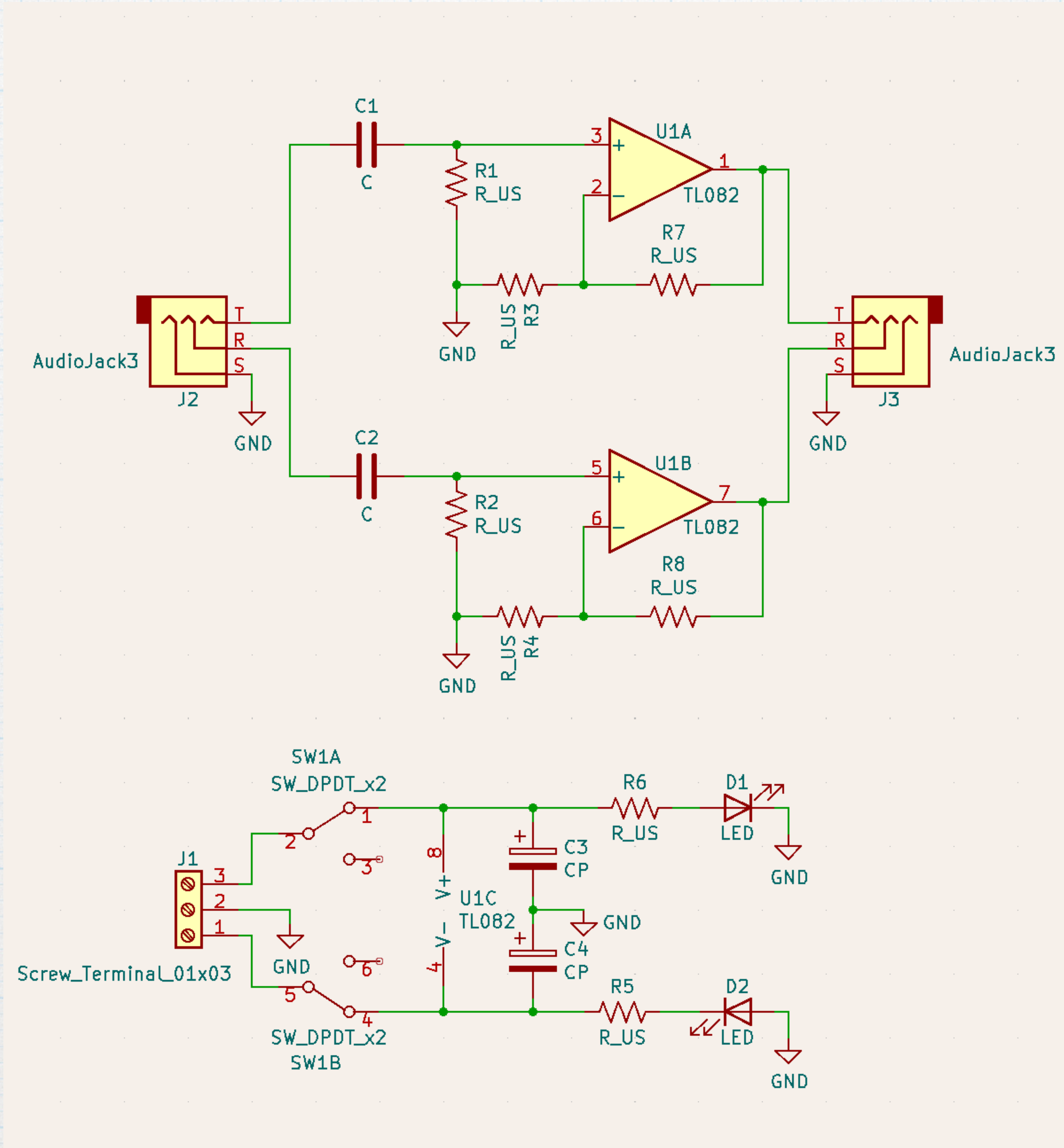
Altoids Amp – Build

Full schematic for the PCB

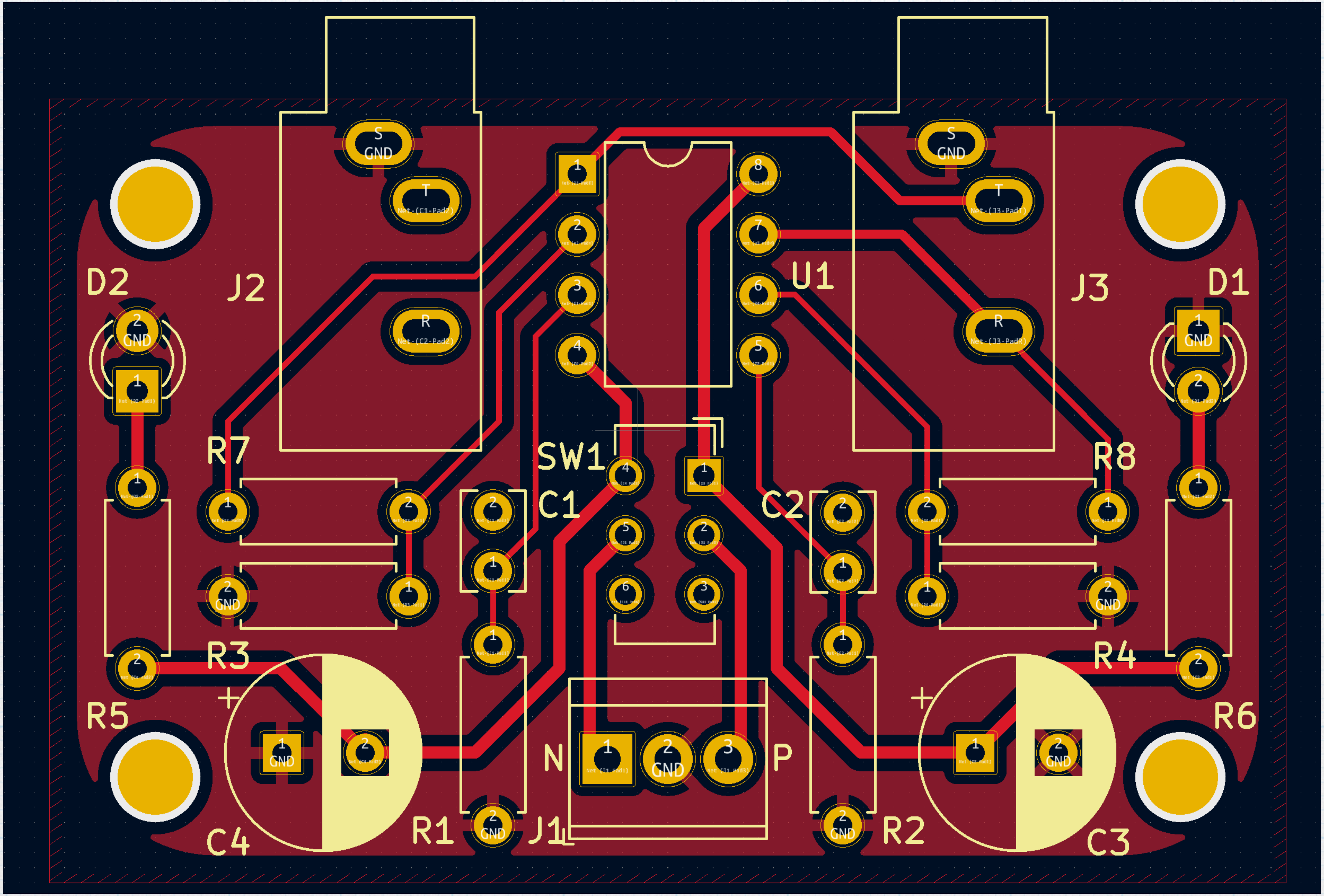


Bill of Materials

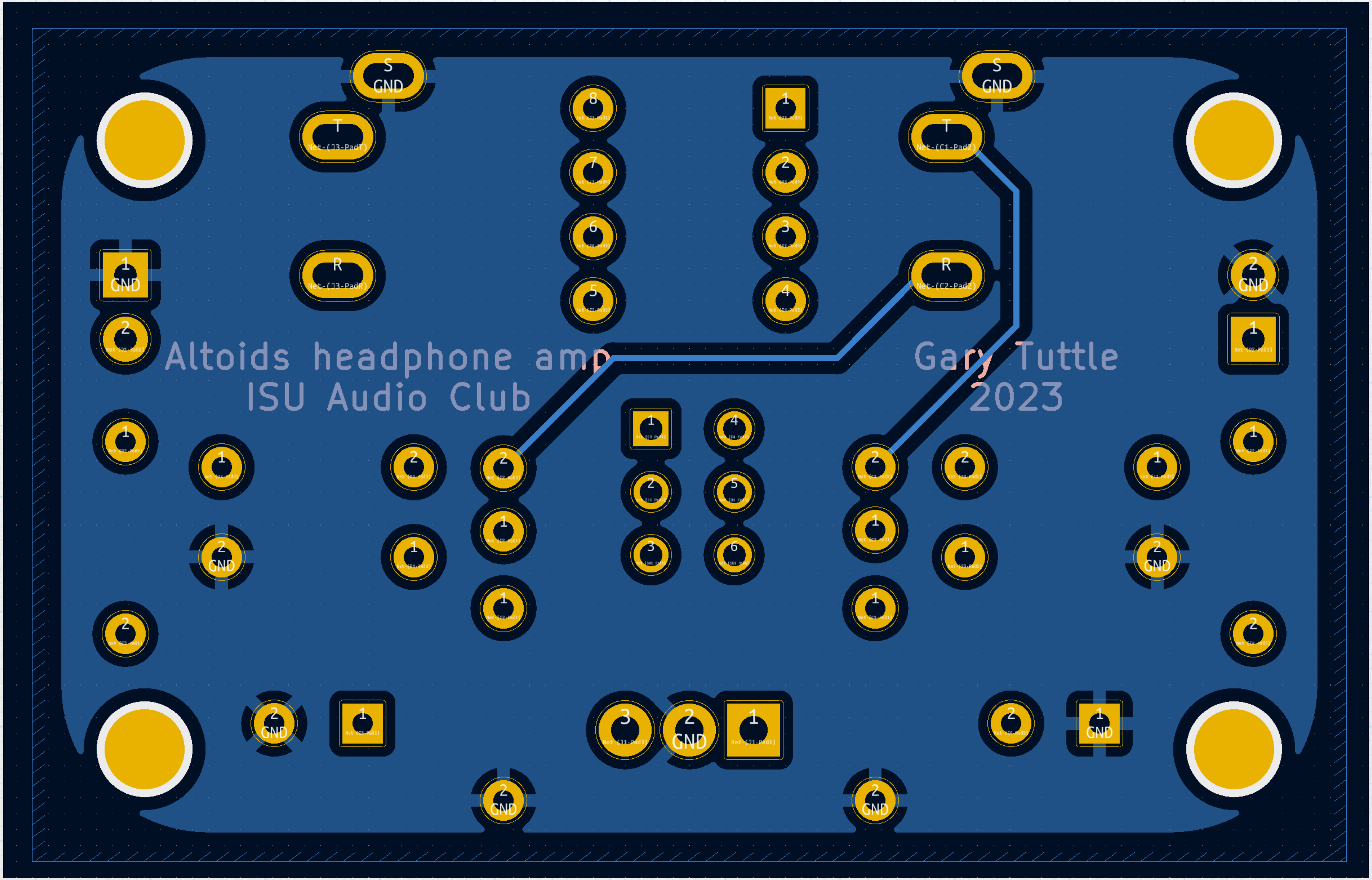
		manufacturer's part number	price	quant	total
socket	U1	Assmann AR 08 HZL-TT	0.50	1	$0.50
TL082	U1	Texas Instruments TL082CP	1.02	1	$1.02
100-nF cap	C1, C2	Vishay K104K15X7RF5TL2	0.23	2	$0.46
100-μF cap	C3, C4	Nichicon UVR1H101MPD1TD	0.34	2	$0.68
15-kΩ resistor	R7, R8	Stackpole CF14JT15K0	0.10	2	$0.20
1-kΩ resistor	R3 - R6	Stackpole CF14JT1K00	0.10	4	$0.40
100-kΩ resistor	R1, R2	Stackpole CF14JT100K	0.10	2	$0.20
red LED	D1	Vishay TLLR4400	0.51	1	$0.51
green LED	D2	Vishay TLVG4200	0.48	1	$0.48
DPDT switch	SW1A,B	C&K JS202011CQN	0.60	1	$0.60
stereo jack	J2, J3	CUI SJ1-3533	2.00	2	$4.00
screw terminal	J1	On Shore OSTVN03A150	1.04	1	$1.04
battery strap		Keystone 84-4	0.68	2	$1.36
board			2.50	1	$2.50
					$13.95

Prices checked Feb 2023 at DigiKey. Prices are for purchasing single components, which is the most expensive. Buying in bulk would lower the cost.

PCB layout - front



PCB - back



Soldering

If you don’t already know how to solder, watch one or two videos to get some basic instruction. There are couple links on the Audio Club web page, but there are many, many more videos on the internet.

The Altoids amp should be a fairly easy soldering exercise — the circuit is simple and the parts are not complicated. It is certainly a good first-time project.

However, there is one aspect that might be a bit tricky. The PCB uses a ground plane, meaning that the two sides of the board are mostly covered with a layer of copper that serves as ground in the circuit. (The ground planes are the large red or blue areas on the previous pages.) Being relatively large, the ground plane is a good conductor for current. However, that means it also a good conductor for heat, which causes some problems with soldering. When trying to solder a lead to the ground plane, the thermal energy quickly diffuses away into the surrounding copper, making it more difficult to heat the lead to a high enough temperature to melt the solder.

Thermals

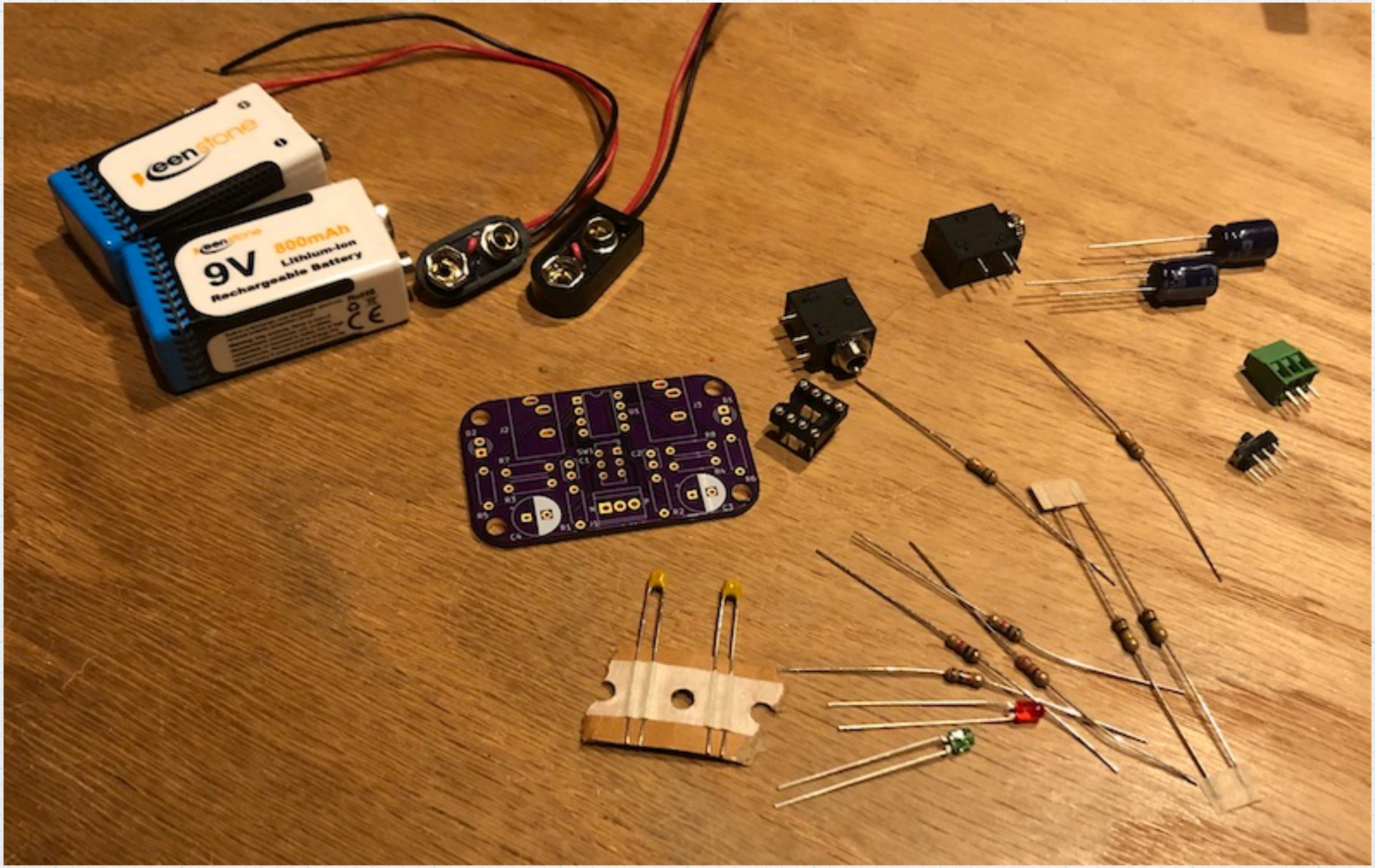
A partial solution to the soldering problem is to reduce the area of contact between the ground plane and the metal of the through-hole, as shown at right. Basically, instead of having contact around the entire periphery of the through-hole opening, smaller “fingers” are used. This is a trade-off between maintaining good electrical conduction while reducing heat conduction. In PCB jargon, this arrangement is known as a “thermal”.

The thermals help, but it will still be more difficult to make solder connections to the ground plane. It will be necessary to get more heat into the connection to melt the solder. Things to do:

1. Hold the soldering iron tip on the lead longer before trying to melt the solder into the joint. It may take 2 or 3 times longer to heat up.
2. Increase the temperature of the soldering iron. Bump up by 25°C, 50°C, or even 100°C.
3. Use a bigger soldering iron tip to get better thermal contact.

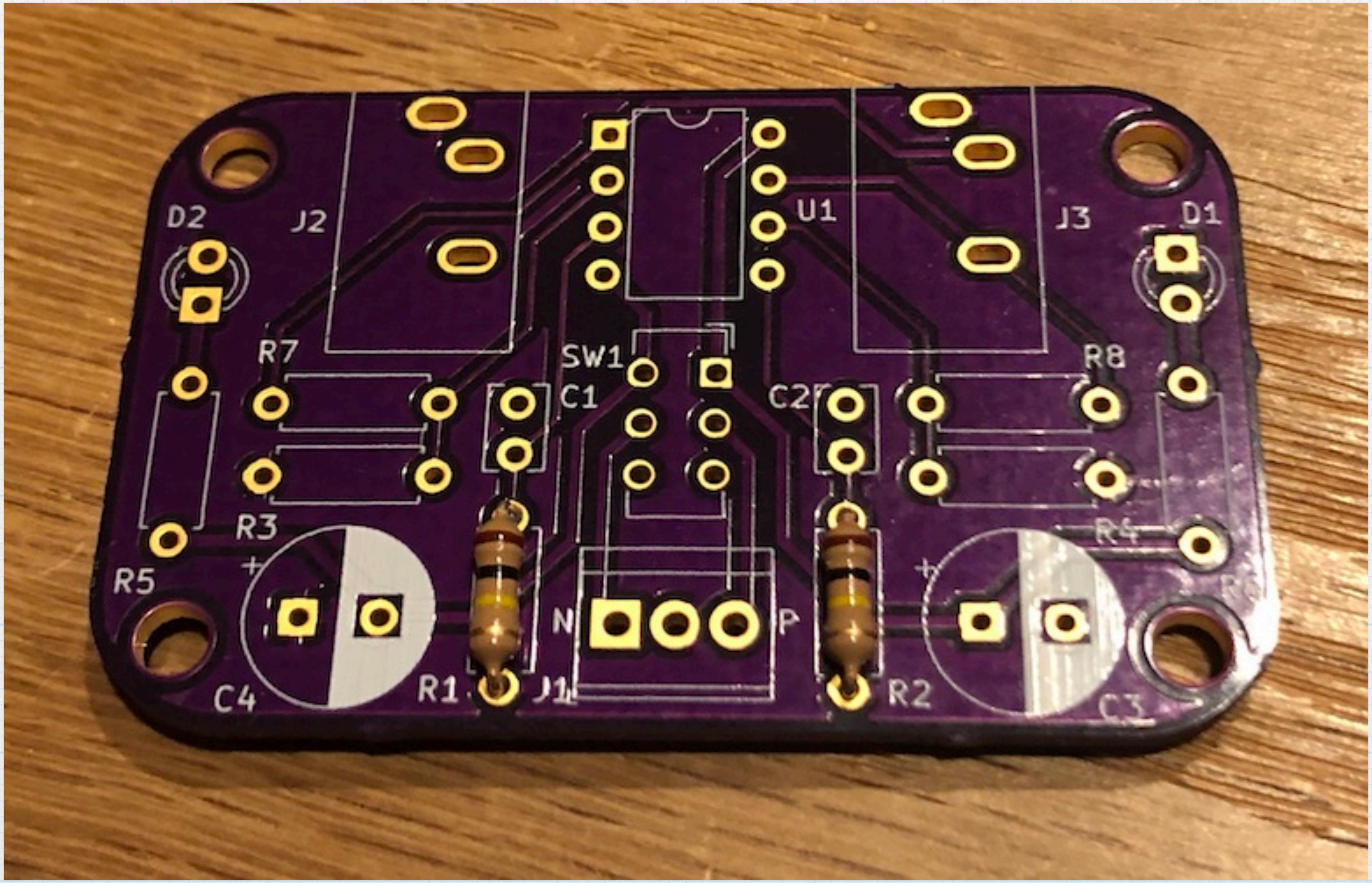
But mainly, be patient.

0. Gather your parts



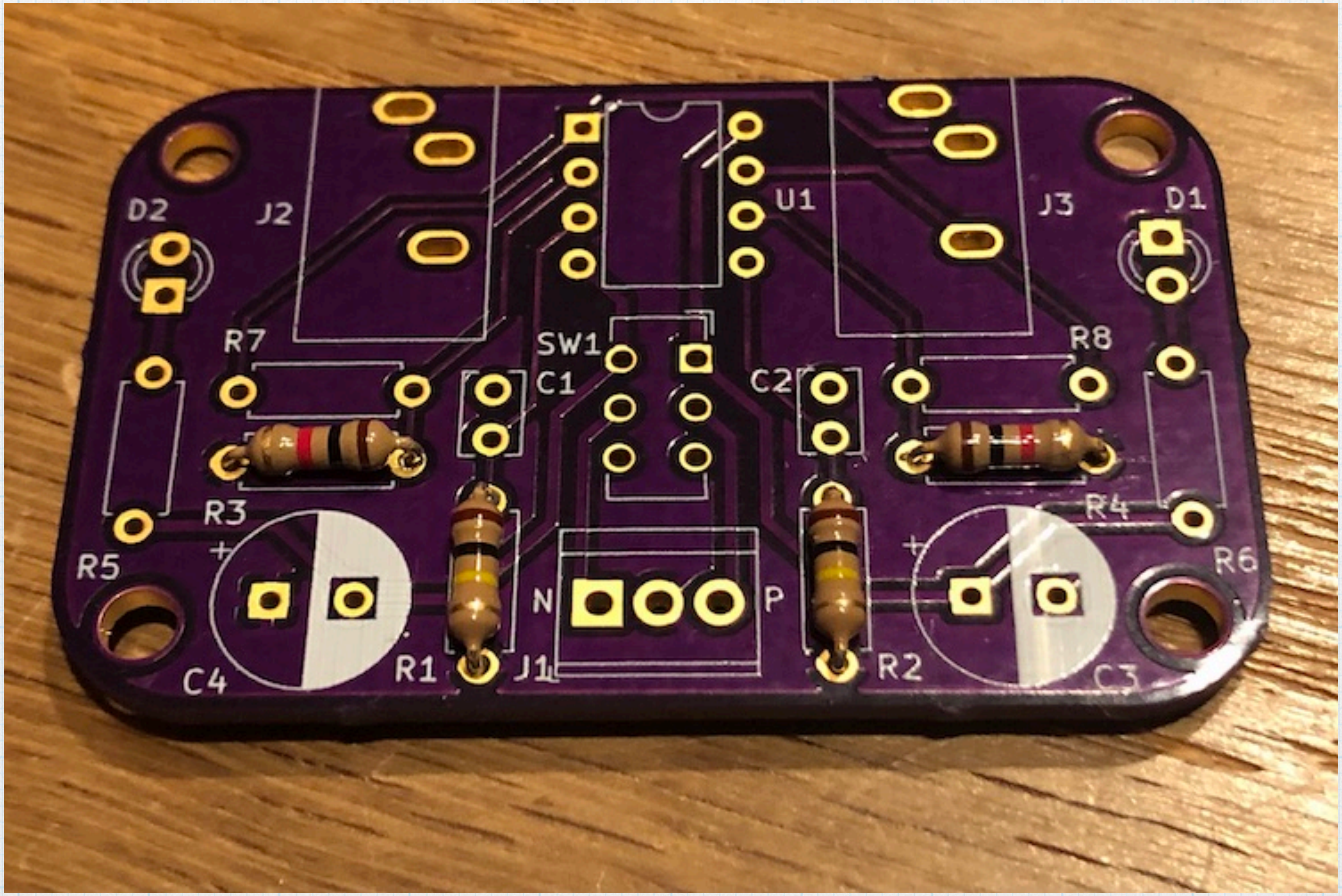
1. Feedback resistors

Solder in the two input resistors — R_{iL} and R_{iR}, each having values of 100 kΩ. (Labeled R1 and R2 on the board.) Note that one side is connected to ground, so extra time/heat is required there.



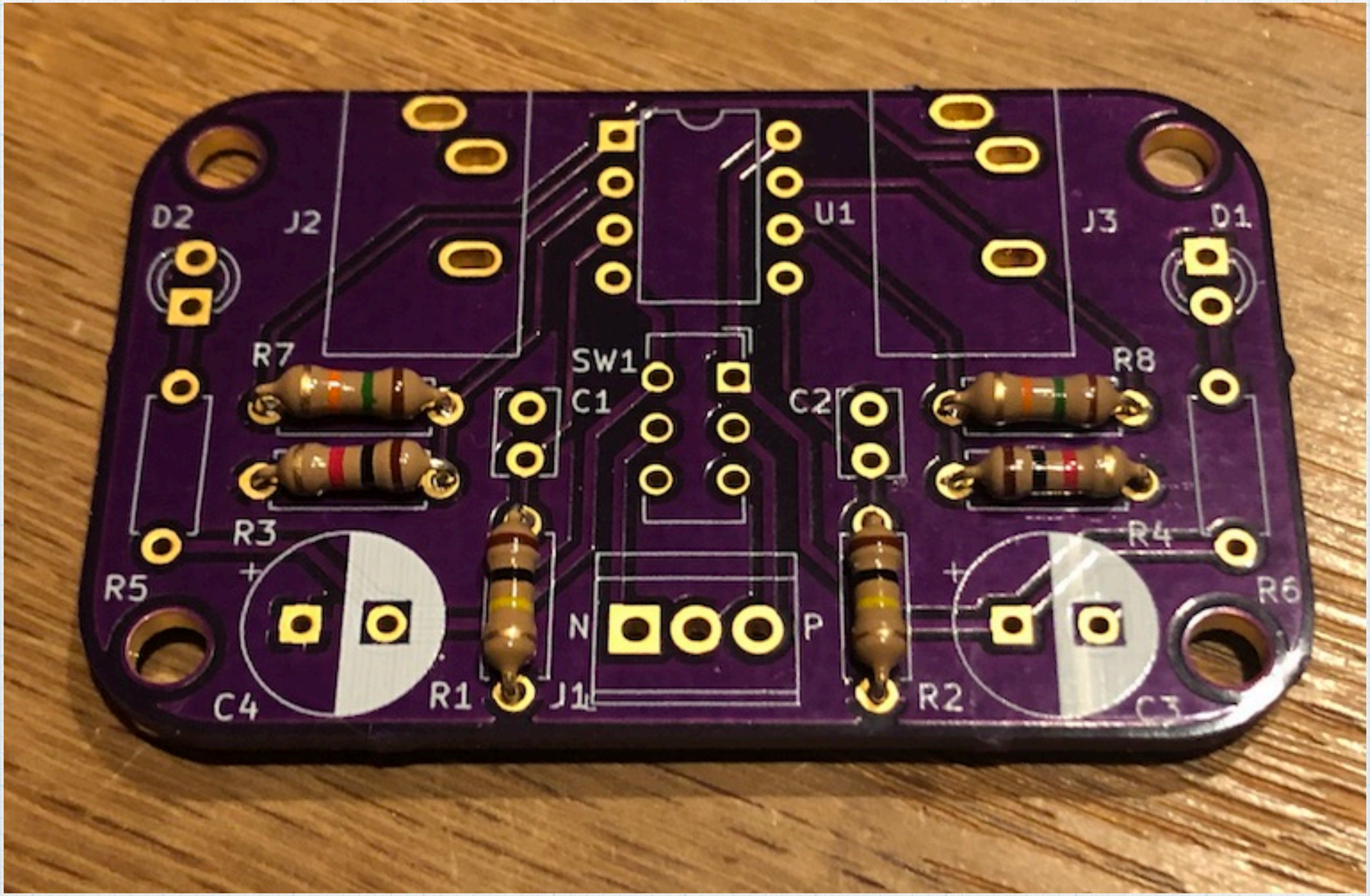
2. First feedback resistors

Solder in the two feedback resistors — R_{1L} and R_{1R}, each having values of 1 kΩ. (Labeled R3 and R4 on the board.) Again, one side of each is connected to the ground plane.



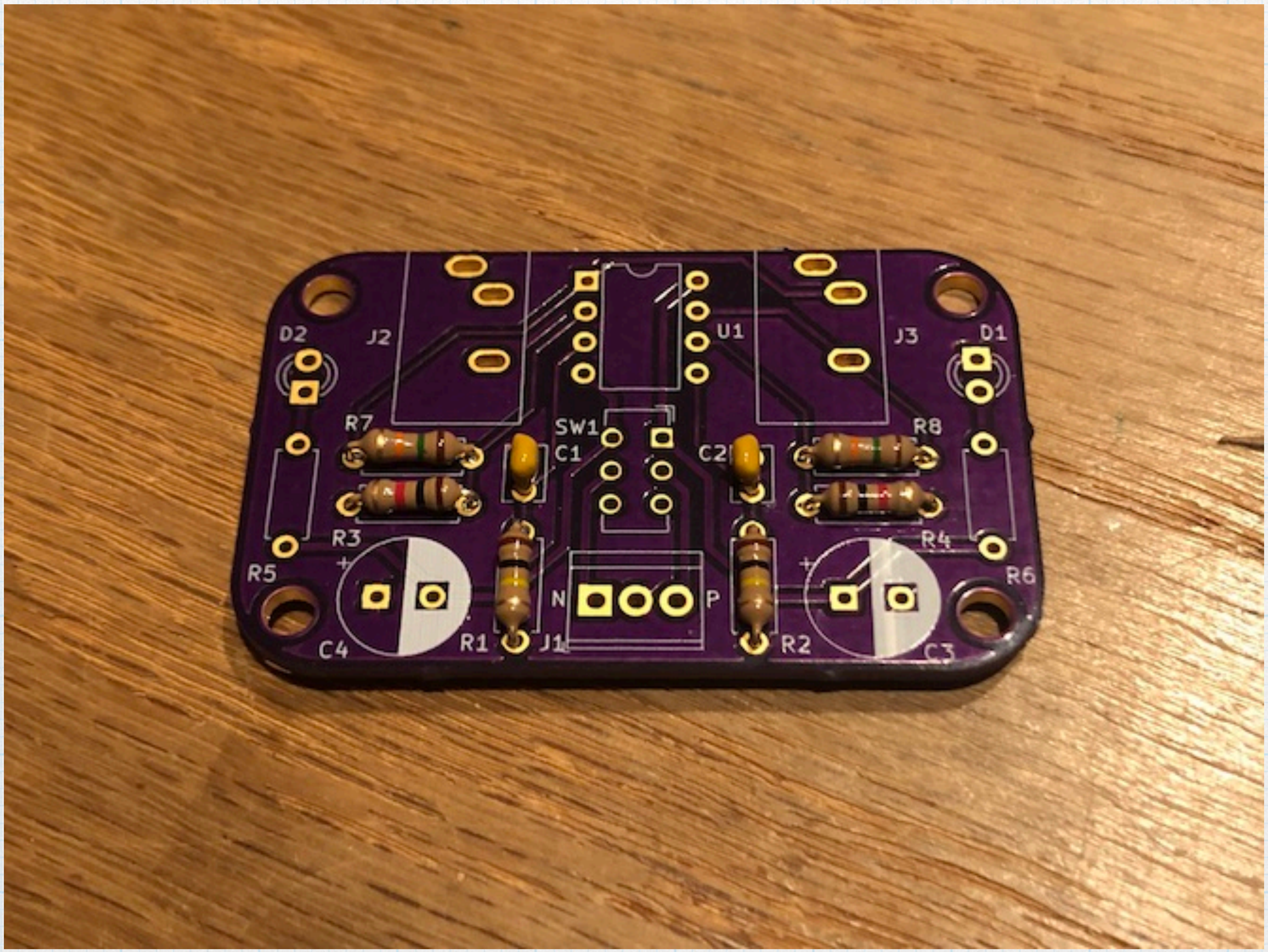
3. Second feedback resistors

Solder in the other feedback resistors — R_{2L} and R_{2R}, having values of 15 kΩ. (Labeled R7 and R8 on the board.) No ground connections here.



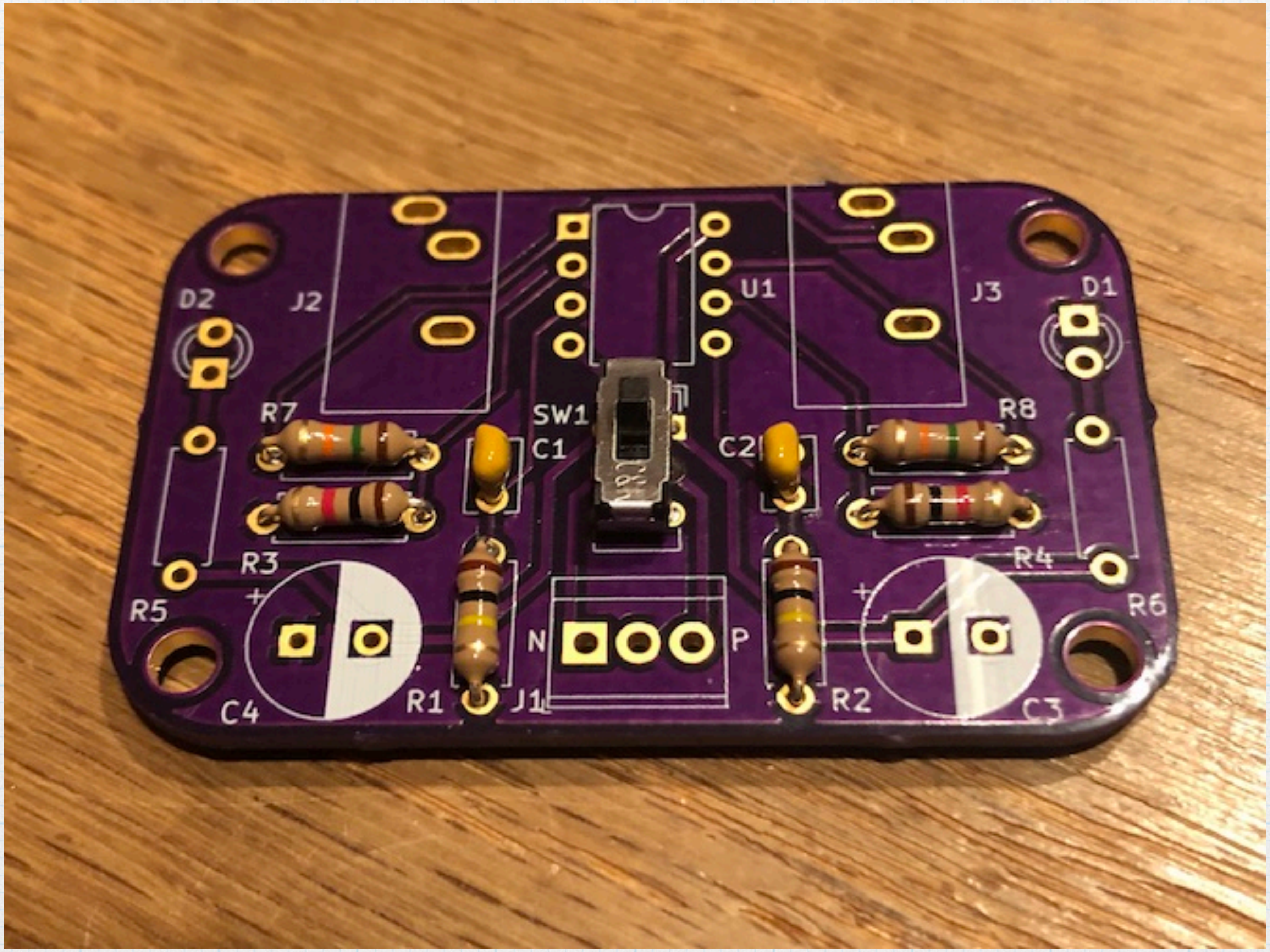
4. Input capacitors

Solder in the two input capacitors — C_{iL} and C_{iR}, having values of 100 nF. (Labeled C1 and C2 on the board.)



5. Double-pole switch

Next, we can add the switch. It doesn't matter which way it goes. The switch is a double throw. Since we are using only one side (i.e. only one of the "throws"), it works the same either way.



6. Socket

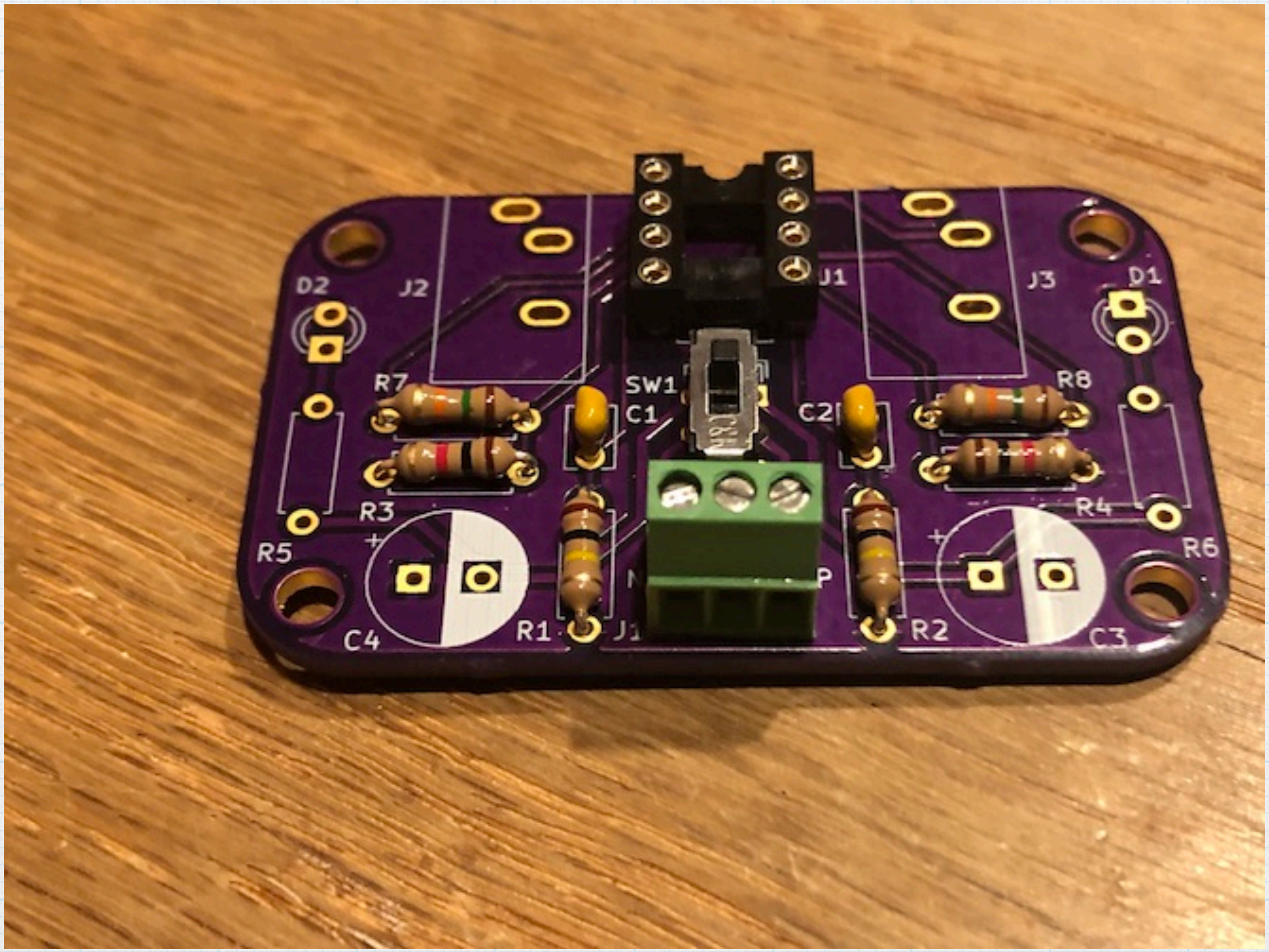
Now comes the socket for the op-amp package. There are no ground connections, so it should be easy to solder. Pro tip: Use a piece of tape (or a third hand) to hold the socket flush to the board. Alternatively, solder just one pin. If the socket is not flush, then push the socket down with one hand while re-melting the solder on the one pin. Let the solder cool before letting go. Then solder the other seven pins.

Since it is a symmetric socket, it really doesn't matter which way it goes.

However, we may as well be pedantic and have the notch on the socket match the outline on the PCB.

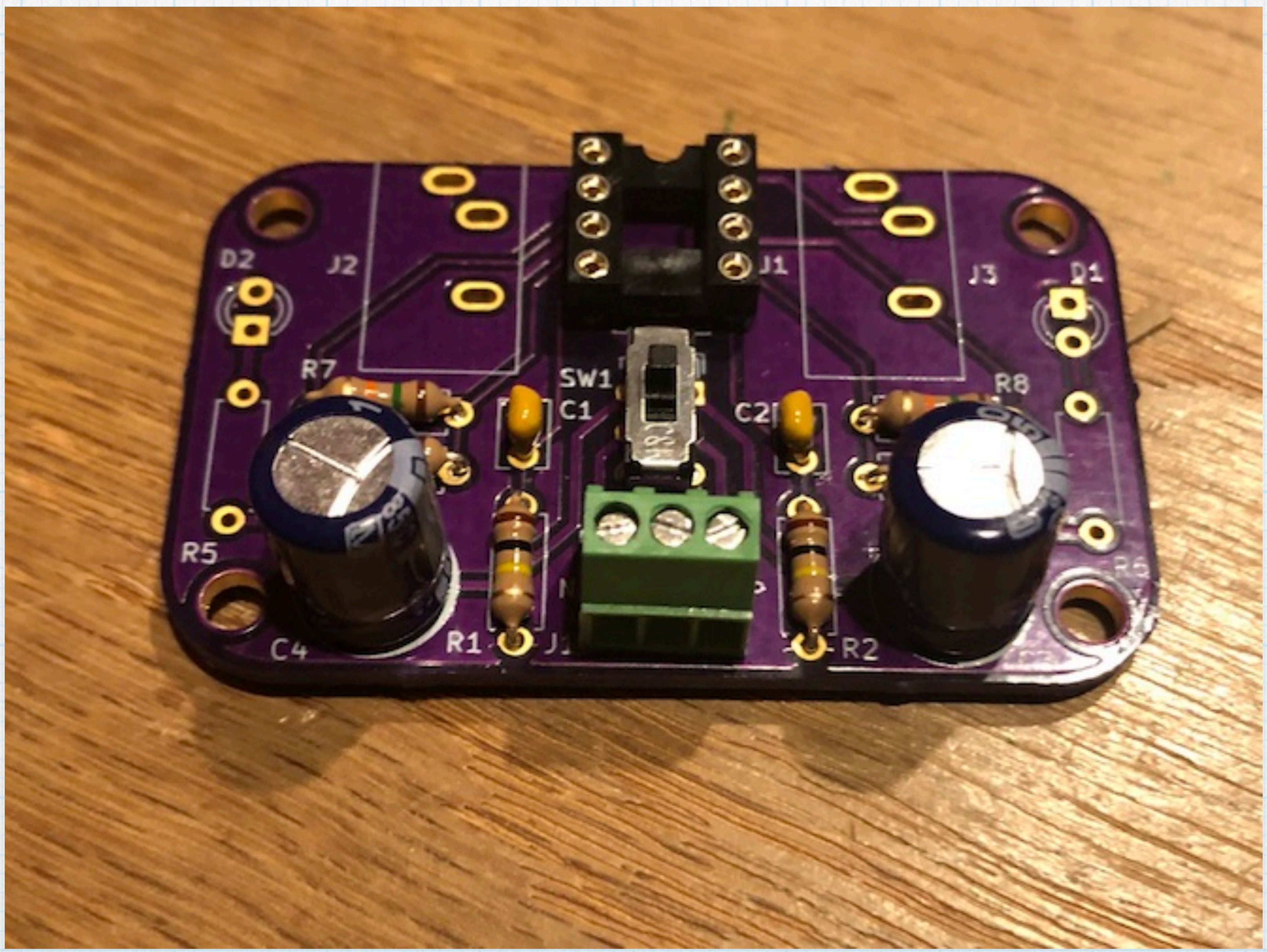
7. Battery connector

Solder in the screw terminals for the battery connections. The center pin is connected to ground — be patient and turn up the temp if needed.



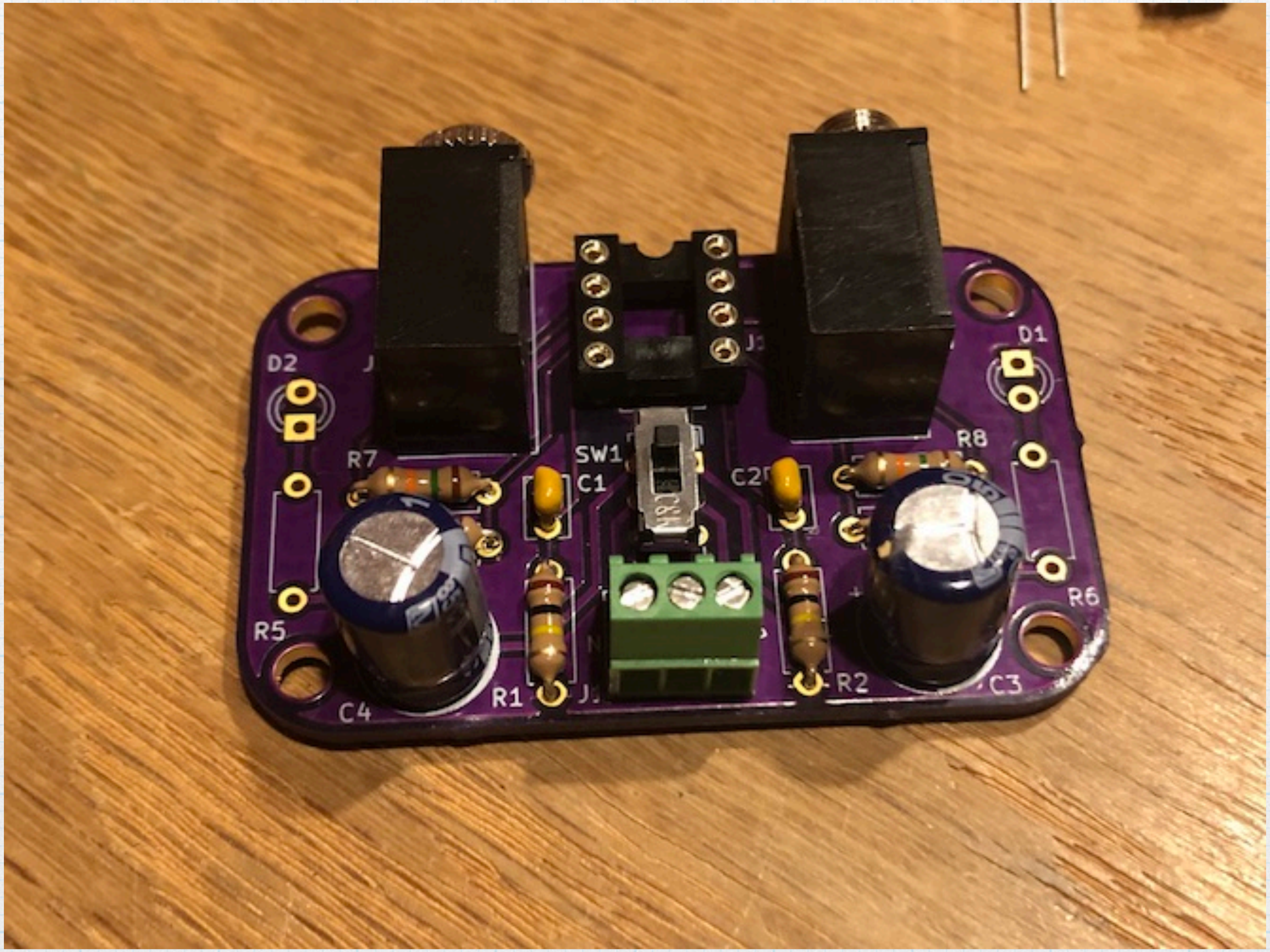
8. By-pass capacitors

Next, we can add the two large 100-µF by-pass capacitors, C_{B+} and C_{B-}. (Labeled C3 and C4 on the board.) Electrolytic capacitors are polarized, so it is essential to get put them correctly. The capacitor negative terminal — clearly indicated on the can — goes into the "white" side of the PCB footprint. Also, one pin of each is connected to ground.



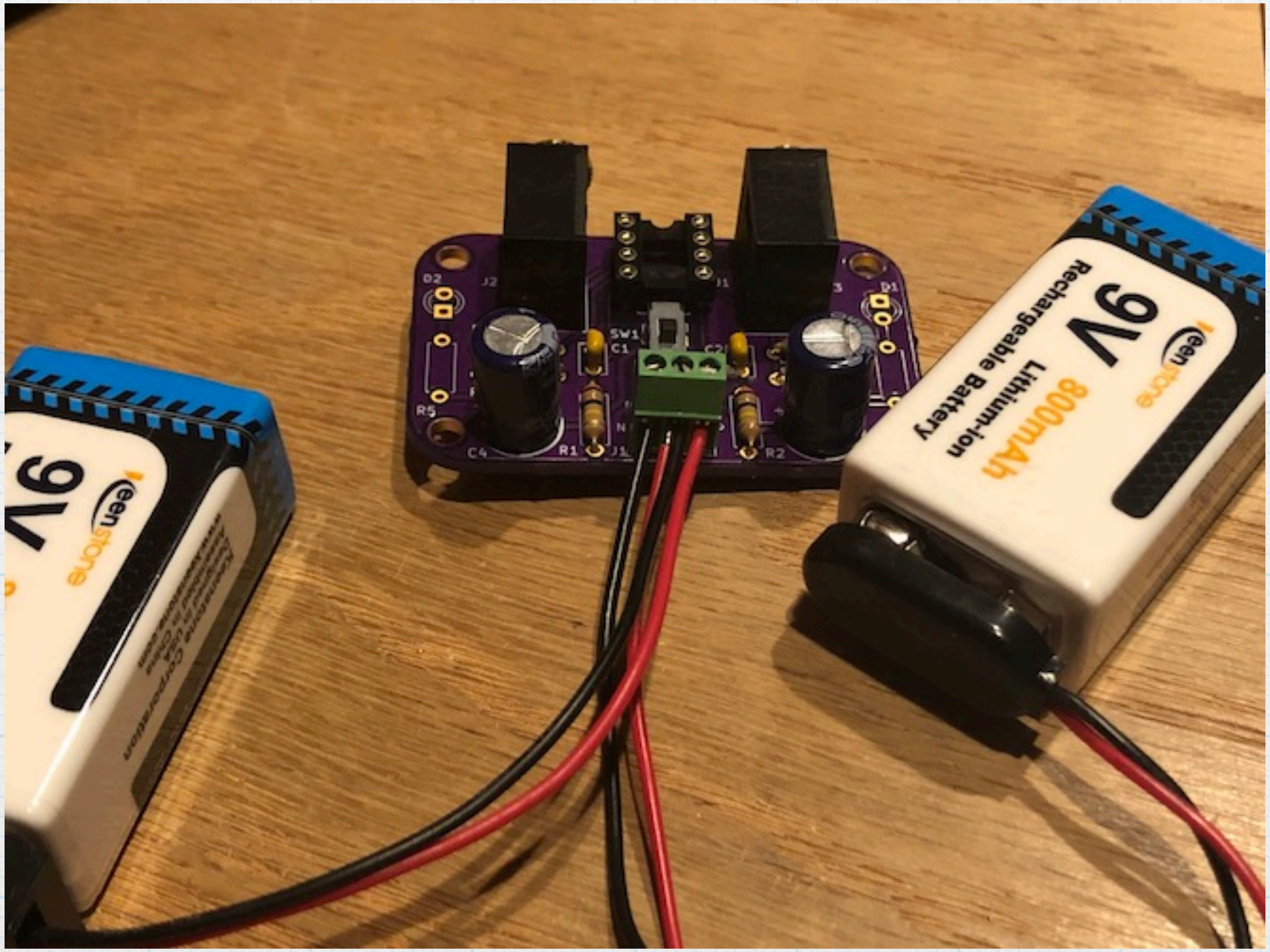
9. Audio jacks

Solder on the two 1/4-in stereo audio jacks. The pin nearest the edge of the board is connected to ground



Intermediate check

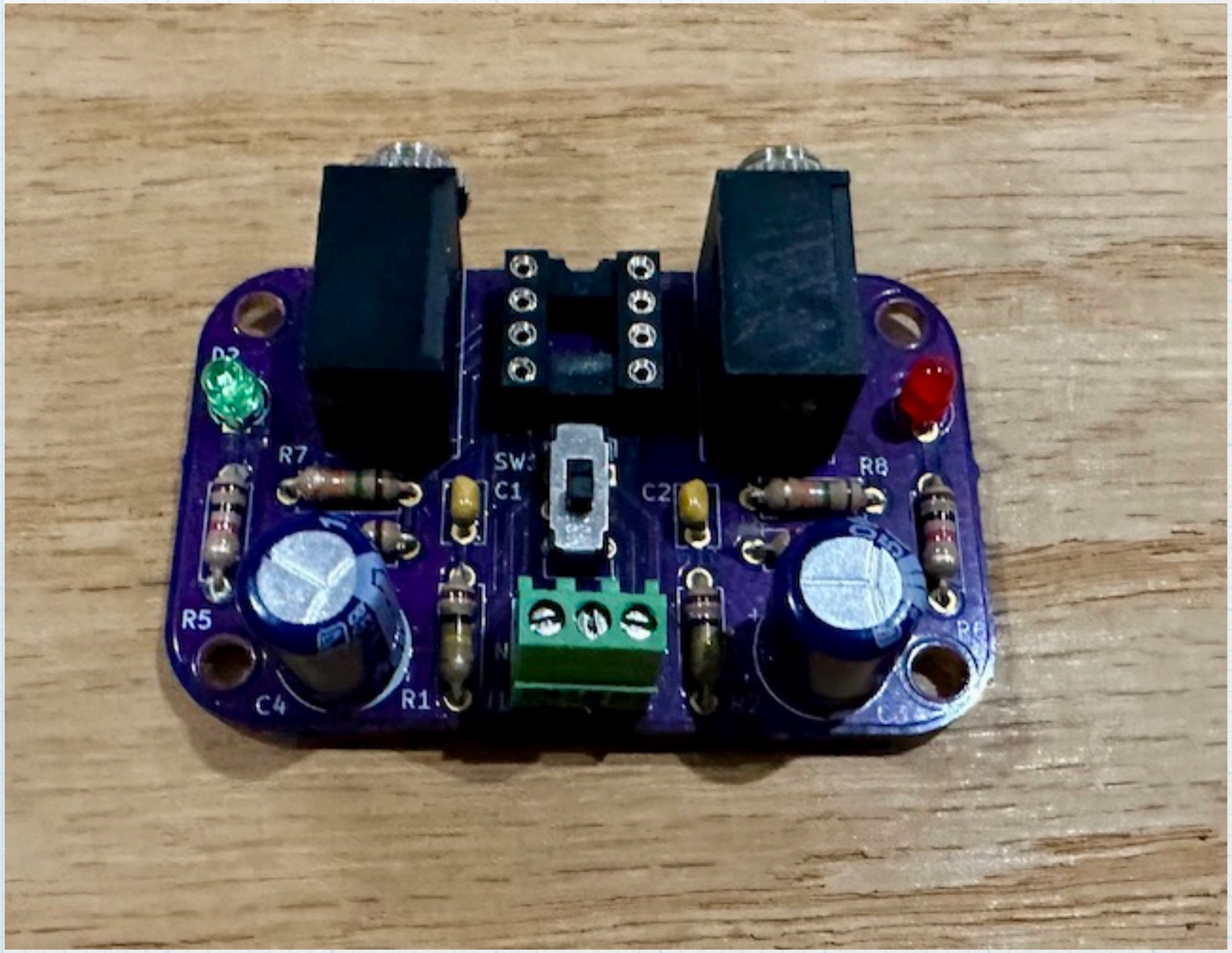
Before adding any semiconductors. It's not a bad idea to connect the batteries and check voltage with the multi-meter. Make sure the switch works properly. Connect one red lead and one black lead together in the center terminal (ground). Connect the other black lead to the negative terminal. (Look for the N label.) Connect the other red lead to the positive side. (P label.) Check pins 4 and 8 on the socket, and the diode resistor connections nearest the big capacitors.



10. LEDs and current-limiting resistor.

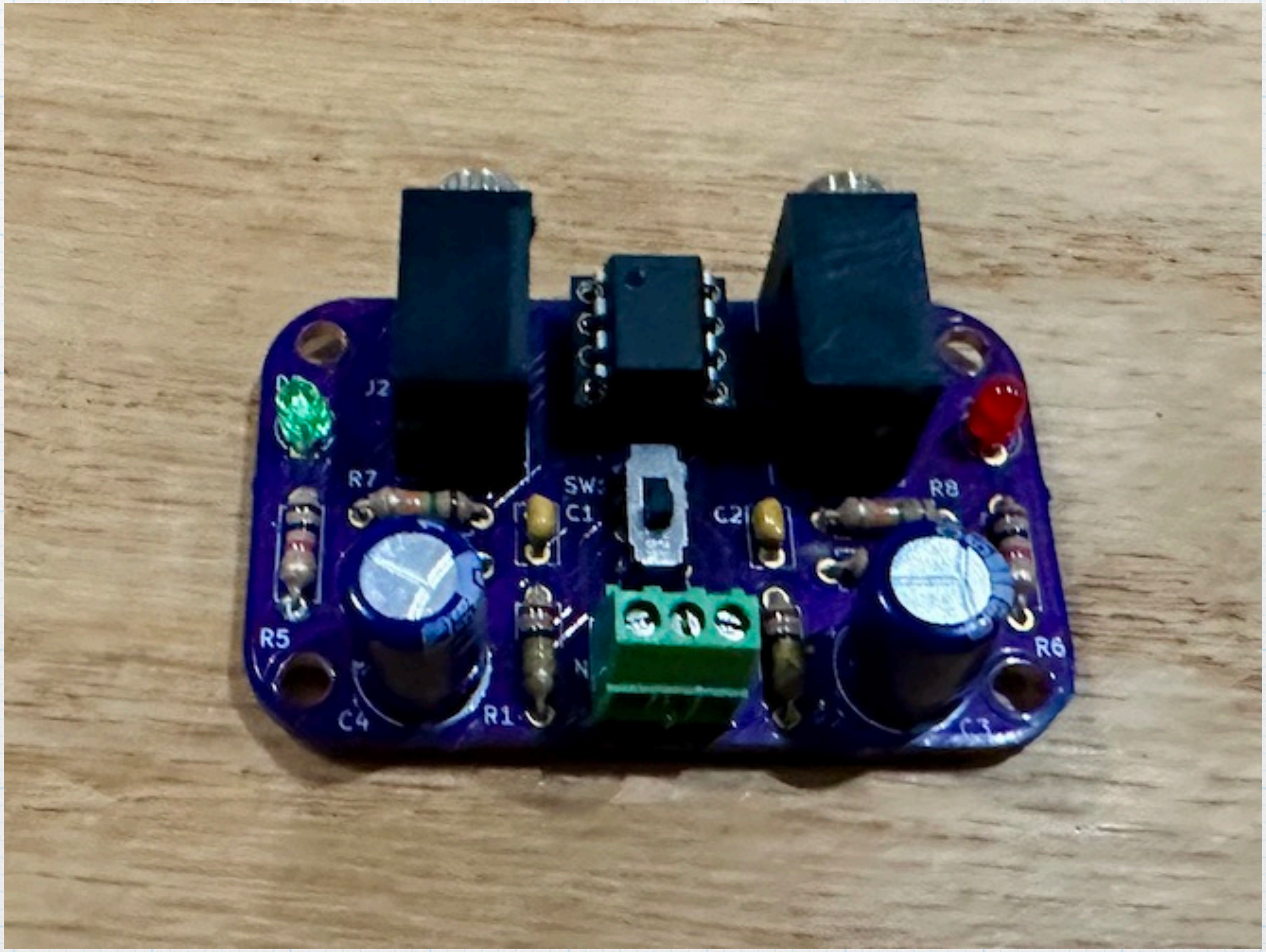
(Recall: LEDs are optional.) If all voltages checks are good, the LEDS (labeled D1 and D2 on the board) and the 1-kΩ limiting resistors (labeled R5 and R6) can be soldered in. The diodes are directional — if put in backwards, they will not light up. The anode (positive terminal) has a slightly longer lead. It goes into the "round" opening on the PCB. Then, obviously, the cathode (negative terminal) goes into the square one.

If still unsure, it doesn't hurt to use a breadboard to check LED operation. The LEDs can probably be checked on the board by applying power *before* soldering — the parts will likely make sufficiently good contact even without solder.



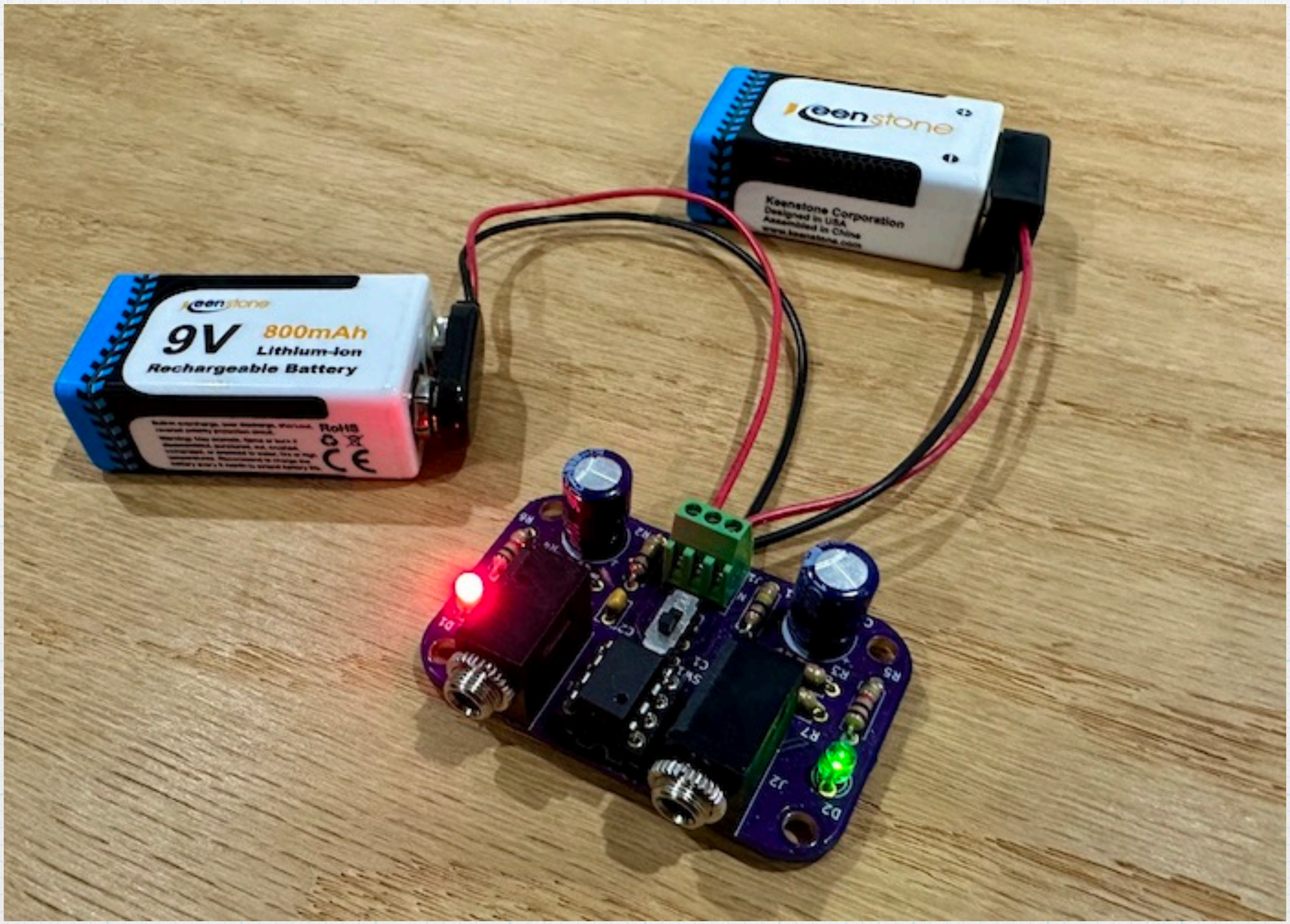
11. Insert the op-amp into the socket

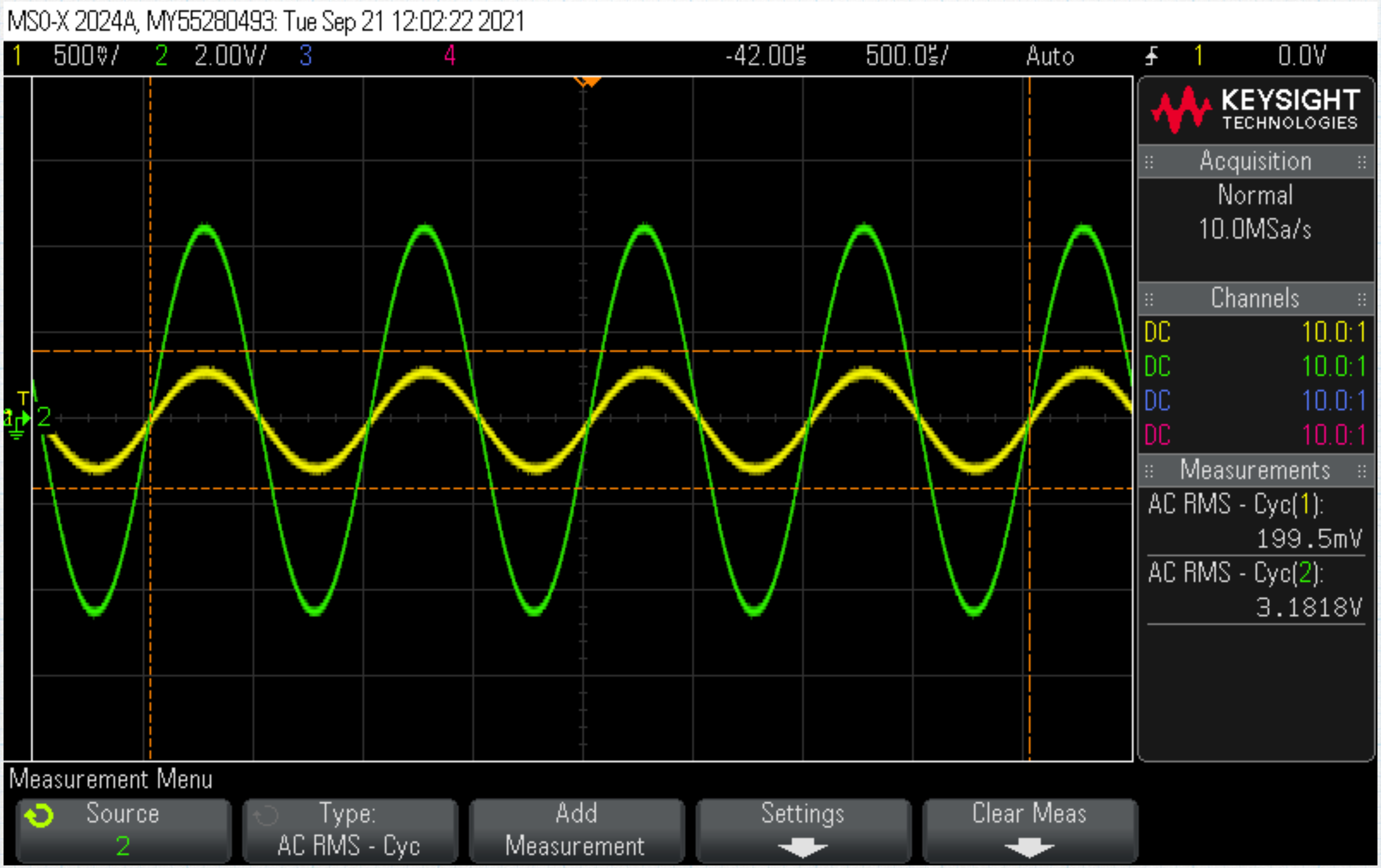
For the finale, insert the op amp. Use caution — it is easy to bend the pins. For a “fresh” op amp, it is usually necessary to bend all the pins in a bit. Also, mind the direction. The small circle on top is nearest pin 1. Inserting the chip backwards and applying power may kill the amps.



Test it!

Now the moment of truth. Connect the batteries and flip the switch. The LEDs should light up. If you have an oscilloscope and a sine-wave source, hook those up and check the waveforms.





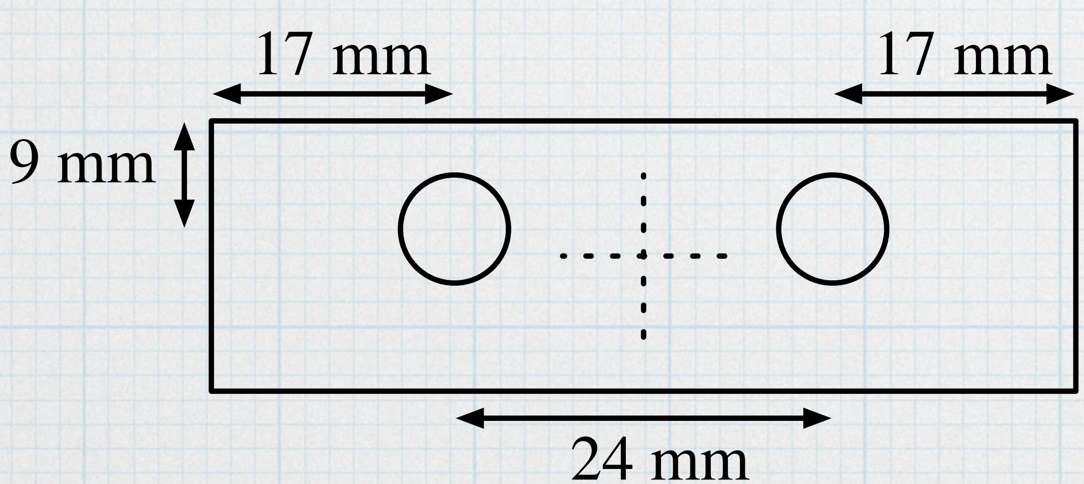
$$G = \frac{v_o}{v_i} = \frac{3.18\ \text{V}}{0.200\ \text{V}} = 15.9$$

As expected.

Using the Altoid tin

Finally, if we want to mount the board and batteries in the mint tin, we will need to cut two holes for the audio connectors.

1. The end of the Altoids tin measures about 58 mm x 20 mm.
2. The holes for the jacks should be separated by 24 mm, center to center.
3. The holes should be offset slightly above the center to make certain their sufficient room for the board to fit against the bottom of the tin.
4. The holes are 1/4-inch in diameter.
5. Use a ruler and make the two marks. (A bit of "eye-balling" is probably necessary due to the curved surfaces.)



Making the holes.

An obvious choice is to use a 1/4-drill bit to drill the two holes. Most of us probably have access to a drill and know how to use it. However, using a standard twist drill bit is tricky because the metal is thin and the box is difficult to hold — the usual result is that the metal tears and leaves ragged edges. This might be OK, but it doesn't look the best and the sharp edges might draw blood.

If available, a drill press in which the tin can be securely clamped might give a better result. Another option is to use a "stepped" drill bit, which starts with a small hole and progressively makes the hole bigger as the bit advanced through.

However, the best option is to use a metal punch, which will create a perfect hole in about 1 second. These are not common tools. Fortunately, members of the ISU Audio club know someone who own a a punch, and he will gladly loan it to anyone who would like to use it.

Punch the holes. Place a sheet of paper or plastic or some other thin insulating material in the bottom of tin to ensure that the interconnections on the bottom of the PCB do not connect that metal of the tin. Insert the PCB and secure with the nuts for the audio connectors. Plug in the batteries and tuck them into the case.

Since the holes are offset slightly from the center, it might be necessary to nip two small chunks out of the lid in order to have it close completely.

Connect a source and your favorite headphones. Power on the amp. Start with the volume low so that you don't blast your ears. Enjoy!