

The Educational DIY Synth Thing

Projects – v0.1 – Nov 2024
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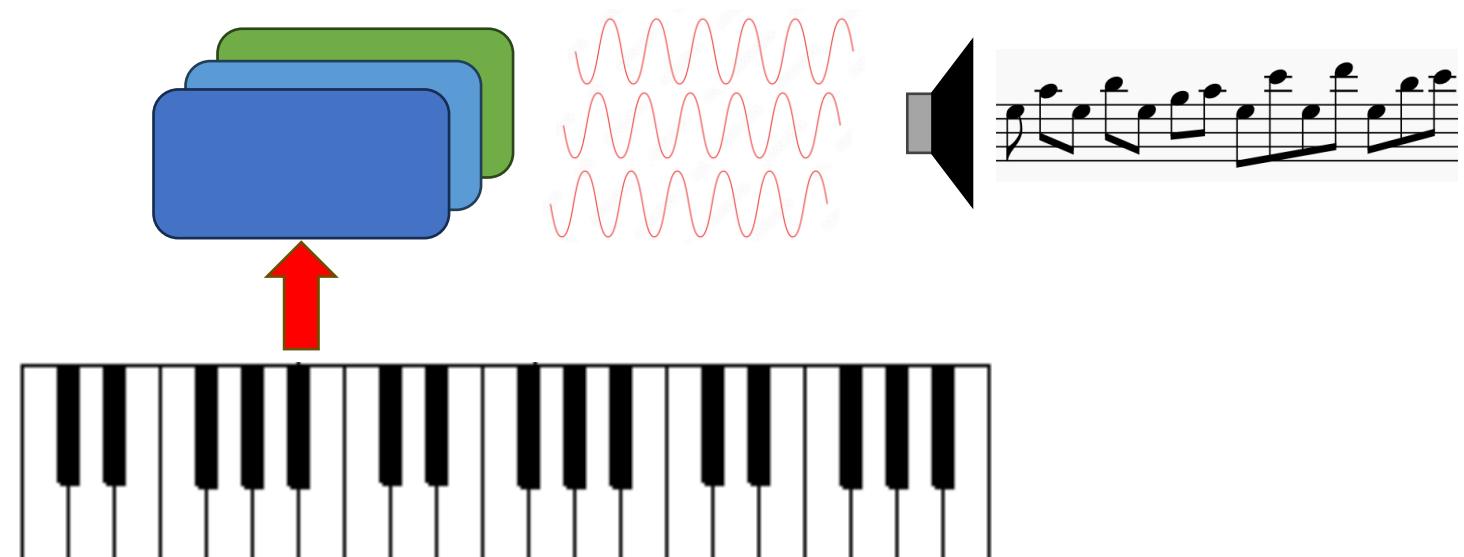
<https://diyelectromusic.com/2024/05/07/educational-diy-synth-thing/>



Introduction

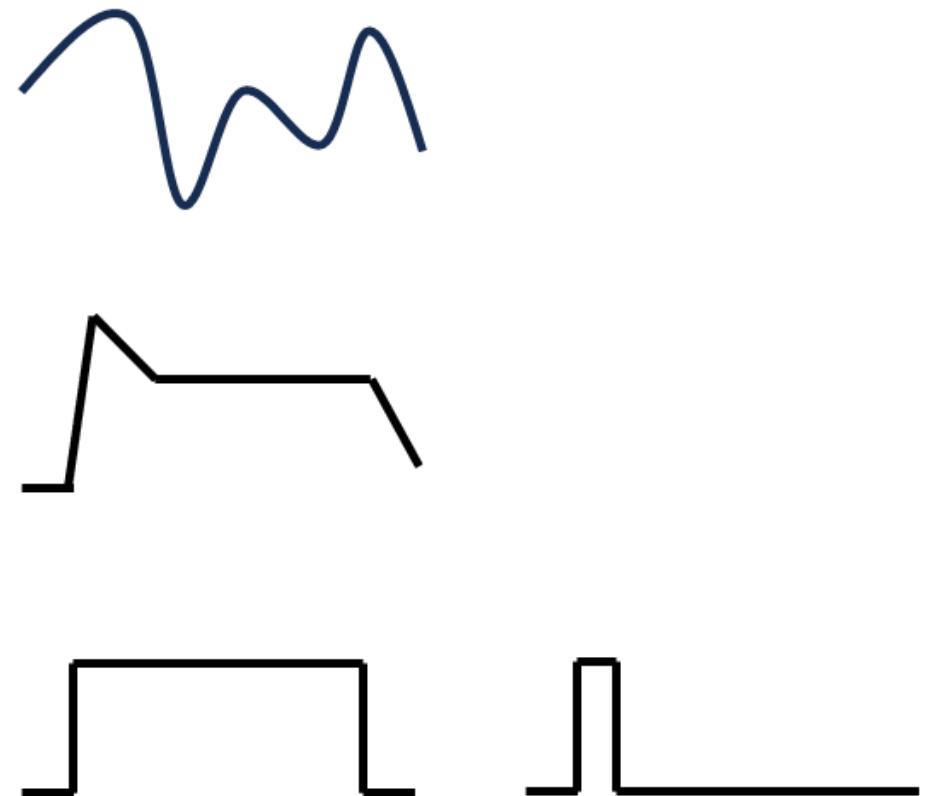
Introduction to Analog Synthesis

- Key Principles:
 - Audio Signals
 - Voltage Control
 - Gate and Trigger Signals
- Other Principles:
 - Envelopes
 - Modules
 - Monophonic
 - Polyphonic

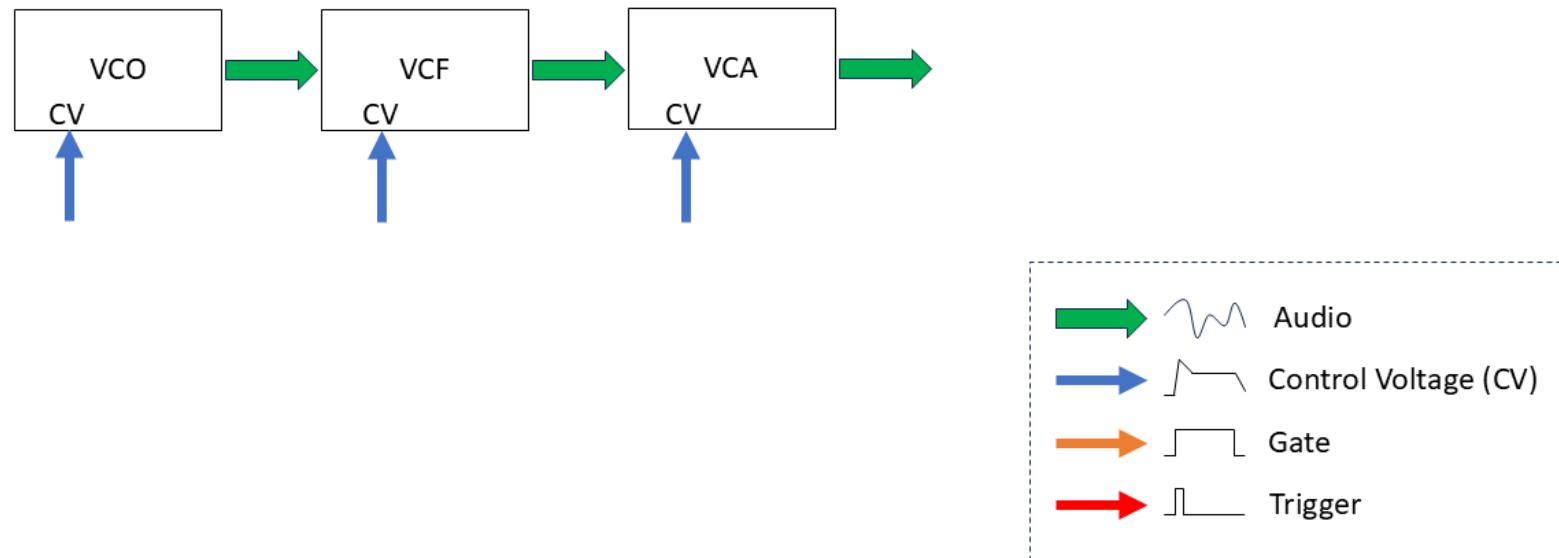


Key Principles

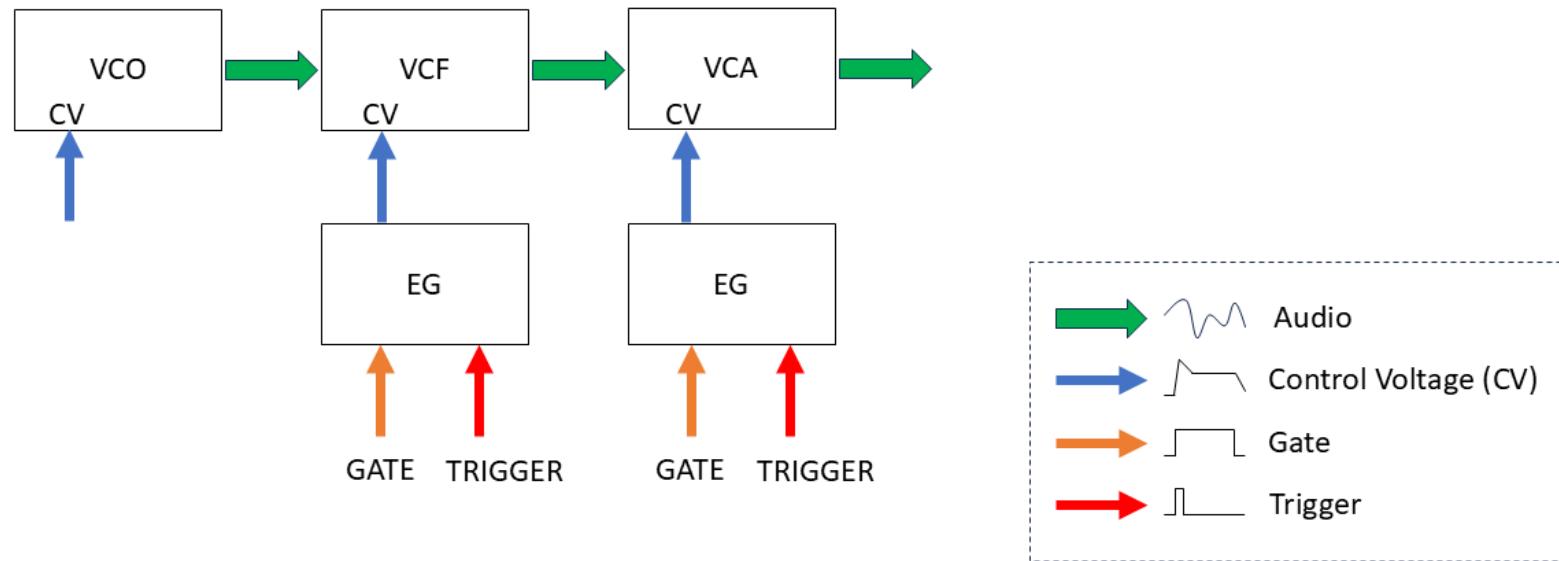
- Audio Signals
 - Produce the sounds.
- Control Voltages
 - Everything is controlled by voltage levels.
 - Can be constant or changing.
 - Can be continuous or with a start and end.
- Gates and Triggers
 - Start and stop sounds.



Basic Structure of an Analog Synthesizer

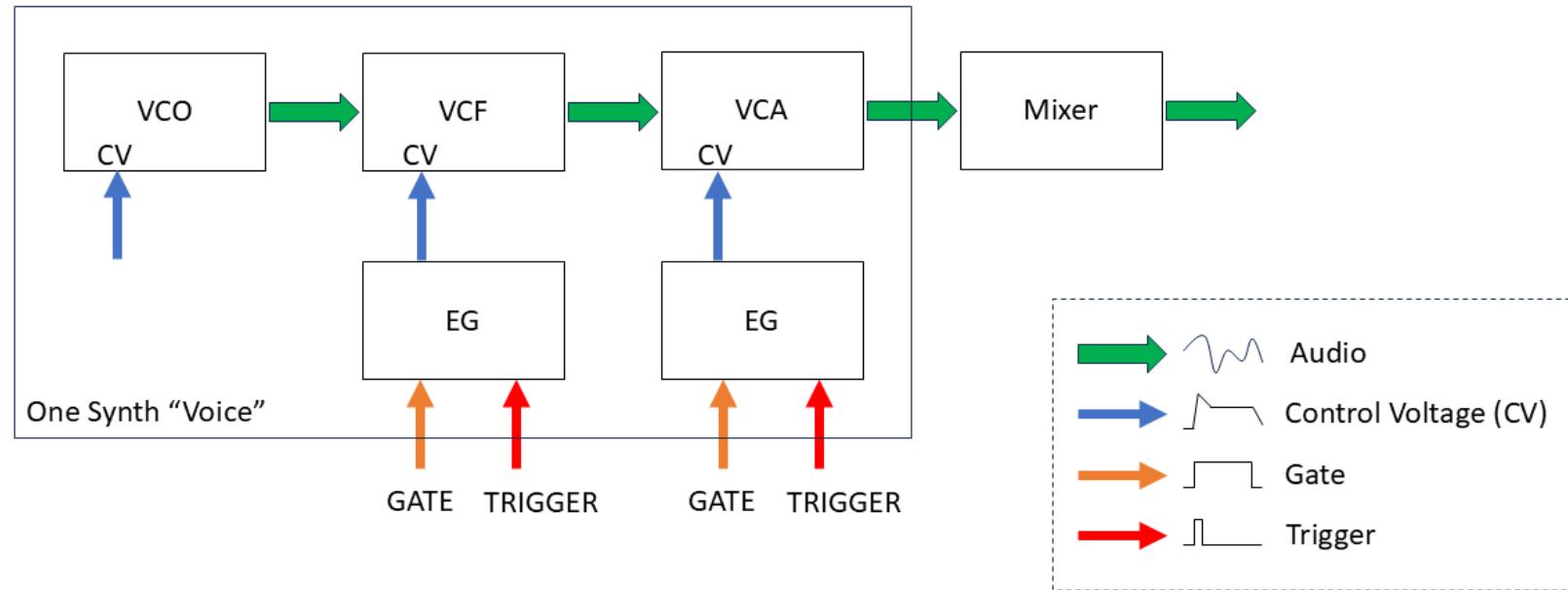


Basic Structure of an Analog Synthesizer



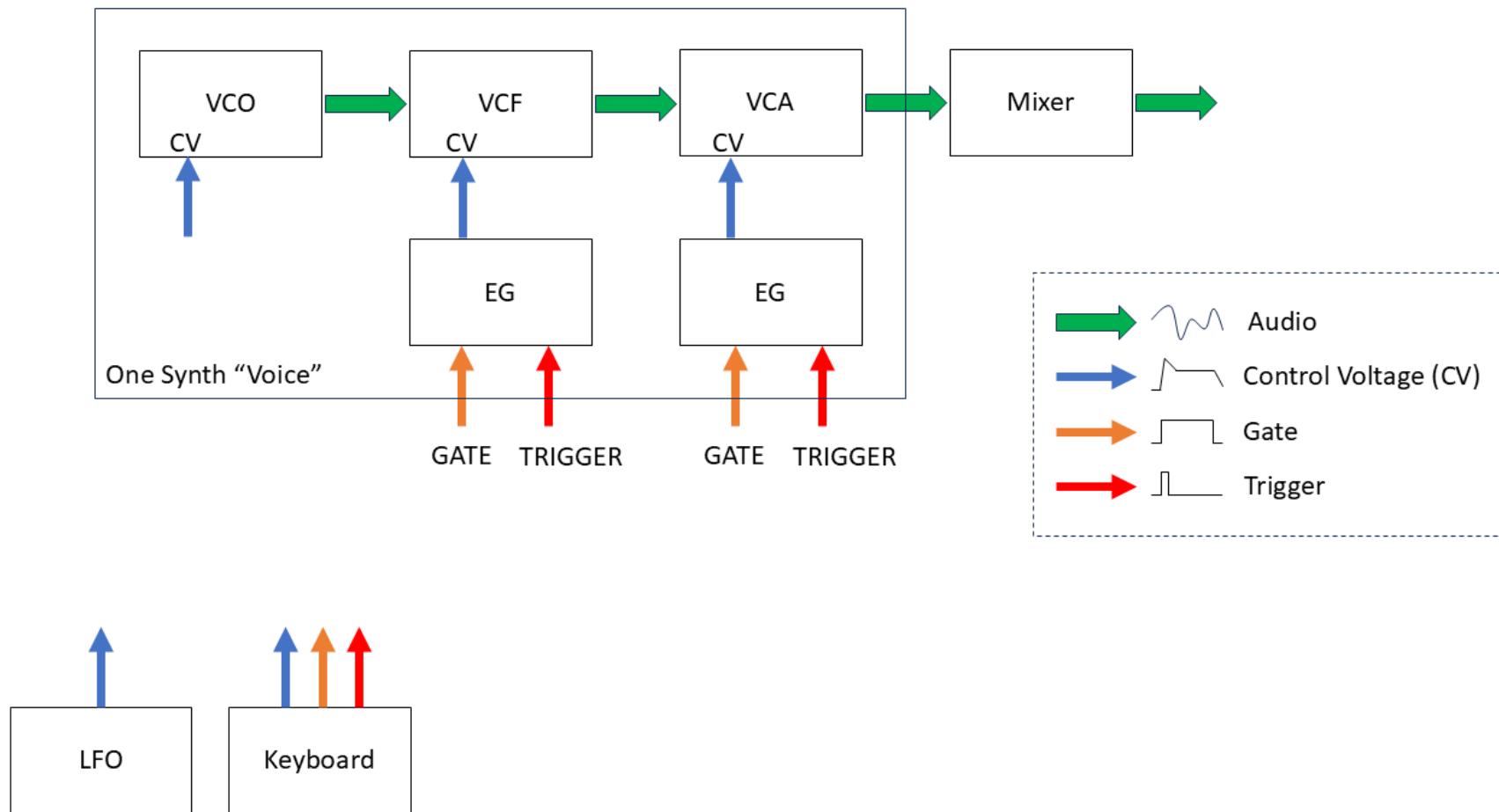
One Voice = Monophonic

Basic Structure of an Analog Synthesizer

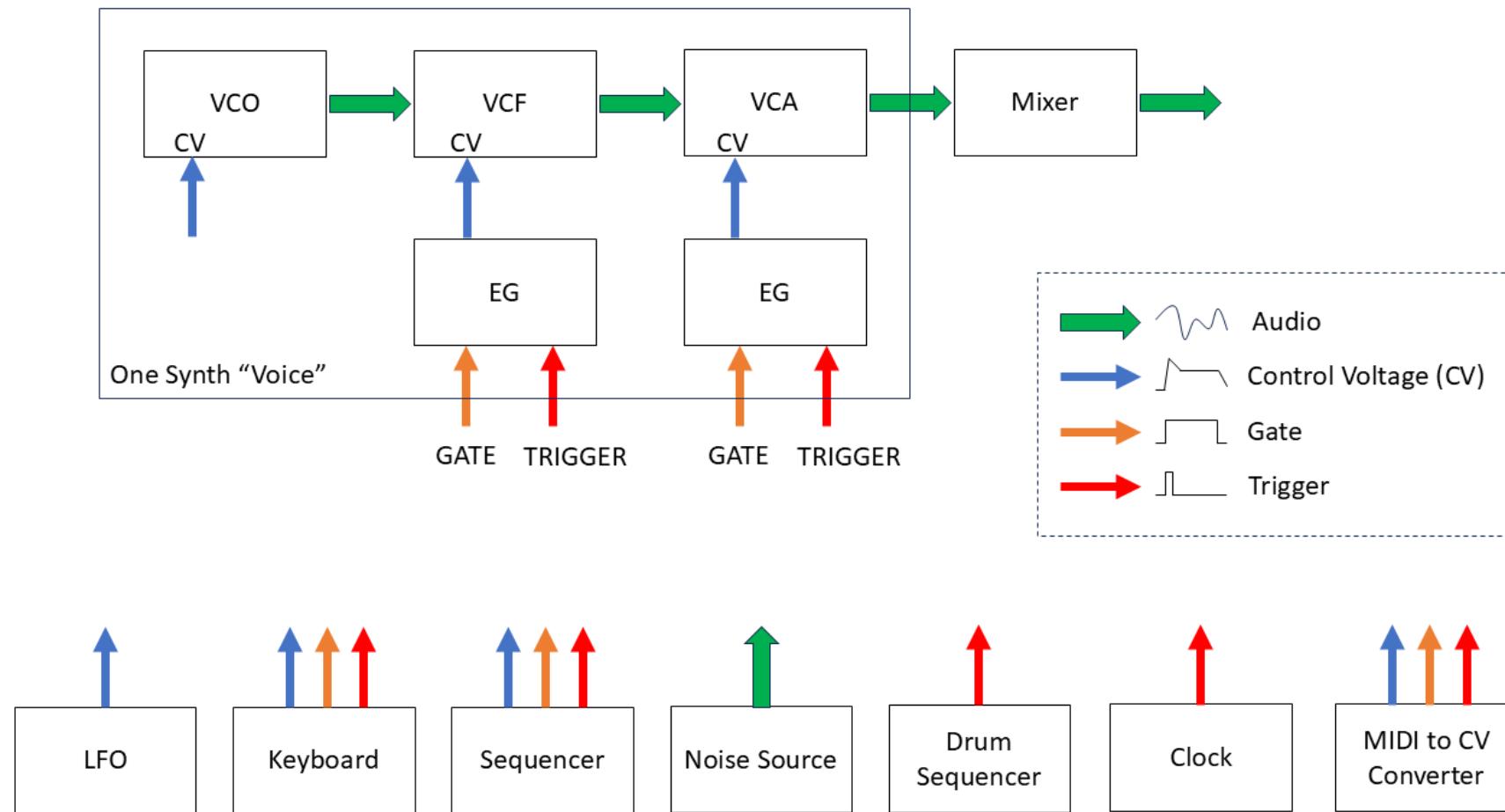


Many Voices = Polyphonic

Basic Structure of an Analog Synthesizer



Basic Structure of an Analog Synthesizer



Waveforms



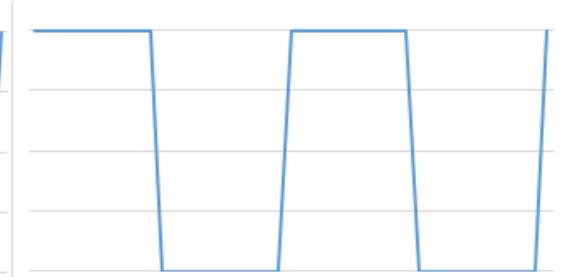
Sine



Triangle

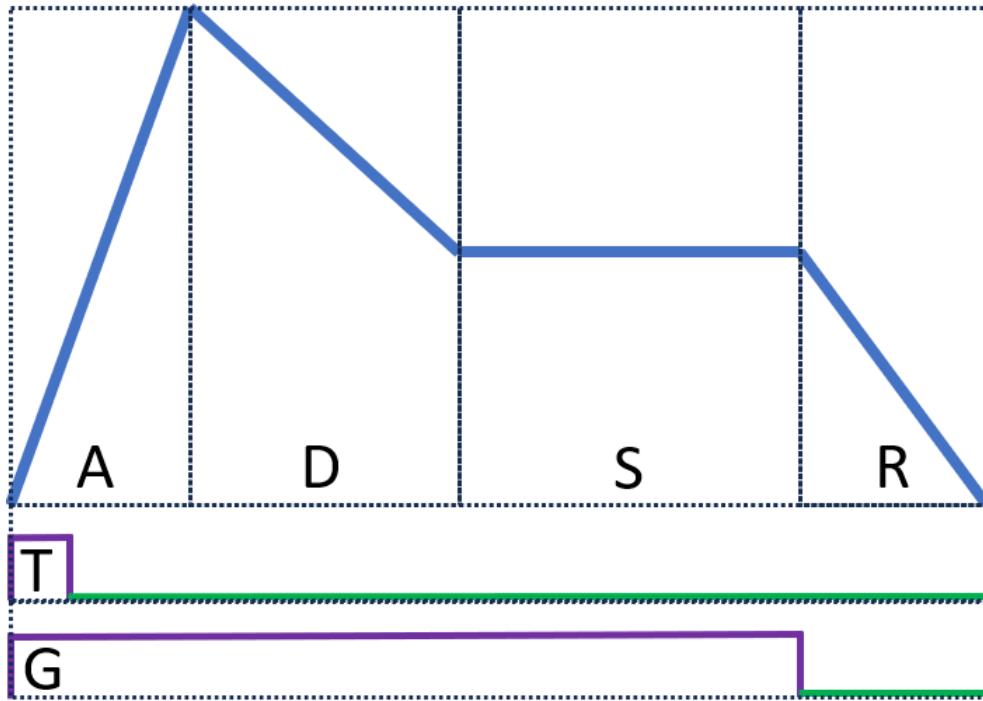


Saw



Square

Envelopes



- Attack (A)
- Decay (D)
- Sustain (S)
- Release (R)

< Trigger

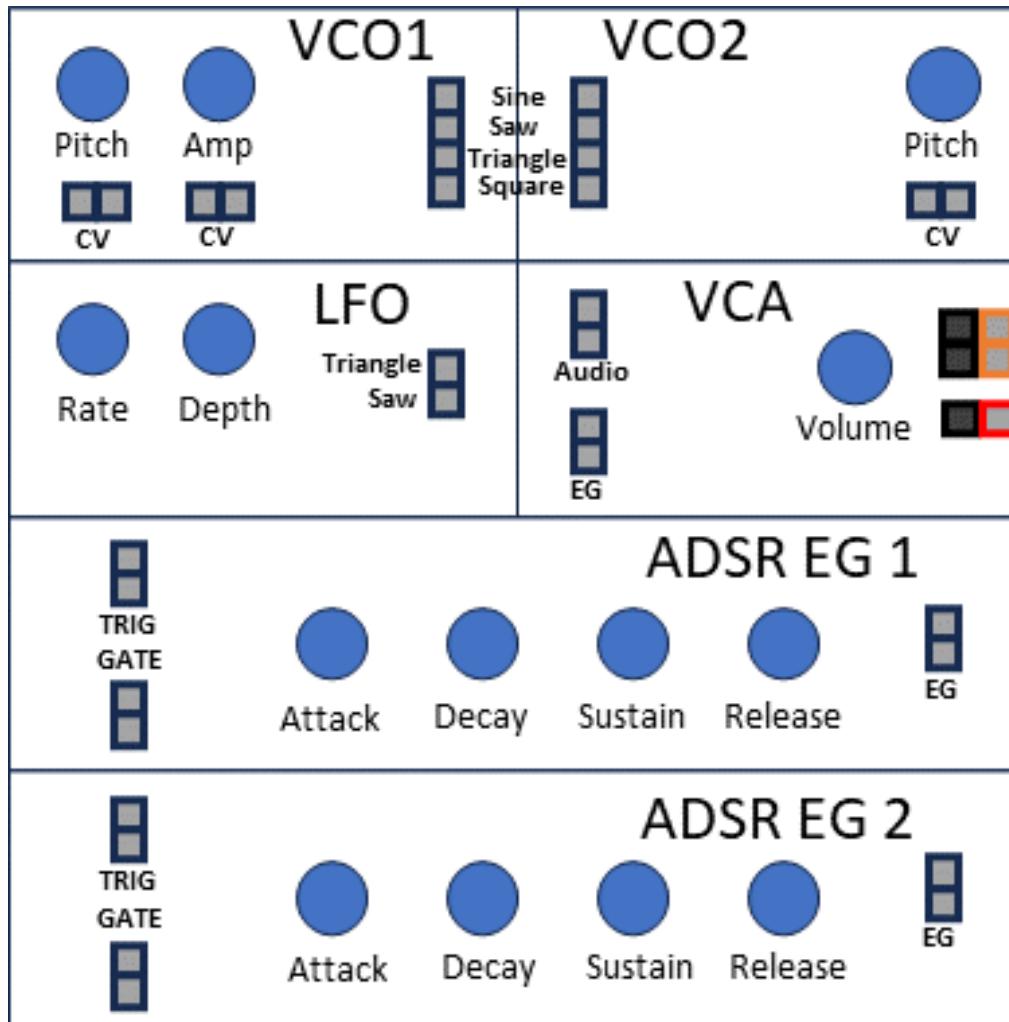
< Gate

Key Points of Analog, Modular Synths

- (Pretty much) Everything can be voltage controlled.
- (Pretty much) Any signal can be a control voltage!

The Synth Thing

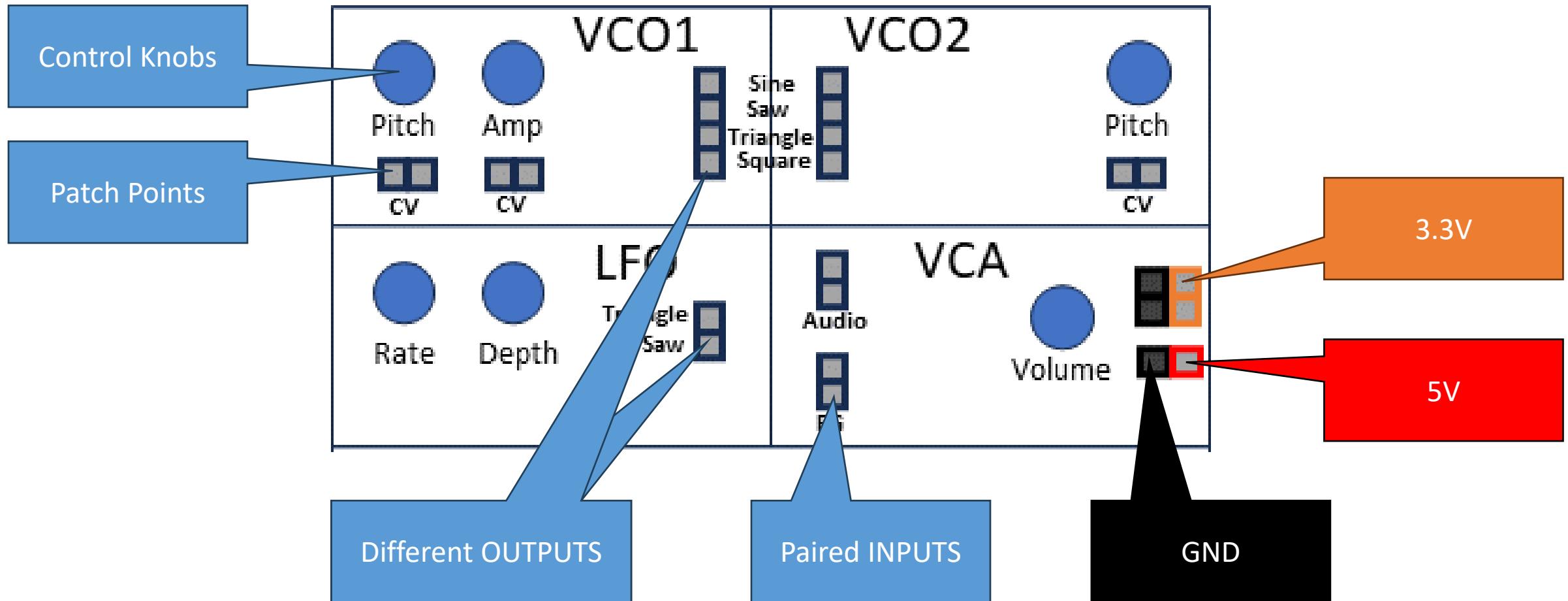
The Synth Thing



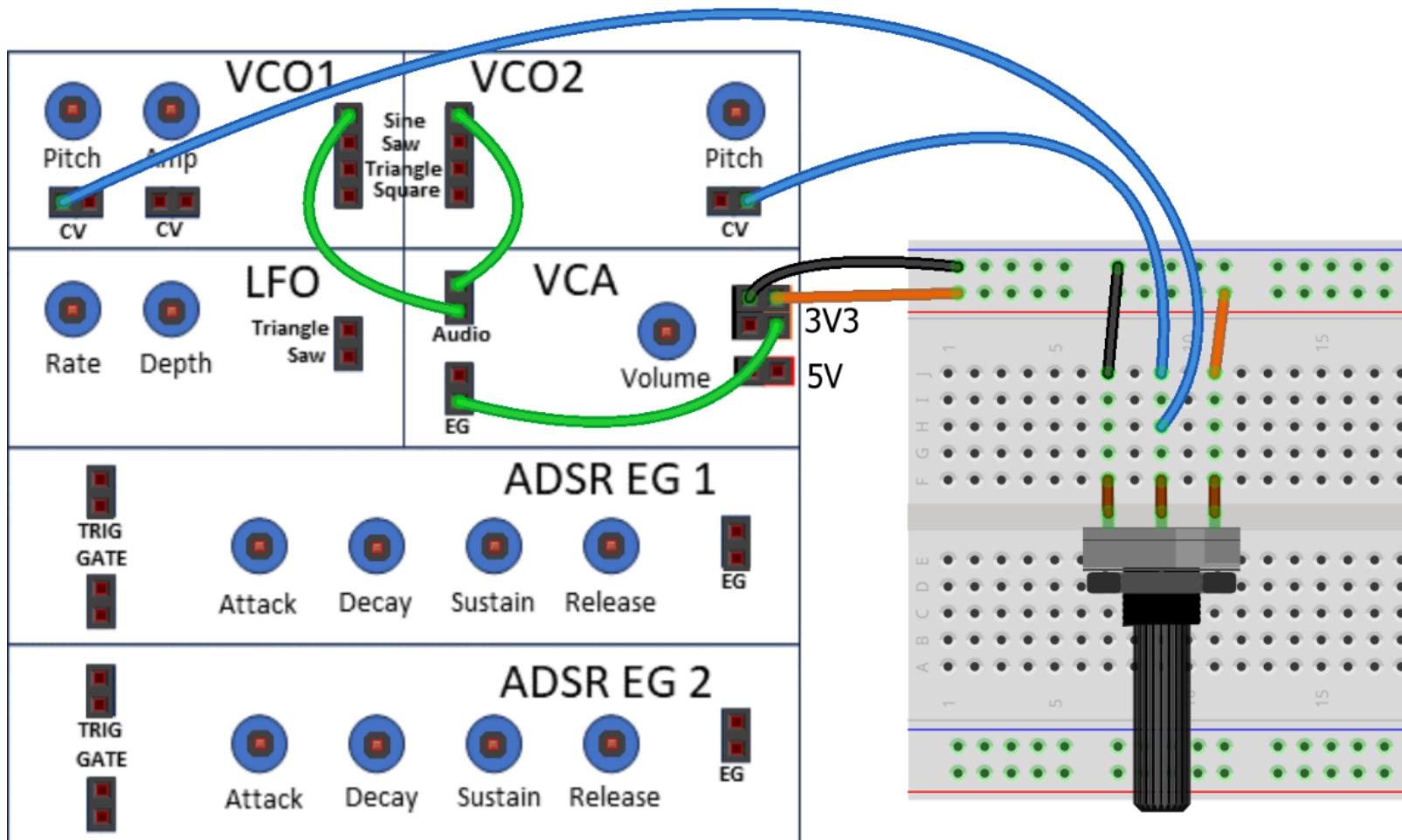
Modules:

- 2x Voltage Controlled Oscillators.
 - 4x VCO waveforms.
- 1x Low-Frequency Oscillator.
 - 2x LFO waveforms.
- 1x Voltage-Controlled Amplifier.
 - Audio output.
- 2x Envelope Generators.
 - ADSR.
- *Every patch point is a real signal!*

Patch Points: control, audio, power

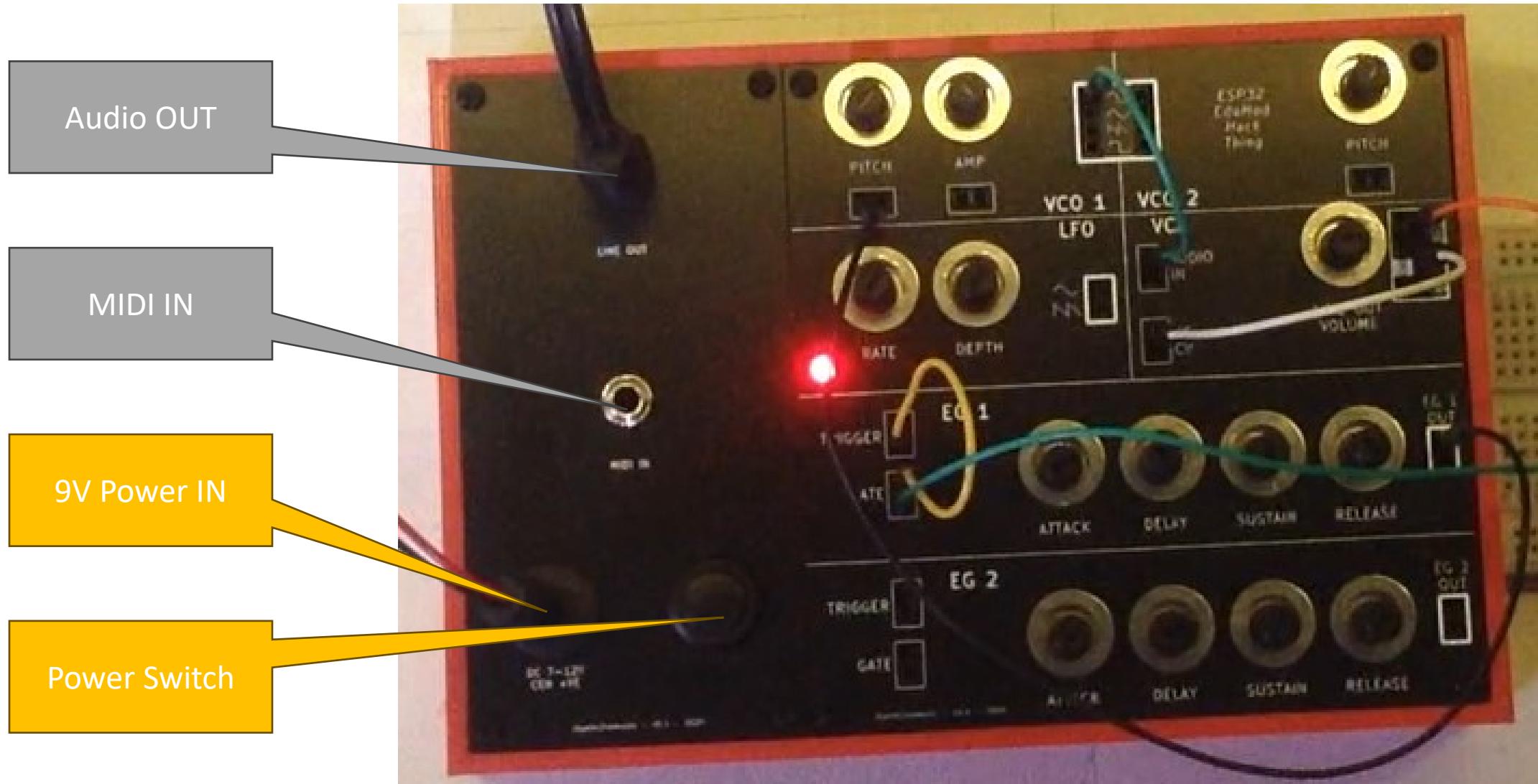


Patch Diagrams



- Green: Internal Links
- Blue: External Links
- Black: GND
- Orange: 3.3V
- Red: 5V

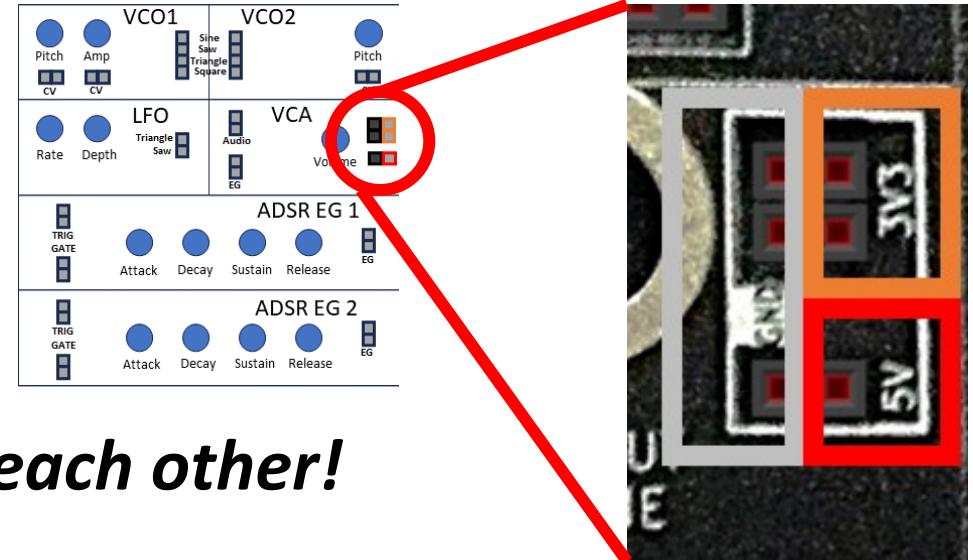
Extra Connections



Basic Dos and Don'ts

Don'ts:

- ***DO NOT CONNECT 3V3 or 5V or GND to each other!***



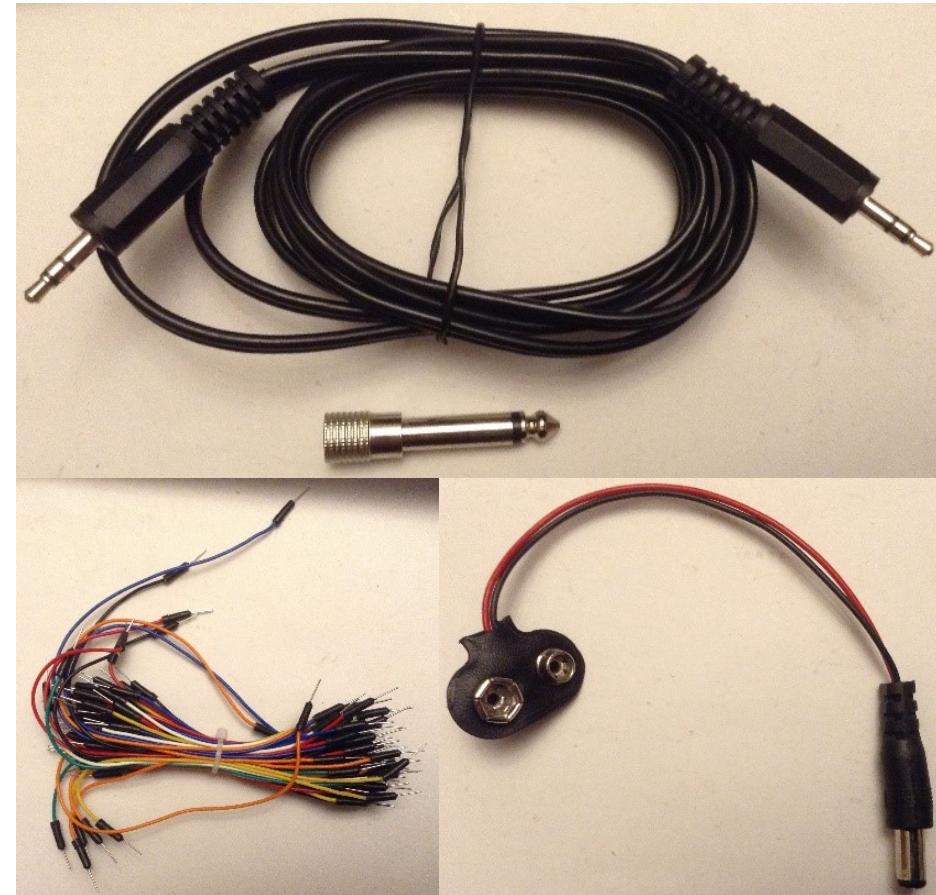
Dos:

- Experiment with the different signals!
- Link to a solderless breadboard to make new circuits.
- Look at signals with an oscilloscope.
- Use MIDI.



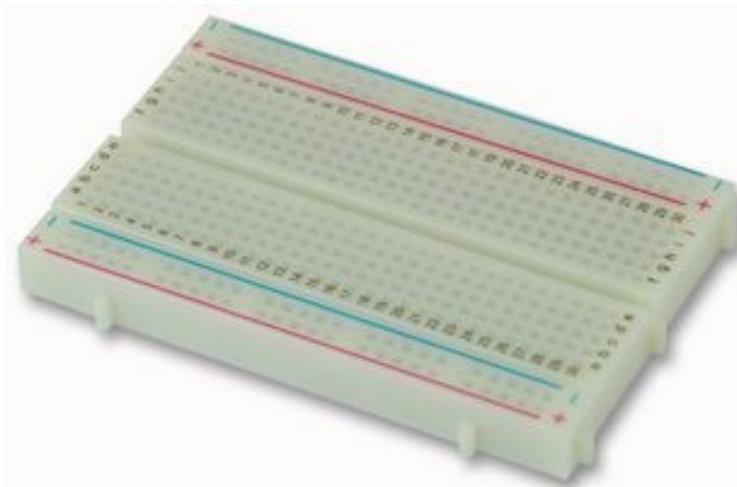
Starter Projects

Getting Started

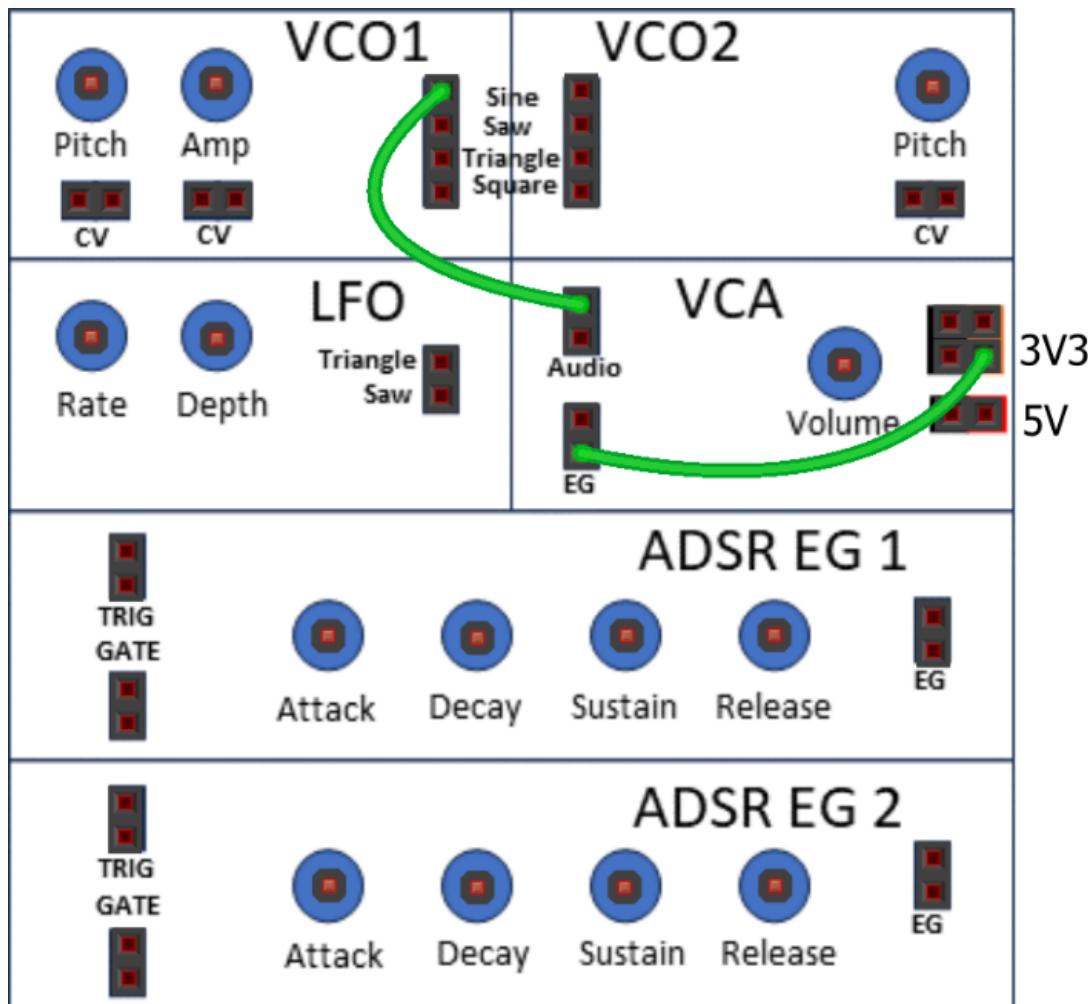


Other Equipment

- Optional: Oscilloscope
- Solderless breadboard
- Potentiometer (10K to 100K)
- Button
- (Cheap/Old) Amplification

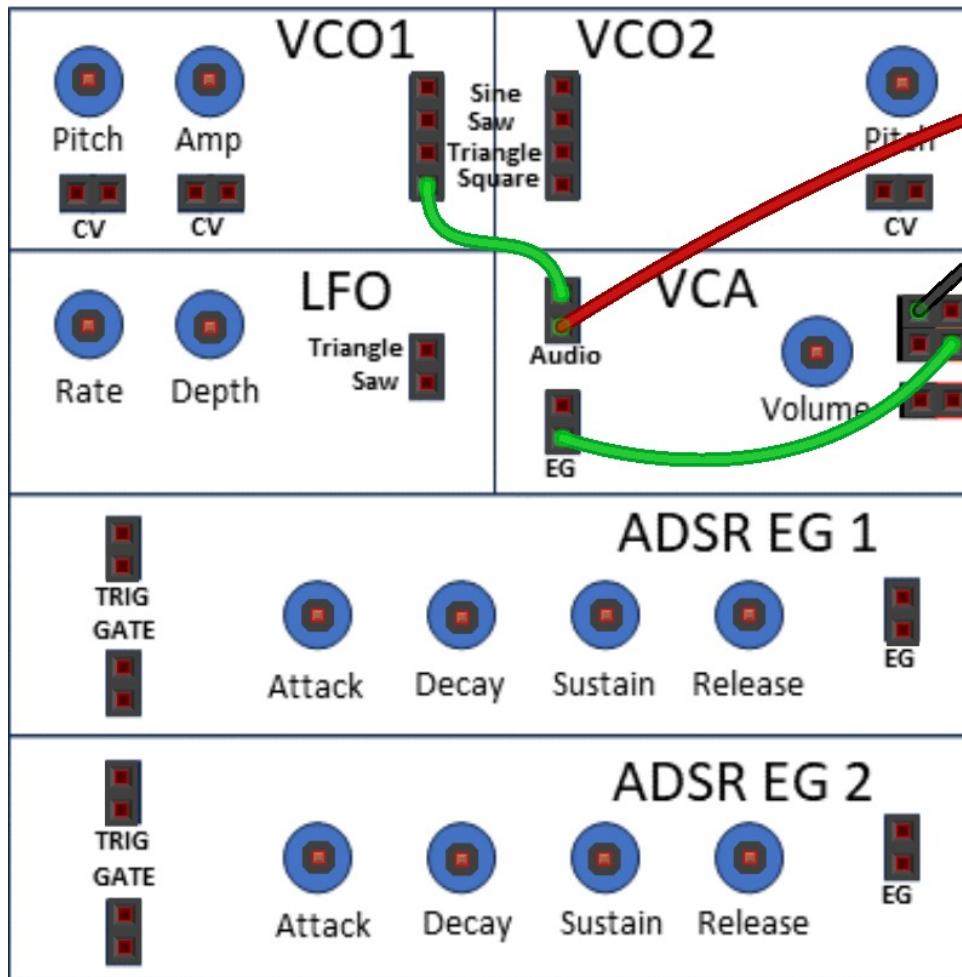


1. Basic Oscillator (VCO) Output



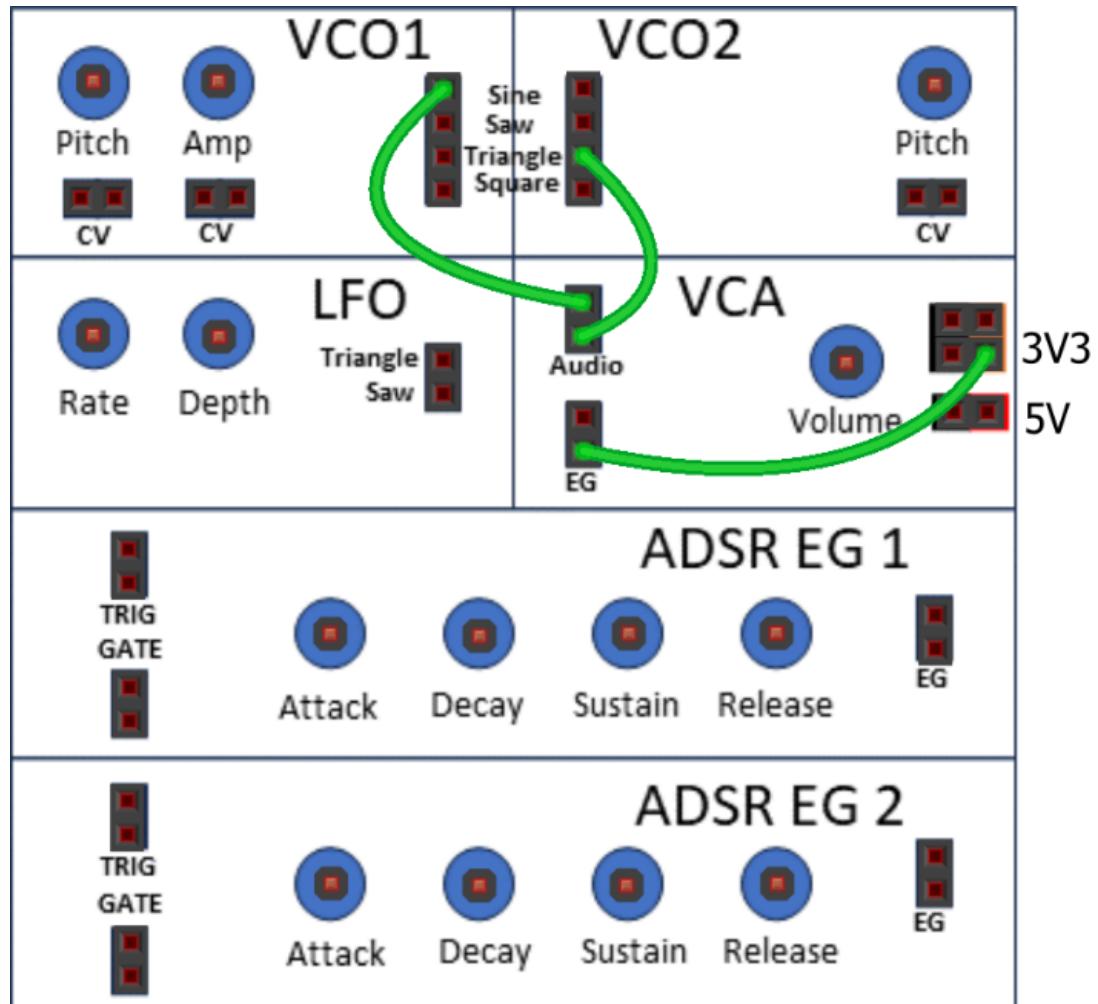
- VCA EG fixed at 3V3.
- Turn up VCA Volume.
- Experiment with:
 - VCO1 Amp.
 - VCO1 Pitch.
- What are the highest and lowest frequencies?

2. VCO Waveform on an Oscilloscope



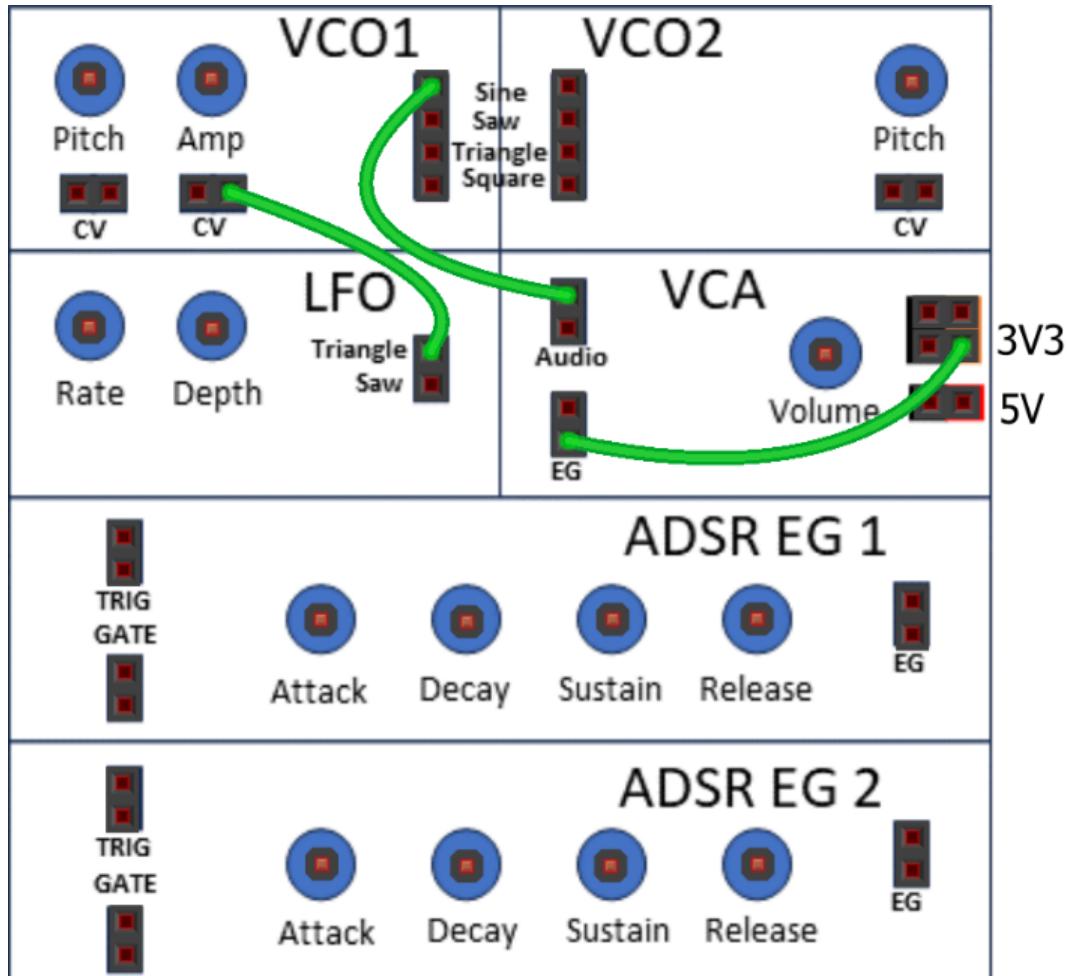
- **Note: Needs a GND connection.**
- Try all four VCO1 waveforms.
- Change the VCO1 Amp and Pitch.
- Measure highest and lowest frequencies.

Dual Oscillator Output



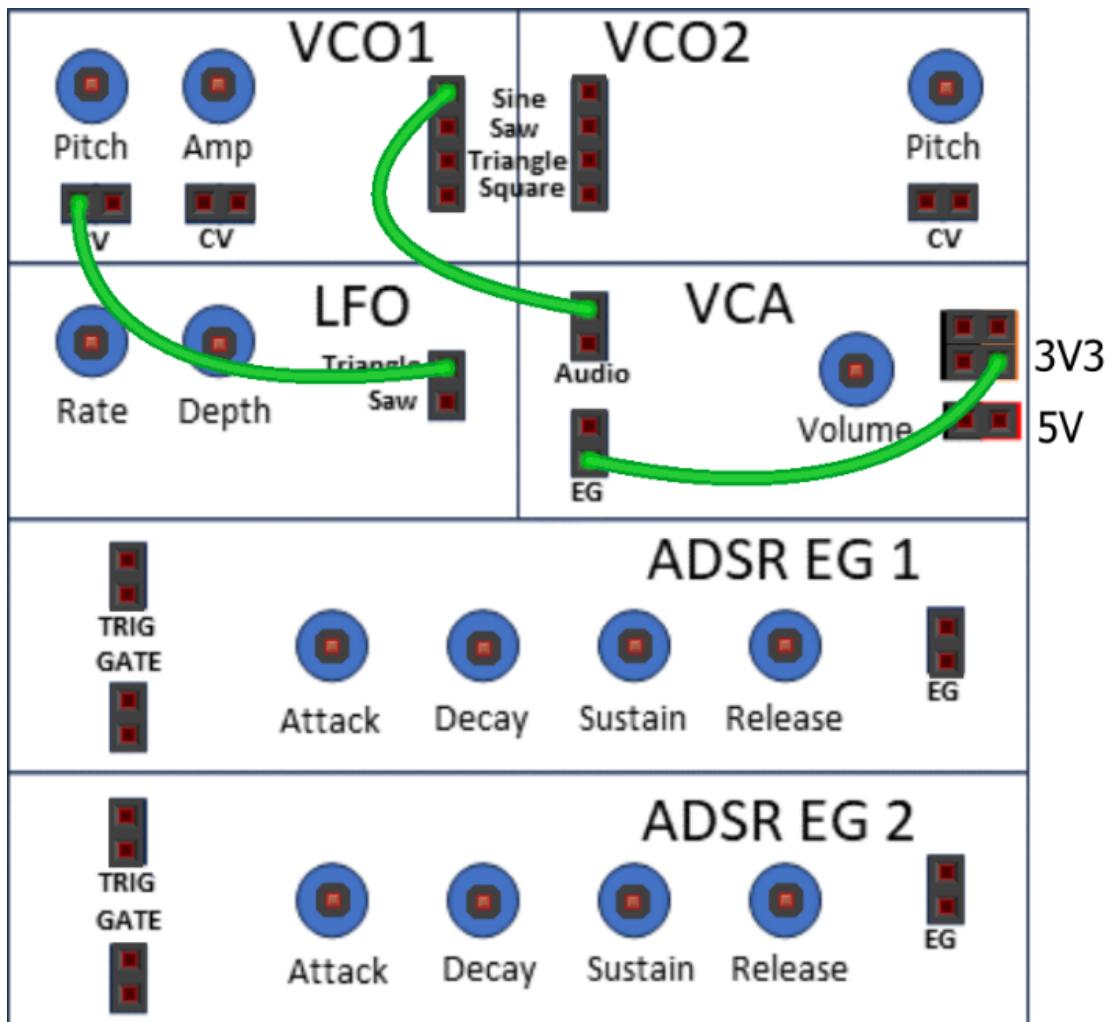
- Change:
 - VCO1 and VCO2 Pitch.
 - VCO1 Amp.
 - VCO1 and VCO2 Waveforms.
- Experiments:
 - Tune to same pitch.
 - Detune one slightly.
 - Tune to 1 octave apart.
 - Tune to 2 octaves.
 - Find other intervals.

4. LFO Amplitude Modulation



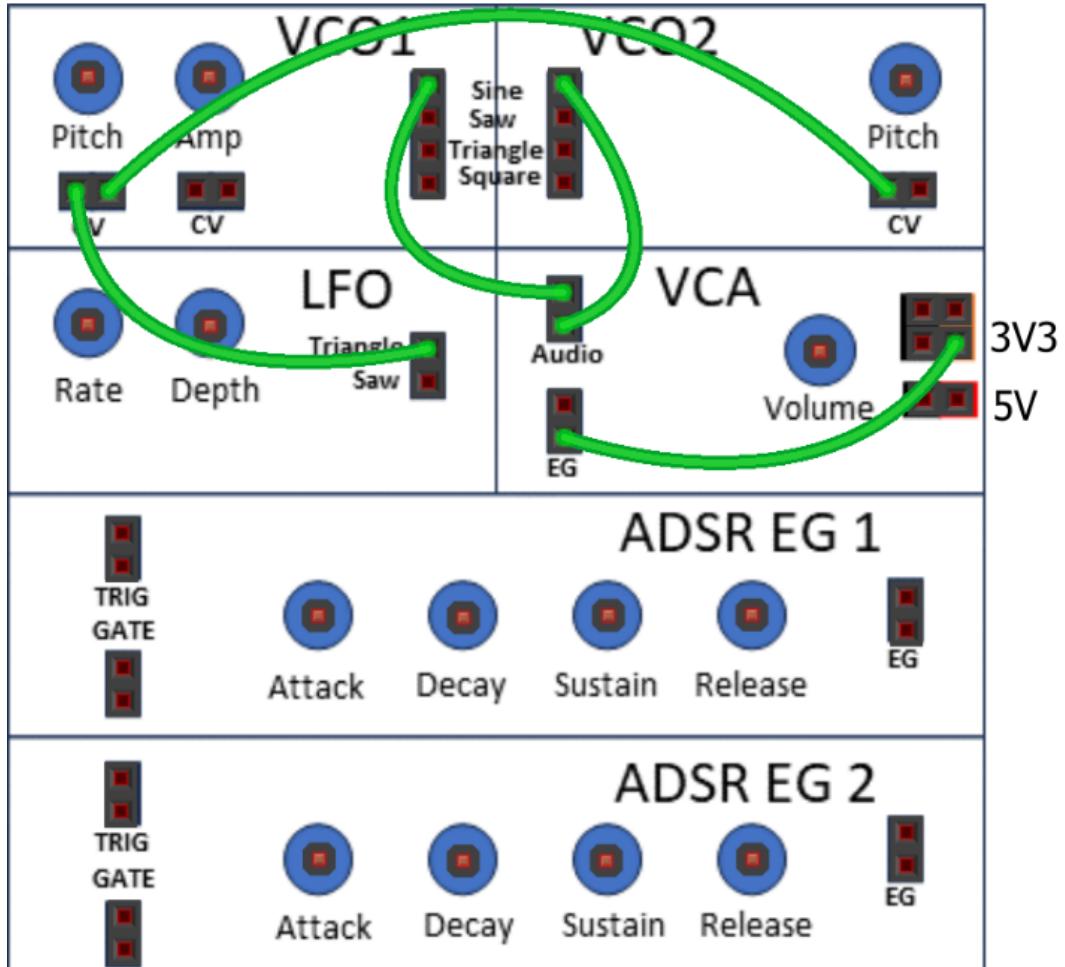
- VCO1 Amp must be turned down.
- Try LFO Rate and Depth.
- Try both LFO waveforms.

5. LFO Pitch Modulation



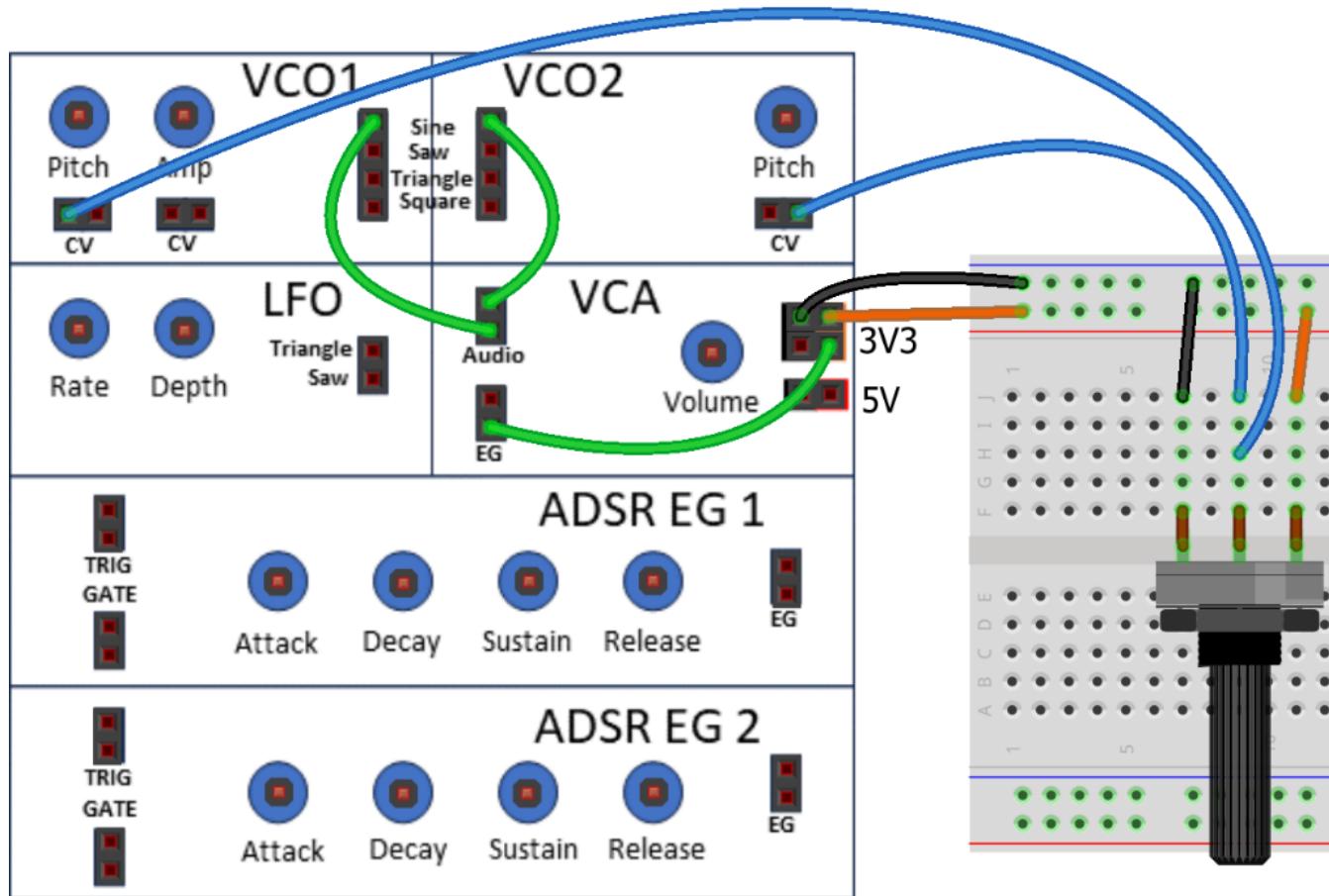
- Turn VCO1 Amp up.
- Try LFO Rate and Depth.
- Try both LFO waveforms.
- Combine Pitch and Amp modulation using both LFO waveforms at the same time.

6. Dual VCO+LFO Pitch Modulation



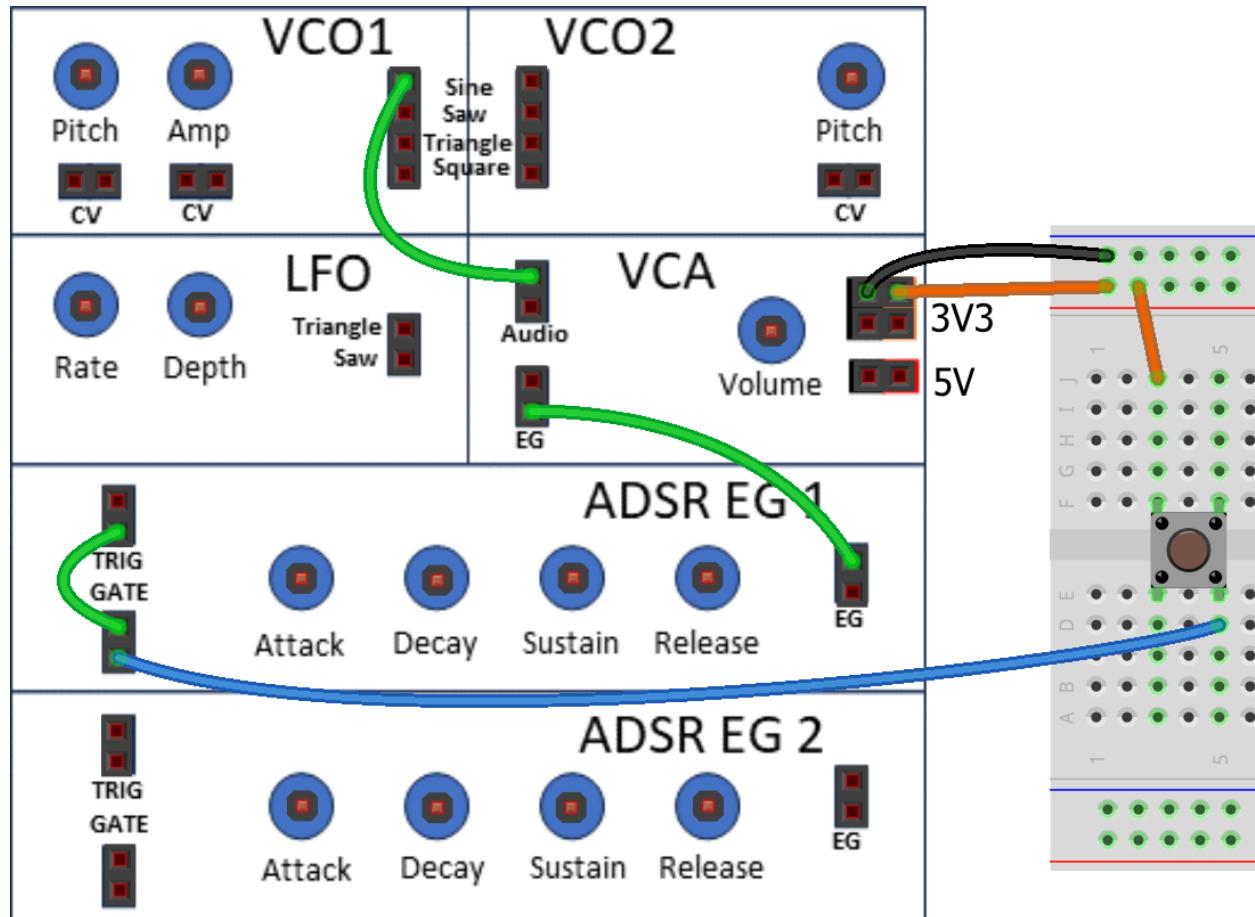
- Links VCO1 and VCO2 CVs.
- Turn LFO off and tune VCOs to 1 octave.
- Try LFO Rate and Depth.
- Try LFO waveforms.
- Connect one LFO waveform to VCO1 and one to VCO2.

7. External Dual VCO Pitch Control



- 3V3 and GND to breadboard.
- Potentiometer to VCO1 and VCO2 CVs.
- Detune one VCO.
- Try:
 - Tune to one octave or different intervals.
 - Different waveforms.
 - Add LFO to amplitude modulate VCO1.

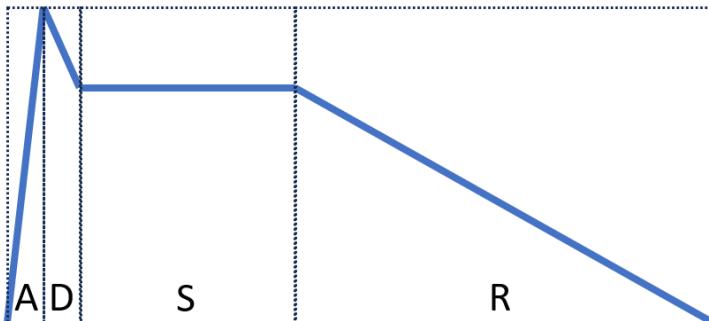
8. ADSR Envelope Generator



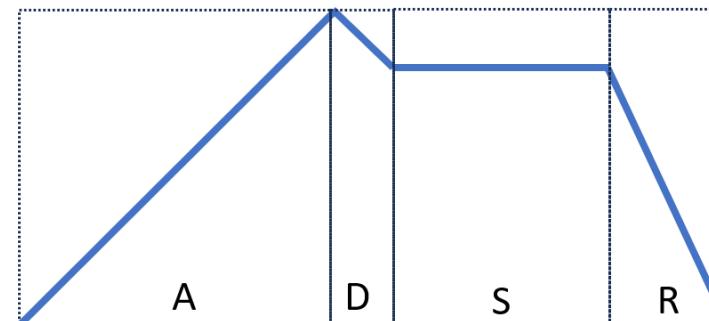
- 3V3 and GND to breadboard.
- ADSR EG1 EG to VCA.
- EG1 TRIG and GATE linked.
- Start with:
 - A: almost full anti-clockwise.
 - D: almost full anti-clockwise.
 - S: fully clockwise.
 - R: in the middle.
- Try different A, D, S, R settings.

9. ADSR Envelope Generator – Part 2

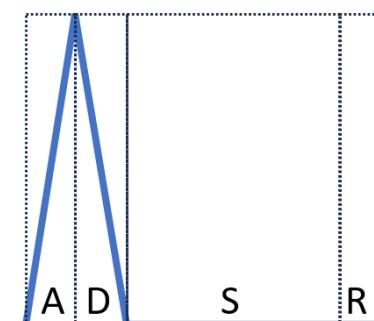
- Attempt to create the following envelopes:



Short attack.
Short decay.
High sustain.
Long release.

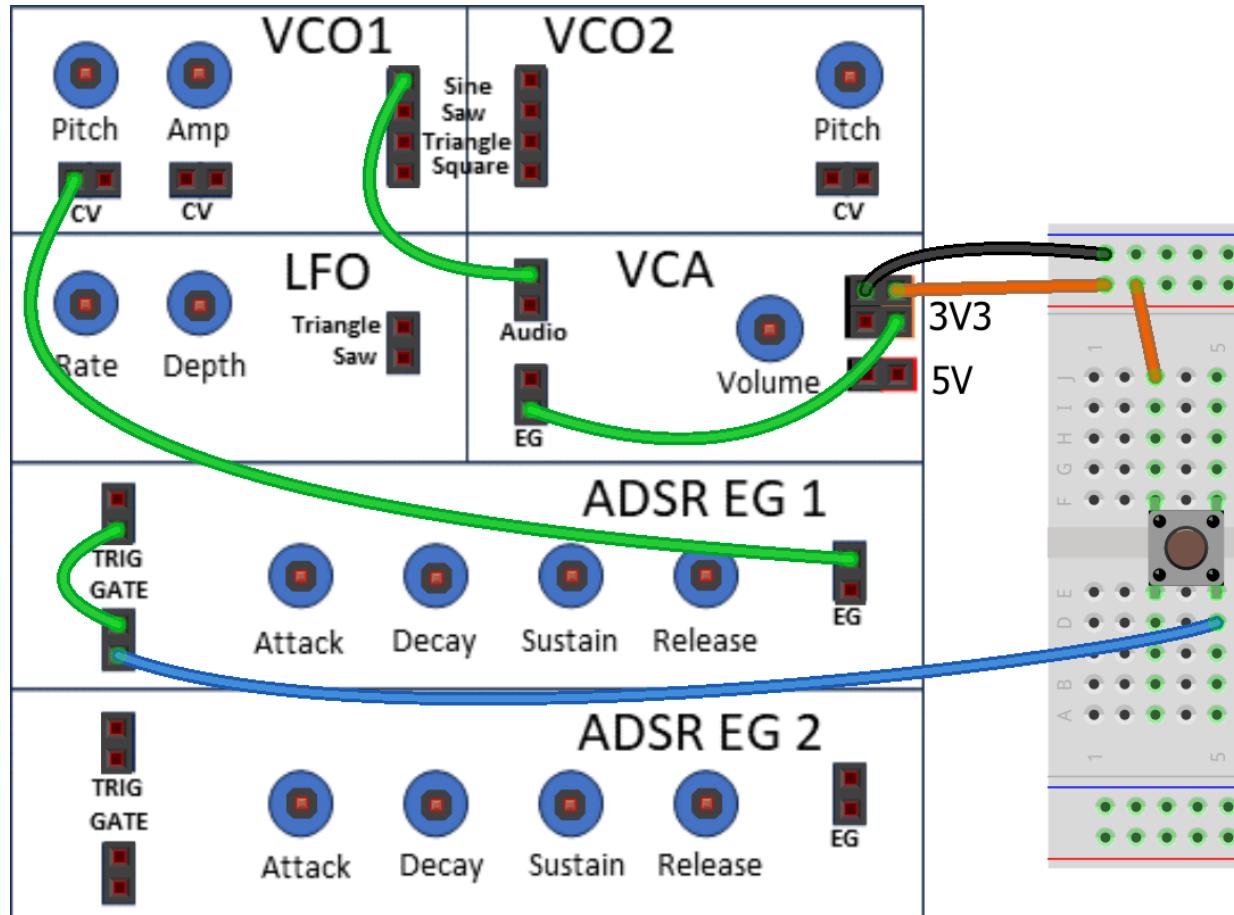


Long attack.
Short Decay.
High sustain.
Short release.



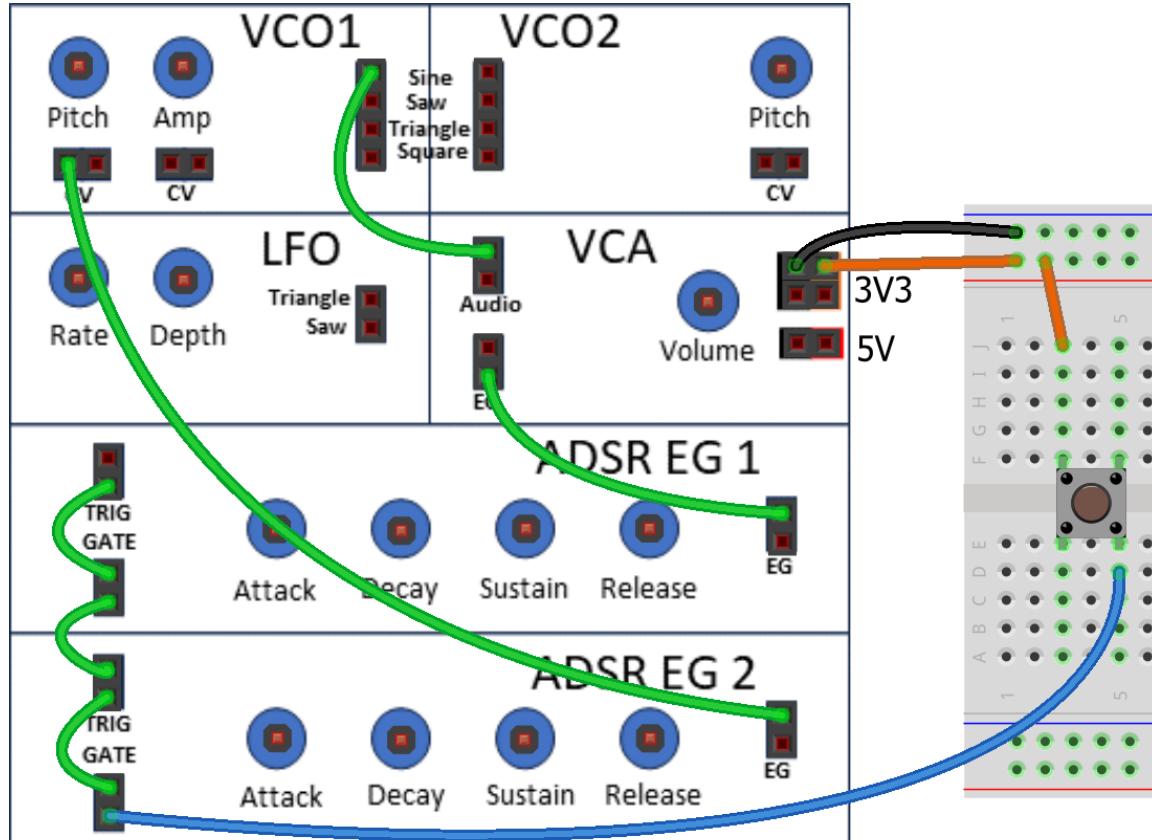
Short attack.
Short decay.
No sustain.
No release.

10. ADSR Envelope Generator for Pitch



- VCA EG to 3V3 again.
- EG1 to VCO1 Pitch.
- Try different A, D, R timings.
- Try different S level.

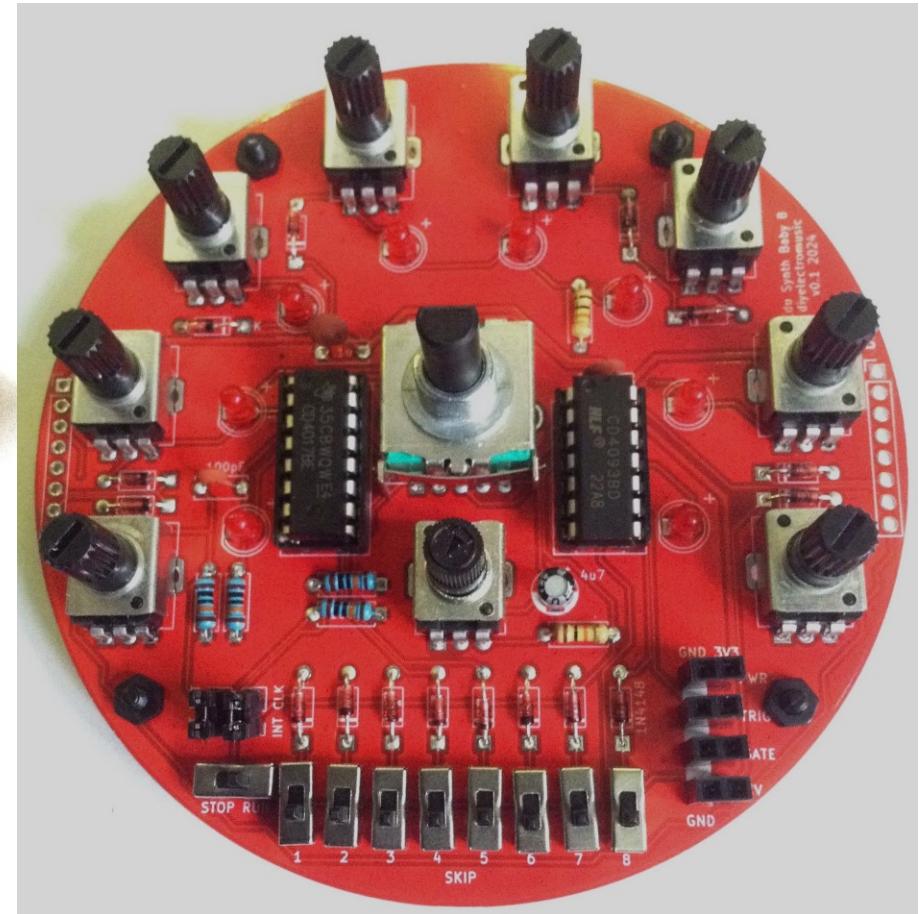
11. ADSR Envelope Generator for Amplitude and Pitch



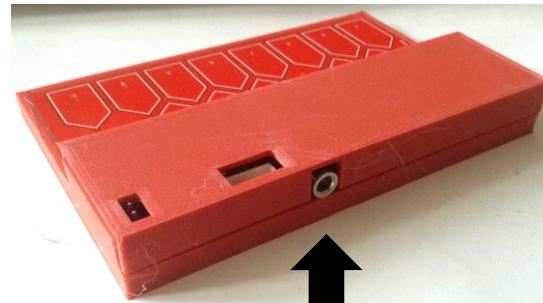
- EG1 back to controlling VCA.
- EG2 now controlling VCO Pitch.
- Try different A, D, S, R settings for both amplitude and pitch.

Optional Add-ons

Keyboard and Sequencer

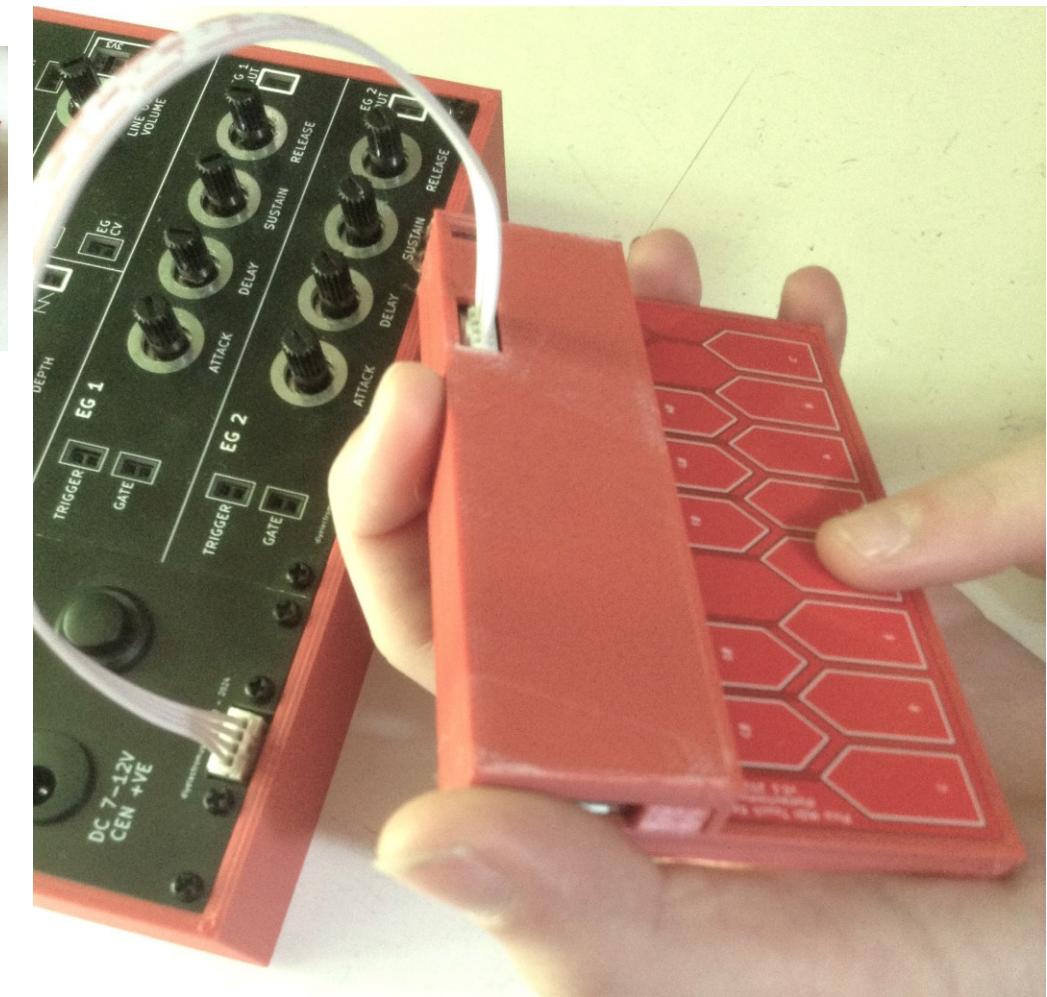


Adding a Touch Keyboard

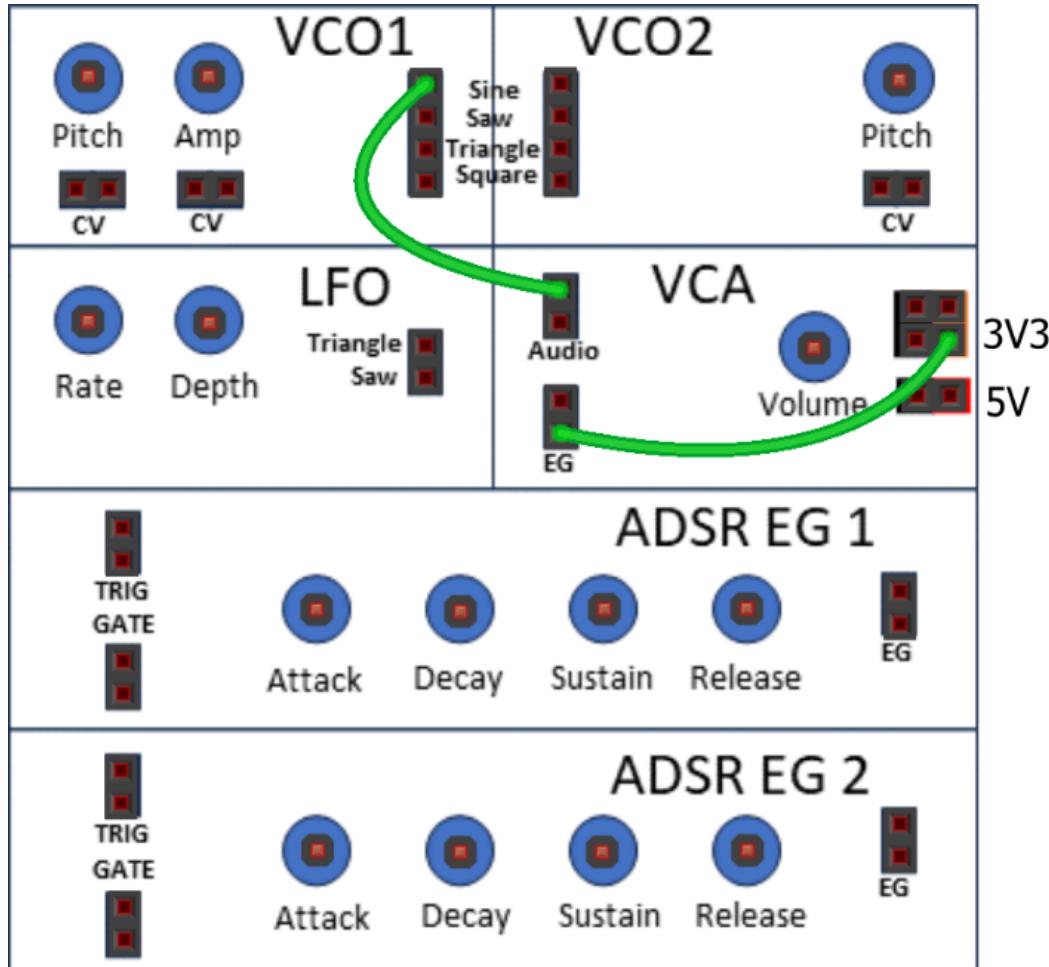


GND Point.

Touch when in use
for better accuracy
and reliability...

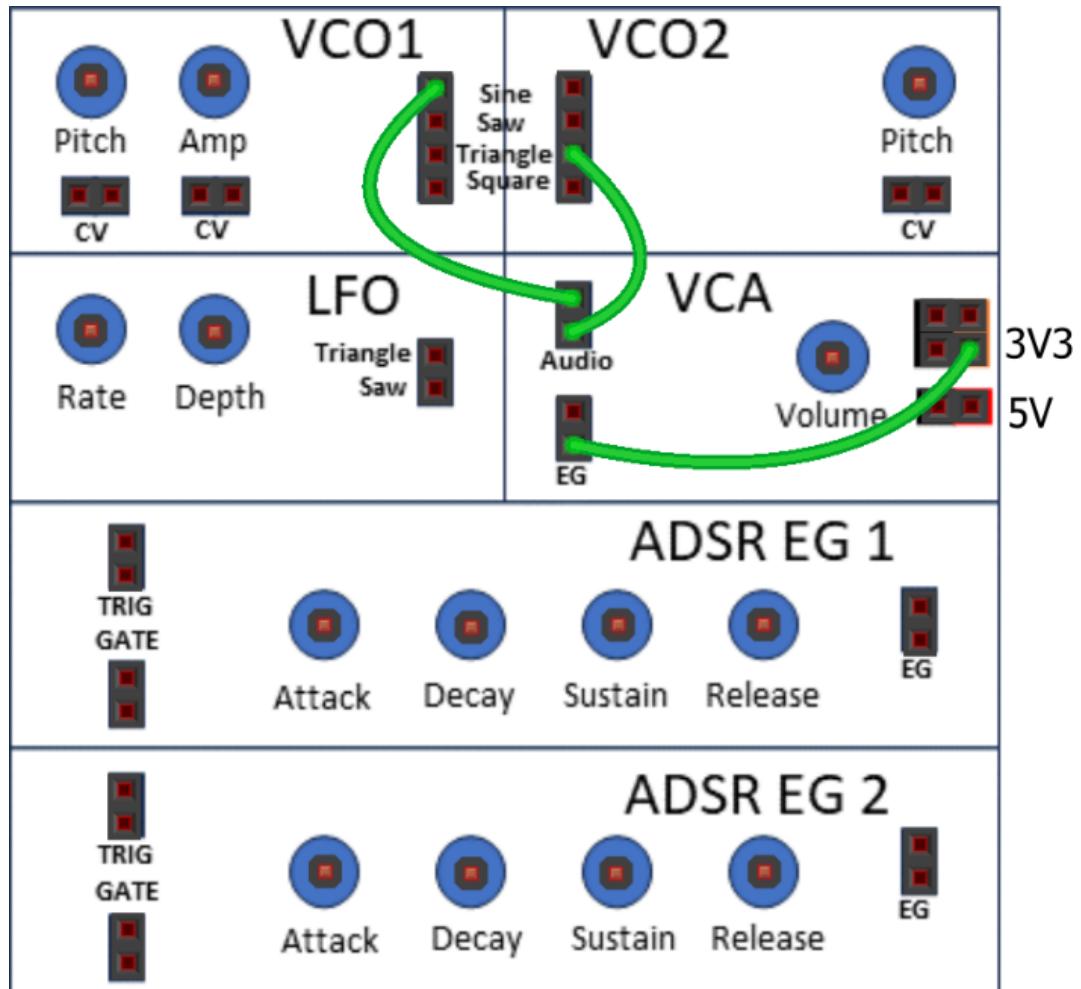


1. Basic Oscillator (VCO) Circuit



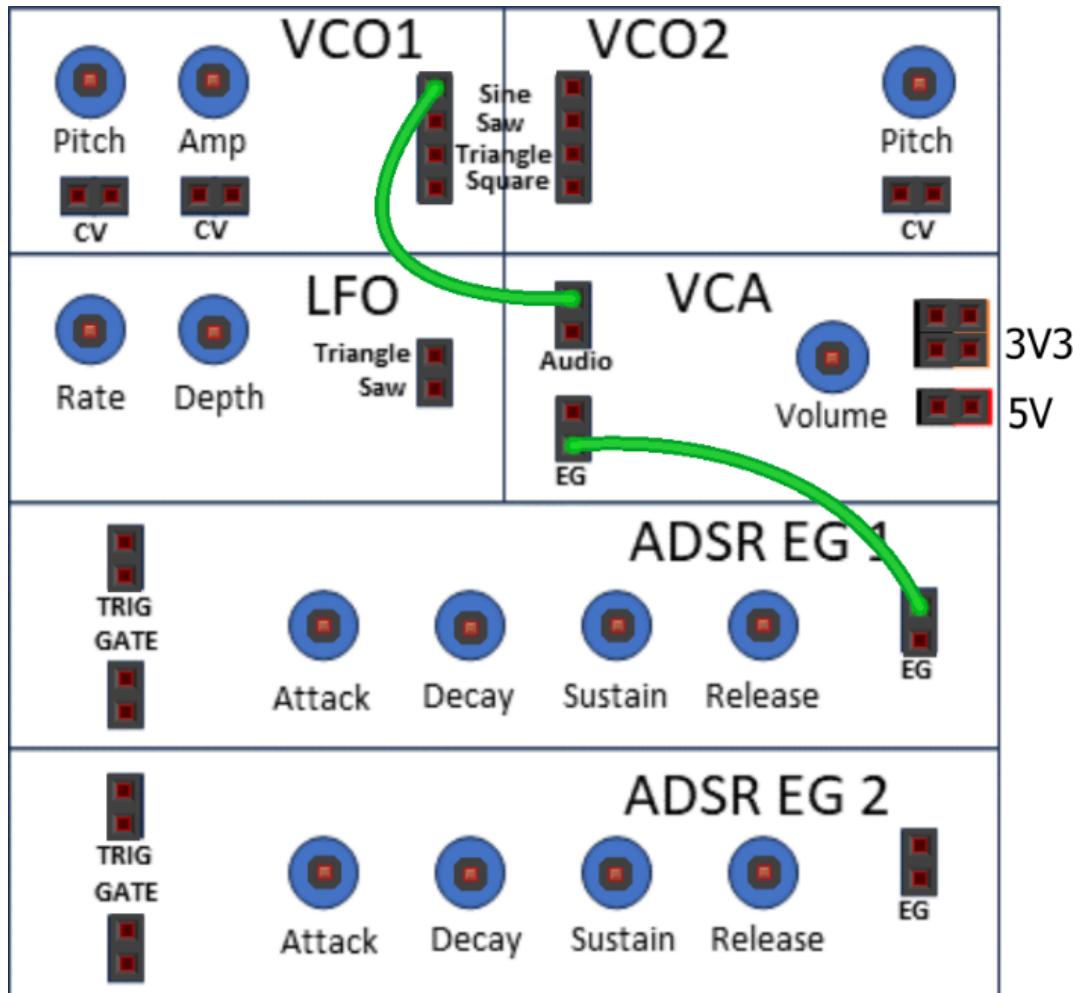
- VCA EG Fixed at 3V3.
- Turn up VCA Volume.
- Turn down VCO1 Pitch.
- Play some notes.
- Experiment with:
 - VCO1 Amp.
 - VCO1 Pitch.

2. Dual Oscillator Circuit



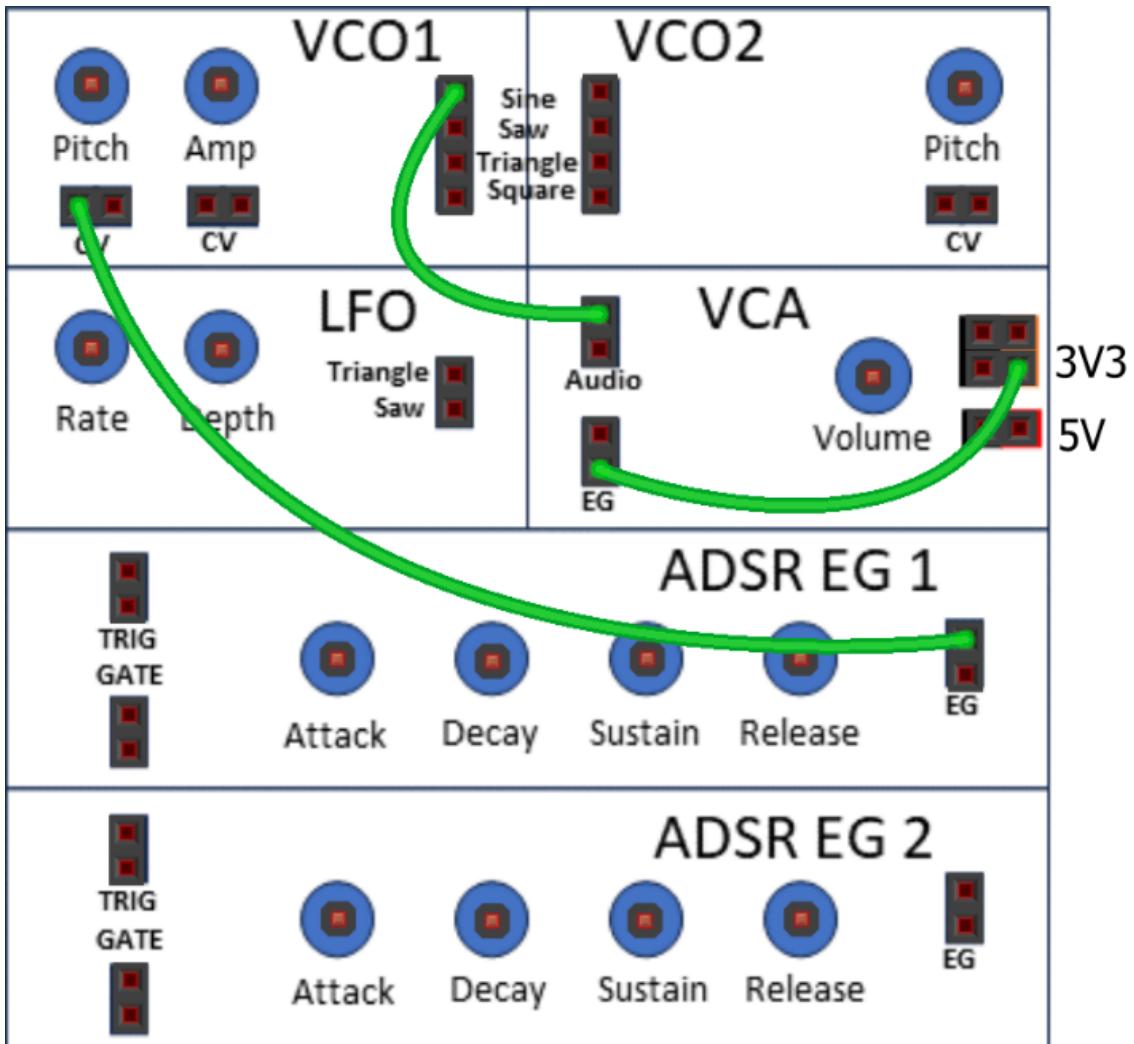
- Turn down VCO1 and VCO2 Pitch.
- Turn up VCO1 Amp and VCA Volume.
- Play some notes.
- Experiment with:
 - Changing VCO2 Pitch to detune.
 - Different Waveforms.
 - Changing VCO1 and VCO2 Pitch.

3. ADSR Envelope Generator



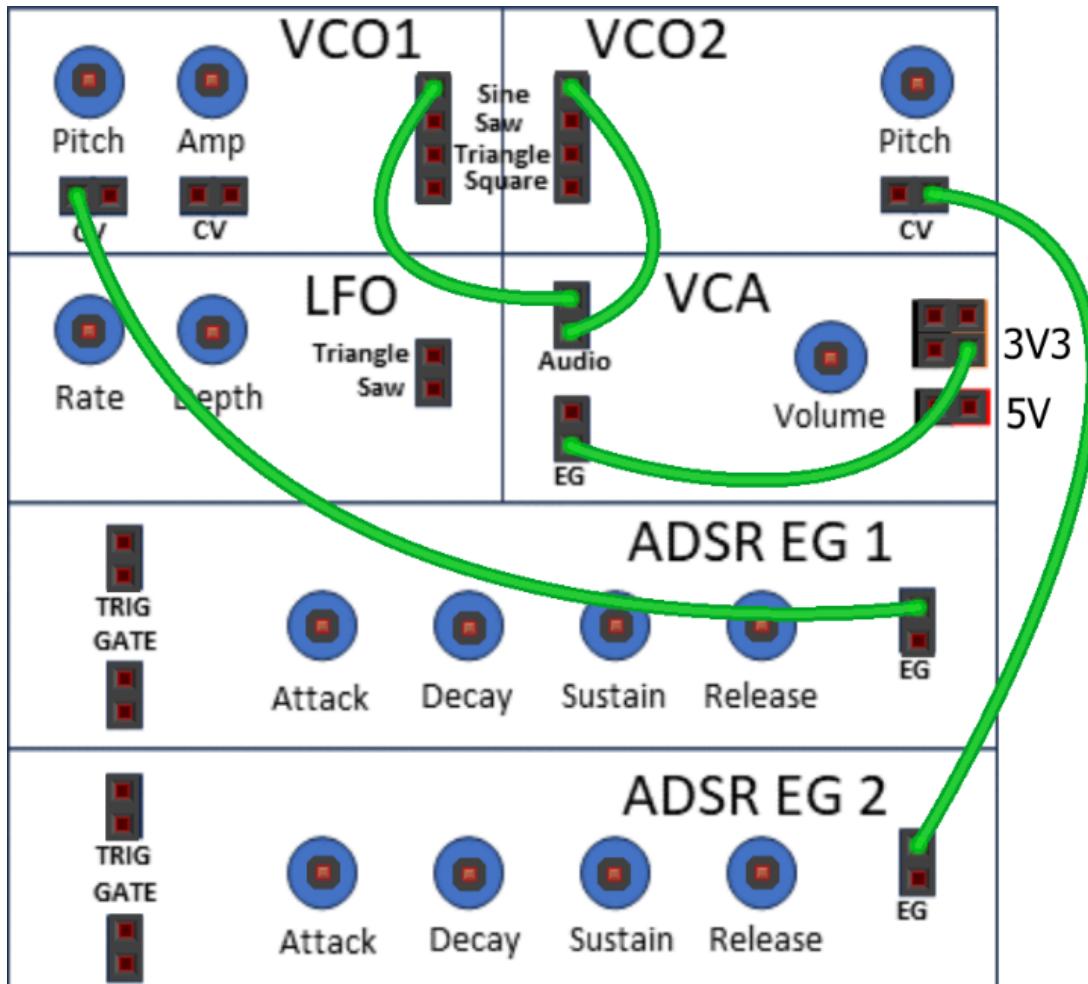
- VCA is now connected to EG1.
- Start with:
 - VCO1 Pitch right down.
 - VCO1 Amp and VCA Volume right up.
 - A: almost full anti-clockwise.
 - D: almost full anti-clockwise.
 - S: fully clockwise.
 - R: in the middle.
- Play some notes.
- Experiment with different ADSR settings.

4. ADSR Generator for Pitch



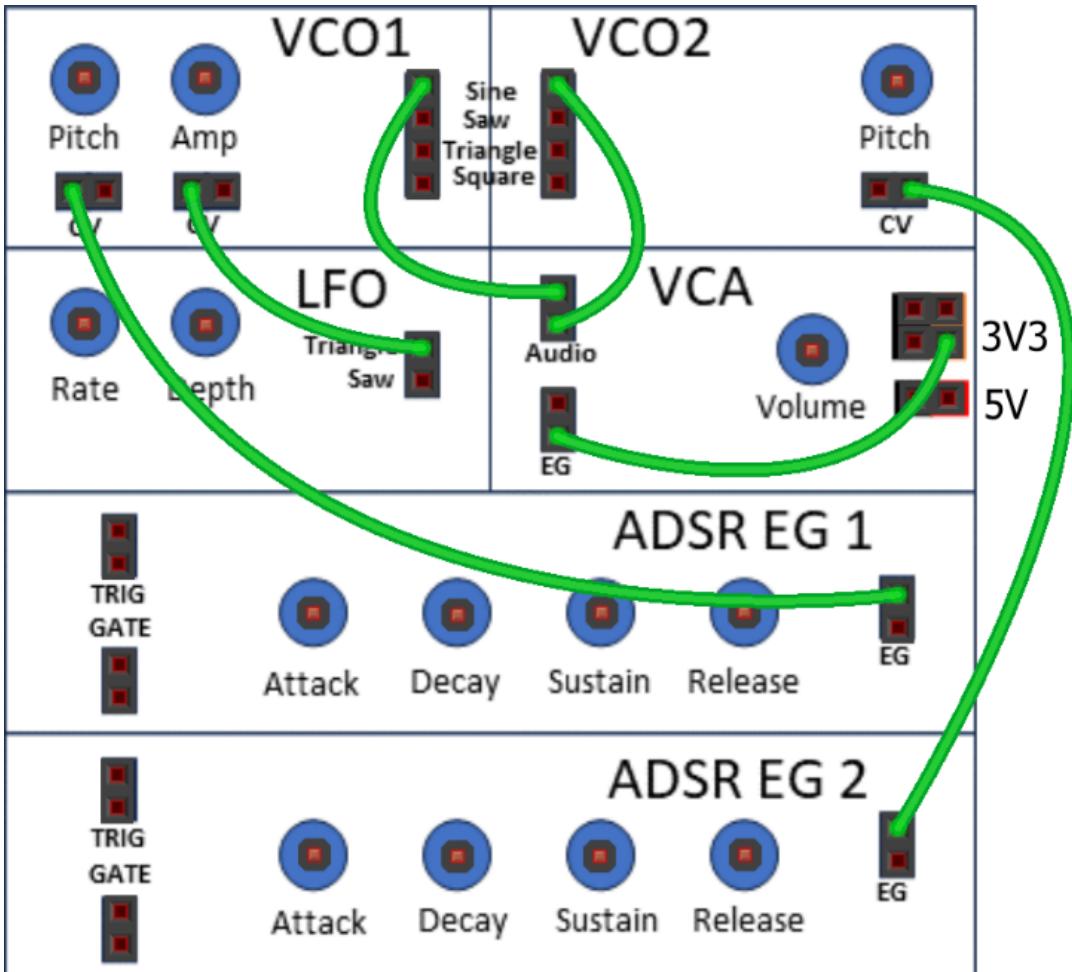
- VCA is back to constant 3V3 CV.
- Start with:
 - VCO1 Pitch turned right down.
 - Fairly low Sustain.
 - VCO1 Amp and VCA Volume turned up.
- Play some notes.
- Experiment with:
 - Different ADSR settings.
 - VCO1 Pitch control.

5. ADSR Envelope Generator – Dual Pitch



- Start with:
 - Both Pitch controls turned right down.
 - Low Sustain (S) level on each EG.
- Play some notes.
- Experiment with:
 - Both sets of ADSR Settings.
 - Detuning VCO2.
 - Setting VCOs an octave apart.
 - Different waveforms.

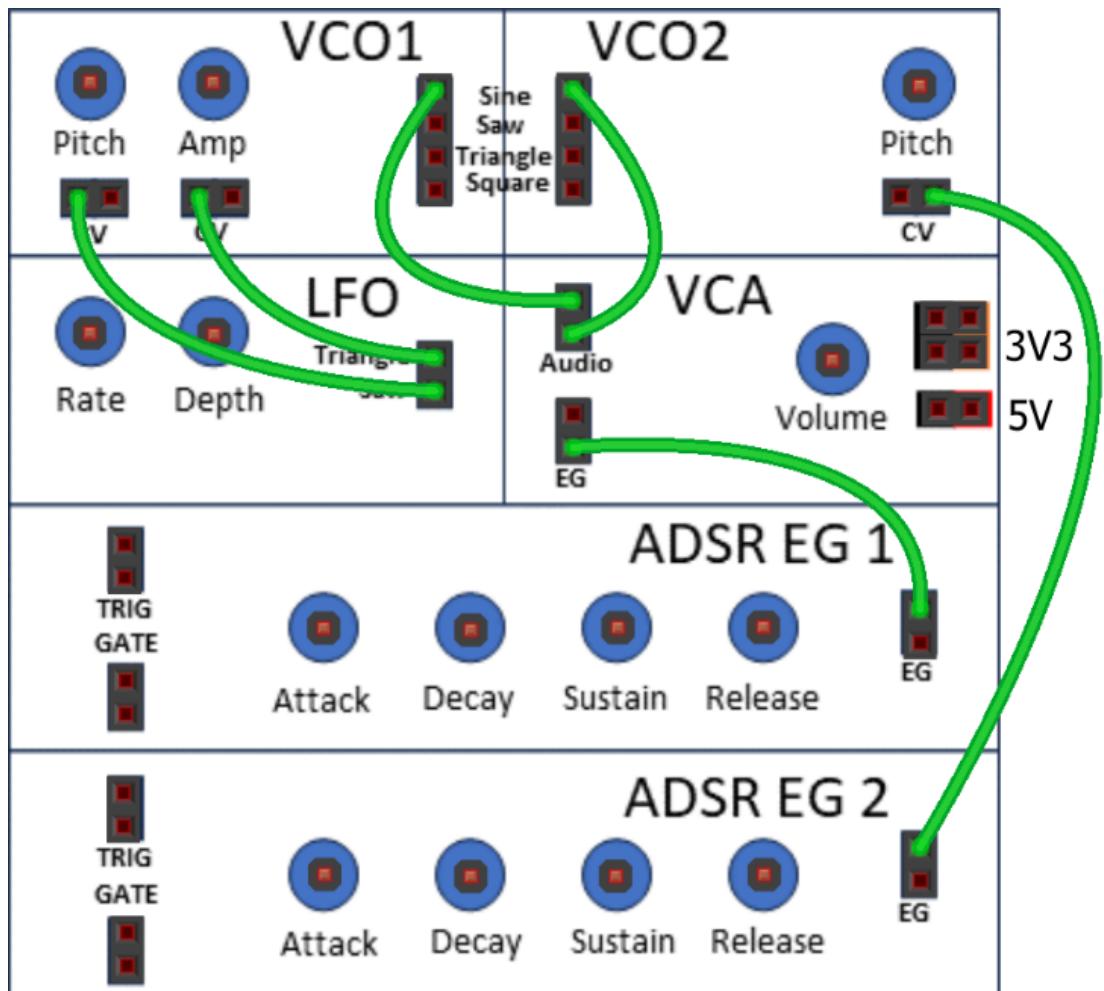
6. Include the LFO



fritzing

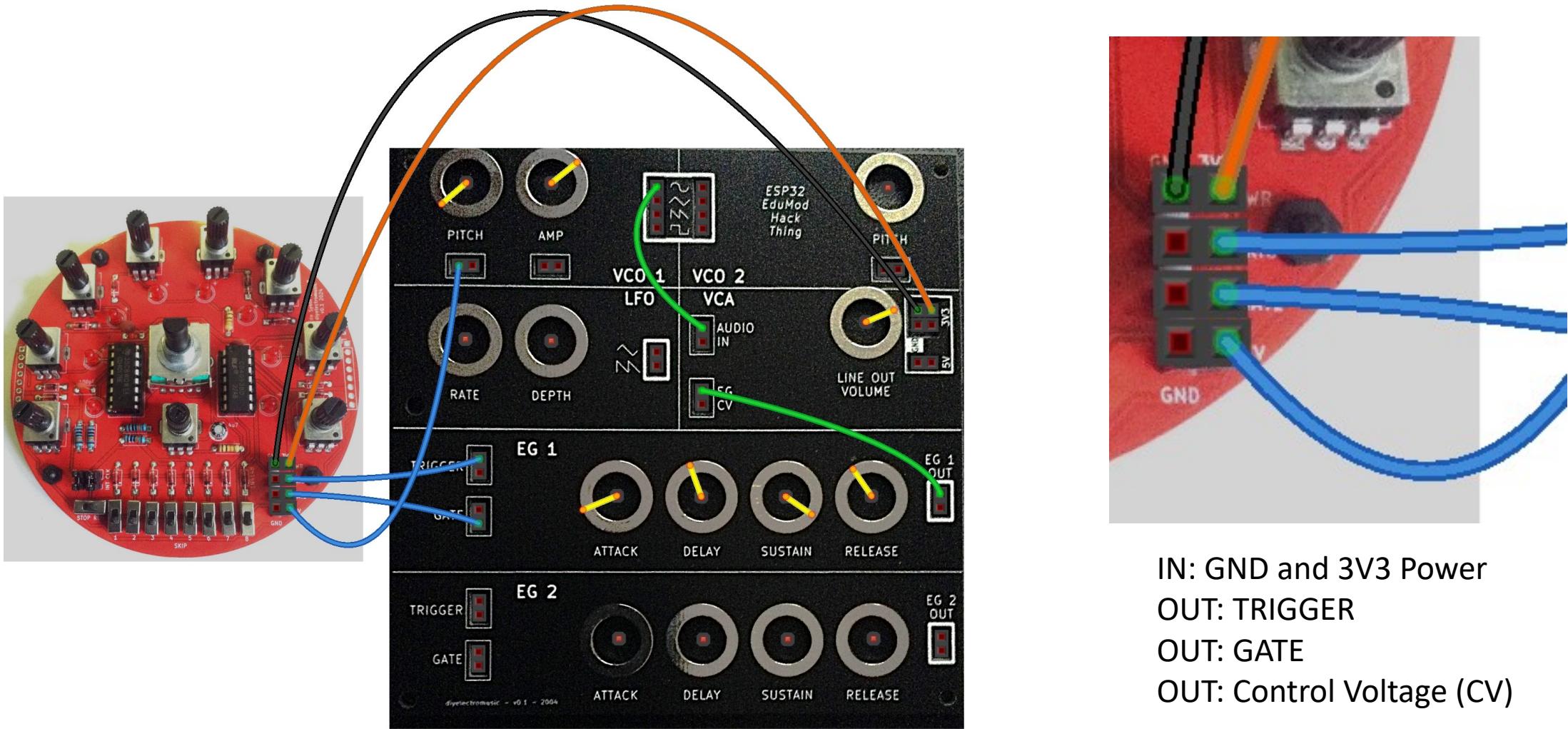
- Start with:
 - Both VCO Pitch turned down.
 - VCO1 Amp turned down.
 - VCA Volume turned up.
 - Sustain (S) pretty low or even disconnect EGs to start with.
- Experiment with:
 - LFO Rate and Depth.
 - LFO Waveforms.
 - ADSR for both EGs.
 - VCO Pitch controls.
 - VCO Waveforms.

7. Final Keyboard Patch



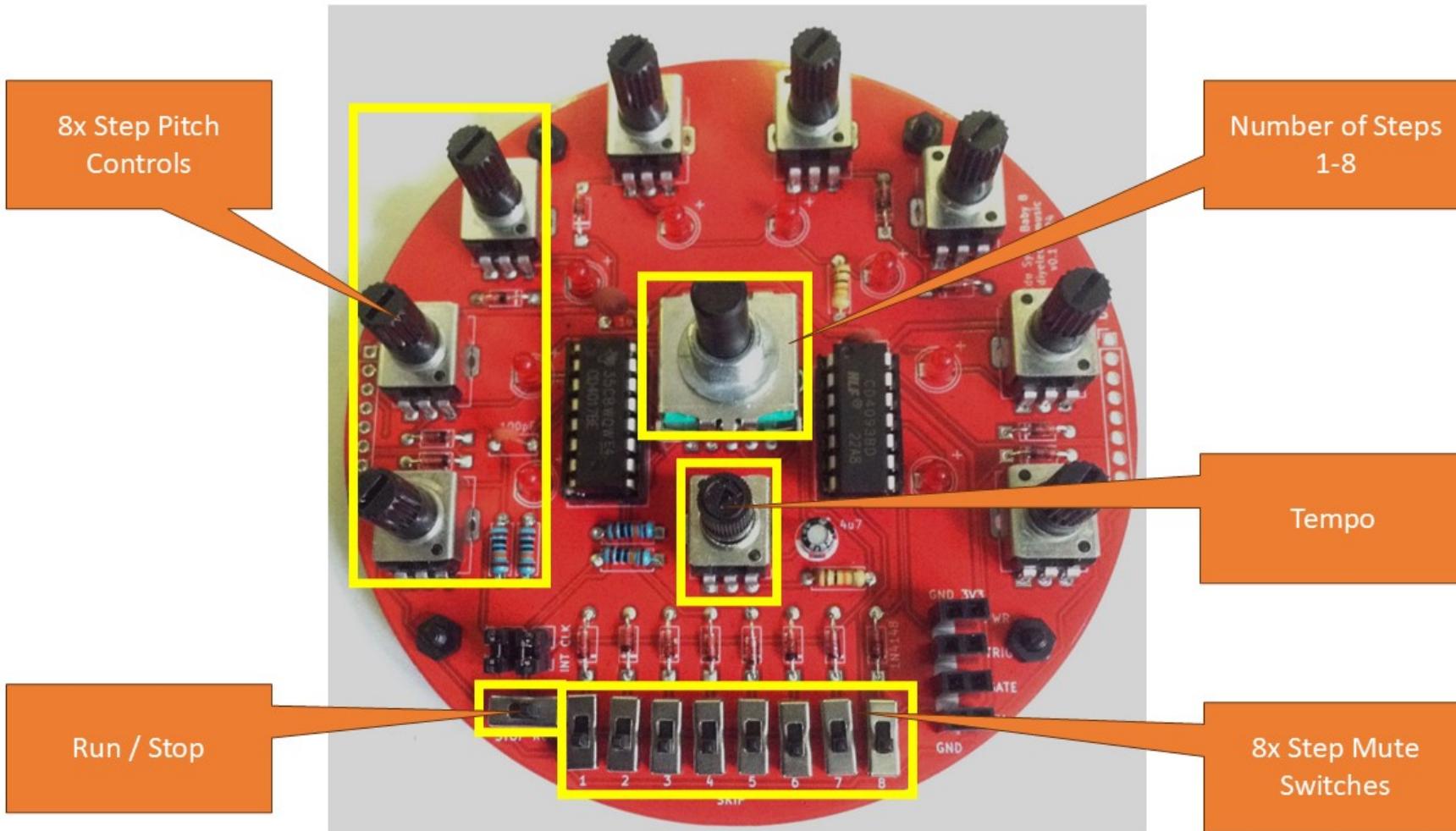
- Complete keyboard patch:
 - EG1 controls VCA.
 - LFO controls both Pitch and Amp for VCO1.
 - EG2 controls VCO2.
- Experiment with:
 - Rate and Depth of LFO.
 - Different links between LFO and VCO1.
 - VCO waveforms.
 - EG1 ADSR.
 - EG2 ADSR.

Adding a Baby-8 Sequencer

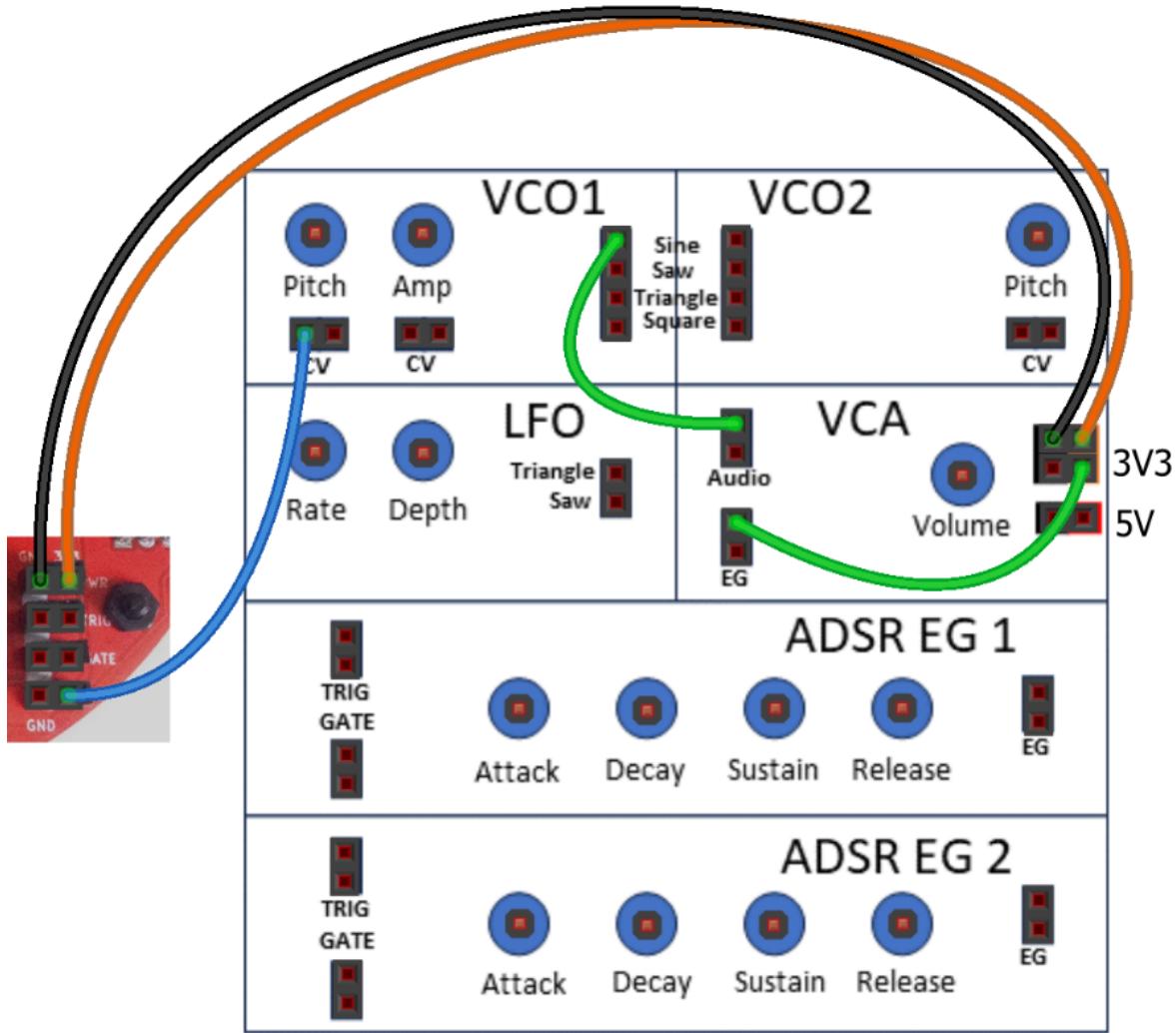


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Basic Controls

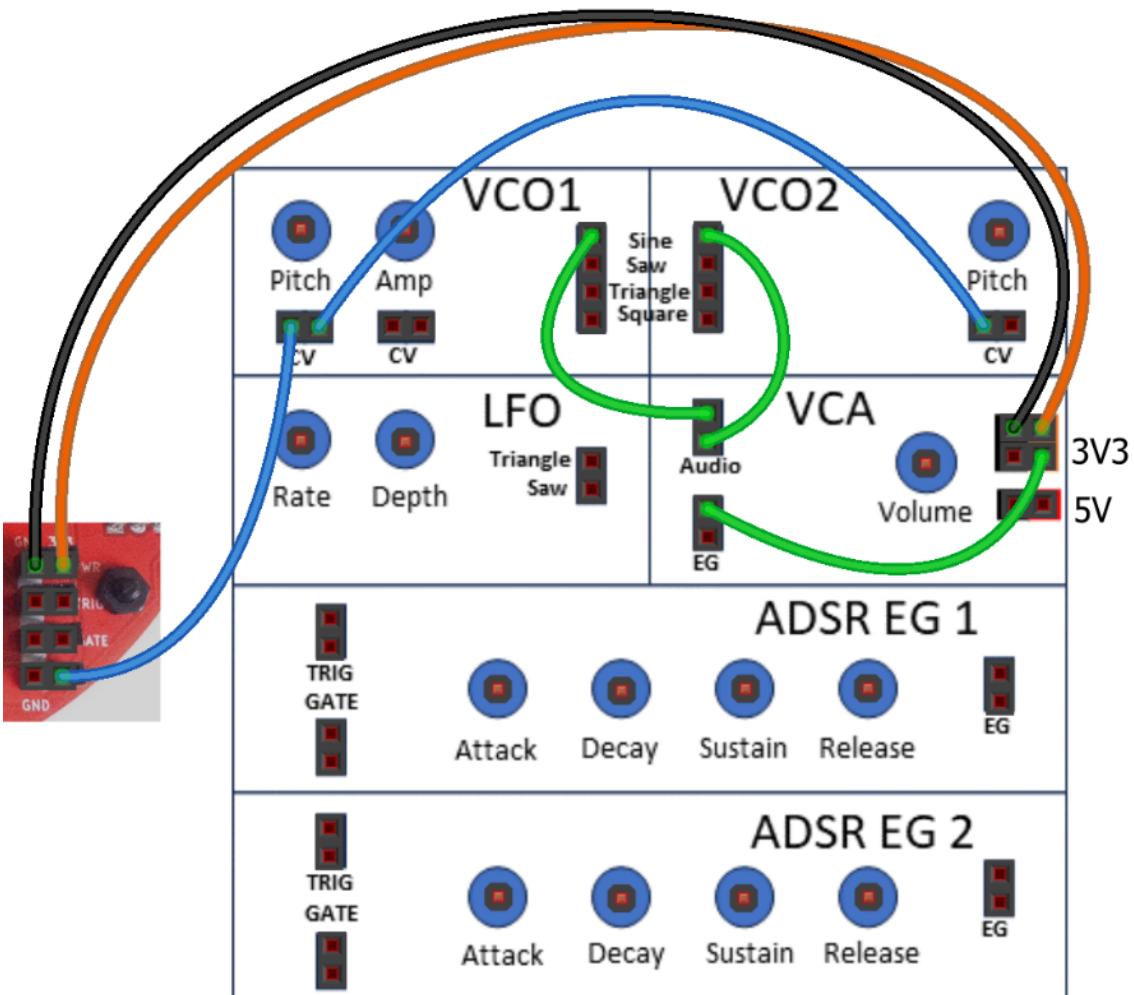


1. Simple Pitch Sequence



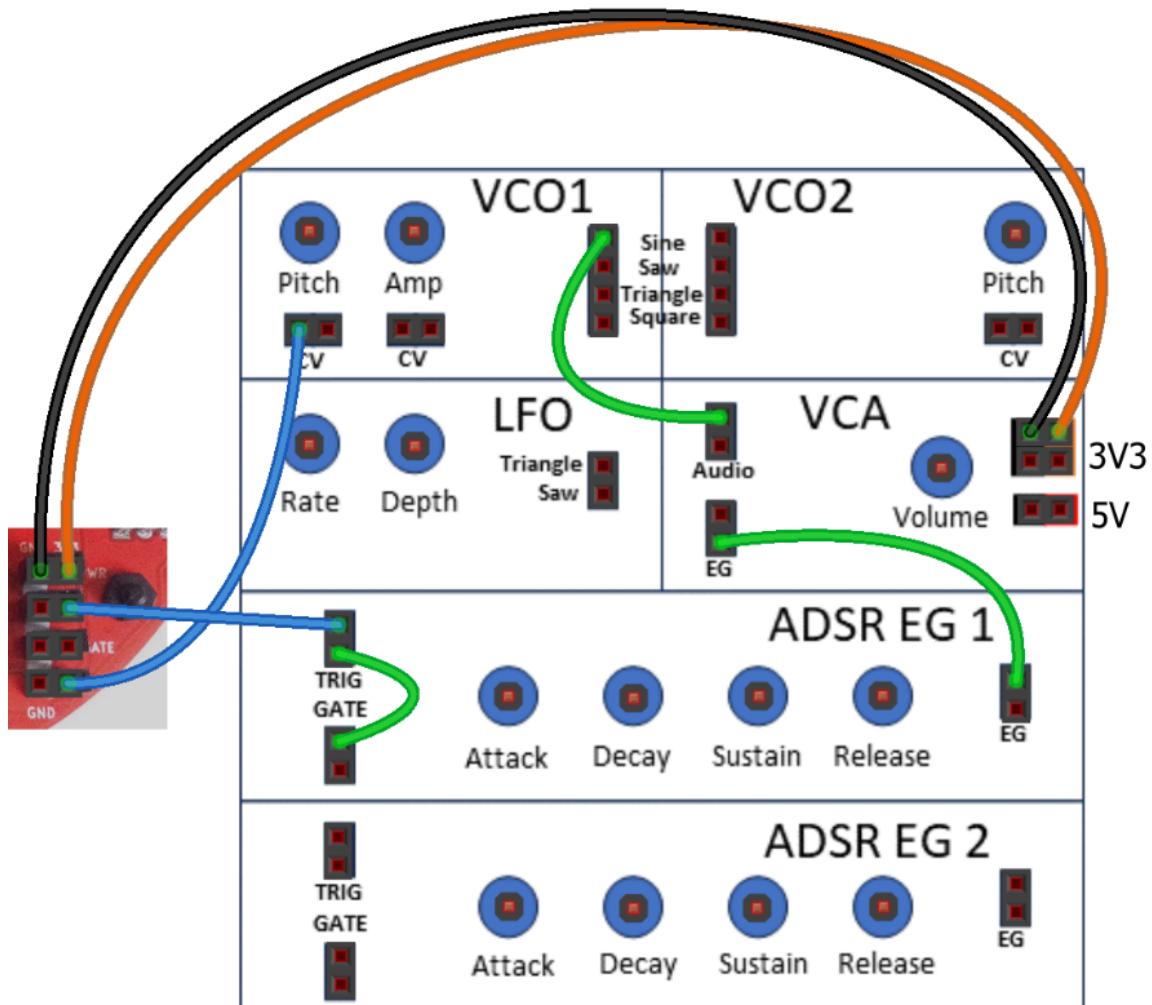
- VCA EG Fixed at 3V3.
- Start with:
 - Turn down VCO1 Pitch.
 - Turn up VCO1 Amp and VCA Volume.
 - Baby 8 Steps fully clockwise (8 steps).
 - Baby 8 Run/Stop -> Run (to the right).
- Experiment with:
 - All 8 Baby 8 step Pitch controls.
 - Baby 8 Tempo.
 - Baby 8 Number of Steps.
 - Baby 8 Run/Stop.

2. Dual Pitch Sequence



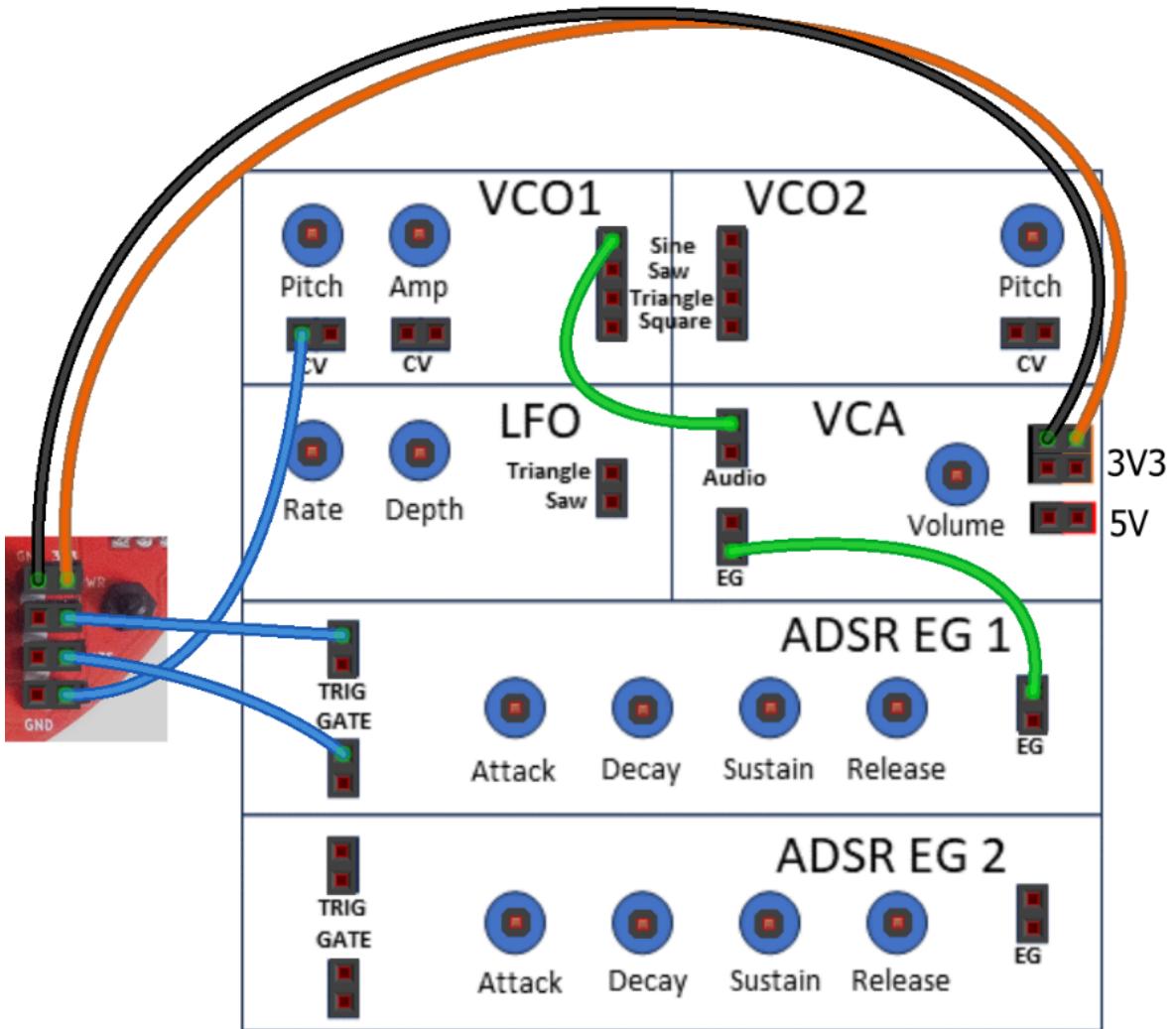
- Both VCOs connected.
- Start with:
 - VCO Pitch controls turned right down.
 - VCO1 Amp and VCA Volume right up.
 - Baby 8 steps fully clockwise (8 steps).
 - Baby 8 Run/Stop -> Run (to the right).
- Experiment with:
 - Detune VCO2.
 - Different Waveforms.
 - Different Pitch controls.
 - Adjust the sequence.

3. Baby 8 Trigger



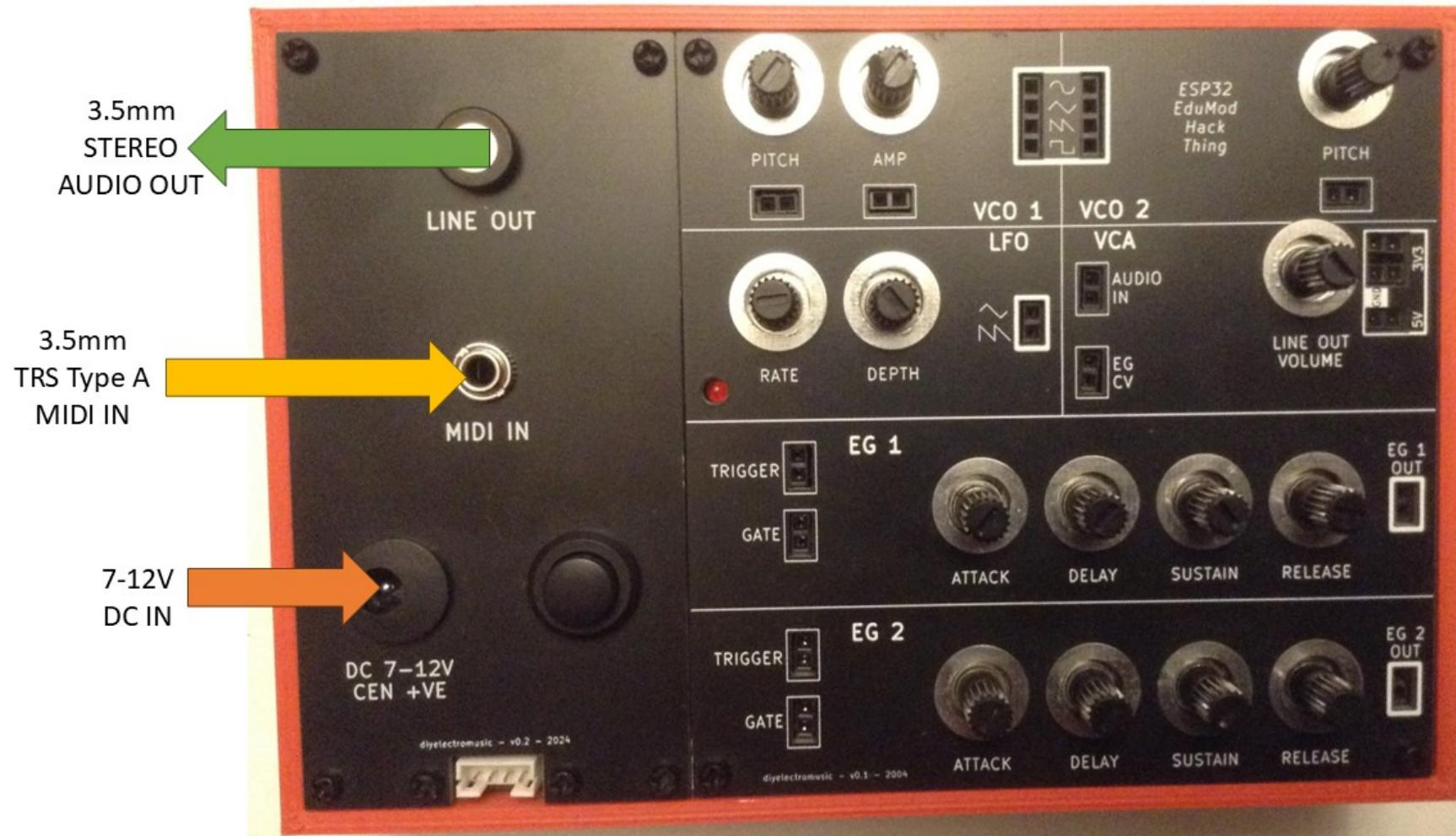
- More useful Baby 8 EG Option
- Start with:
 - VCO1 Pitch right down.
 - VCO1 Amp and VCA Volume right up.
 - A: almost full anti-clockwise.
 - D: almost full anti-clockwise.
 - S: fully clockwise.
 - R: in the middle.
 - Baby 8 slow Tempo (anti-clockwise).
- Experiment with:
 - Adjust ADSR settings.
 - Baby 8 mute switches.
 - Baby 8 Tempo.

4. Baby 8 Trigger and Gate

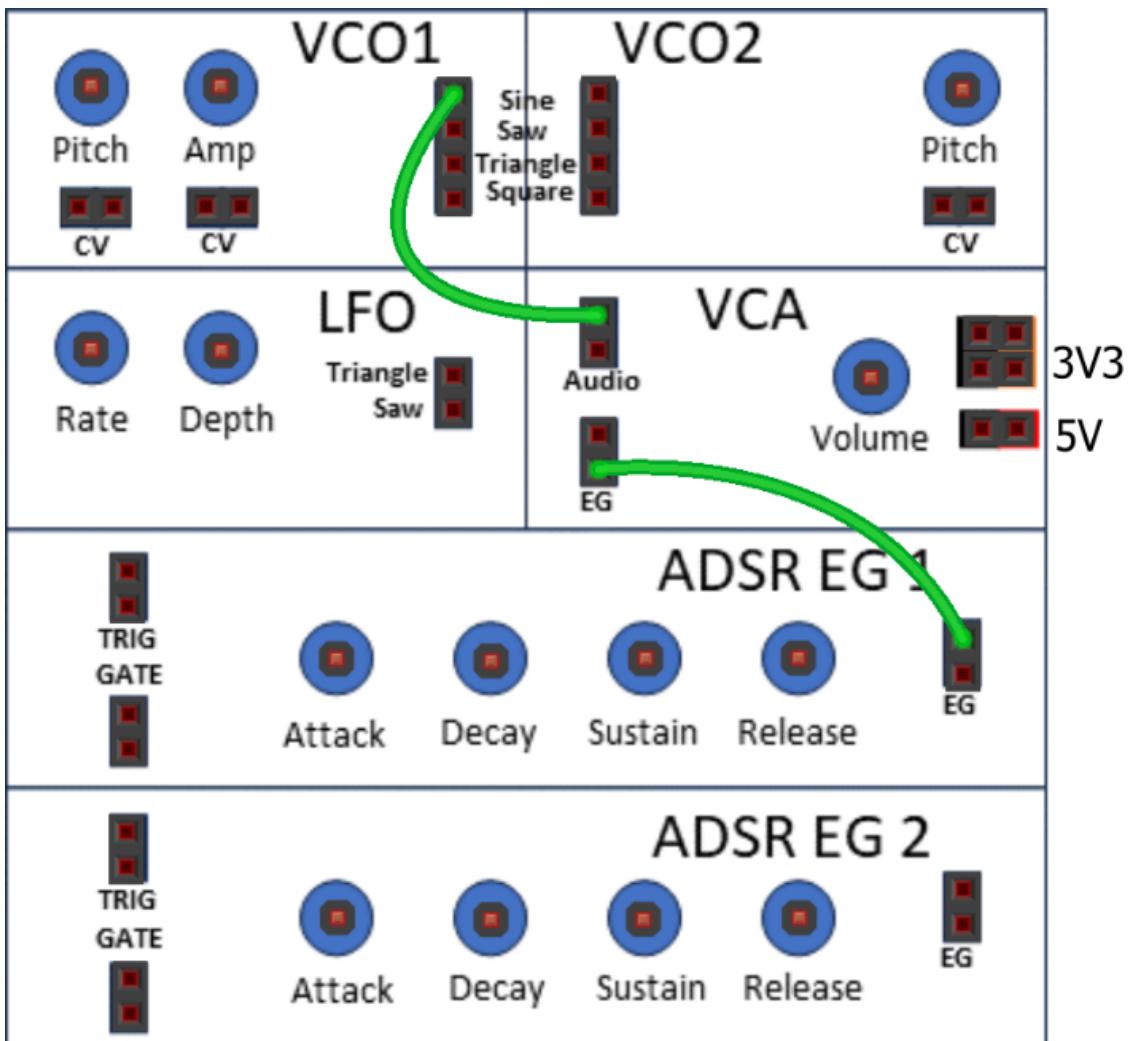


- The less useful (more complex) option!
- Start – as previous experiment.
- Try muting steps 2, 4, 6 and 8.
- Experiment with ADSR settings.

MIDI



Basic MIDI Patch



- MIDI Channel 1. Mapped to:
 - Both VCO Pitch CVs.
 - Both EG TRIG and GATE.
- Start with:
 - VCO1 Pitch turned right down.
 - VCO1 Amp and VCA Volume turned right up.
 - EG1: Short A, Short D, High S, Medium R.
- Experiment with:
 - Pitch range available through MIDI.
 - Adding second VCO.
 - ADSR settings.
 - Adding LFO.
 - Adding second EG2.