The Educational DIY Synth Thing

External Active Circuit Projects

Introduction

This carries on from the previous chapters and assumes that one has a working Synth Thing and has worked through all of the starter projects.

There are five sections in this chapter covering the following:

- Basic Principles and Connections

In each case once general amplification and power are required as used previously.

Core Components Required

The following basic additional components are required to perform all the experiments in this chapter:

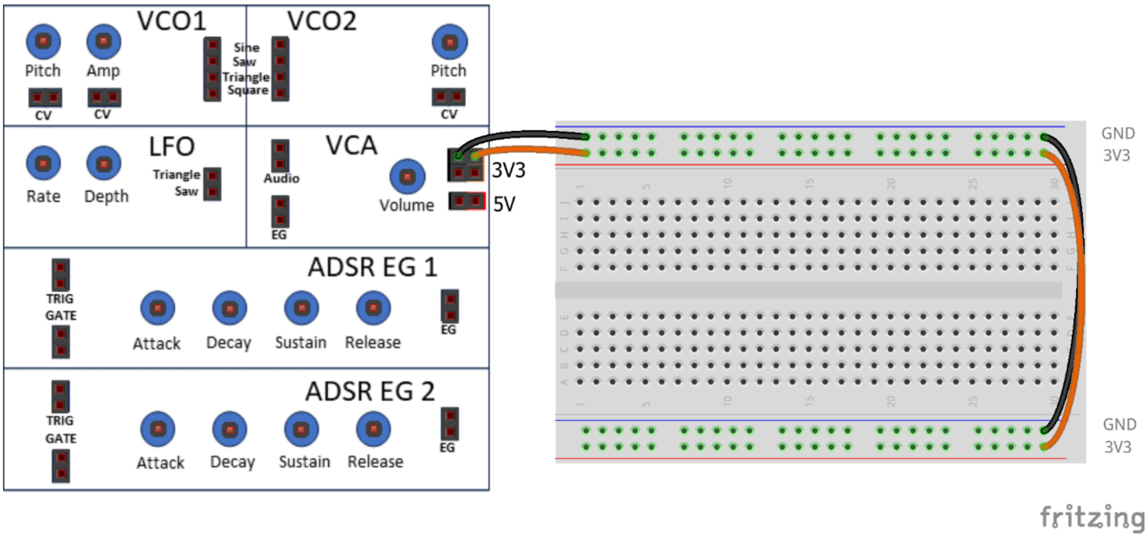
- Solderless breadboard – ideally a “half+” type.
- Optional: Oscilloscope, adaptors and probes (see previous chapter on oscilloscope use).
- CD4093 Quad Schmitt Trigger NAND Gate
- 74LS175 Quad D-Type flip flop
- Range of additional passive components

Basic Principles and Connections

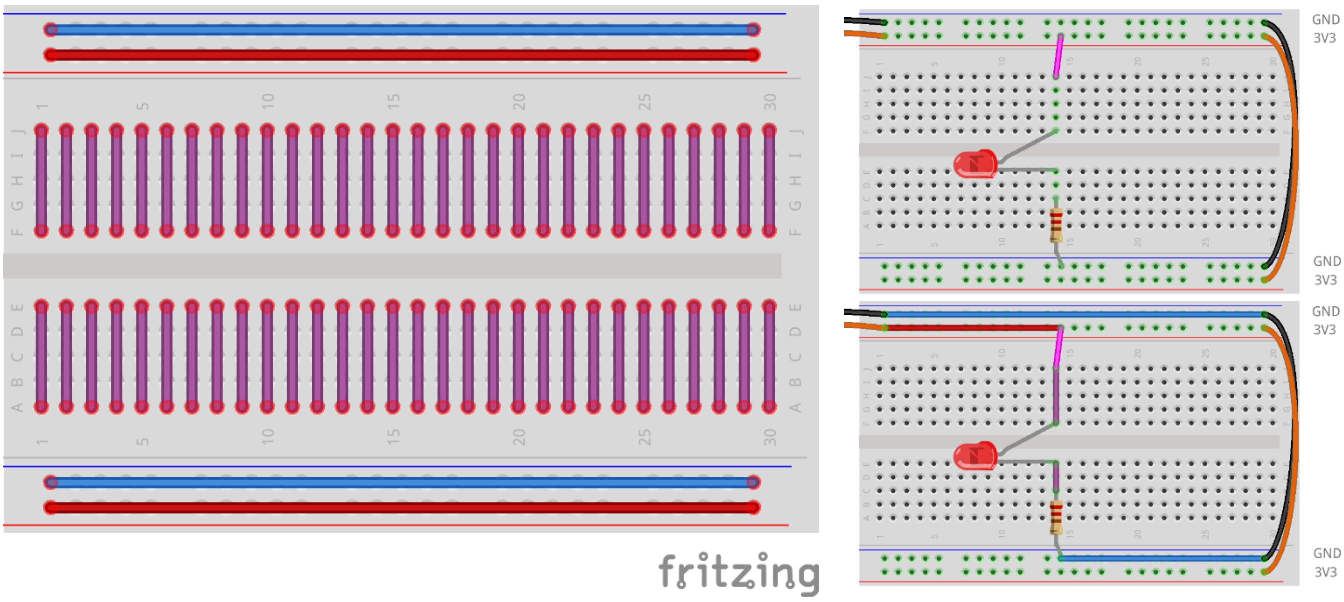
Repeating the notes from the previous section, this again shows how to connect a solderless breadboard ready to start some experiments.

The power should ideally be kept within the 0-3V3 range, so it is recommended that, unless it is stated otherwise, the solderless breadboard is connected to GND and 3V3 as shown below.

It is also recommended that the blue row is used to signify GND and the red row is used for 3V3.



The holes in a solderless breadboard are internally connected as show below, making joining circuits relatively straightforward. Anything plugged into one of the holes in a row or column is automatically connected to anything plugged into any of the other holes in the same row or column.



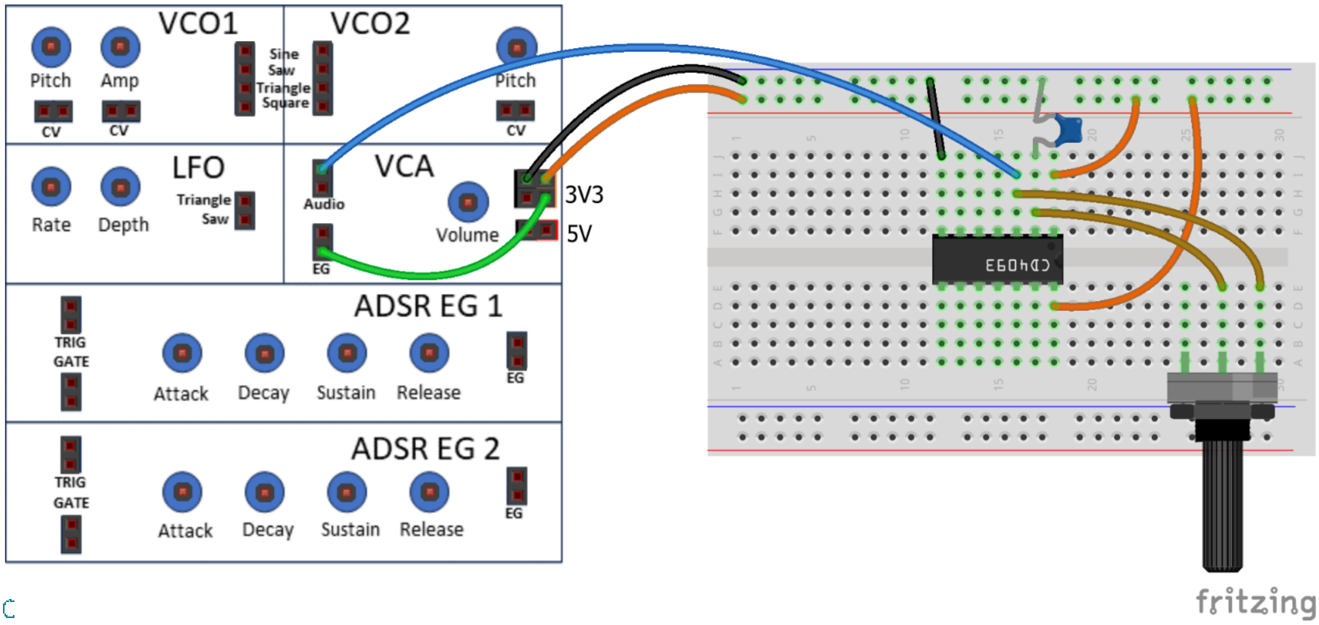
The top (right) diagram shows how an LED could be wired to 3V3 and GND. The bottom (right) diagram shows the path of the completed circuit through the solderless breadboard.

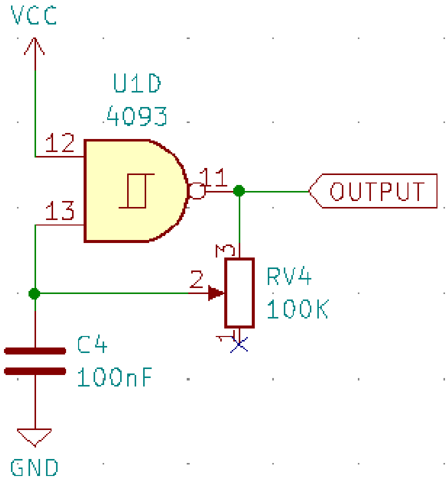
Summary of the colours used in these project diagrams:

- Green – internal connections between patch points on the Synth Thing.
- Blue – external connections between the Synth Thing and the breadboard.
- Black – GND connections.
- Orange – 3V3 connections.
- Red – 5V connections.
- Other Colours – other connections on the breadboard as required.

Oscillators

1. NAND Schmitt Trigger Oscillator





This circuit is a Schmitt Trigger NAND simple square wave oscillator. A NAND gate has the following sequence of logic states:

IN 1	IN 2	OUT
0	0	1
0	1	1
1	0	1
1	1	0

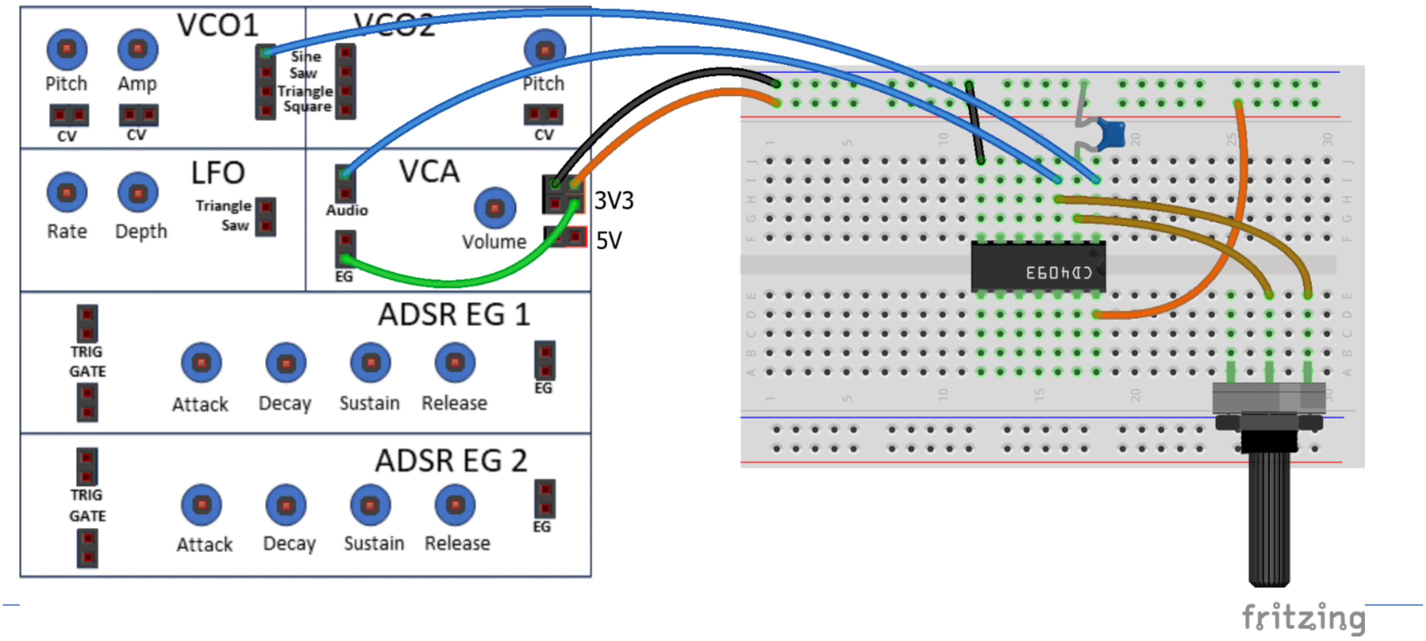
On power up, with the second input LOW the output will be HIGH thus charging the capacitor.

At some point the capacitor will be charged sending the second input HIGH.

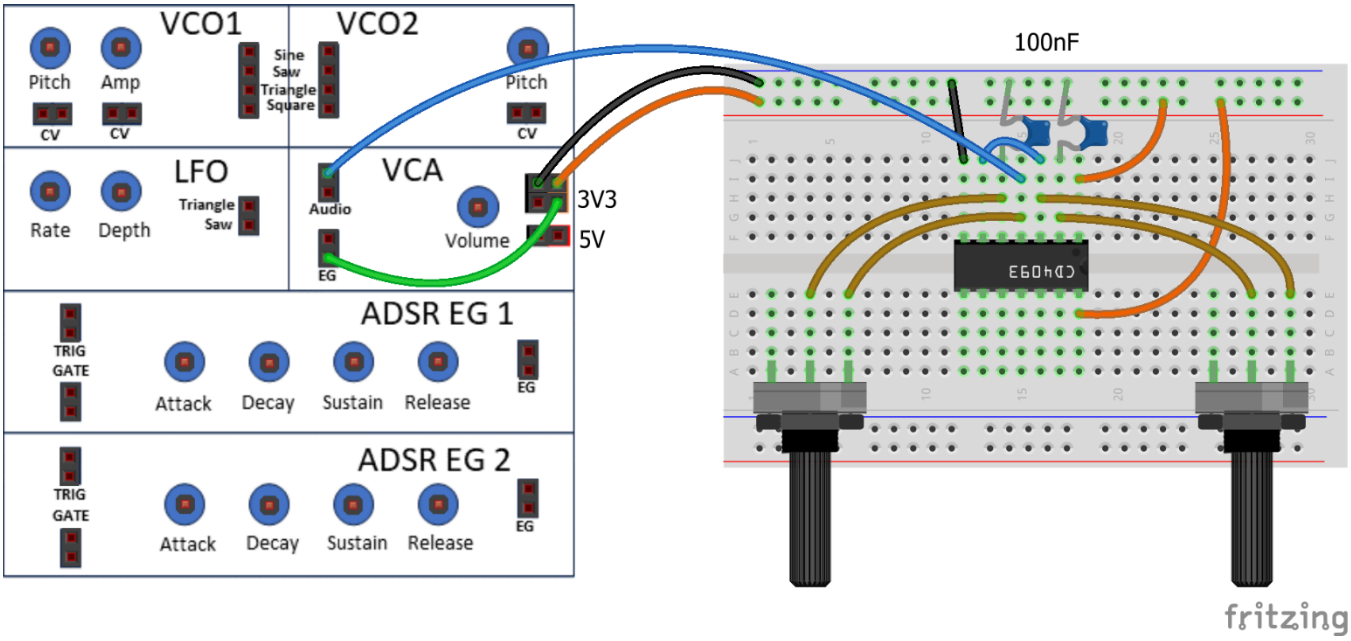
With both inputs HIGH the gate will output LOW and the cycle repeats. The resistor (potentiometer) and capacitor values determine how long it takes for the charging and discharging to happen.

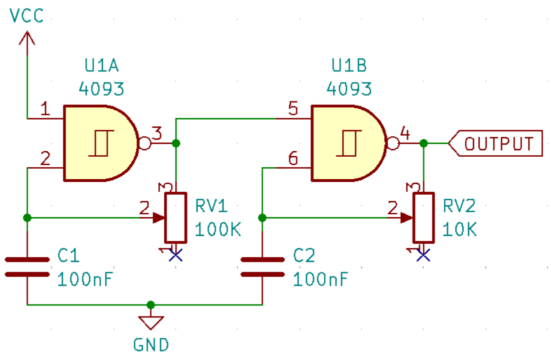
As the NAND gate has a threshold for registering a HIGH input and a specified HIGH or LOW output, this creates a square wave.

For a further experiment, replace the fixed HIGH signal into the NAND gate with the output from one of the VCOs as shown below.



2. NAND Schmitt Trigger Dual Oscillator



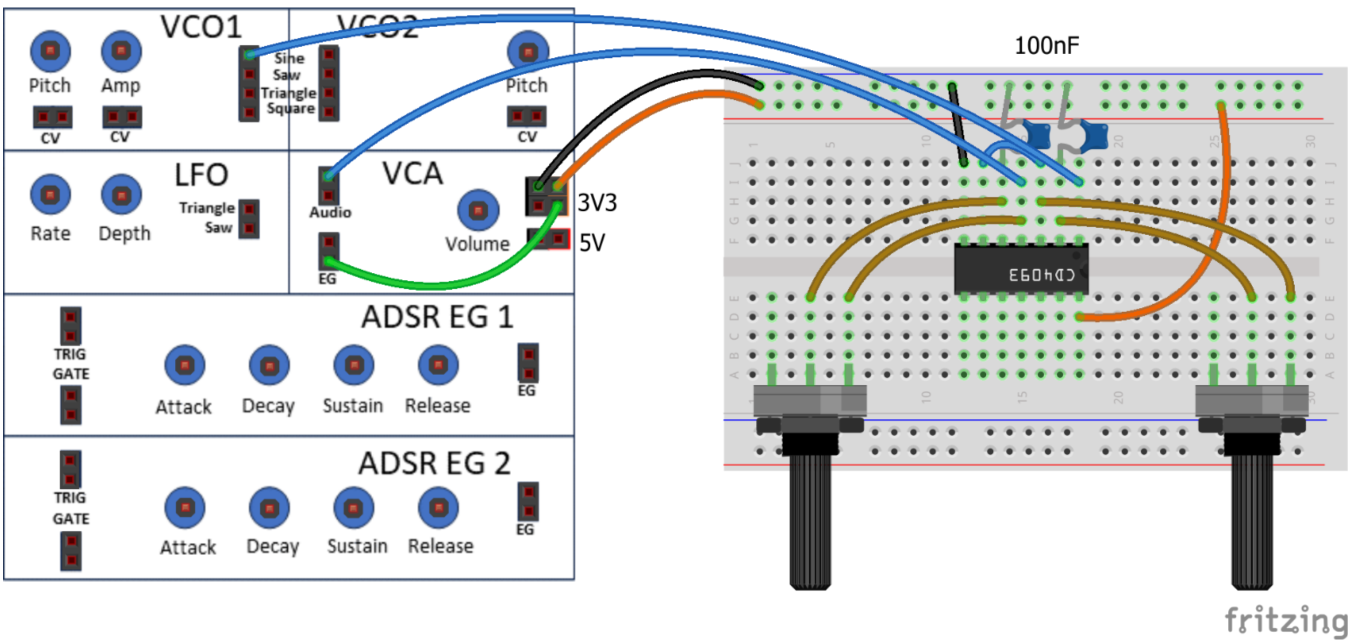


This circuit uses two Schmitt trigger NAND gates from a 4093 quad NAND IC.

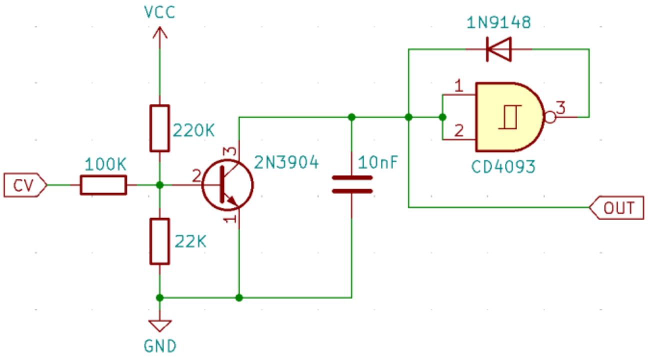
Each NAND gate is configured as a simple square wave oscillator with one input via a capacitor to GND, the other to a voltage source, and with feedback controlled by a potentiometer.

The first oscillator starts with a constant VCC. The second oscillator is fed from the output of the first leading to some fascinating dual-oscillator effects.

Once again replace the fixed input to the NAND gates with the output from VCO and now experiment with all three potentiometers and different waveforms. For an additional experiment use the output of the LFO instead.



3. NAND Schmitt Trigger VCO

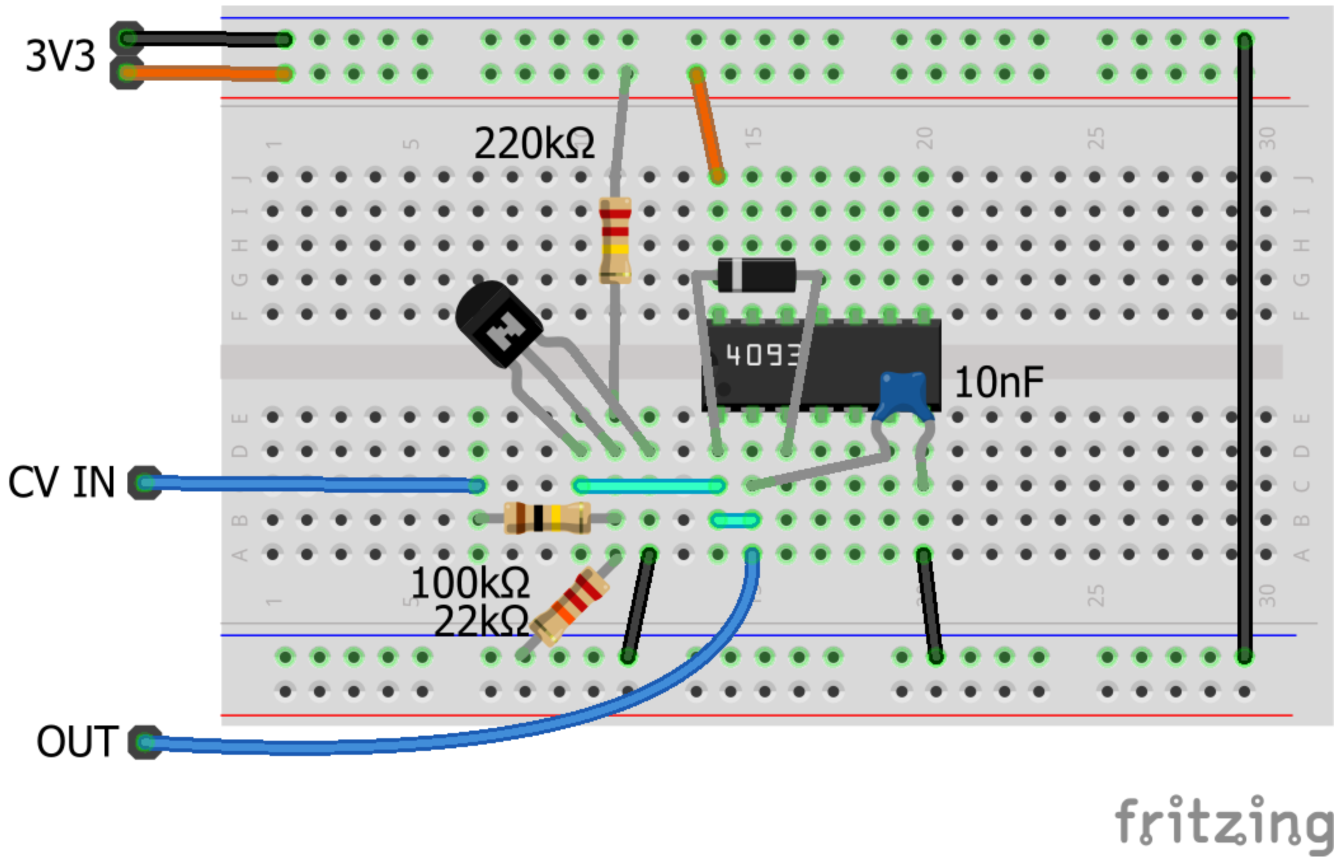


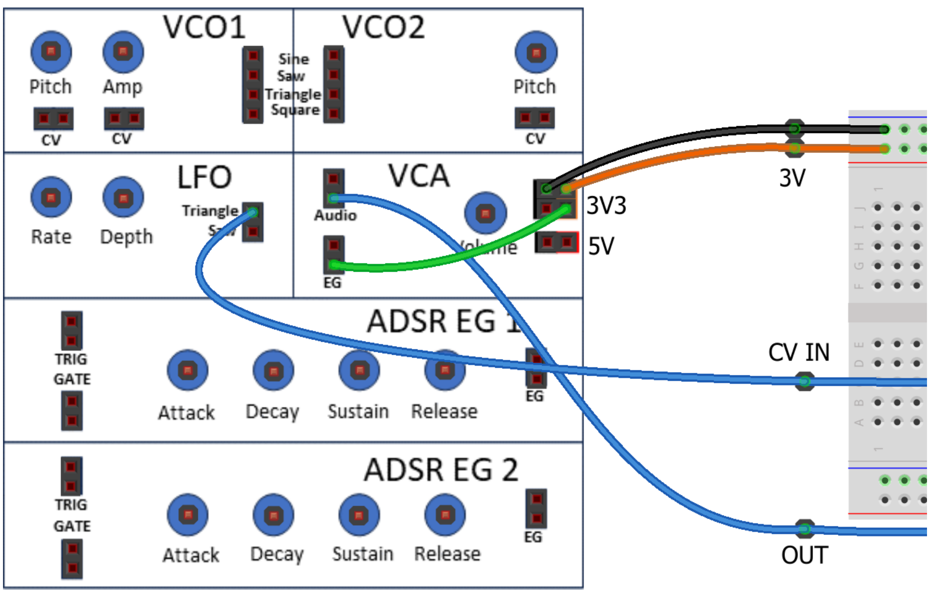
This uses a Schmitt Trigger NAND gate as an inverter oscillator, whose oscillation frequency is dependent on an input voltage.

The circuit is calibrated using resistors to ensure a 0-3.3V input control voltage directly affects the output frequency.

List of components:

- 4093 chip, 10nF capacitor
- 2N3904 transistor, 1N9148 diode
- Resistors: 22K, 100K, 220K





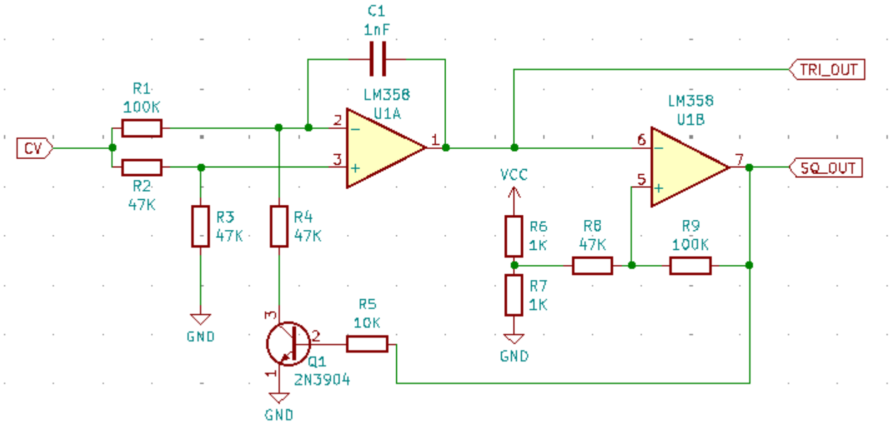
Initial Setup:

- VCA Amp fully clockwise.
- LFO Depth half-way.
- LFO Rate almost fully anti-clockwise.

Experiment with:

- Changing LFO Rate and Depth.
- Change LFO waveform.
- Try with VCO1 – vary Pitch, Amp, Waveform

4. LM358 Based VCO

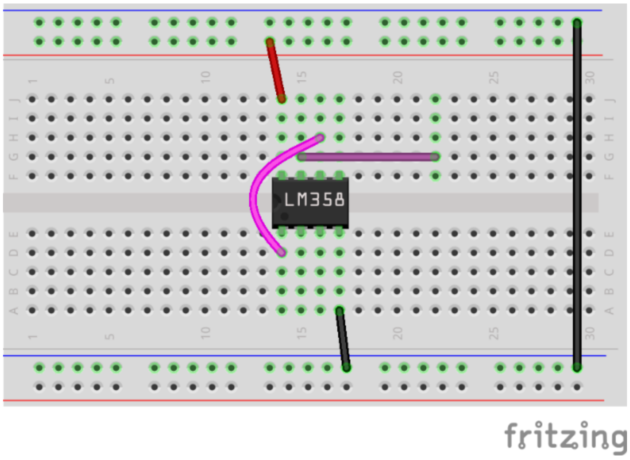


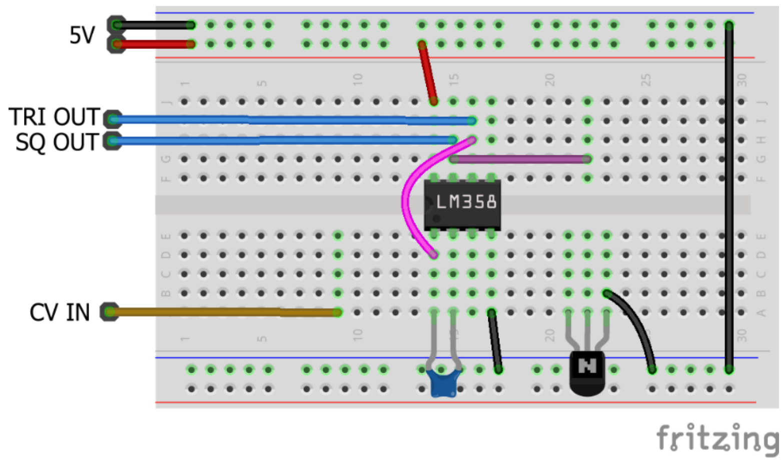
Based on Mitch Electronics VCO:
https://www.mitchelectronics.co.uk/resources/voltage-controlled-oscillator-kit-instructions

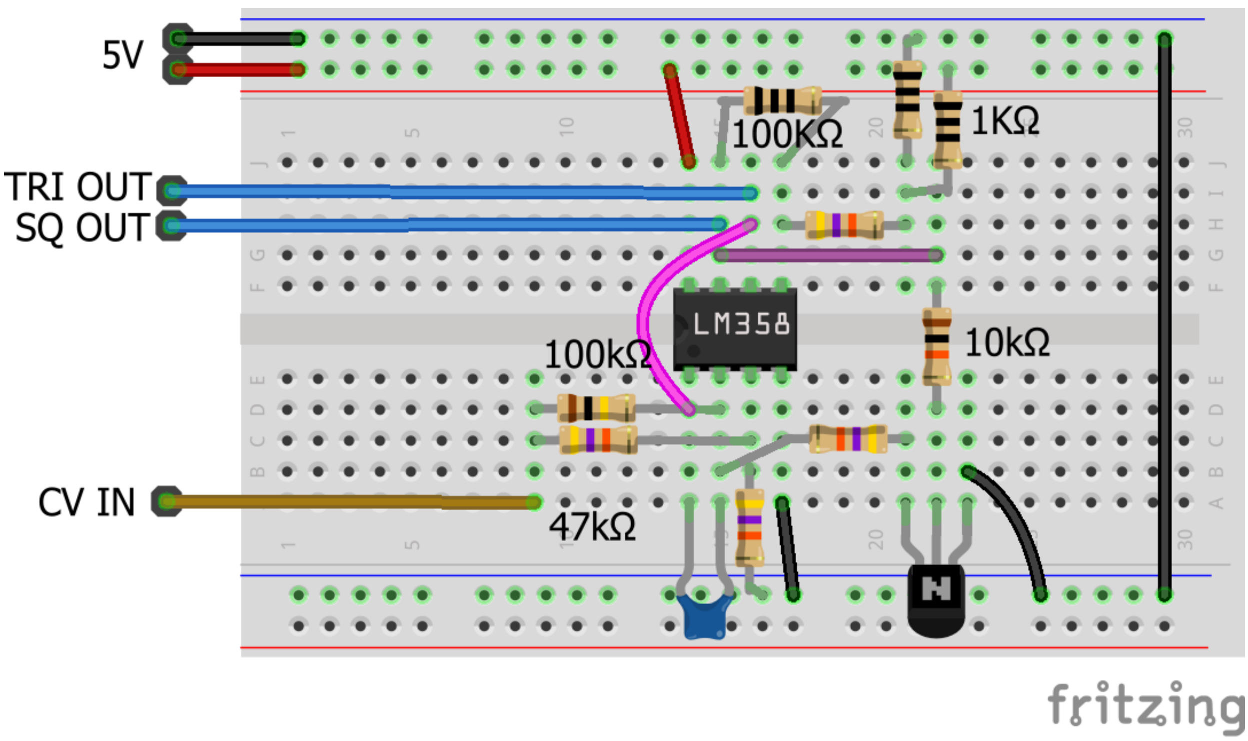
This uses both stages of an LM358 OpAmp to provide a voltage-controlled triangle and square wave oscillator output.

List of components:

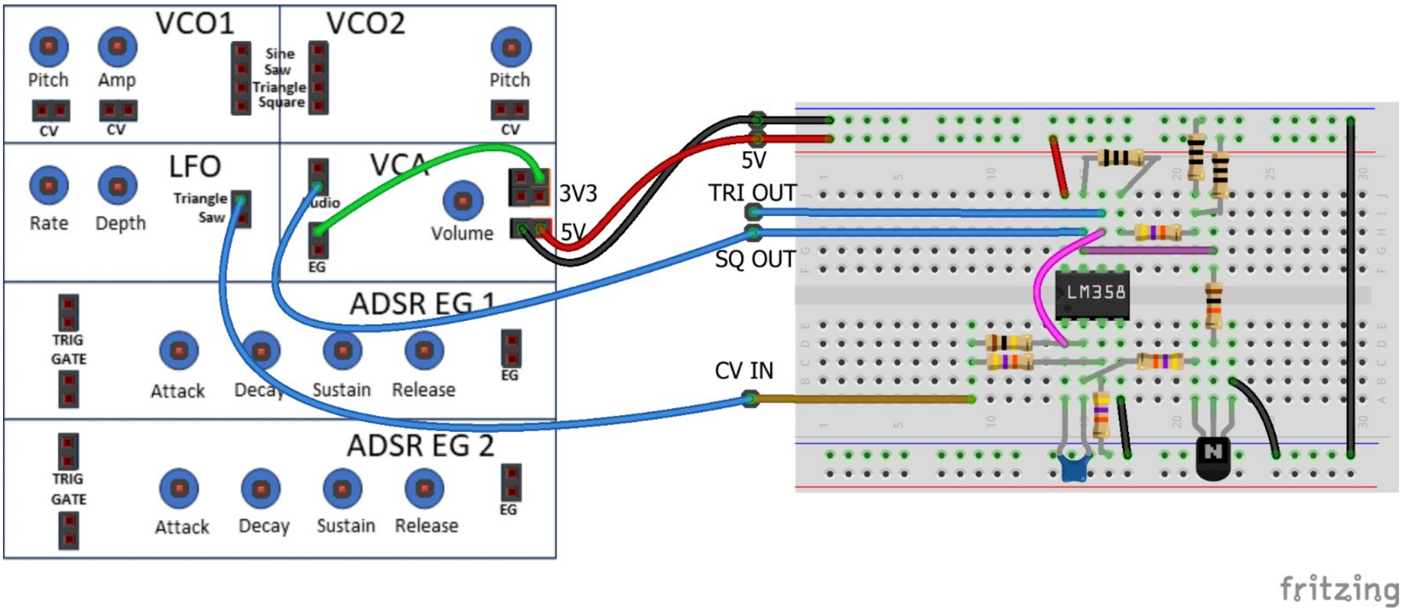
- LM358 OpAmp
- 2N3904 NPN transistor
- 1nf ceramic capacitor
- Resistors: 2x 1K, 1x 10K, 4x 47K, 2x 100K







Connection to the Synth Thing requires GND/5V. There is one input to the circuit FROM the synth thing – the CV IN; and one of the TRI or SQ OUT can be connect TO the synth thing VCA audio input.



Start with the VCA volume fully clockwise (turned up); the LFO depth and rate about half-way.

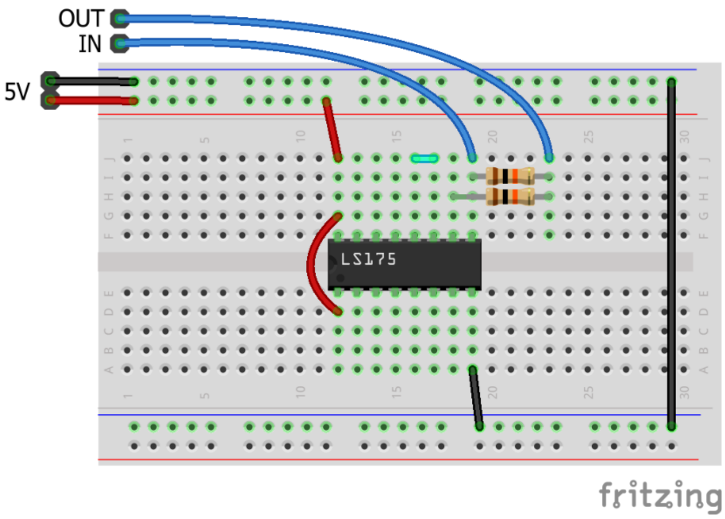
Use an oscilloscope on GND and AUDIO IN to see the produced waveforms.

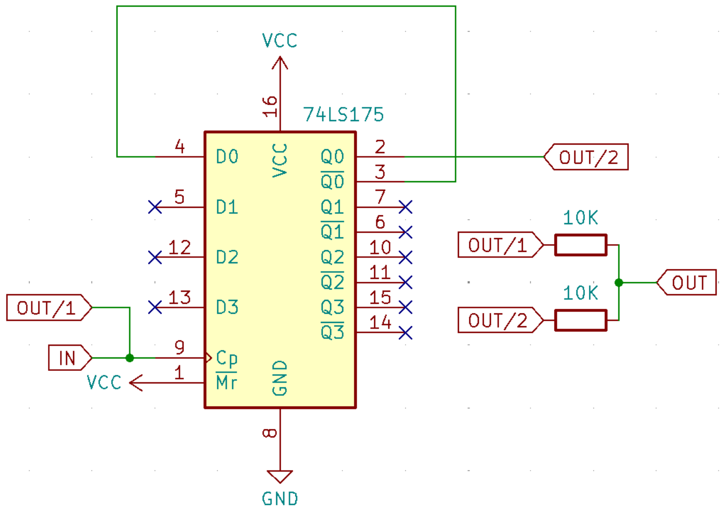
Experiment with the following:

- Vary the LFO Rate and Depth and see the effect on the wave form.
- Switch to the Saw output and vary the LFO Rate and Depth.
- Switch from the LFO to the output of VCO1, start with VCO pitch fully anticlockwise and Amp half-way round.
- Vary the VCO1 Pitch.
- Vary the VCO1 Amp.
- Try alternative VCO1 waveforms.

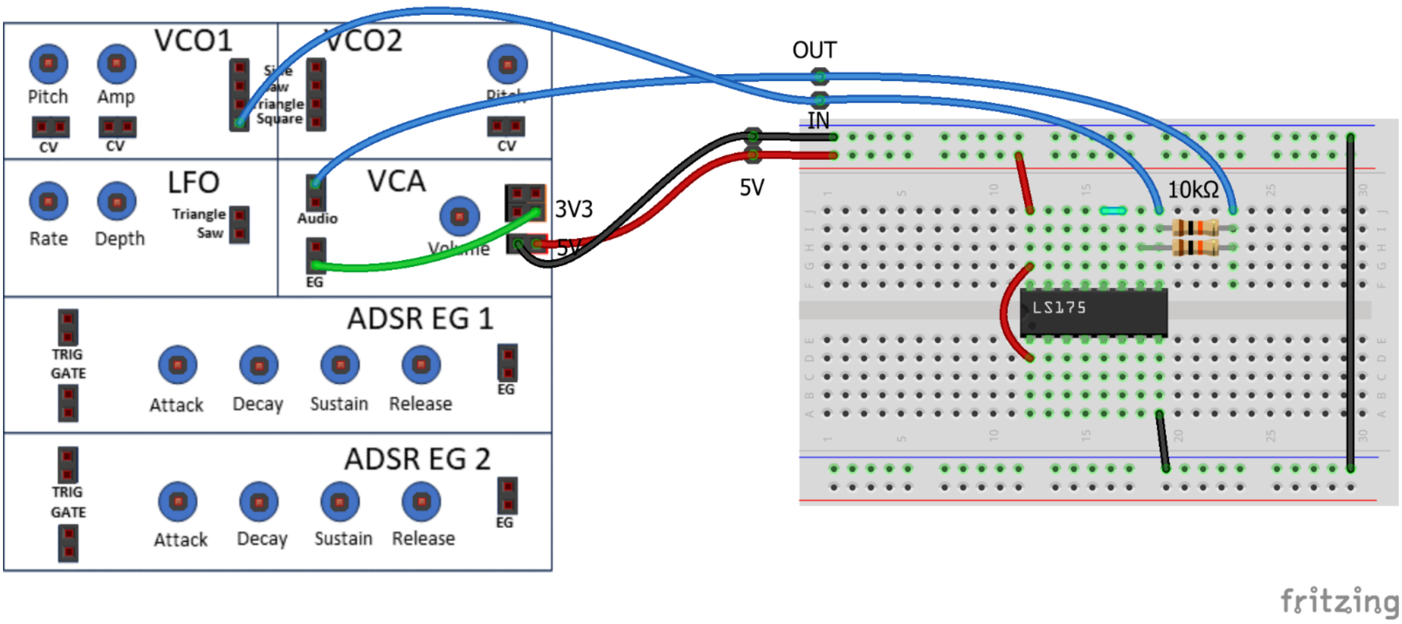
5. LS175 Flip Flop Frequency Divider

This uses a “D-type flip flop” as a clock divider to half the frequency of the input signal.





A flip-flop is used to half the frequency of the incoming signal. Then the incoming and halved signals are combined via a simple resistor passive mixer to give a combined output. The halved signal is always a square wave, but the triggering signal can be any waveform, but it may trigger a change of state at different times depending on the thresholds for “high” and “low” that the device has.



Initial Setup:

- VCA volume fully clockwise.
- VCO1 amplitude around half-way.
- VCO1 pitch turned fully anticlockwise.

Experiment:

- Experiment with VCO1 patch, amplitude and waveforms.
- View the output waveform on an oscilloscope and see how the different waveforms combine with the half-frequency square wave produced.