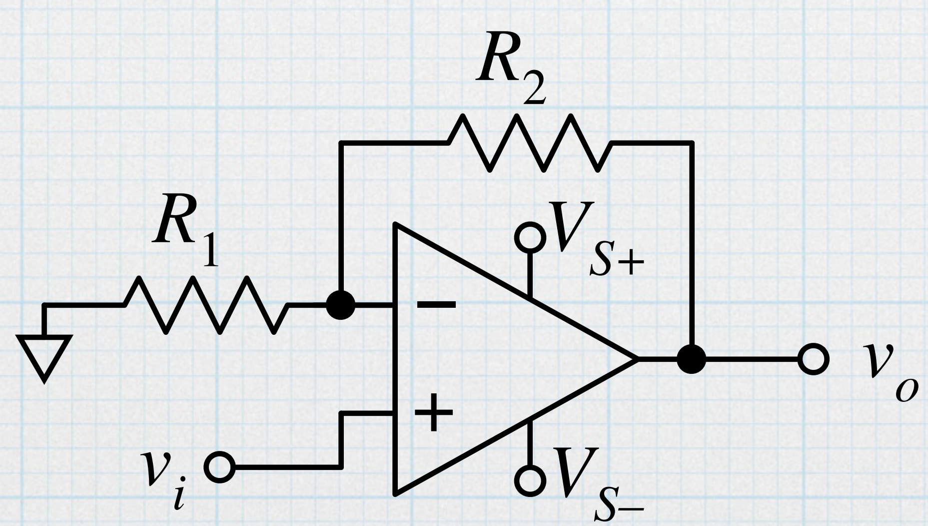
Altoids Amp

Headphone amplifier

- Used between audio source (e.g. smart phone, tablet, computer) and wired headphones. Boosts the audio signal to improve the sound quality and the volume.)
- Less used today due to the advances in wireless headphone tech. But still fun to play with.
- The circuitry is fairly simple, so it is a great first audio project. It is easy to understand and easy to build.
- More complicated amplifier designs can derived from this basic circuit.
- By using a socket for the amplifier, it is easy to test out different op amps to see how those effect the sound quality.

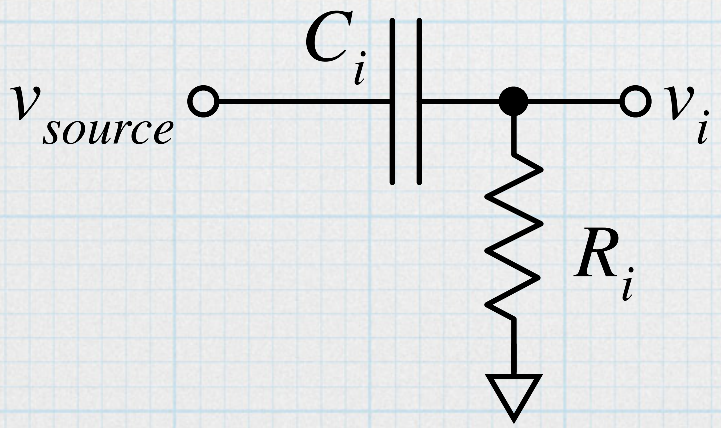
Basic amplifier

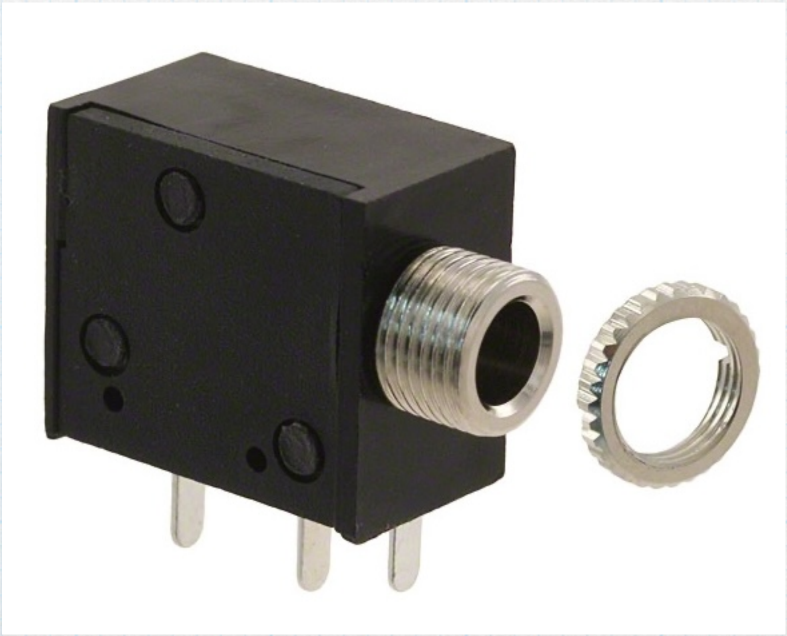
- Non-inverting amp, straight out of EE 201.
- The amp included in the kit is the TL082 dual op-amp chip. (Included in the EE 230 lab kit.) This is a medium-grade audio amp from Texas Instruments. The basic op amp has average specs for the most part. It does have fairly high slew rate, which can be advantageous in some applications. It is possible to substitute other amps, as long as they are pin-compatible.
- Gain of 16, which is more than adequate. Line-level audio output from most audio source is a few tenths of a volt, so the amp output will be in the range of a few volts, which is more than enough to drive typical headphone speakers.
- The amp is powered using two 9-V batteries, so the output should be able to reach ±7 V — this will probably distort the speakers and make your ears hurt.
- This is a stereo amplifier, so there will be two identical op-amp circuits.



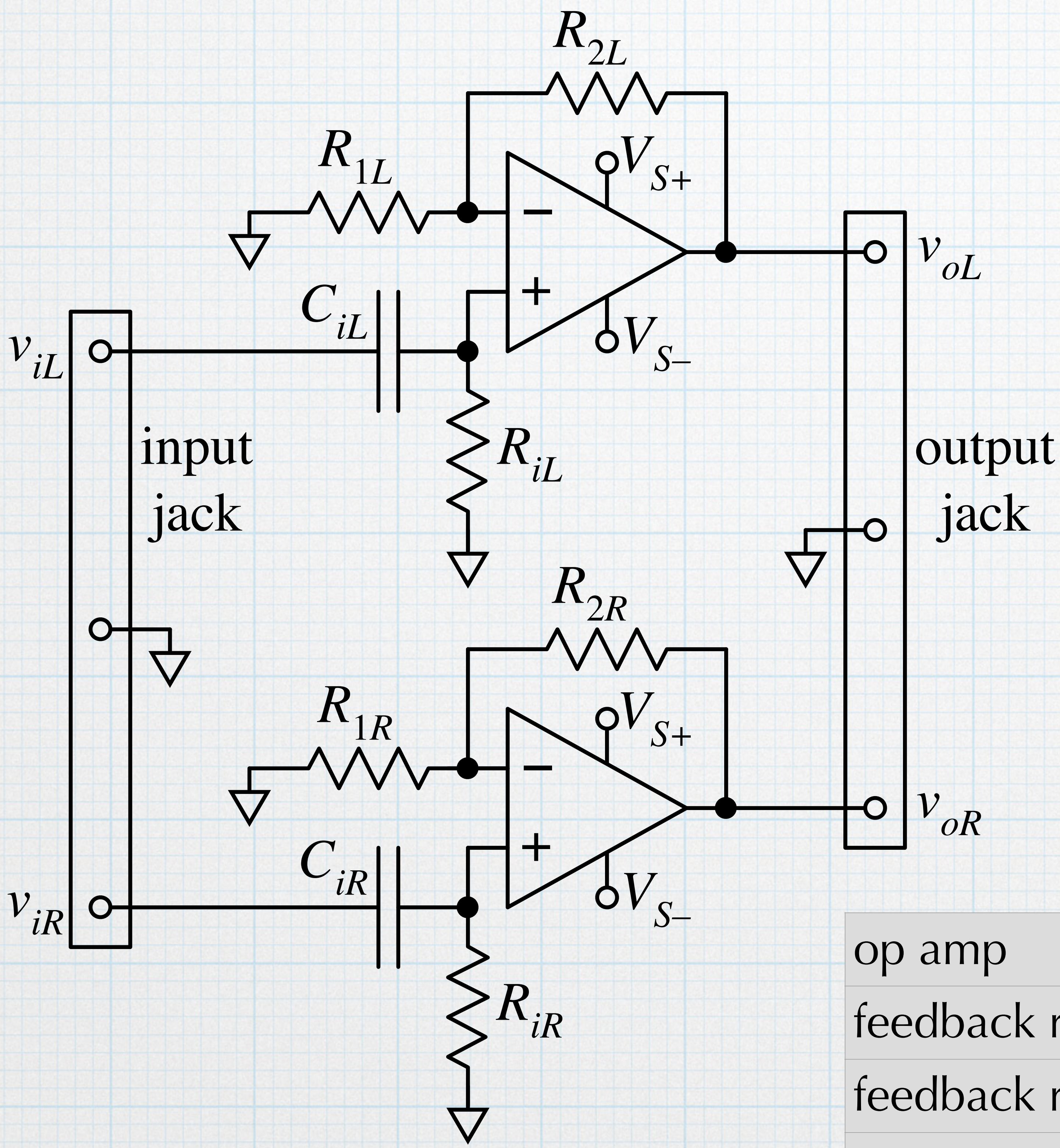
Input filter and connectors

- An *RC* combination is used at the input of each amp.
- It serves as a high-pass filter (f_c = 16 Hz). Lower frequencies, including DC, are cut off.
- More importantly, the series capacitor provides decoupling to prevent any stray DC voltages from accidentally damaging our music source. (Which is most likely a smart phone. Don't want that blowing up!)
- Almost all of our amp designs will use a series capacitor of some sort as input protection.
- Audio input and output connections use two 1/8-inch stereo jack that mates to a "tip-ring-sleeve" (TRS) audio plug. These are mounted directly on the printed circuit board.





Complete amplifier circuit

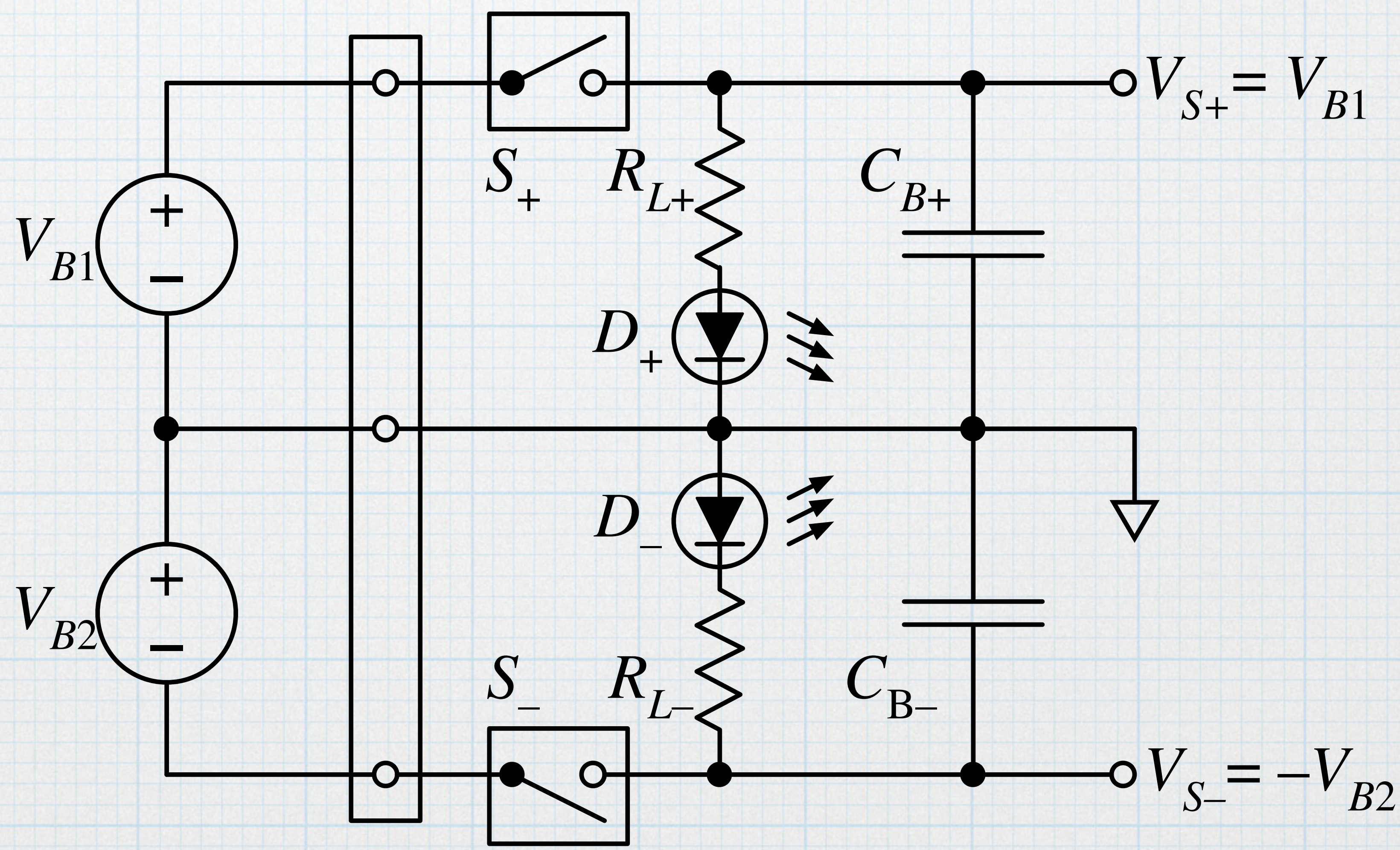


op amp	TL082	
feedback resistor	R_{1L}, R_{1R}	1 kΩ
feedback resistor	R_{2L}, R_{2R}	15 kΩ
input filter capacitor	C_{iL}, C_{iR}	0.1 μF
input filter resistor	R_{iL}, R_{iR}	100 kΩ

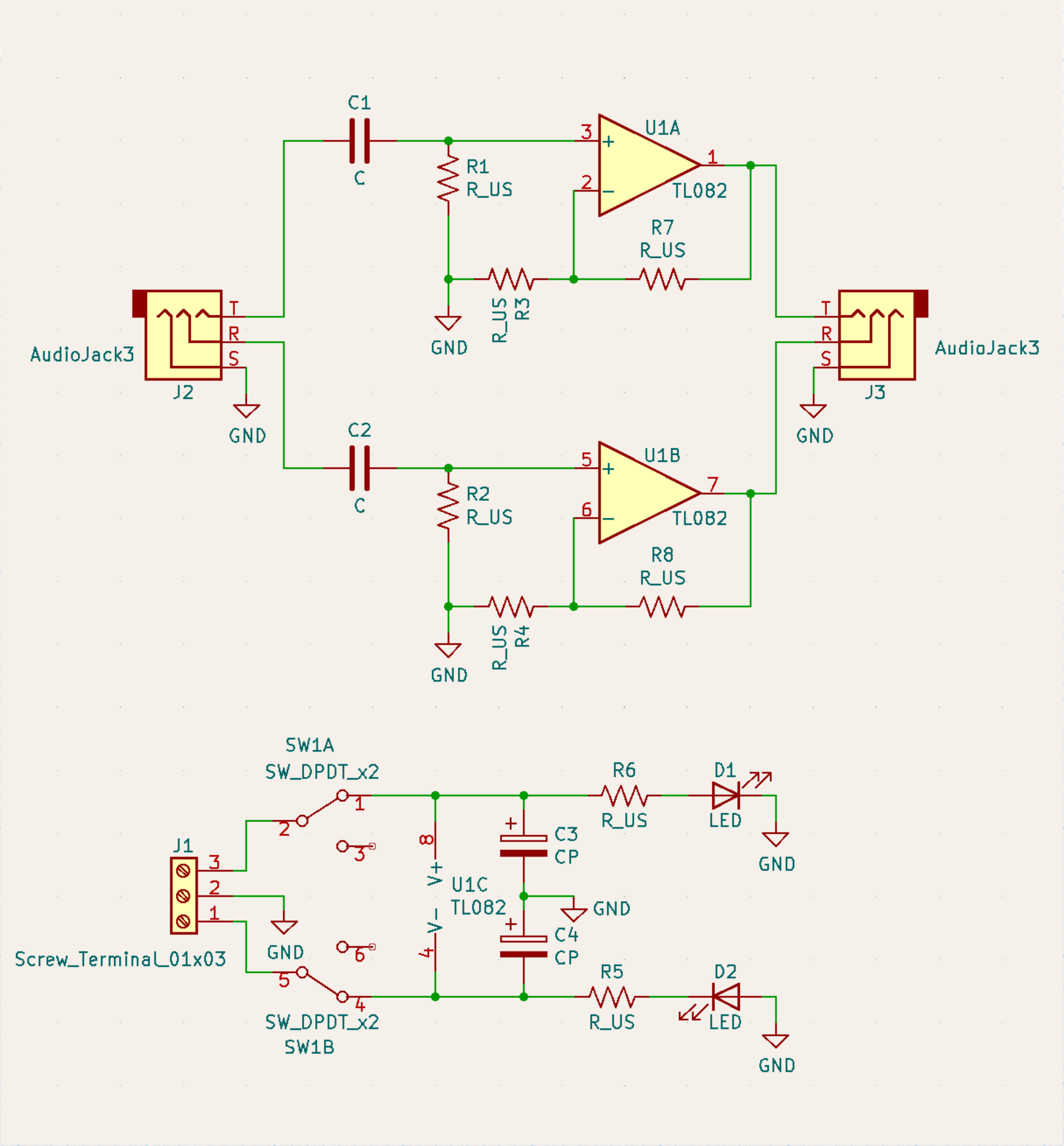
DC power

- Two 9-V batteries, connected to give ±9 V with the common connection serving as ground.
- A small double-pole double-throw switch to connect/disconnect the power. (Note: A single-throw switch would be sufficient, but double-throw switches are more common and probably cheaper.)
- Light-emitting diodes (and current-limiting resistors) are included indicating when the power is on. (These are optional.)

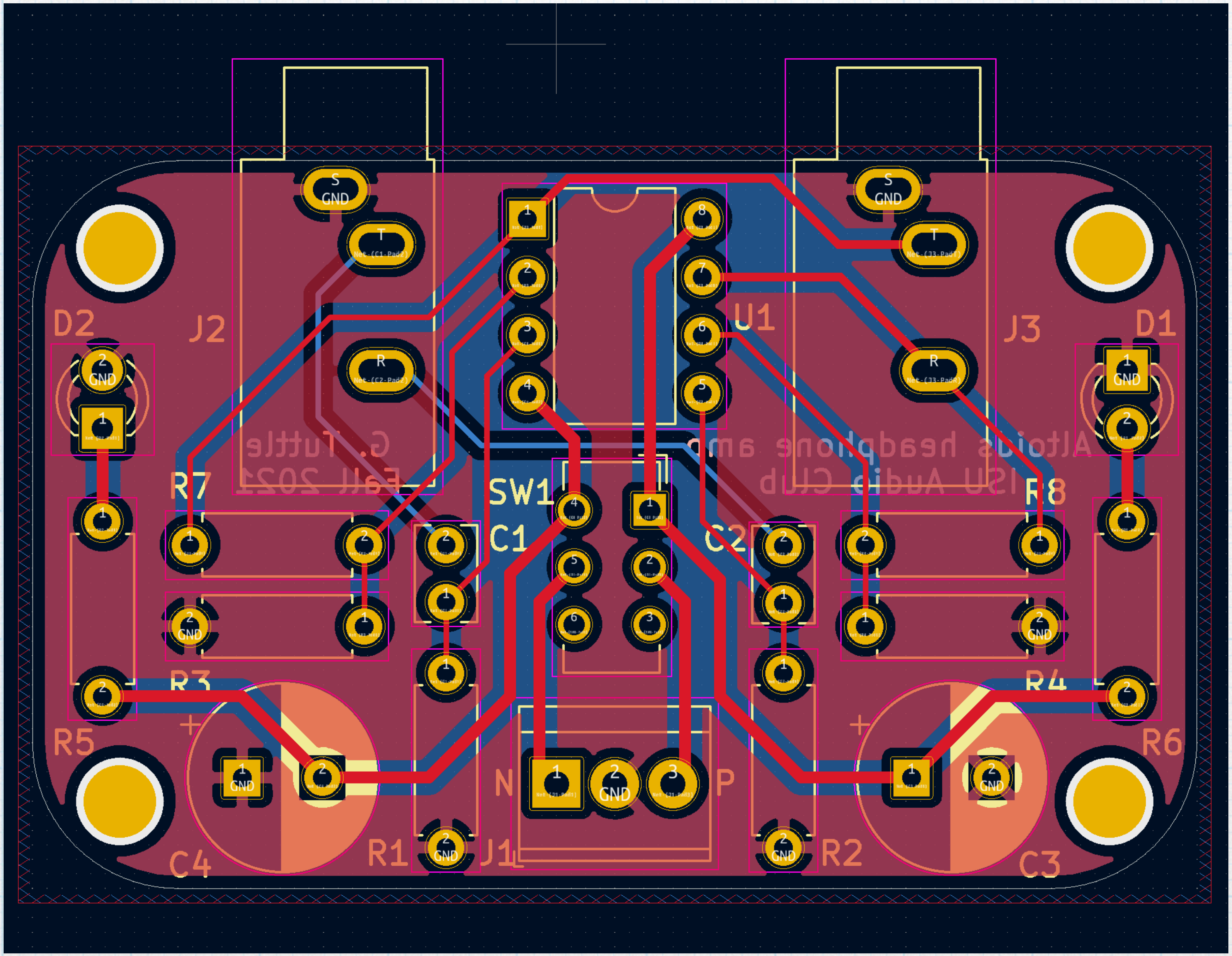
- Large 100-μF capacitors are used to smooth out any power-supply transients.
- Battery connections are standard 9-V battery straps.



Full schematic for the PCB



PCB layout



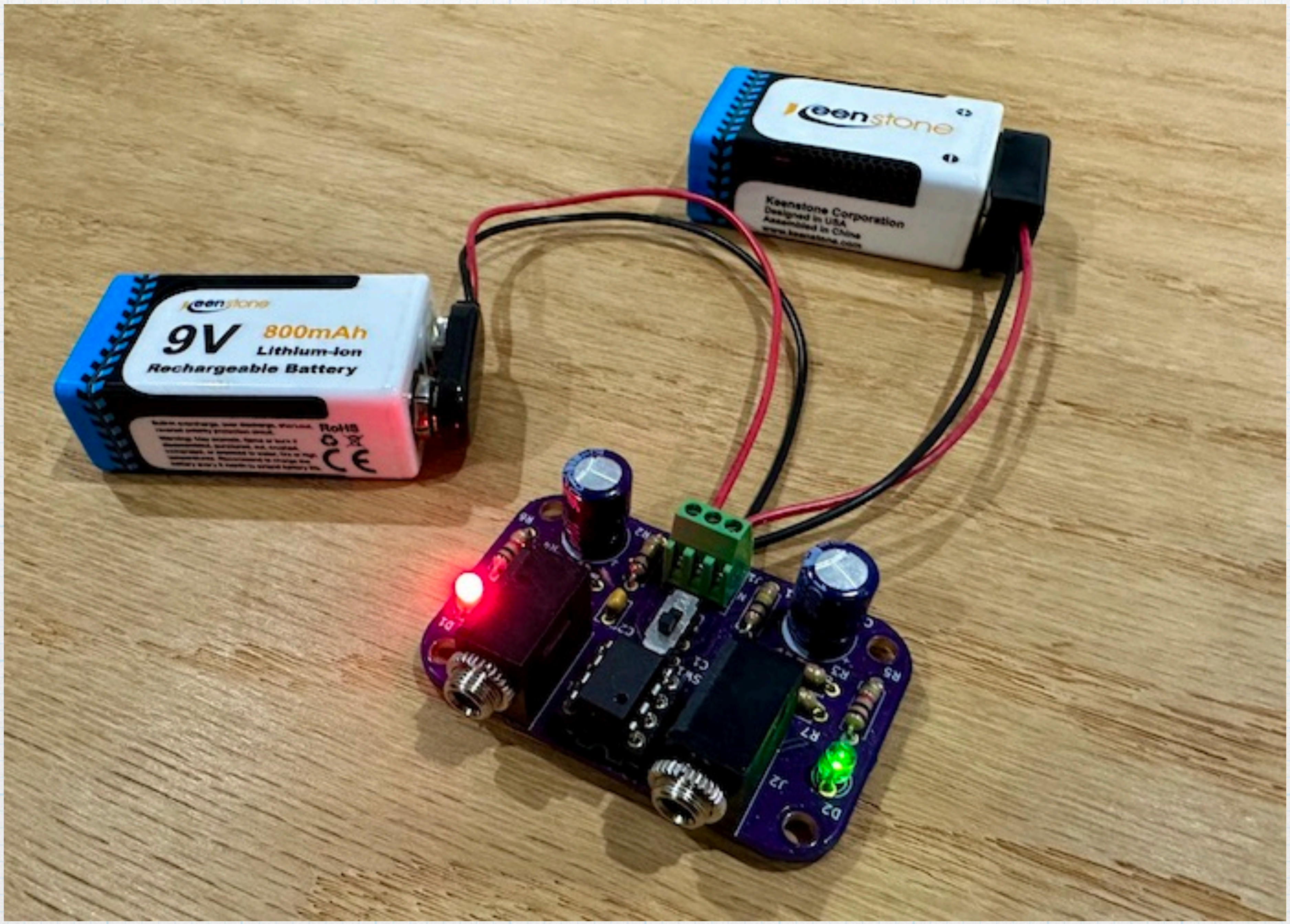
Bill of Materials

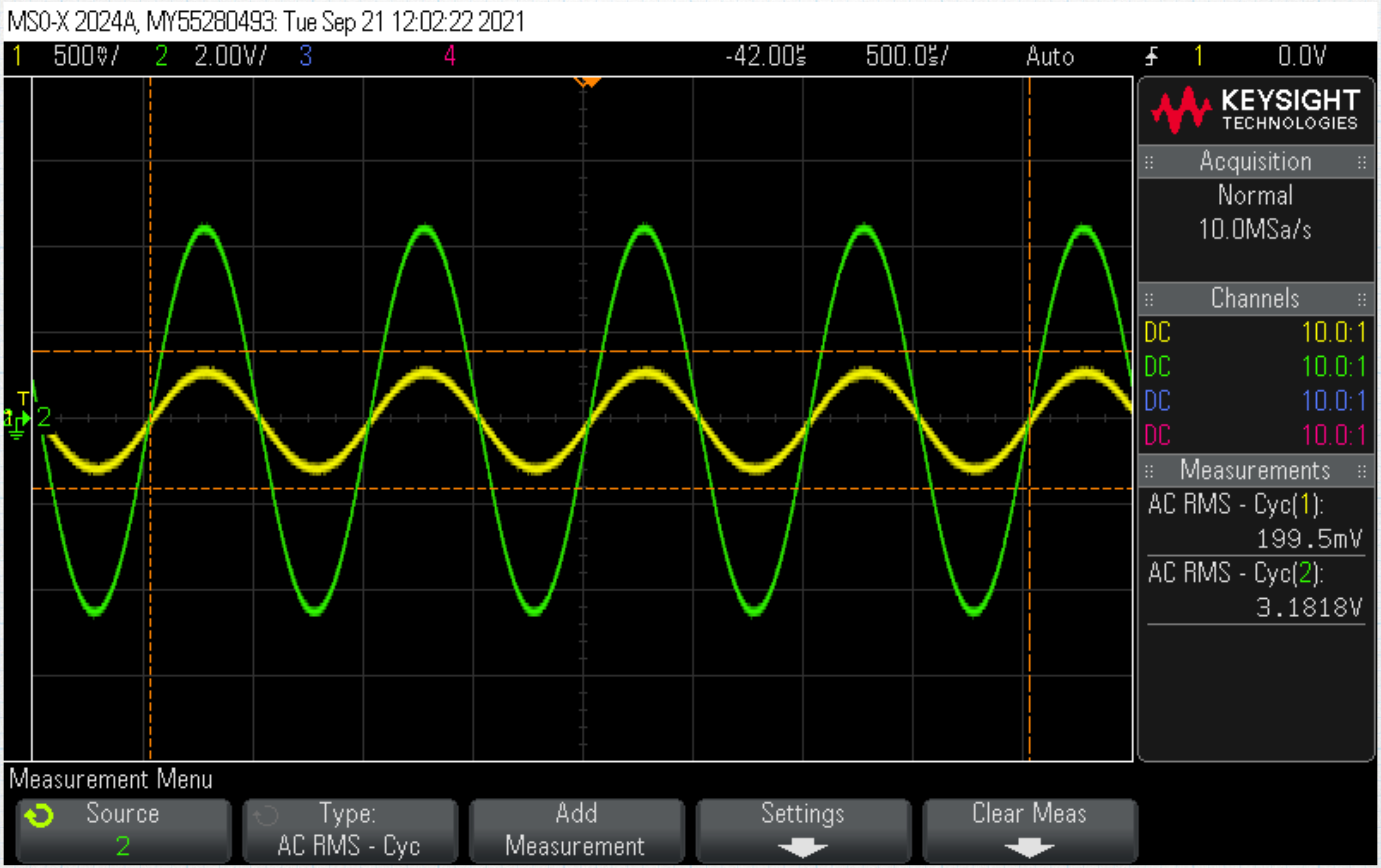
	manufacturer's part number	price	quant	total
socket	Assmann AR 08 HZL-TT	0.50	1	$0.50
TL082	Texas Instruments TL082CP	1.02	1	$1.02
100-nF cap	Vishay K104K15X7RF5TL2	0.23	2	$0.46
100-μF cap	Nichicon UVR1H101MPD1TD	0.34	2	$0.68
15-kΩ resistor	Stackpole CF14JT15K0	0.10	2	$0.20
1-kΩ resistor	Stackpole CF14JT1K00	0.10	4	$0.40
100-kΩ resistor	Stackpole CF14JT100K	0.10	2	$0.20
red LED	Vishay TLLR4400	0.51	1	$0.51
green LED	Vishay TLVG4200	0.48	1	$0.48
DPDT switch	C&K JS202011CQN	0.60	1	$0.60
stereo jack	CUI SJ1-3533	2.00	2	$4.00
battery strap	Keystone 84-4	0.68	2	$1.36
screw terminal	On Shore OSTVN03A150	1.04	1	$1.04
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.

Finished circuit

With batteries connected and the switch set to “on”, the LEDs should light up. We can connect a test signal (1-kHz, 0.2-V RMS) and examine the output with an oscilloscope. (Or measure the signal levels with a multi-meter.)





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

As expected.

Altoids tin

It's fun (though hardly necessary) to put the amp into an Altoids mint container. This requires punching two 1/4-inch holes in the tin where stereo connectors will fit through. There should be adequate room for the PCB and the two 9-V batteries.