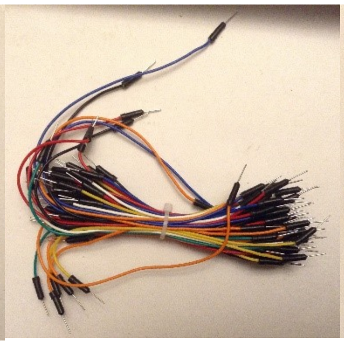
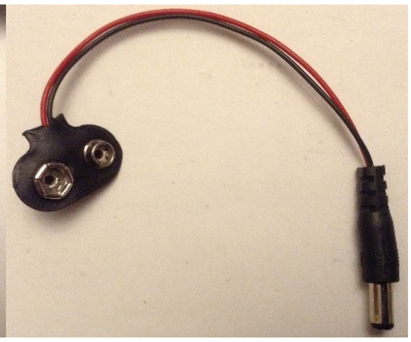
The Educational DIY Synth Thing

Introductory Projects

Core Kit List

- Educational Synth Thing – ideally with additional “connector” panel (as shown below).
- Pin to Pin Jumper Wires.
- 3.5mm stereo jack (headphone-style) lead.
- Amplification for a line-level signal.
- Optional: 3.5mm to std jack Stereo to Mono converter.
- 7-12V power source: 2.1mm barrel jack – centre positive.

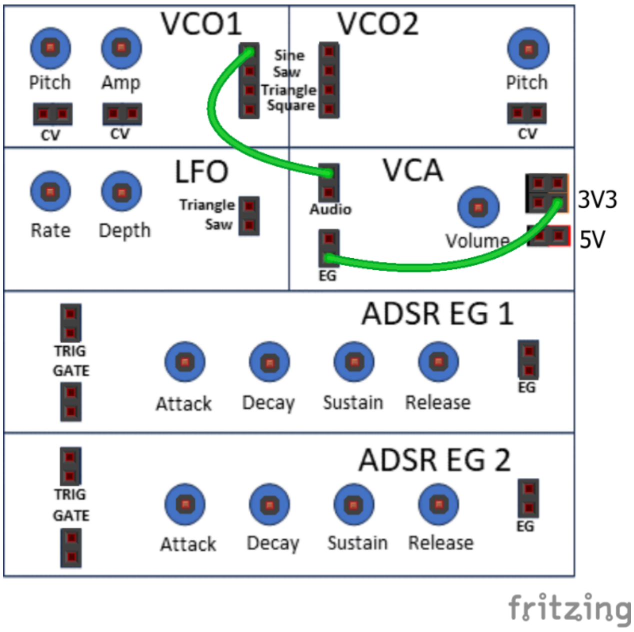
Depending on the amplification used, it might be necessary to convert a 3.5mm stereo (TRS) jack physical connection to a STD (1/4”) mono jack; twin photo jacks; etc.

For power using a 9V battery via a battery clip to 2.1mm barrel jack lead works very well.

Basic Connections

1. Basic Oscillator (VCO) Output

This project explores the sounds of the individual oscillators.



Connect the wires as shown.

This provides a fixed HIGH level signal (3V3) to the VCA which means it will always be sounding – there will be no beginning or end to the sound.

The output of VCO1 is fed into the audio input of the VCA so what is heard is the sound of the VCO directly.

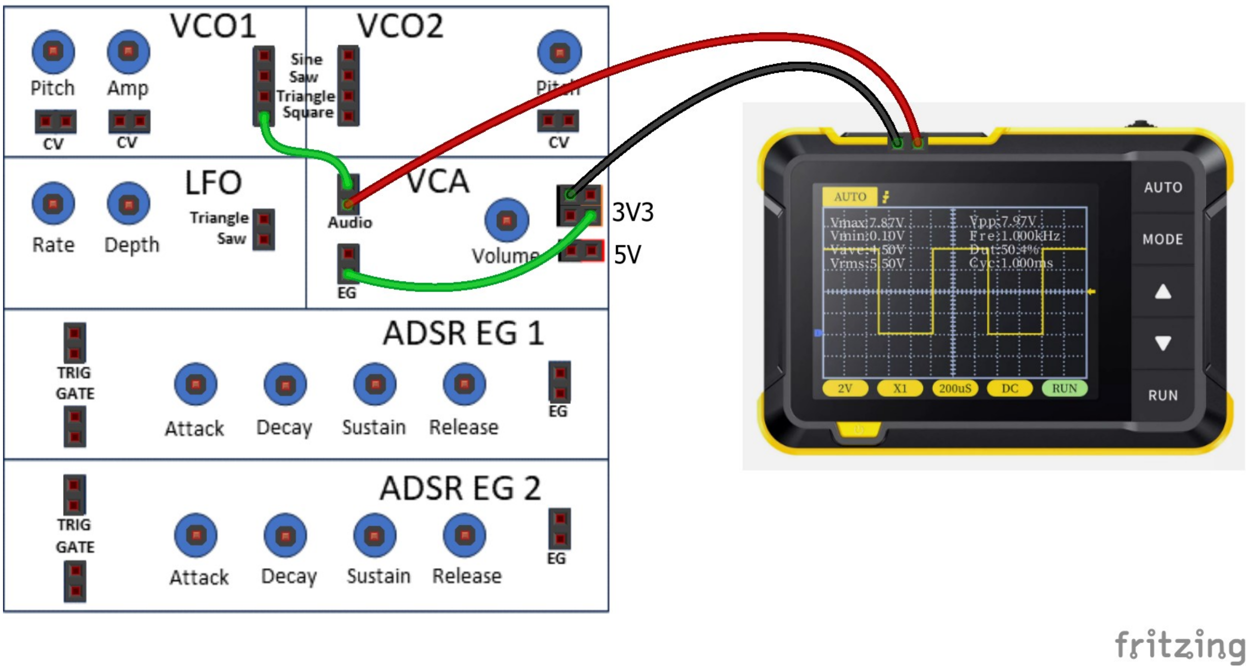
Turn up the VCA volume and the VCO1 amplitude then experiment with the VCO1 pitch control.

What are the lowest and highest sounds it can produce? How do these compare to the lowest and highest notes on a piano?

2. VCO Waveform on an Oscilloscope

In this experiment we hook up an oscilloscope to actually view the waveform created in the first experiment.

The Oscilloscope has two wires to connect to the Synth Thing: a GND wire (black) and a SIGNAL wire (red). The GND



wire has to be connected to one of the GND connections on the Synth Thing and the SIGNAL wire can then be used to probe different connections on the Synth Thing.

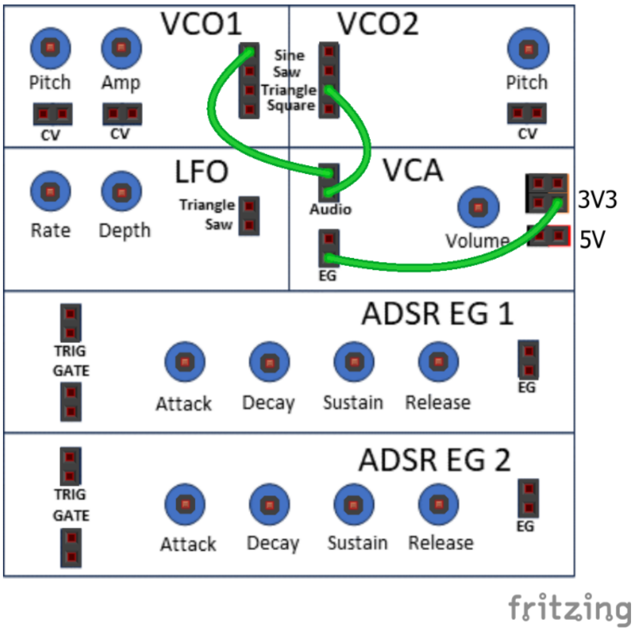
All the connection points apart from the VCO/LFO outputs and the power connections have two header connections. This means it is quite easy to add an extra wire to double up the connection. It is particularly convenient when using an oscilloscope as can be seen here, where it is probing the signal that is being sent into the VCA.

The simplest way to use the oscilloscope is to select “AUTO” mode where it will self-set an appropriate scale to show what it is receiving. If it includes a “frequency” measure try to find the lowest and highest frequencies from the VCO.

Try all four waveforms of the VCO. See how they differ in sound and on the oscilloscope display. See what happens on the oscilloscope as the pitch is changed. See what happens when the amplitude is changed.

3. Dual Oscillator Output

Repeat the first experiment with the second oscillator then try sounding them both at the same time.



Once again connect the wires as shown, again with a constant HIGH signal into the VCA.

This now feeds the outputs of both oscillators into the VCA audio input which performs some rudimentary mixing of the two signals.

The combined sound won't be as loud as a single oscillator for reasons to do with the electronics that I won't go into here.

Experiment with changing the pitches. Experiment with mixing different waveforms.

Use the amplitude setting for VCO1 to fade that signal in and out.

Can you get the oscillators to essentially the same pitch with the same waveform (sine wave probably works best)?

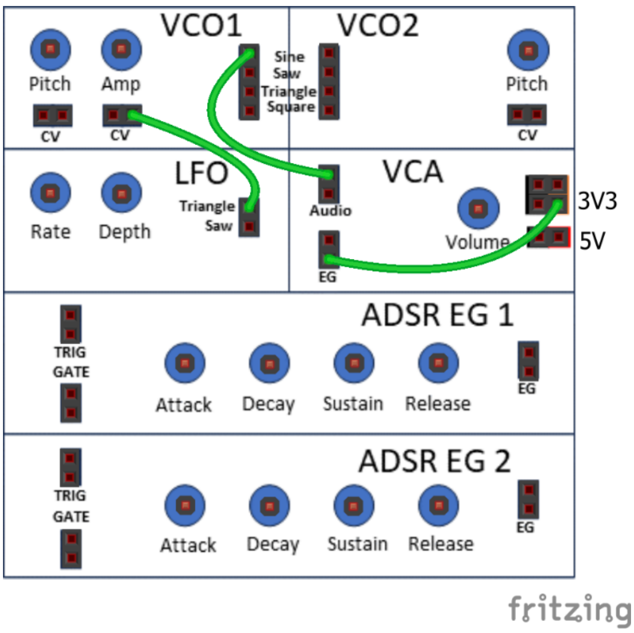
Now make one slightly out of tune. If you're careful you may hear "beats" as the close together pitches react with each other. This is called a ***detune*** effect.

Can you get one oscillator to sound exactly one octave above the other? How about two octaves?

Can you find other intervals, for example a third, a fourth, or a fifth?

4. LFO Amplitude Modulation

This experiment modulates an oscillator using the low-frequency oscillator (LFO).



This time we're using a single oscillator again but connecting its control voltage input to the triangle output of the LFO.

With the amplitude setting turned right down, the only amplitude control will come from the LFO. This means the LFO will be turning the volume up and down according to the rate and depth knobs.

Turn the depth knob all the way up and change the rate knob to see what happens.

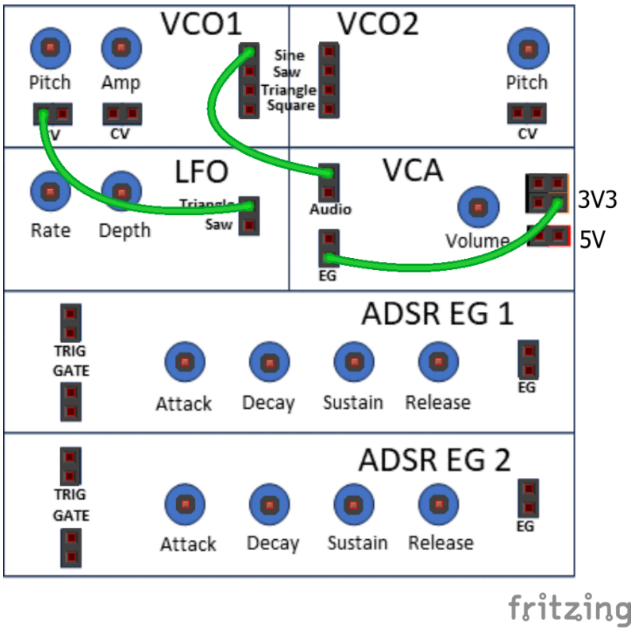
Then turn the rate knob to something in the middle and experiment with changing the depth knob.

Change to use the saw output of the LFO. How does the sound change?

When one module (the LFO) is controlling another module in the synthesizer (the VCO in this case) this is called ***modulation***. In this case the LFO is ***modulating*** the VCO signal. In musical terms, modulating the amplitude gives a ***tremolo*** type effect.

5. LFO Pitch Modulation

This repeats the previous experiment but this time seeing how the LFO can affect pitch.



Wire the triangle output of the LFO into the pitch CV rather than the amplitude CV and turn the amplitude right back up.

This time, with the depth set to a middle value vary the rate.

Now pick a relatively low rate and vary the depth settings.

Change to the Saw waveform and experiment with the rate and depth settings. See if you can produce a “pew pew” type sound.

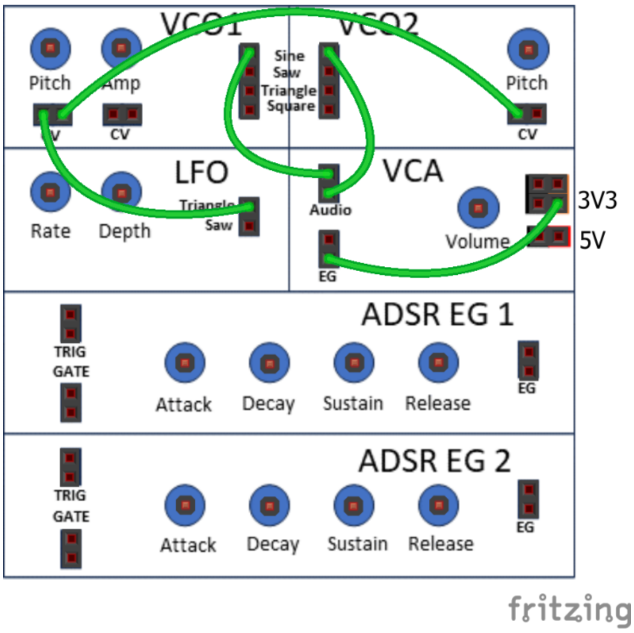
Try it will the oscillators Saw or Square wave and you might get a sound typical of 1980s early electronic video games!

Again in musical terms, modulating the pitch gives a ***vibrato*** like effect.

Feel free to try connecting both outputs of the LFO to the VCO – one to the pitch and one to the amplitude.

6. Dual VCO+LFO Pitch Modulation

This time we’re hooking up the LFO to the pitch CVs for both oscillators at the same time.



Two extra wires are now added to the previous experiment

One to connect the output of VCO2 to the VCA (in addition to VCO1) and one to duplicate the LFO input into both CVs of the VCOs at the same time.

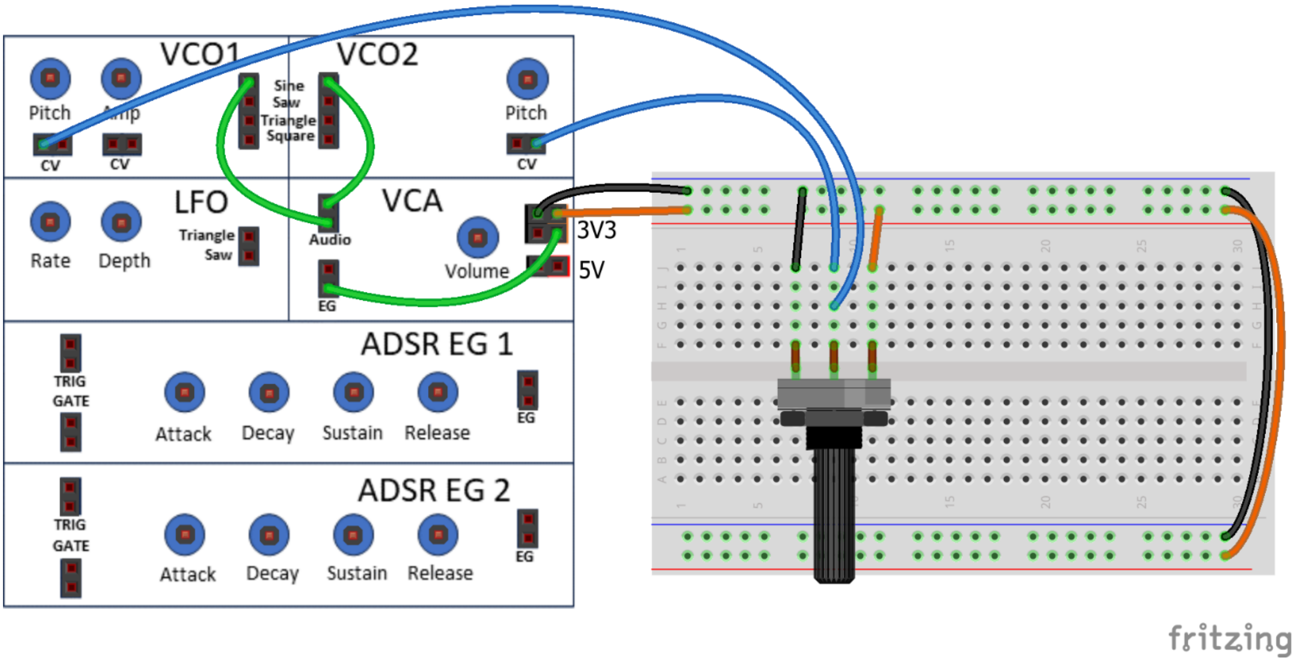
Start with the LFO rate and depth turned fully anti-clockwise - i.e. essentially “off” and tune the two VCOs to an octave.

Now experiment with the LFO depth and rate controls and hear how the LFO is modulating both VCOs at the same time.

For a different type of effect try connecting the Triangle LFO output to VCO1 CV and the Saw LFO output to VCO2 CV.

7. External Dual VCO Pitch Control

In this experiment we hook up a solderless breadboard for the first time and use an external component to control the Synth Thing.



We're going to wire up the breadboards GND and power rails to the Synth Things GND and 3V3 supplies (shown in black and orange).

The we're going to use an external potentiometer to provide a control voltage to both oscillators at the same time. With the wiring shown above the control voltage from the external potentiometer should vary between 0V (fully anti-clockwise) and 3.3V (fully clockwise).

Both oscillators are wired into the VCO, which is still configured for a constant HIGH control voltage. Turn down both pitch controls for each oscillator and turn the amplitude for VCO1 up full.

Now turn the external potentiometer and note what happens to the sound.

Now slightly detune one of the oscillators by adjusting its own control knob a little.

Notice how the detuning "follows" the setting of the external control. This is because the internal control level is added to the external control.

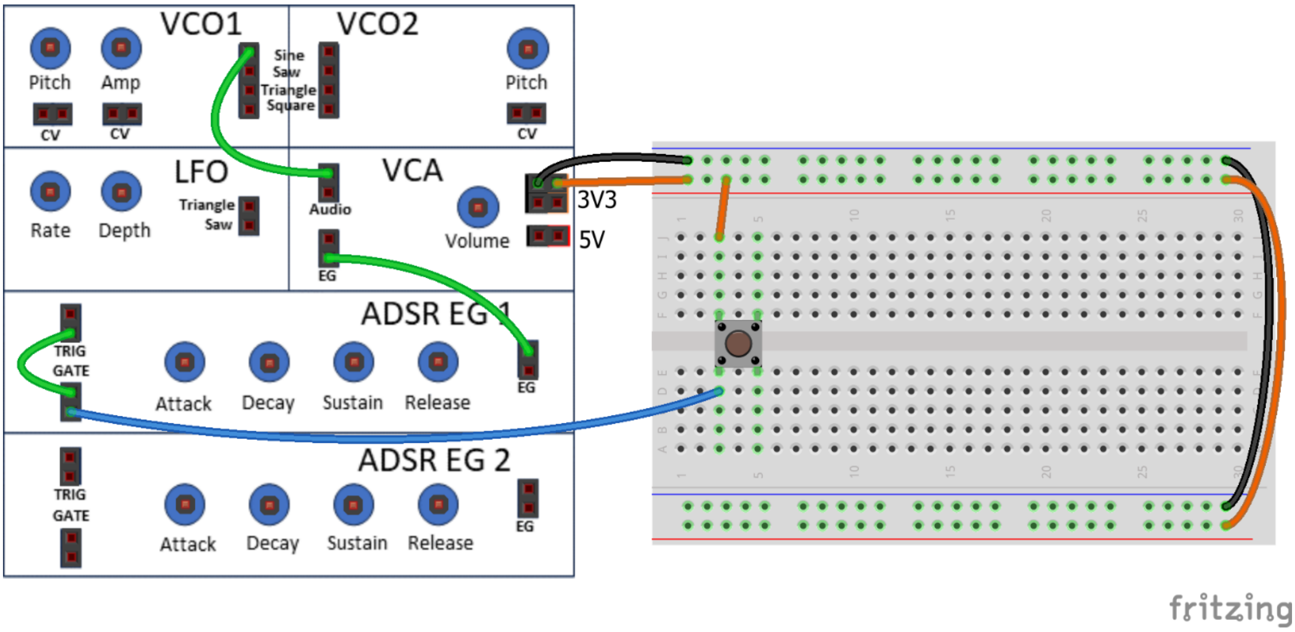
See if you can set one of the VCOs to be exactly one octave above the other and vary the external control. Try it with different intervals – a fifth, a third, something else.

Experiment with using different waveforms for each oscillator and changing the amplitude of VCO1 to fade it in and out.

As a final experiment, bring in the LFO to control VCO1's amplitude to automatically modulate the signal from VCO1. Remember to turn the amplitude knob right down to let the LFO take over the control of VCO1.

8. ADSR Envelope Generator – Part 1

Now that we've seen how to connect a solderless breadboard, we can use this to include a switch to trigger one of the envelope generators.



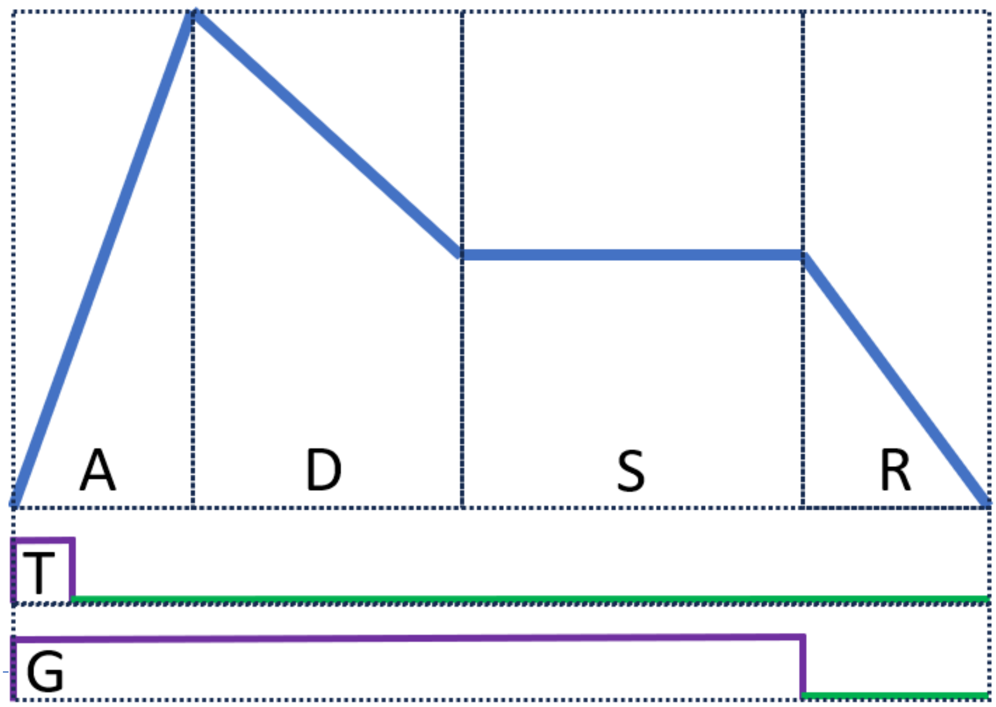
Notice that the VCA EG signal is no longer connected to 3V3 – it is now connected to the output of the first envelope generator EG1.

An envelope will shape the sound – giving it a beginning, a middle, and eventually an end. The TRIG input is used to start the shape. The GATE input is used to determine how long the middle should last before starting to end the sound.

In this experiment, they are connected together and controlled by a single button. This works as the TRIG input is an "edge" input – it is only active when it detects a signal going HIGH, but once it is HIGH it no-longer cares. The GATE input is a "level" input – it will be active for as long as the input is HIGH. When the level stops being HIGH the Synth Thing will end the sound.

There are four controls that set how the shape changes during the playing of the sound: Attack (A), Decay (D), Sustain (S), Release (R). The AD and R knobs control how quickly those stages of the sound change. The S knob controls at what level the "sustain" (middle) part of the sound waits.

The diagram below shows the four stages and how they relate to the TRIG (T) and GATE (G) signals.



Set the ADSR knobs roughly as follows:

A – almost fully anti-clockwise.

D – almost fully anti-clockwise.

S – fully clockwise.

R – in the middle.

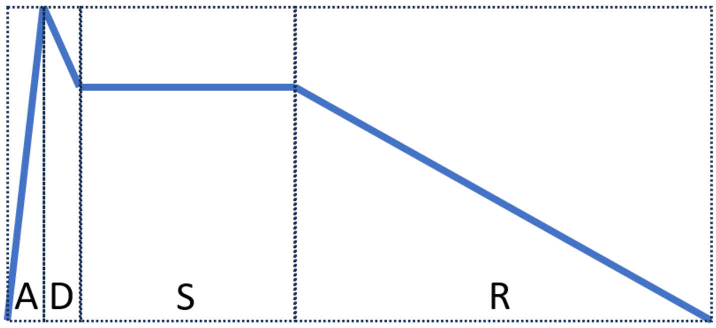
Ensure the VCO1 and VCA volume are turned up and press the button.

Try a short press and a long press and see how the sound changes.

9. ADSR Envelope Generator – Part 2

Continuing from part 1, the following experiments show different envelopes. Use the ADSR controls to set something that closely matches the diagram and listen to how the sound changes.

Strong Attack, Long Release

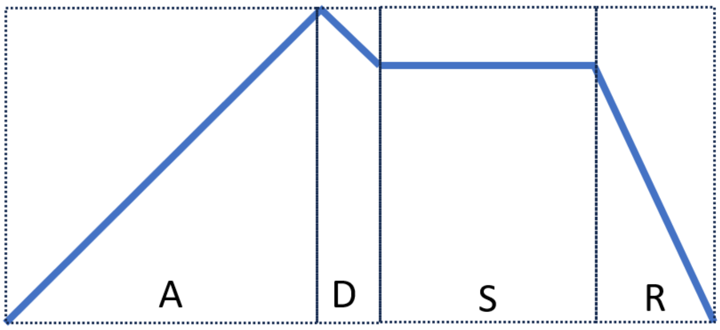


The A and D are very short (hard anti-clockwise), meaning the sound will rise and drop to the S level pretty quickly giving quite a "hard" start to the sound.

S is fairly high (clockwise) so the sound will keep sounding whilst the button is pressed.

When the button is released, the sound will die away slowly due to the long R time (clockwise).

Slow Attack, Quick Release



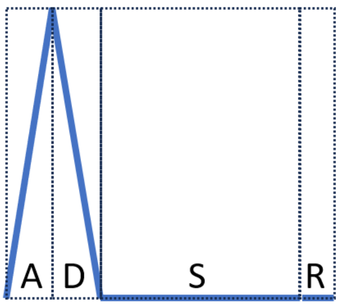
A is set very long (clockwise), meaning that the sound will take a while to arrive.

Once at full volume will quickly settle to the S level, which is pretty high (clockwise) once again.

This will create a characteristic "mwha" type of effect for the sound popular in certain synthesizer music.

When the button is released the sound will die fairly quickly due to the short R time (anti-clockwise).

Short Attack, Immediate Decay



This sound will only sound for a very short length of time, no matter how long the button is pressed.

This is due to the almost zero S level and quick A and D times (all anti-clockwise). The setting of R is largely irrelevant as the sound will have already dropped to nothing before the button is released.

This is the type of envelope that might be wanted for a very percussive sound.

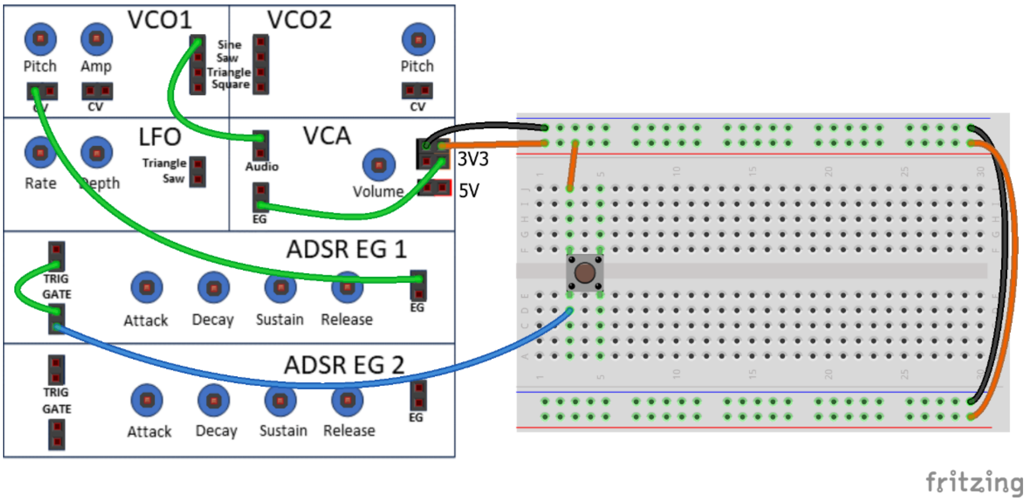
Other ADSR Experiments

With the different envelopes above, investigate what happens for:

- A short press of the button.
- A long press of the button.
- Repeatedly pressing the button slowly.
- Repeatedly pressing the button quickly.

10. ADSR Envelope Generator for Pitch

The EGs provide a control voltage (CV) that can also be used to control the pitch of an oscillator.



The VCA amplitude has been set back to a constant HIGH level (connected to the 3V3 output) and now the output of EG1 is connected to the VCO1 pitch CV.

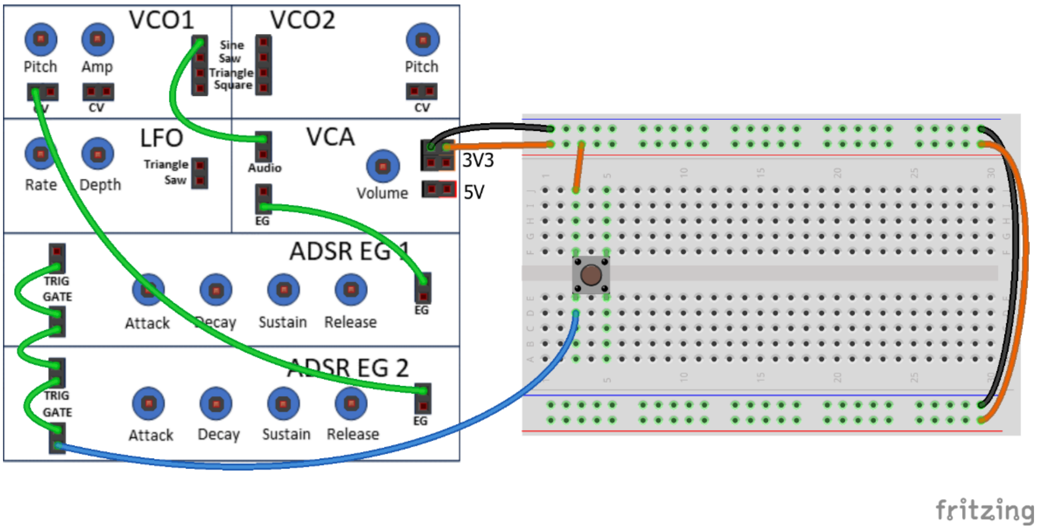
With the VCA and VCO1 amplitudes turned up, find a nice "middle" pitch for VCO1.

Set the A and D fairly short (anti-clockwise), set the S level somewhere in the middle, and set the R time fairly short too. Now press the button.

Experiment with both different A,D and R settings and experiment with different S levels.

11. ADSR Envelope Generator for Amplitude and Pitch

This now uses both EGs, one to control amplitude and one to control pitch.



In this experiment the button is still triggering EG1 as before, but it also now triggers EG2 as all the GATE and TRIG signals are connected together.

EG1 is once again controlling the amplitude of the VCA but now EG2 has been connected to the pitch CV input of VCO1.

Reset ADSR for both EGs as for the first EG experiment: short A and D, high S and long R.

Turn up the volume of the VCA and VCO1 and set the pitch to somewhere in the middle.

Now press the button and experiment with the different ADSR settings for both EG1 (amplitude) and EG2 (pitch).