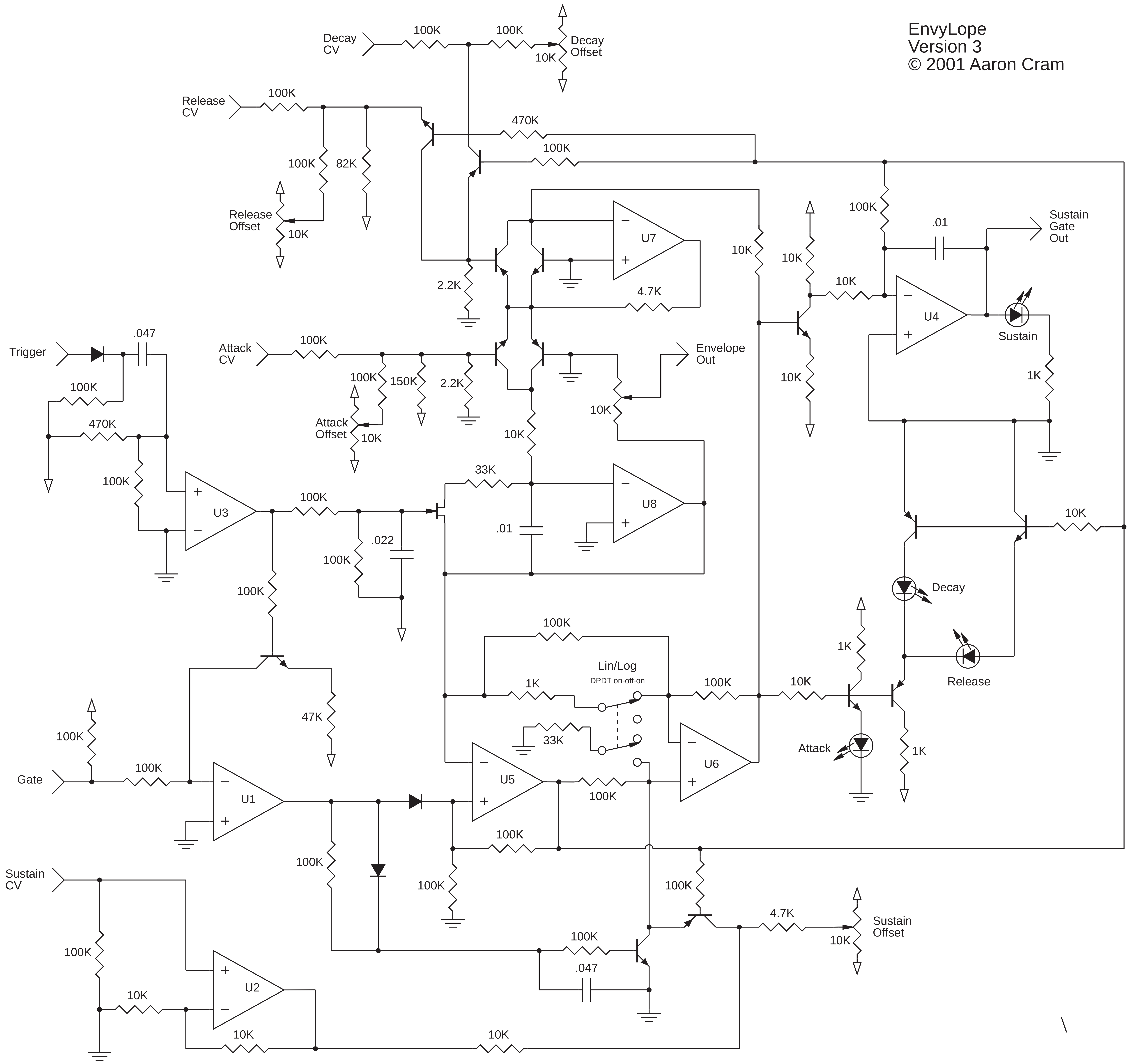
EnvyLope
Version 3



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"EnvyLope" -- Voltage Controlled ADSR, LFO, and Glide

Description:

I set out to design the ultimate multi-function envelope generator circuit. I think I came close, for my needs anyway. With nothing plugged into the *gate* input, the circuit is locked in sustain mode. You can use this as a voltage controlled glide by patching a signal into the *sustain* input. The *attack/decay* voltages will then control the up and down glide speed. If the sustain knob is turned all the way down, the circuit re-triggers itself and becomes a voltage controlled triangle LFO with separately adjustable up and down ramp times. If the *gate* input is connected, it becomes a gated LFO, and will only run when the gate is high. The *trigger* input resets the cycle, and can be used as a sync.

Of course, the main function of the circuit is the ADSR. This is implemented with the envelope starting out at zero and going up from there, allowing you to send the envelope output through a VCA to control the overall amplitude. This is important when, for example, you want the velocity control from your MIDI keyboard to properly modulate the loudness of a tone. Note also that the sustain point can be set "below ground." However, in this configuration, you lose the separate release slope and the envelope returns up to ground at attack speed. The slope of all envelope ramps are exponential with respect to the control voltages.

The ramps themselves can be either linear or R/C. There are actually three modes to the EG, which can be controlled from the front panel by an on-off-on DPDT switch. Mode 1 is linear for all stages. Mode 2 (center position) is linear attack and R/C decay and release. Mode 3 is R/C for all stages.

The *trigger* input resets the envelope, from wherever it may be in the cycle, and if a *gate* is sent at the same time it will start the cycle over. This reset happens smoothly so that you don't hear a "pop" when the trigger is fired. Finally, you'll notice that there is a separate LED that shows the current state the envelope generator is in.

There is a *sustain gate* output, which is low except when the EG is in the sustain state. This allows cascading multiple EGs together to make more complex contours. It could also trigger other modules on the synth. Or it could simply be used as a timer.

Engineering notes:

The core of this circuit is a funny looking bridge thing made out of two complimentary transistor pairs. This core controls the current that gets fed to the main integrator. Not only does it allow for separate control of positive and negative current, it also gives exponential voltage control of the current for free. I must give credit to Jürgen Haible for this excellent idea. It works beautifully!

The rest of the circuit switches different control voltages into the core, buffers the gate and trigger inputs, and runs a state machine with an attack, decay, sustain, and release state. My goal in designing this circuit was to stay away from CMOS MUXes, logic gates, flip/flops, and 555 timers. The CVs are all switched with transistors, and the logic and latching operations are all handled with op-amps. This works quite well, since you can latch up an op-amp with positive feedback, and then control it by giving it a "push" one way or the other. (Also called a Schmitt trigger.)

Great pains were taken to make sure that the trigger input reset the system without sending a sharp edge to the output. Applying positive voltage to the FET across the integrating cap discharges it quick, fast, and in a hurry. But in testing this caused a very audible and annoying click when the circuit was patched into a VCA. I added a 100K/.022uF R/C filter to the gate of the FET to smooth this out a bit. This worked, but caused another problem. My PAIA "MIDI2CV8" controller sends the gate and trigger at approximately the same time. This caused the circuit to start the attack before it was done resetting. To fix this, I had to delay the start of the attack phase. So, the transistor responsible for clamping the integrator to ground got a diode, 100K resistor, and .047uF cap added to its base.

Mods:

I have gone against convention, but I prefer to have higher voltages (and clockwise turning of the knobs) create a faster envelope. This can be reversed easily by swapping the four "core" transistors around. (NPN -> PNP and PNP ->NPN. I think.)

I have my MIDI to CV controller set up so that the trigger and gate are low at –5v, and high at +5V. So, as you can see from the schematic, the comparators that sense the gate/trigger are referenced to ground. If your gate goes from 0 to 5v or something, this might not work too well. It is easy to change, however, and a trimpot could even be added to adjust the trigger point.

Changes from V2:

I decided to add an R/C differentiator to the input of the trigger.

I added the sustain gate. This required another op-amp, but I didn't want to add another chip. So I substituted a transistor for an op-amp near the trigger input.

I completely reworked the LEDs. The way I had them before was draining too much current from the critical op-amps that controlled the circuit, causing all sorts of problems.

Two of the transistors in the V2 schemo where drawn backwards (E and C swapped.)

I tweaked some resistor values for better performance.