BLEEPHAUS:ASSEMBLE!

Instructions for Hex Schmitt Square Wave synth

Version 1.0 Designed for International Drone Day, 10 May 2014

Welcome to **BLEEPHAUS:ASSEMBLE!**

If you are taking part in the workshop, please sign the disclaimer below.

Name:

Email:

Emergency contact details:

I, the undersigned, understand that building circuits has a level of danger, but I also understand that life without danger is worthless, that ultimately we are all mortals who are going to die, and that this is what gives life its fundamental meaning.

Having said that, I understand that it would be really inconvenient if I died at **BLEEPHAUS:ASSEMBLE!** and as such I will endeavour to work with the organisers to keep myself and others safe. Y'know, just the basics, like keeping drinks away from the electrics, remembering which end of the soldering iron is which, going outside for a breath of fresh air after soldering, and not plugging anything into the mains that I've built myself.

If I do end up burning or electrocuting myself, it's my own damn fault, and neither Grumpy Whiskers or the organisers of **BLEEPHAUS:ASSEMBLE!** are responsible. Nothing I will be asked to do will be out of the ordinary or unduly dangerous, and if I were to do it in the privacy of my own home, no-one would care. I'm a responsible human being, and I would like to be treated as one. In fact, I resent reading this far, knowing that the whole statement could have been summed up with that last sentence. Show me the gadgets already.

Signed:

Date:

Signature of parent or guardian if under 18:

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Instructions for
Hex Schmitt Square Wave synth

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For more information and kits,
visit us at www.bleephaus.co.uk

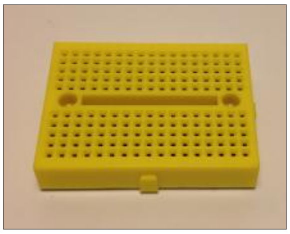
Today we are going to be building a square-wave synth based on a Hex Schmitt inverter chip which, in a nutshell, takes zeroes and turns them into ones, and turns ones into zeros to create an oscillator. The frequency with which it does this can be controlled, and we can turn that into a square wave that we can change the pitch of to make some drones.

Once we've got the basics in place, we will experiment with adding some controls. The good thing about the Hex Schmitt chip is that it has not one, not two, but six inverters, so you can mix up to six square waves of different frequencies to make a properly horrible noise.

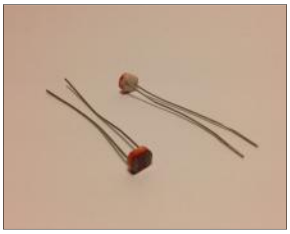
The kit you have purchased has the parts to connect up two of the six oscillators and experiment with the control of them in a variety of ways without the need for soldering any components. Pretty much all of the noises you will be making are horrible, but in different ways.

First, let's identify the components in your kit:

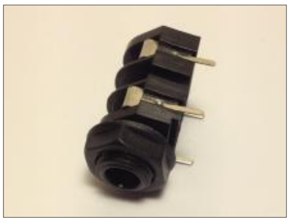
Mini Breadboard



Light Dependent Resistors (LDR) x 2



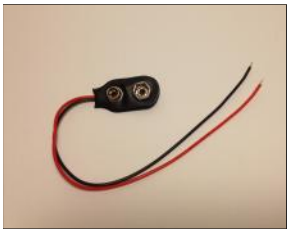
¼"/6.35mm Jack Socket



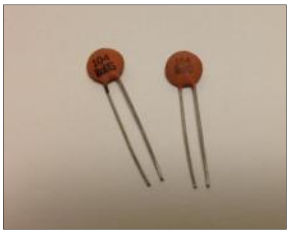
Potentiometer (trim-pot) + spindle

Hex Schmitt Integrated Circuit (IC)

9v Battery clip



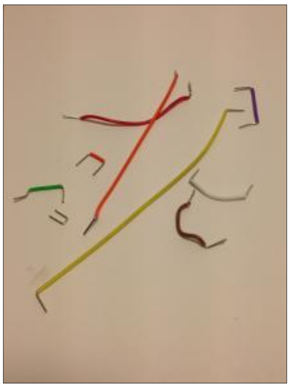
100nF Capacitors (104) x 2



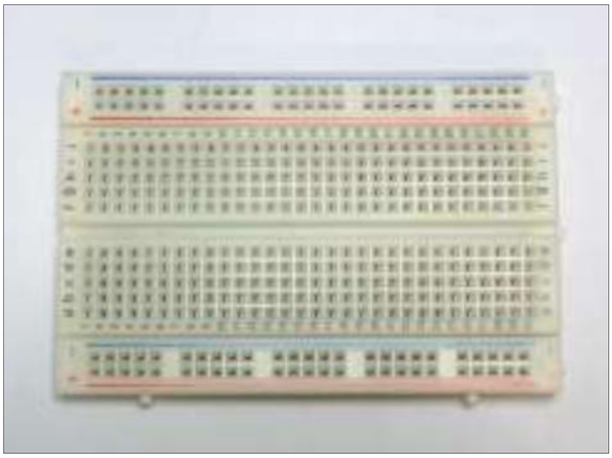
9v Battery (brand may vary)

220kOhm Resistors (Red Red Yellow Gold) x 2

Jumper wires (sometimes called hook-up wire)

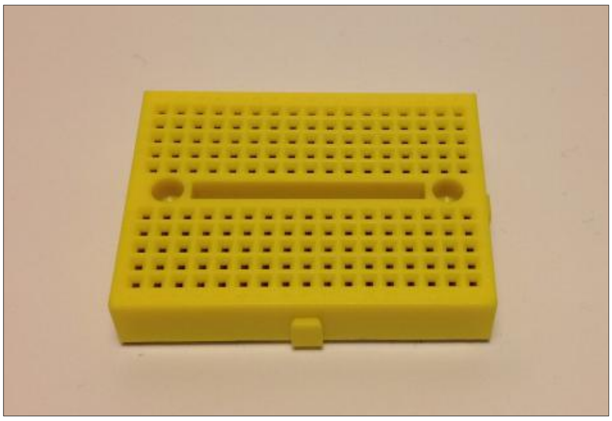


We're going to build our synth on a mini breadboard. These are used for prototyping circuits, and are awesome as you can just push the components in without having to solder anything. This means if you make a mistake – and you almost certainly will – it's easy to fix. It's like the difference between making a Lego kit and an Airfix kit.



Most regular sized breadboards look like the one on the right. The top 2 and bottom 2 horizontal rows of holes are all connected underneath the breadboard, and each of the 5 vertical columns of holes is connected. So, thinking of things a bit like a game of Battleships, if you plug one component into 'A1' and one into 'E1' then they will be connected as if they were soldered together.

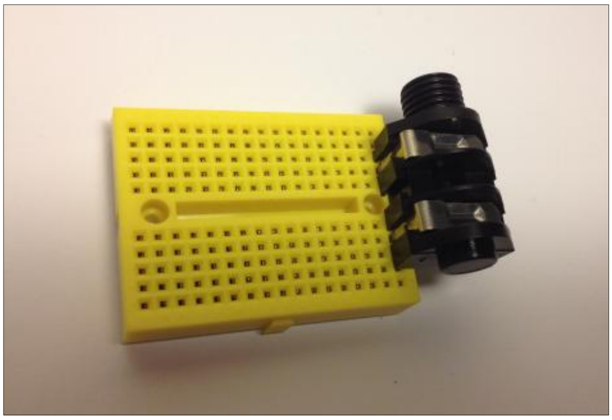
However, we're going to cram everything on to a slightly smaller breadboard, which only has the vertical columns connected, like this one.



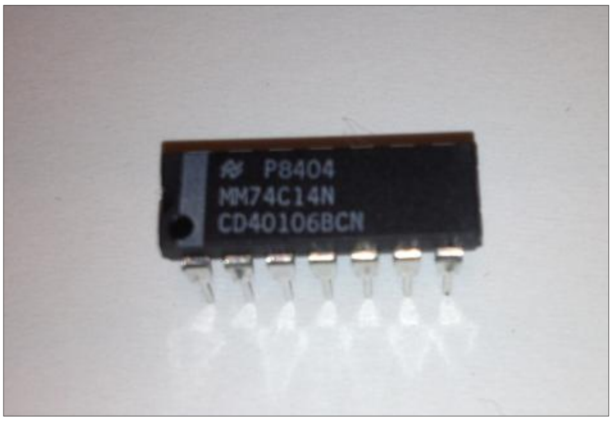
If you look **really** closely you'll see that the board is marked A-J along the short edge and 1-17 along the top long edge.

Start off with 1A in the bottom corner. If you can play Battleships, this will come in handy for finding the location of the holes on the breadboard.

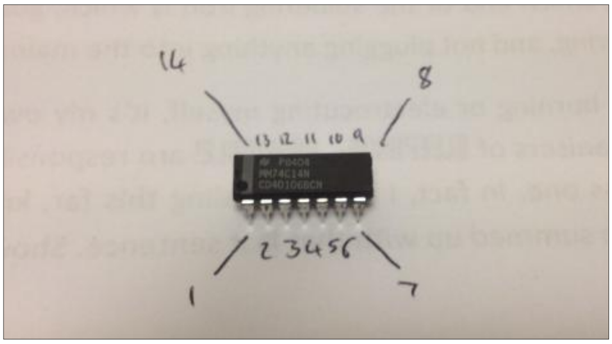
The first thing we are going to do is attach the jack socket to the mini-breadboard. Hold the socket so the input hole is at the top. Firmly push the socket onto the breadboard so that top left pin of the socket is in hole G17 of the breadboard, and the bottom left pin is in D17. Be careful not to bend the clips as you do this.



Grab the Hex Schmitt integrated circuit (IC) chip. Make sure the **semi-circle is on the left hand side**.

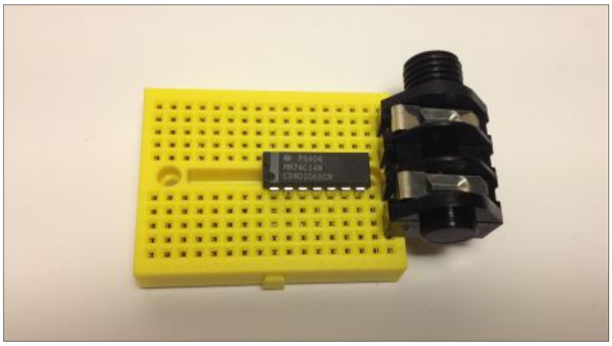


This means pin 1 is in the bottom left corner, and then counting anti-clockwise, pin 7 is bottom right, pin 8 is top right and pin 14 is top left.



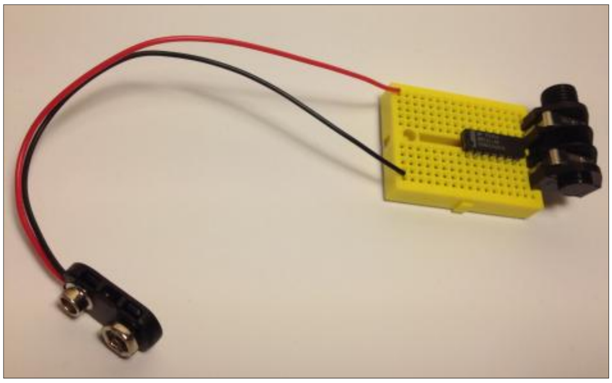
On this chip (and many others), pin 14 on the top left is connected to the positive (+ve) terminal of the battery and pin 7 on the bottom right is connected to ground, or the negative (-ve) terminal to power the chip.

Put it in the breadboard so it straddles the central groove. Push it in so that pin 1 is in location **E9** and pin 8 is in **F15**.



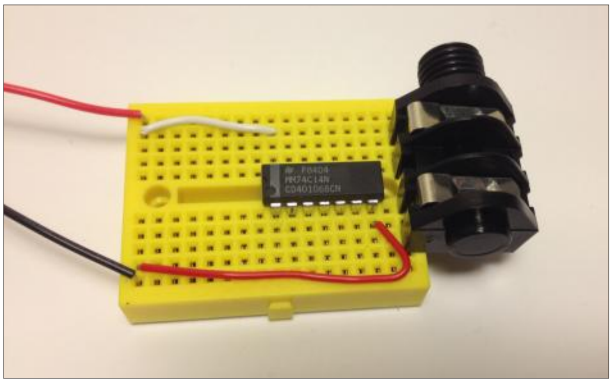
Next up, connect the battery pad – the polarity is important here. Connect the red, positive (+ve) lead to **J1** and the black, negative (-ve) / ground lead to **A1**.

This means the strip from F1 – J1 will be where we get the power and the strip from A1 – E1 will be where we make connections to the ground terminal to complete the circuit.

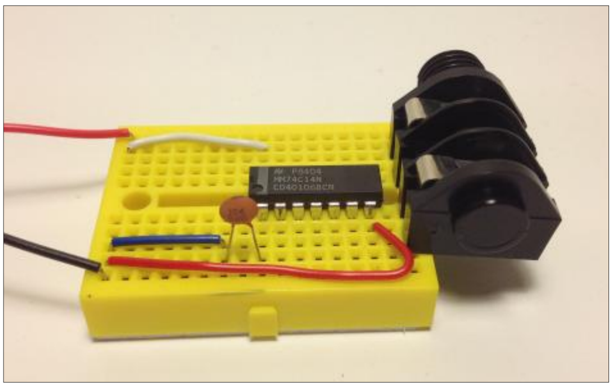


Next we need to connect the power terminals of the battery to the IC chip. Using the hook-up wire, connect **I1** to **I9** to make the positive connection and connect **B1** to **D15** to make the ground connection.

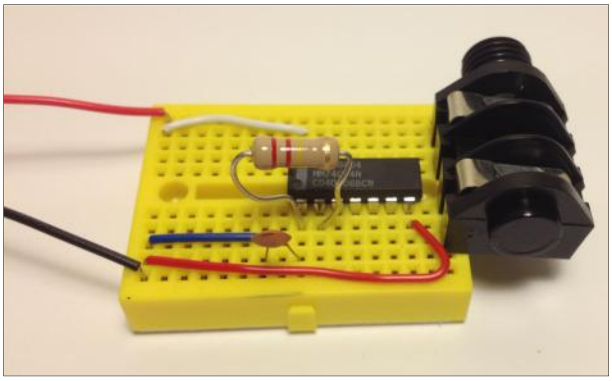
It doesn't matter which colour wires you choose, but if you stick to the colours illustrated you won't end up running out of what you need towards the end.



Next we need to connect the capacitor (the disc with **104** printed on it) between pin 1 of the IC and the ground rail. Do this by first putting a piece of wire between **C1** and **C7**, and then plugging the capacitor between **B7** and **B9**. It doesn't matter which way round this capacitor goes in – but other capacitors can be more fussy.

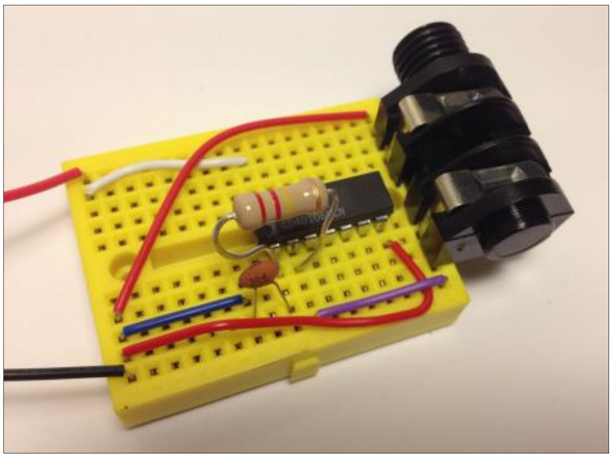


Locate the resistors and remove one from the paper. Bend the wires coming off the resistor (sometimes called the 'legs') so that they both point down. We then need to use the resistor to connect pins 1 and 2 on the IC. Do this by pushing one leg into **D9** and one into **D10**. They are a tight fit so you might need to use more force than you expect. As with the capacitor, it doesn't matter which way round it goes.



Next we need to make the connections between the IC chip which is generating a wave, and the jack socket which we can use to connect it to an amplifier. A standard guitar lead has 2 connections, the 'tip' and the 'sleeve' – the tip carries the signal, and the sleeve connects to the ground. When we push a lead into our socket, the tip will connect to the bottom left leg in **D17**, and the sleeve will connect to the top left leg in **G17**.

We get our signal from pin 2 of the IC, so to do this we connect **A10** to **A17** (the purple wire). We then need to ground the audio signal, and we do this by connecting **D1** to **J17** (the red wire running from bottom left to top right).



Connect your synth to a battery-powered amplifier and snap on the battery – if all has gone to plan, this should create a note of a constant, annoying, surprisingly loud pitch (for musicians, it's about 170hZ, which is close to an F). If so – well done! You have built your first synth! If this has been hard work, you can stop here and feel a sense of achievement.

If it doesn't make a noise, don't worry, just check your connections. It's fine to swear, rip the whole thing apart and start again, or take a more methodical approach, whichever feels good to you.

A quick simplified note on how it works:

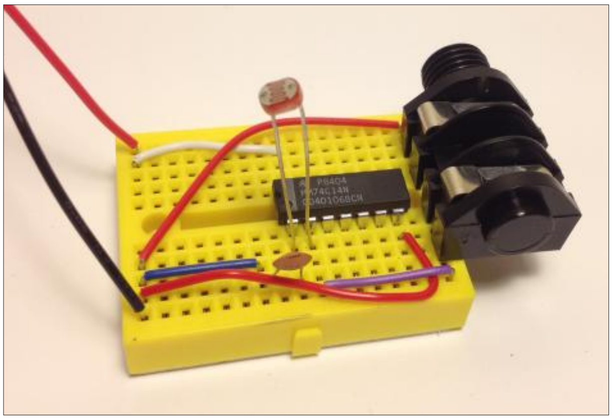
The chip contains six 'inverters' and by connecting pins 1 and 2 and then sending a voltage through the circuit, we cause one of those inverters to alternate between on and off. If we then send this signal out of an audio socket, it causes the speaker to move back and forth in a similar way, creating sound.

We add a resistor to slow down these oscillations so that we can hear them – without the resistor the speaker would still move but at a frequency we couldn't hear. The more resistance in the circuit, the more the oscillations slow down, and the lower the pitch we hear.

What we are going to do next is demonstrate three different ways that the pitch of the oscillator can be changed, with varying levels of control – yes, now we've built our synth, we're going to start pulling it apart and hacking it, which is why making synths on breadboards is awesome.

When changing the components on your breadboard, **remove the battery** and only connect it again once you have finished making your connections.

Method 1: Light dependent resistor

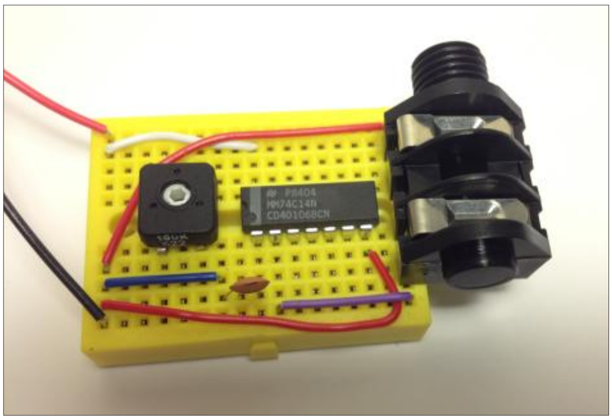


Take a good look at where the resistor is in the circuit in **D8** and **D9**, then remove it and replace it with the light dependent resistor (or LDR) – this is the small disc with the wiggly line on top and 2 wires coming off it. This is a different type of resistor that varies its resistance depending on how much light falls on it.

You should now find that waving your hand or a source of light over the LDR changes the pitch.

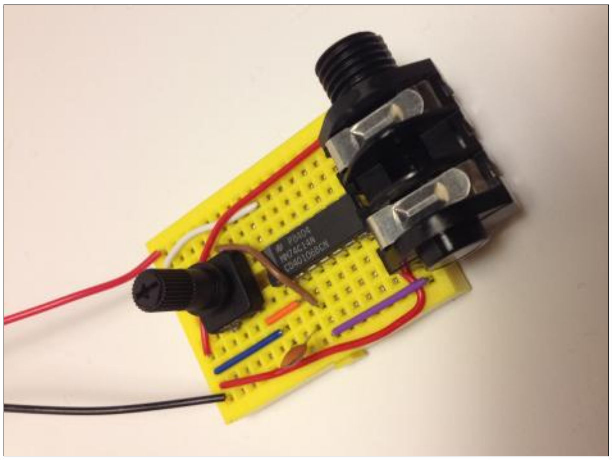
This is sometimes called an 'optical Theremin' because you can play it without touching it. The sound generating process is entirely different to a real Theremin – but much cheaper!

Method 2: Potentiometer



The above is really cool, but it can be tricky to control accurately and you might want to generate specific frequencies to create harmony (or dissonance) with your fellow noisemakers. A potentiometer (or pot for short) is a resistor whose resistance you can adjust. For this synth you can use it to adjust the pitch.

Start by removing the LDR if you've not already done so and carefully pushing the pot in to the breadboard so that the bottom two legs are in **E4** and **E6** and the top leg is in **G5**. Be sure not to put it right next to the IC chip.

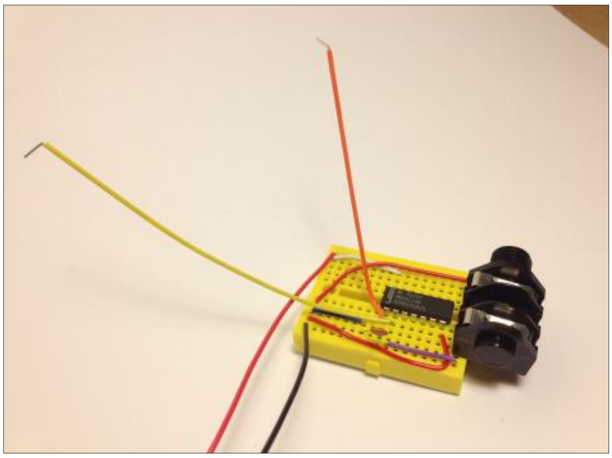


Next, we need to connect the top pin and one of the bottom pins into our circuit in place of the resistor or LDR we removed. Take a small piece of wire and connect **D6** to **D9** to connect the lower pin of the pot to pin 1 of the IC. With a longer piece of wire connect **C10** to **H5** to connect the upper pin of the pot to pin 2 of the IC. Finally, connect the control spindle.

We can now vary the resistance, and this will vary the pitch from very low to ultrasonic. Be aware that at higher frequencies you will not only annoy all the dogs in the area but also drain your battery much faster!

Method 3: Body Contact

This method seems very wrong and produces the most unpredictable results. Passing the circuit through your own body is like using yourself as a resistor. It is okay to do this with a 9-volt battery connected but you should **NEVER EVER do this with anything connected to the mains, EVEN IF you use a power adapter.** Remove the pot and the jumper wire that runs from **D6** to **D9**. This time, instead of putting a resistor or LDR into **D8** and **D9**, push in 2 long wires. Now connect the synth to the amp, then the battery.



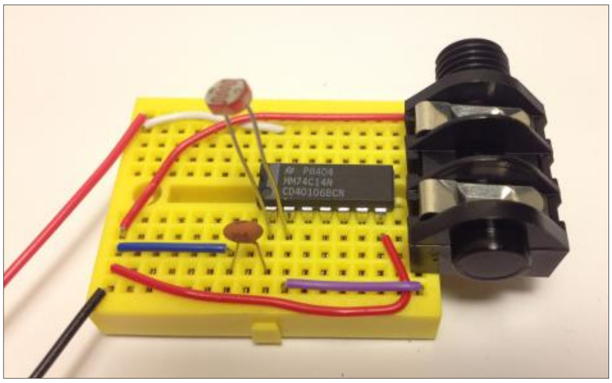
In its current state, the circuit is broken and will not make a noise. But if you hold one end of the wire with your left hand and one with the right, you complete the circuit with your body acting as a resistor. Try changing your grip on the wire, and you should be able to change the pitch of the sound. **Remember this is safe ONLY if we use a battery.**

The above techniques can be mixed and matched - without going into details, there are big differences between whether you connect things up in series (one after the other, such as the pot then the LDR in the circuit) or in parallel (so that, for example, both the LDR and the pot are connected to the same column of holes on the breadboard).

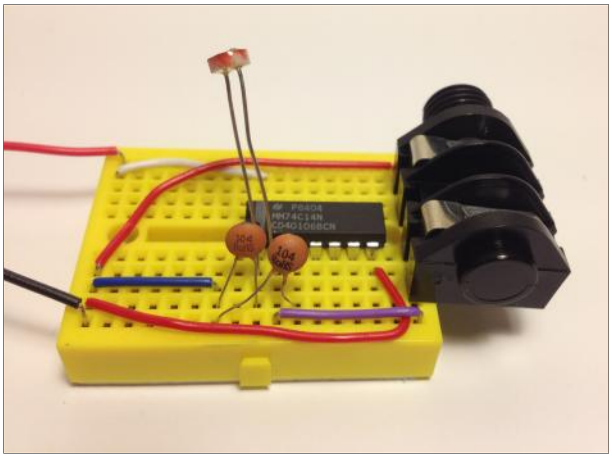
Have a play and see what happens. Remember to remove the battery in between each setup. If it stops making a noise, just remove all the components and start again. You might find it easier to make notes of your setup as you go – at this stage you don't need to use the correct symbols, just do it in a way that helps you to remember.

So far we are using one oscillator, but the Hex Schmitt IC gets part of its name from the fact it has six inverters on board. The methods we used to control the pitch above can be used on six separate oscillators at the same time! We'll show you how to set up both the LDR and the pot on 2 separate oscillators, and then leave you to experiment.

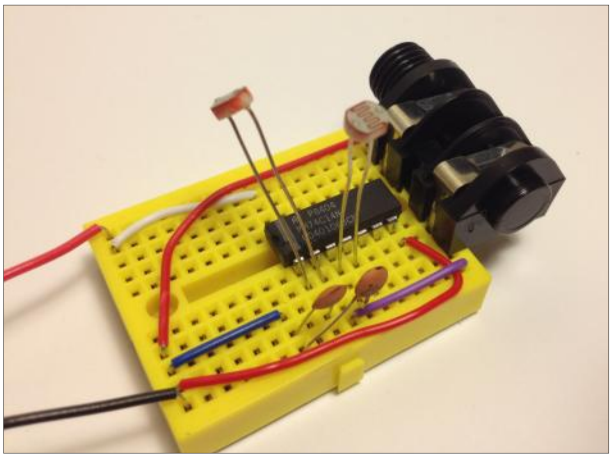
Start by following the steps to add a LDR to the first inverter on pins 1 and 2 of the IC as shown in Method 2 above. It might be a good idea to check this circuit makes a noise before things get a little more complicated.



Next we are going to add a second capacitor – this needs to go from pin 3 to ground. Push one leg into **A7** and the other into **B11**.

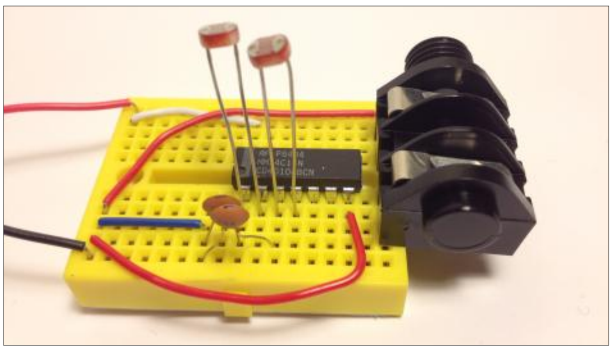


Now we can add the second of the LDRs between pins 3 and 4 of the IC. Push this into **D11** and **D12**.

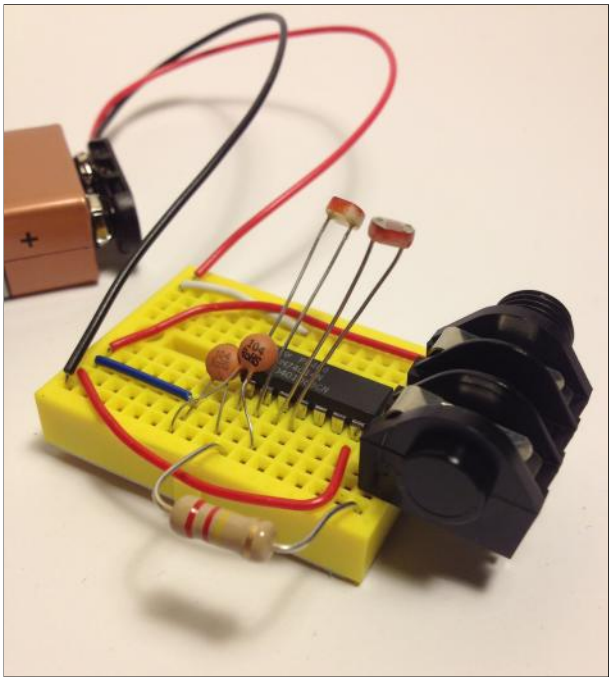


Next we need to make the connections to the tip of the jack socket. However, we can't just connect up multiple outputs from the IC to the tip of the jack socket – we need to send them through a resistor.

The first thing we need to do is to remove the purple jumper wire between **A10** and **A17** to make way for new connections.

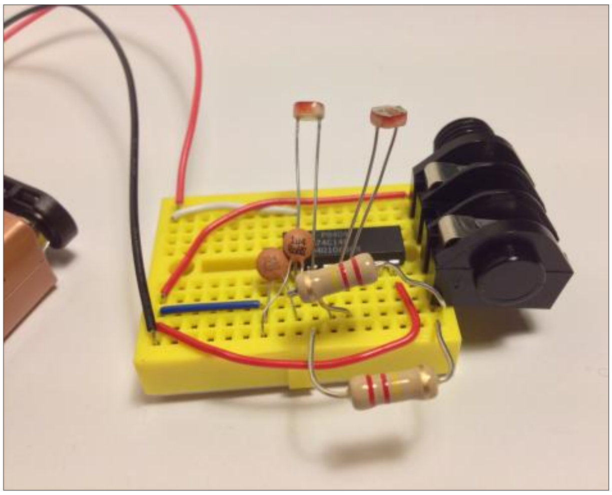


Next we are going to connect up our first signal output through a resistor by connecting pin 2 of the IC to the tip of the jack socket. Push one leg of the resistor into **A10**, and the other into **A17**.



Now we are going to connect up the second signal output by using the second resistor to connect pin 4 of the IC to the tip of the jack socket.

First, remove the remaining paper from the resistor if you have not already done so. Then push one leg of the resistor into **B12**, and squeeze the other into **B17** – you may need to temporarily lift out the jack socket to do this.



Finally, connect your synth to the amplifier and snap on the battery – if all has gone to plan, you should now hear two sounds, and you should be able to change each one separately by waving your hand over each of the LDRs creating a spectacularly horrible sound!

Some of you might be content with the noise machine you have just built, and it can provide hours of irritating atonal sonic entertainment in any of its configurations. However, we hope that this is just the start of an exciting adventure into electronics and music for you. Perhaps you can already think of ways of modifying and hacking the designs above. Perhaps you want to expand on this design and get all six of those inverters running at once! Perhaps you'd like to build this inot a bigger design full of LEDs, torches, Lego motors, or other equipment. Have a chat to us about your ideas – we are in no way qualified electrical engineers but we are enthusiastic hackers who know where to look for more information so that we can all learn together.

Thank you for building with Bleephaus!

For more information and kits, visit us at www.bleephaus.co.uk