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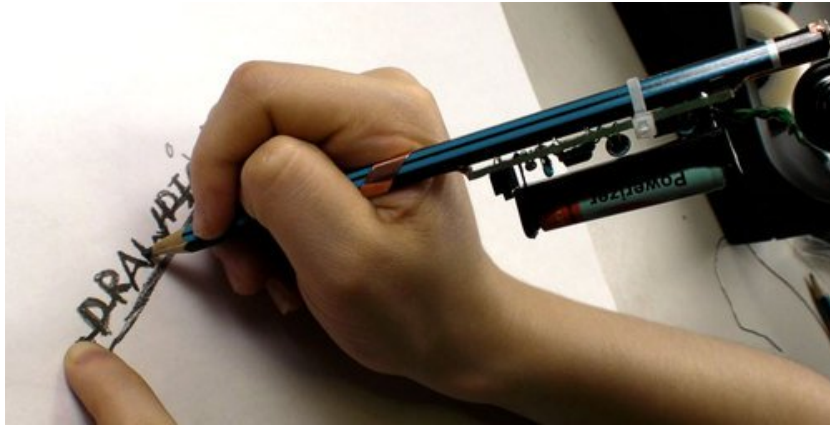
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Drawdio

Created by lady ada



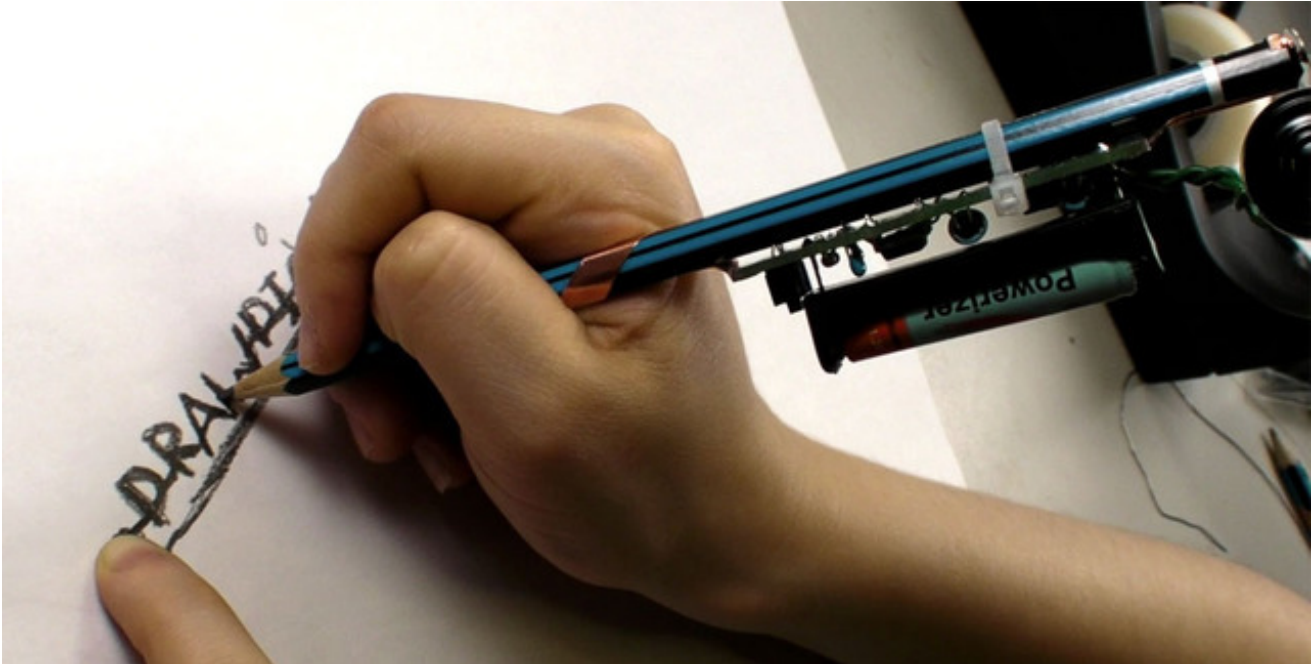
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Overview

Sketching with Hardware



Drawdio: A pencil that lets you draw with music!

When I first saw the [Drawdio](http://adafru.it/c1G) (<http://adafru.it/c1G>) at Maker Faire I knew it would be a great project for beginners: A lot of fun with instant gratification! Essentially, its a very simple musical synthesizer that uses the conductive properties of pencil [graphite](http://adafru.it/c1H) (<http://adafru.it/c1H>) to create different sounds. The result is a fun toy that lets you draw musical instruments on any piece of paper.

- Runs on a single AAA battery for many hours (even 'nearly dead' batteries will work).
- Use any pencil - mechanical or plain. The kit comes with a 2B pencil, the softer the lead the better.
- Ridiculously fun for all ages!

Video!

The best way to see how Drawdio works is to watch a video...

Here are some videos from JJ Silver himself! These videos are of an earlier revision so it looks a little different.

Credits

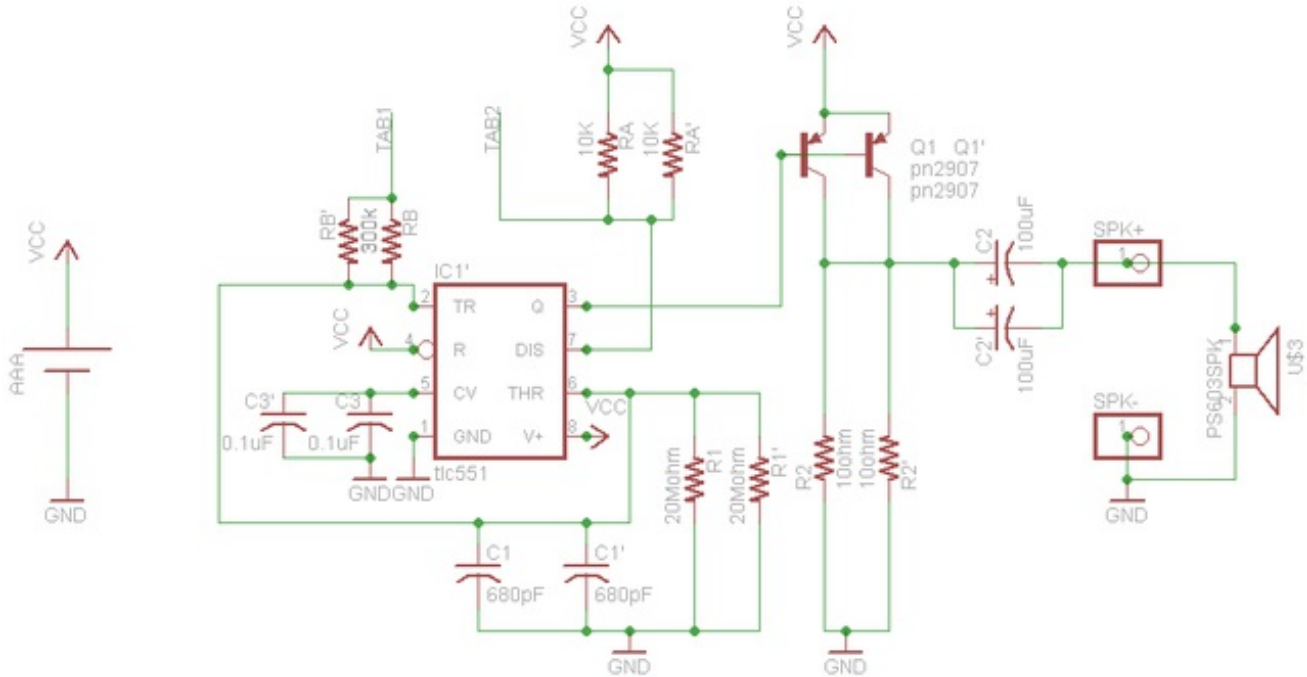
The Drawdio kit was designed in collaboration with [Jay Silver](http://adafru.it/c1I) & based on his [original design](http://adafru.it/c1G)!

Design

How does it work?

The Drawdio kit is pretty simple compared to most electronic projects.

We will go through it one section at a time, please refer to the schematic.



Power supply

The first part to understand is the power supply, which keeps everything running. The power source is a single AAA battery which is held in a plastic container that is soldered to the PCB. There is also a switch **S1** which can connect or disconnect the battery from the rest of the circuit. Finally there is a large electrolytic capacitor **C4**, which is used as a 'bypass capacitor'. This means that it goes across the AAA battery and smooths out any ripples that are caused from power surges (like when the drawdio makes noise!)

The Oscillator

The heart of the kit is a TLC551 chip, which is a low voltage version of the famous [LM555](http://adafru.it/c1J) (<http://adafru.it/c1J>) timer chip. This integrated circuit is specifically designed for

creating timers and oscillators. The original LM555 needs at least 5V to run (which is more than 3 1.5 batteries!) so we are using the 551 which can run as low as 1V. It's a little more expensive but makes the whole thing fit on a pencil.

One of the more popular ways that '555s are used is as a 'astable multivibrator' which is another way of saying an oscillator. The frequency of the oscillation is set by 2 resistors and a capacitor. The chip slowly feeds current into the capacitor until it is full and then, likewise, slowly drains it out. The resistors set how fast to fill and drain the capacitor and the size of the capacitor indicates how long it takes before it fills.

This system is pretty much identical to Japanese water fountains, as this video shows: Except its all with electrons instead of water molecules and capacitor **C1** is the 'bucket'. The water fountain oscillates maybe once a minute (1/60 Hz). But electrons are so much faster, a '555 can oscillate at thousands of Hertz, which means it can make audible sound. (Human hearing tends to range from 20Hz to 20000 Hz.)

$$f = 1.44 / (C3 * (RA + 2 * RB))$$

$$C3 = 680 \text{ pF} = 0.00000000068 \text{ F}$$

$$RA = 10000 \text{ ohms}$$

$$RB = 300000 \text{ ohm to } 1000000 \text{ ohm (1 Mohm)}$$

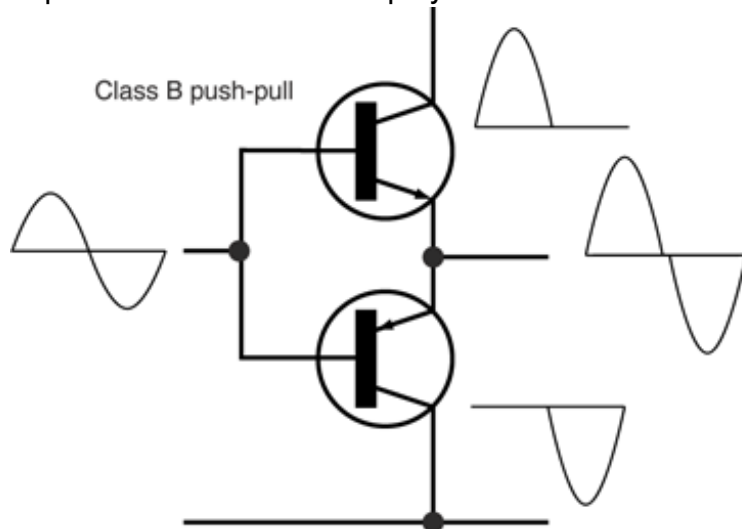
In this case, we use two resistors **RA** and **RB** but also have an 'open connection': two tabs at the end of the PCB. If the two tabs are shorted with a piece of wire, then the frequency of the oscillation is 3500 Hz, if instead there is a resistor of 1 Megaohms between the two tabs, the frequency of oscillation is about 1000 Hz. You can use a calculator to do the math yourself using the formula above.

Instead of a 'everyday' resistor between the tabs, however, we use something else - the conductivity of the human body and graphite! The human body has a resistance similar to a 200,000 ohm resistor. Graphite has resistance of about 1 ohm per inch when it's in the form of a pencil lead. When it's spread out on a piece of paper, the resistance goes up a lot, up to a megaohm for a few inches of 'drawn resistor.'

Amplifier

The 551 can create audio-frequency oscillations but it is not powerful enough to play them on a speaker, just like an MP3 player needs an amp to play music on large speakers. That's because the 551 was designed mostly for digital logic, not for low impedance (8 ohm) audio outputs. So we will use a [Class B 'pushpull' amplifier \(http://adafru.it/c1K\)](http://adafru.it/c1K), which uses two

seperate transistors to amplify the sound.



This is pretty much the same thing in your stereo, except your stereo has *enormous* transistors with gigantic heatsinks so that it can drive large speakers.

Make it!

Three step plan for success

This is a vey easy kit to make, just go through each of these steps to build the kit:

1. [Tools and preparation](http://adafru.it/c1L) (<http://adafru.it/c1L>)
2. [Check the parts list](http://adafru.it/c1M) (<http://adafru.it/c1M>)
3. [Assemble it](http://adafru.it/c1N) (<http://adafru.it/c1N>)

Preparation

[Learn how to solder with tons of tutorials!](http://adafru.it/aTk)(<http://adafru.it/aTk>)

[Don't forget to learn how to use your multimeter too!](http://adafru.it/aOy)(<http://adafru.it/aOy>)

Tools

There are a few tools that are required for assembly. None of these tools are included. If you don't have them, now would be a good time to borrow or purchase them. They are very very handy whenever assembling/fixing/modifying electronic devices! I provide links to buy them, but of course, you should get them wherever is most convenient/inexpensive. Many of these parts are available in a place like Radio Shack or other (higher quality) DIY electronics stores.

Soldering iron

Any entry level 'all-in-one' soldering iron that you might find at your local hardware store should work. As with most things in life, you get what you pay for.

Upgrading to a higher end soldering iron setup, like the [Hakko FX-888 that we stock in our store](http://adafru.it/180) (<http://adafru.it/180>), will make soldering fun and easy.



Do not use a "ColdHeat" soldering iron! They are not suitable for delicate electronics work and can damage the kit ([see here](http://adafru.it/aOo) (<http://adafru.it/aOo>)).

[Click here to buy our entry level adjustable 30W 110V soldering iron](http://adafru.it/180) (<http://adafru.it/180>).

[Click here to upgrade to a Genuine Hakko FX-888 adjustable temperature soldering iron.](http://adafru.it/303) (<http://adafru.it/303>)



Solder

You will want rosin core, 60/40 solder. Good solder is a good thing. Bad solder leads to bridging and cold solder joints which can be tough to find.

[Click here to buy a spool of leaded solder \(recommended for beginners\)](http://adafru.it/145) (<http://adafru.it/145>).

[Click here to buy a spool of lead-free solder](http://adafru.it/734) (<http://adafru.it/734>).





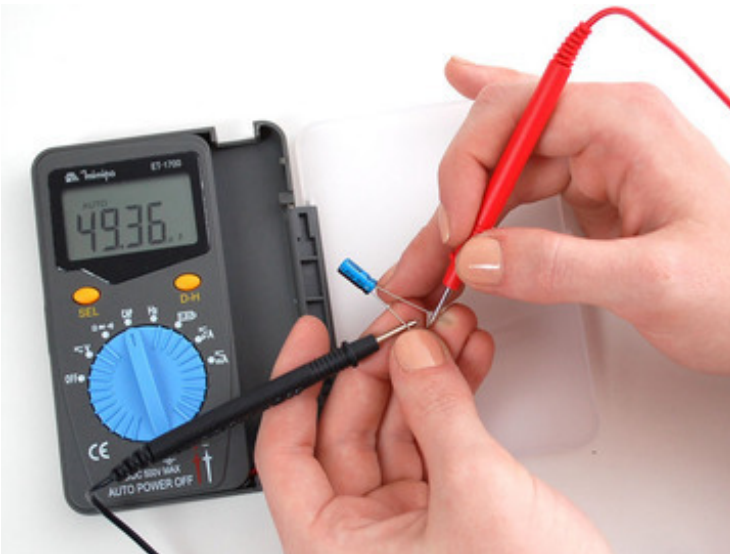
Multimeter

You will need a good quality basic multimeter that can measure voltage and continuity.

[Click here to buy a basic multimeter.](http://adafru.it/71) (<http://adafru.it/71>)

[Click here to buy a top of the line multimeter.](http://adafru.it/308) (<http://adafru.it/308>)

[Click here to buy a pocket multimeter.](http://adafru.it/850) (<http://adafru.it/850>)





Flush Diagonal Cutters

You will need flush diagonal cutters to trim the wires and leads off of components once you have soldered them in place.

[Click here to buy our favorite cutters \(http://adafru.it/152\)](http://adafru.it/152).



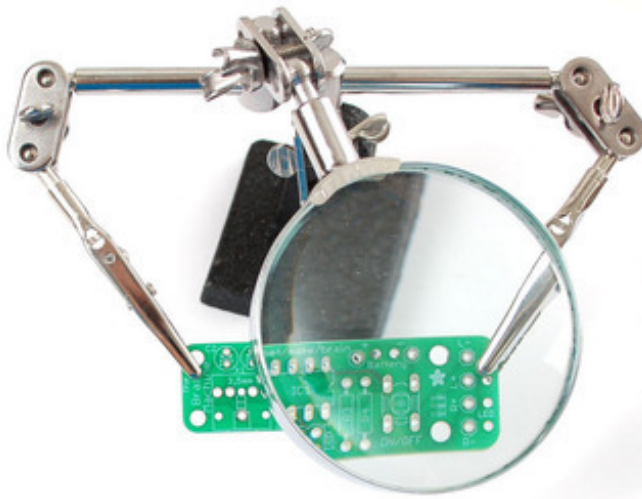
Solder Sucker

Strangely enough, that's the technical term for this desoldering vacuum tool. Useful in cleaning up mistakes, every electrical engineer has one of these on their desk.

[Click here to buy a one \(http://adafru.it/148\)](http://adafru.it/148).

Helping Third Hand With Magnifier

Not absolutely necessary but will make things go much much faster, and it will make soldering



much easier.








[Pick one up here \(http://adafru.it/291\)](http://adafru.it/291).









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Parts list

Bill of Materials for v1.1

Check to make sure your kit comes with the following parts. Sometimes we make mistakes so double check everything and email support@adafruit.com if you need replacements!

Image	Name	Description	Information	Qty
	PCB	Printed circuit board (actually looks a little longer/different than this one).	Adafruit	1
	IC1	TLC551 or similar low voltage '555 timer chip.	TLC551	1
	Q1	PNP transistor, EBC pinout Such as PN2907 or 2N3806	PN2907	1
	C1	680pF ceramic capacitor	Generic	1
	C3	0.1uF ceramic capacitor (104)	Generic	1
	C2	100uF / 6.3V capacitor (or higher)	Generic	1
		1/4W 5% 10 MEGAohm resistor Brown, Black, Blue, Gold		
		OR		
	R1	1/4W 5% 20 MEGAohm resistor Red, Black, Blue, Gold	Generic	1
		<i>If you don't have this part, you may have an older v1.0 kit see below!</i>		




		1/4W 5% 10 ohm resistor		
	R2	Brown, Black, Black, Gold	Generic	1
		<i>If you don't have this part, you may have an older v1.0 kit see below!</i>		
	RA	1/4W 5% 10K resistor Brown, Black, Orange, Gold	Generic	1
	RB	1/4W 5% 300K resistor Orange, Black, Yellow, Gold	Generic	1
	BATT	AAA battery holder	EPD BH412	1
	SPK	Small 8ohm speaker	Kobitone PS603	1
		Copper foil tape	3M 1181	6"
		Thumbtack	Any stationary store	1
		Pencil	Any stationary store	1
		Zip Tie	Any hardware store	1
		Wire	Any electronics or hardware store	6"

Bill of Materials for v1.0

Check to make sure your kit comes with the following parts. Sometimes we make mistakes so double check everything and email support@adafruit.com if you need replacements! This is for the very old v1.0 kit, its unlikely you have this one but we will leave this up for historical record!

Image	Name	Description	Information	Qty
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<input type="text"/>	PCB	Printed circuit board	Adafruit	1
<input type="text"/>	IC1	TLC551 or similar low voltage '555 timer chip	TLC551	1
<input type="text"/>	Q1	NPN transistor, EBC pinout Such as PN2222 or 2N3904 <i>If you don't have this part, you may have a newer v1.2 kit see above!</i>	PN2222	1
<input type="text"/>	Q2	PNP transistor, EBC pinout Such as PN2907 or 2N3806	PN2907	1
<input type="text"/>	C1	680pF ceramic capacitor	Generic	1
<input type="text"/>	C3	0.1uF ceramic capacitor (104) 100uF / 6.3V capacitor	Generic	1
<input type="text"/>	C2, C4	<i>If you only have one of this part, you may have a newer v1.2 kit see above!</i> 1/4W 5% 10K resistor	Generic	2
<input type="text"/>	RA	Brown, Black, Orange, Gold 1/4W 5% 300K resistor	Generic	1
<input type="text"/>	RB	Orange, Black, Yellow, Gold Switch	Generic	1
<input type="text"/>	ON/OFF	<i>If you don't have this part, you may have a newer v1.2 kit see above!</i>	E-Switch EG1218	1
<input type="text"/>	BATT	AAA battery holder	EPD BH412	1
<input type="text"/>	SPK	Small 8ohm speaker	Kobitone	1

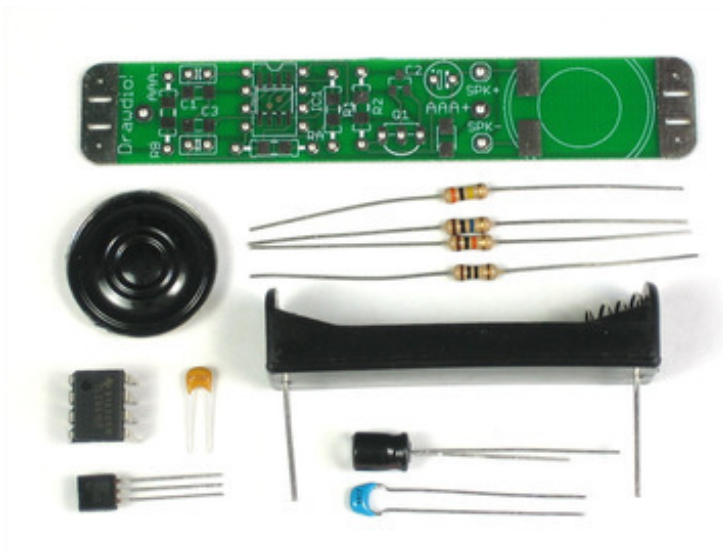
	Copper foil tape	PS603 3M 1181	6"
	Thumbtack	Any stationary store	1
	Pencil	Any stationary store	1
	Zip Tie	Any stationary store	1
	Wire	Any electronics or hardware store	6"

Solder it!

Instructions for v1.1

These instructions are for the newer v1.1 kit with a thinner PCB and slightly different components. It makes minor upgrades to the kit which reduce power usage. If the photos don't match up, you probably have a v1.0 kit and [you should follow the instructions here!](http://adafru.it/c1O) (<http://adafru.it/c1O>)

Lets go!

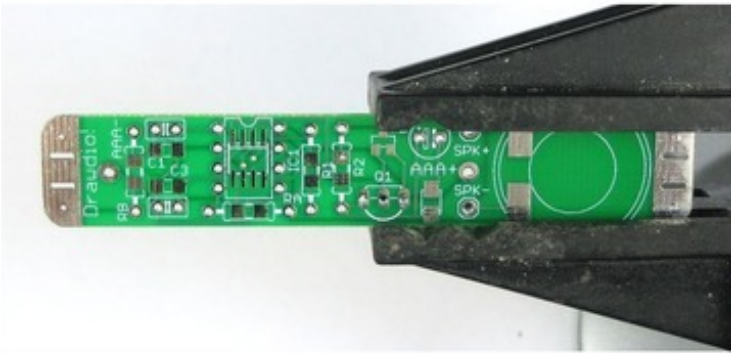


Make sure you have all the parts necessary. [Check the BOM](http://adafru.it/c1M) (<http://adafru.it/c1M>) for a list of everything in the kit.

These instructions are for the newer v1.1 kit with a thinner PCB and slightly different components. It makes minor upgrades to the kit which reduce power usage. If the photos don't match up, you probably have a v1.0 kit and [you should follow the instructions here!](http://adafru.it/c1O) (<http://adafru.it/c1O>)

Get ready by placing the PCB in a vise.

Heat up your soldering iron to 700deg F, clean the tip and make sure your sponge is wet.



Lets go!

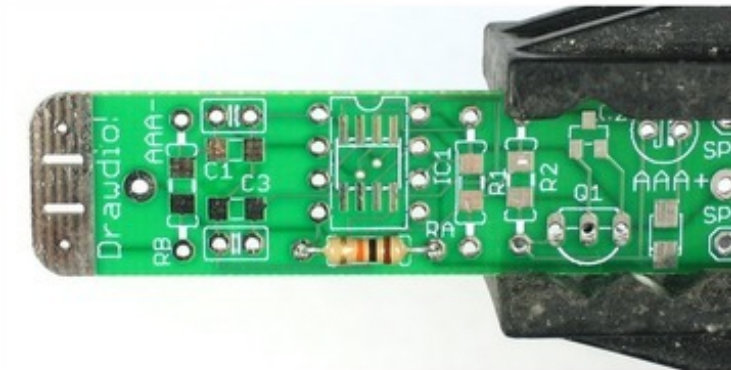
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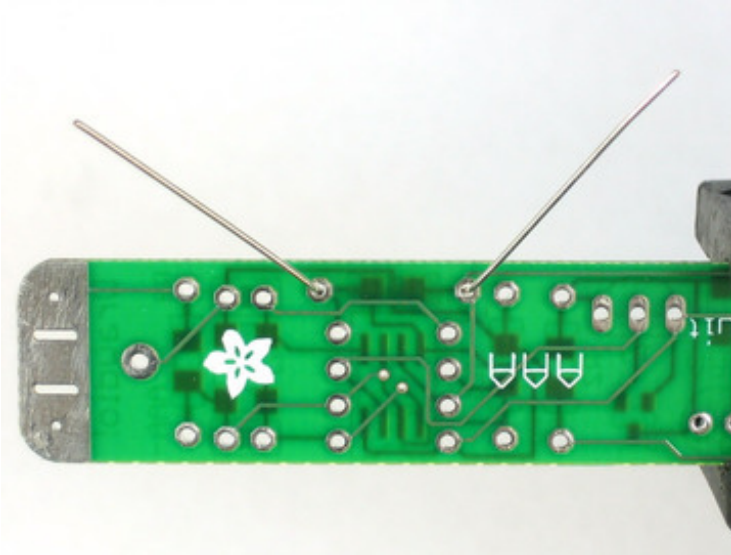
First thing we will place is **RA**, a 10K resistor (brown, black, orange gold).

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Bend the resistor into a staple as shown, and slip it in.



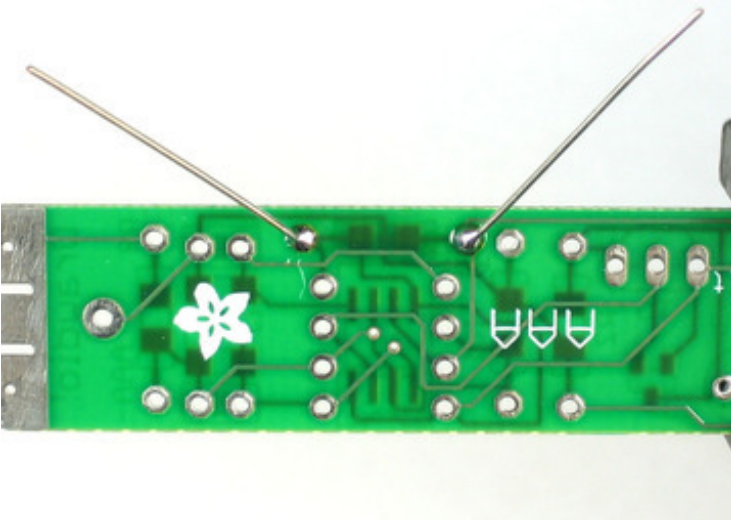
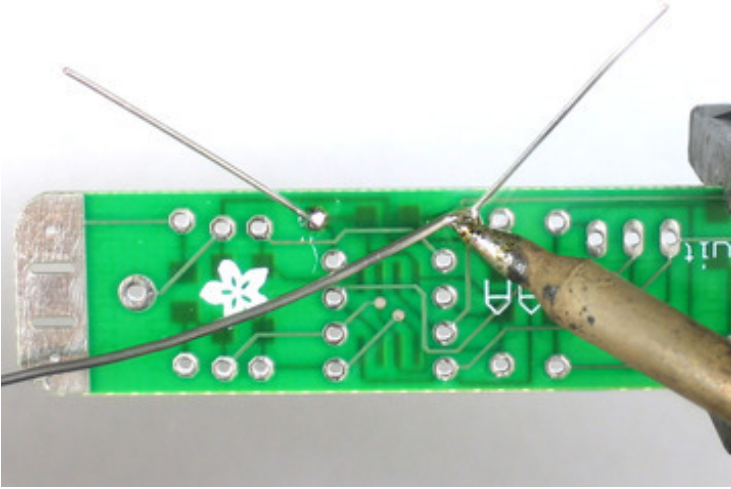
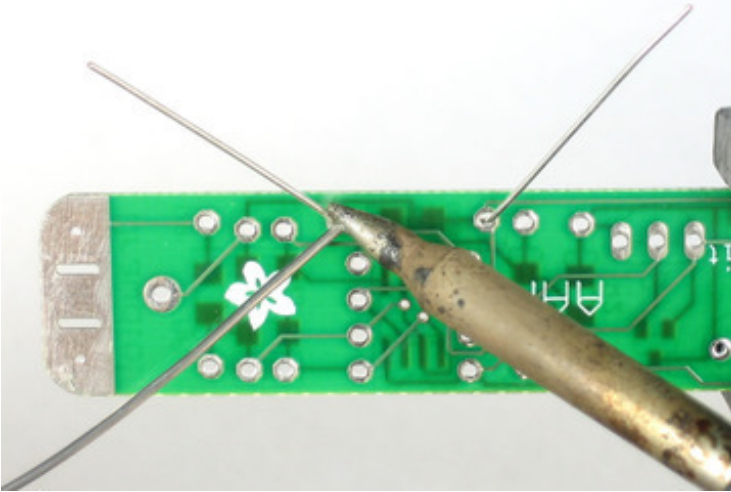
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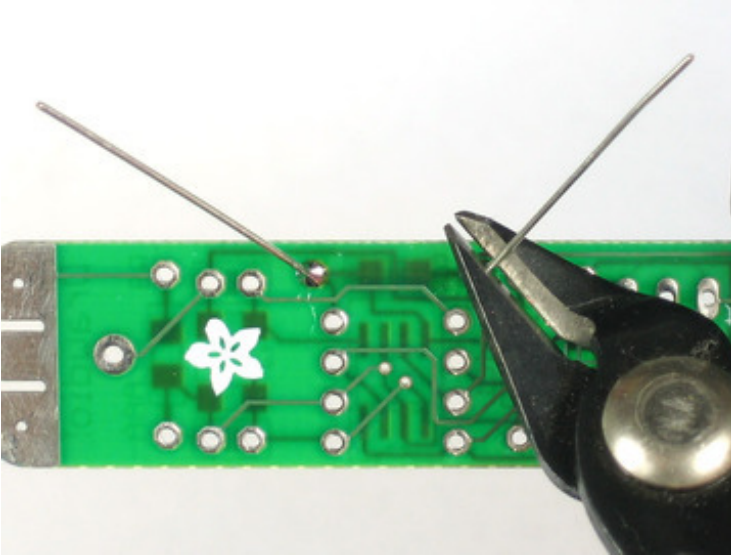


Place the resistor in the location marked **RA**. Resistors do not have *polarity* which means you can put it in 'either way' and it will work just fine. Bend the wire legs out so that the resistor sits flat against the PCB.

Turn the PCB over. Using your soldering iron tip, press and heat

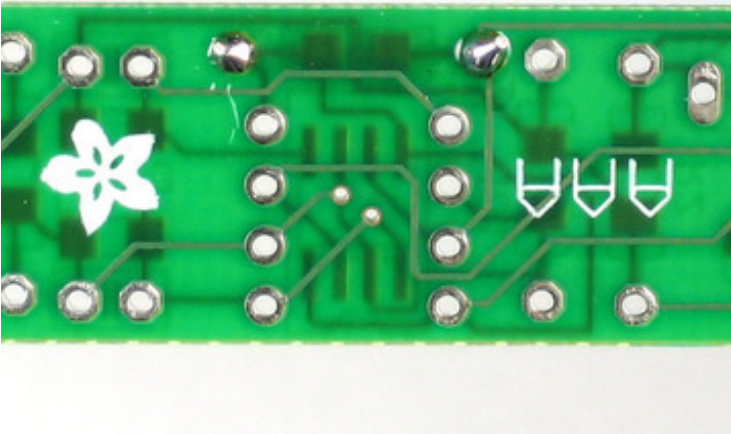
both the pad (the silver ring around the hole) and lead (wire) at the same time for 2 or 3 seconds. Then poke the end of the solder in to create a nice solder joint. Do this for both leads.





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Using your diagonal cutters, cut off the long leads just above the solder joint.

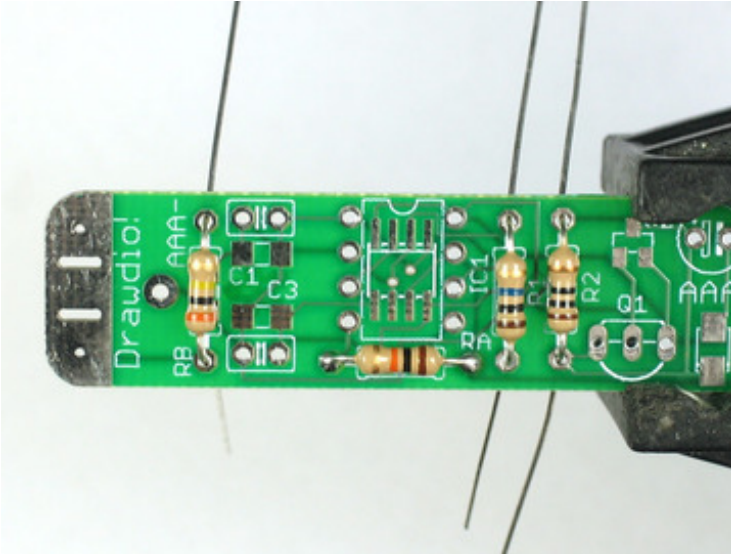


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Next are the other 3 resistors.

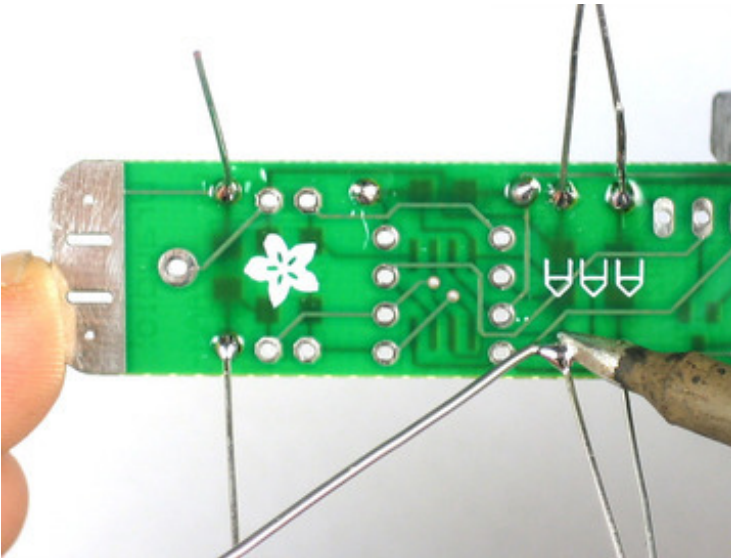
Start with the resistor **RB**. This resistor has a different value, 300K. The stripes are Orange, Black, Yellow, Gold. Place that on the left, next to the RB silkscreen.

Then place **R1** this is a **10 or 20 megaohm** resistor! The stripes are brown, black, blue, gold or red, black, blue, gold. Make sure you do not confuse this with R2 which is a 10 ohm resistor. Look under a bright light to tell which one has a blue stripe and which one has a black stripe. If you're not sure, a multimeter will help measure the resistance.

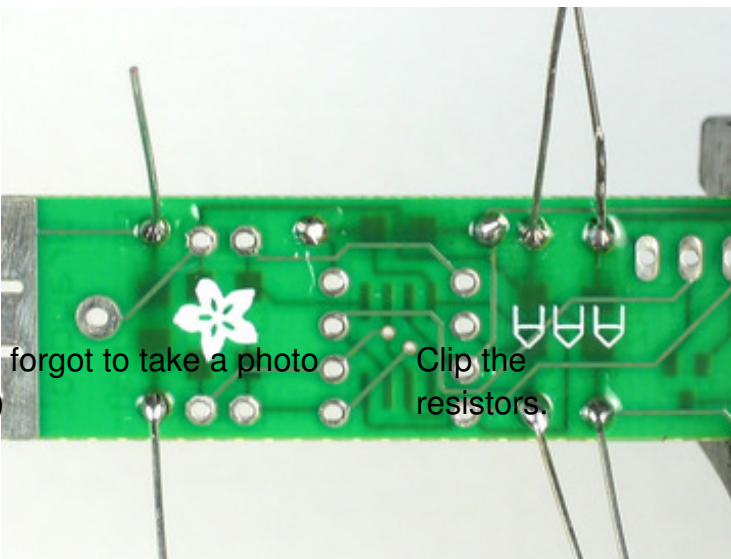


Finally, place **R2** which is a 10 ohm resistor. The stripes are brown, black, black, gold. Make sure you do not confuse this with R1 which is a 10 **megaohm** resistor. Look under a bright light to tell which one has a blue stripe and which one has a black stripe. If you are not sure, a multimeter will help measure the resistance.

Check again to make sure you did not confuse R1 and R2. Really, you need to look under a good light and a mistake here will be difficult to determine later!



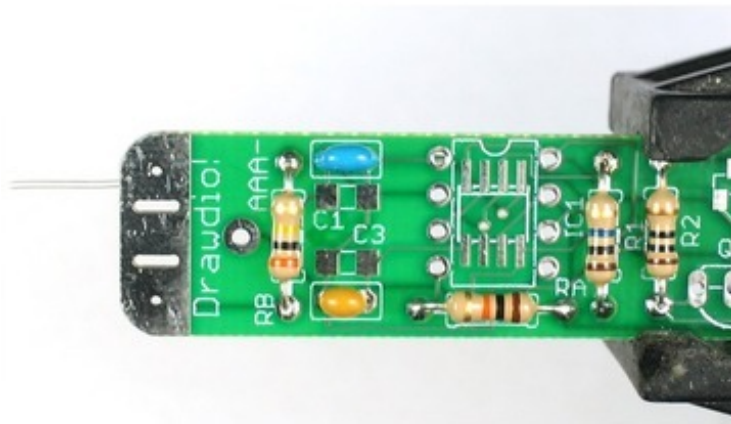
Once you are positive about R1 and R2, solder in these resistors using the same technique you used for the first resistor.



(oops forgot to take a photo here!)

Clip the resistors.

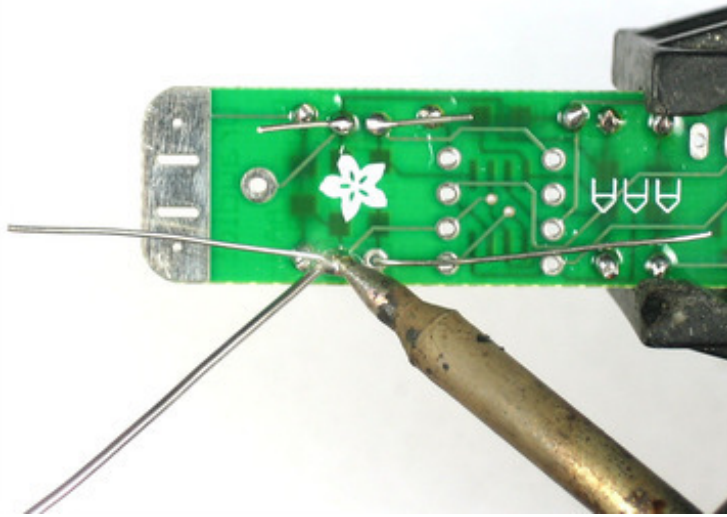
Next are the two ceramic capacitors **C1** and **C3**. Ceramic capacitors also have a nice property that they are symmetric/non-polarized. That means they can go in 'either way'. The capacitors are different values so make sure to not mix them up.



C3 is a yellow 0.1uF capacitor and has a "104" marking on it. **C1** is the blue 680pF capacitor and has a "682" marking on it.

Place the capacitors so that the 2 legs (leads) slide thru the two metal holes in the PCB (pads).

The capacitor will sit flat against the PCB.



Solder in the capacitors.

