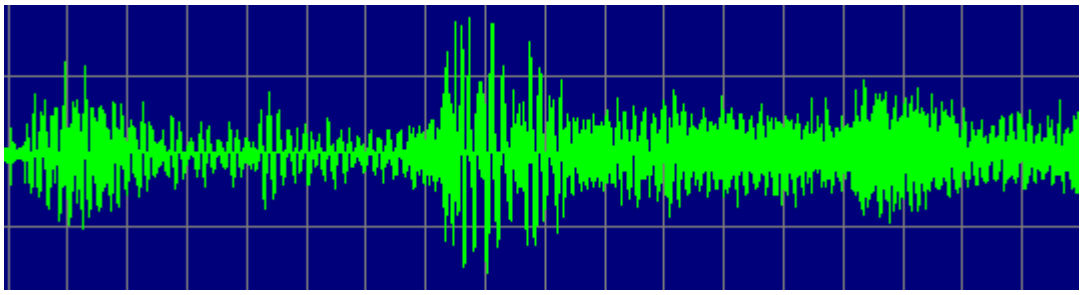
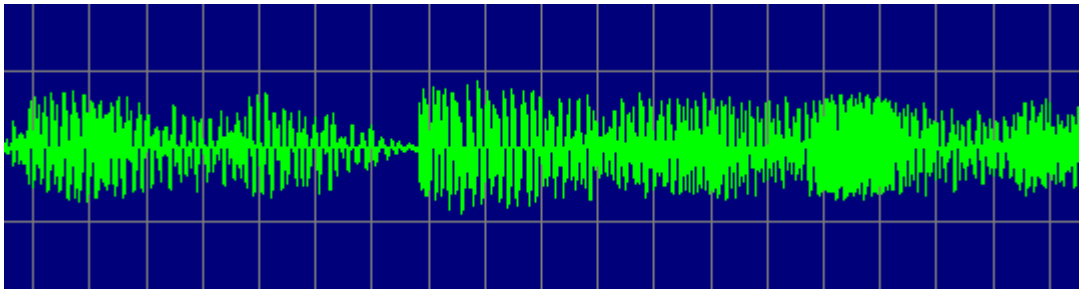
Simple Stereo Electret Microphone Preamplifier



Would you rather record this (unclipped)?



or this (R91 mic preamp going nuts)

Thanks Tom. Hope this helps the people who are a bit leery of making a board.

Intro

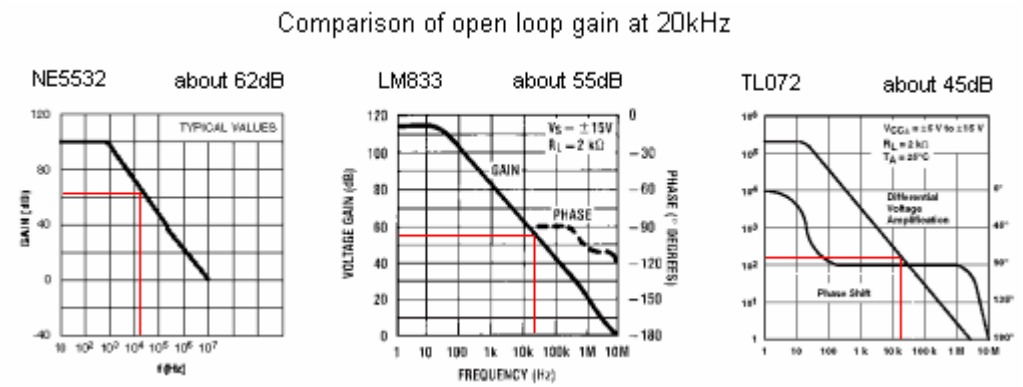
This design was born of frustration with the mic preamp in my Sony R91. It clips at ridiculously low levels, basically it has 28mV of headroom to deal with an input that could be as high as 1800mV (depending on mic & volume), so this design attempts to cure that by :

A: Providing a higher electret bias voltage, 9V through a 10k resistor to give the mic's fet more headroom. (The R91 provides 2.5V through a 6k8 resistor.)

B: Having much greater preamp headroom, and bypassing the R91's mic preamp altogether, using a hi-fi or low noise op-amp to go straight into the line input.

Design Considerations

The circuit needs to bring the signal from an electret microphone up to a level suitable for a line input. Based on measurement of the microphone output under a range of conditions, I have chosen two gain levels - 2 & 23. 23 is suitable for everyday general recording. 2 is suitable for live music such as a rock concert. There is a output pot to allow fine-tuning of the level if necessary, but it is intended that usually the wiper will be on the land.



When choosing an op-amp, it's important to find out the open loop gain at 20kHz. The circuit has roughly 27dB of gain, and at least 47dB at 20kHz (i.e. 20dB higher) is desirable. This is because op-amp circuits are predicated on an ideally infinite open loop gain, while in reality 10 times (20dB) higher than the closed loop gain at highest frequency of interest is acceptable. Otherwise the amplifier becomes progressively non-linear. The TL072 at roughly 45dB just makes it. The LM833 is good at »55dB and the NE5532 sparkles at »60+dB.

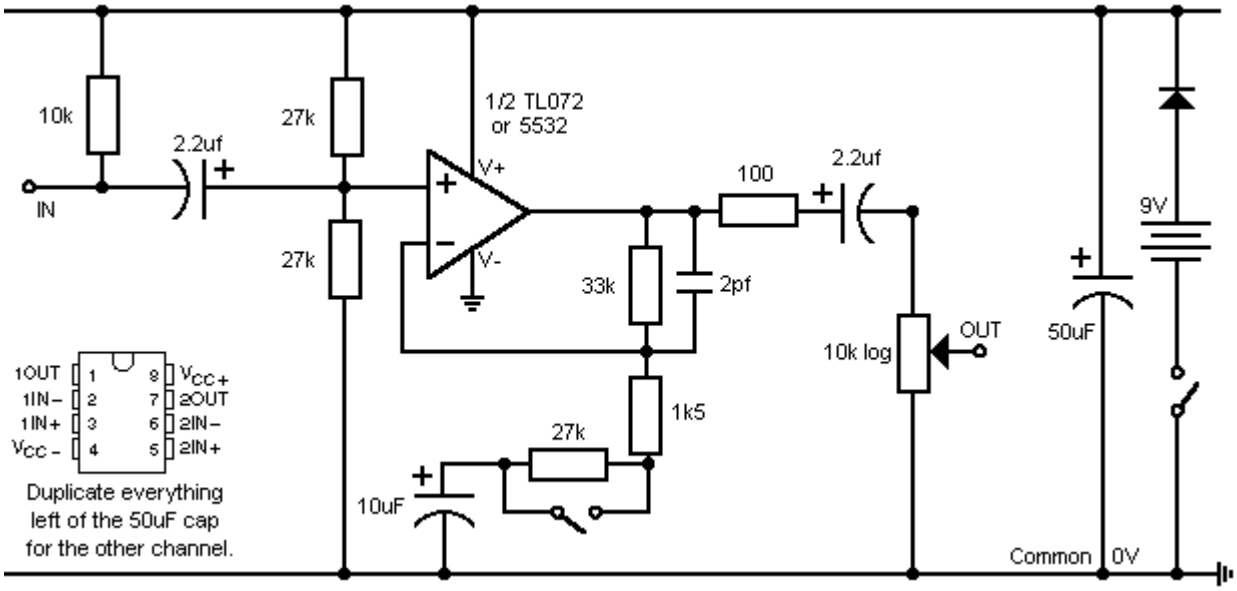
If you're going for ultra small size, you can build it single supply rail, but an LM833 won't run like that. A TL072 will, with reduced output swing, it'll swing about 1.8VRMS off a single ended 9V supply, which is adequate for the purpose. Otherwise two 9V batteries will do the trick.

Fairly high quality components have been used - 1% metal film resistors, solid aluminium caps, though the output pot is a bit miserable.

Now about these solid aluminium capacitors - in some respects very good capacitors, but I think now I would use 1uF film capacitors as input and output capacitors. They are likely to more closely match the other channel (tighter tolerances), and the golden ear brigade seem to like film capacitors better.

So in summary, it's supposed to have a lot of headroom, be small, quiet, cheap, have a low part count, somewhere between a battery box and a full fledged professional box.

The Circuit



Schematic Of One Channel - Single Rail Version (Slight Difference From Text)

The leftmost 10k resistor supplies plug-in-power to the electret, forming part of the FET amplifier in the electret capsule. This could be anything from 2k to 10k, the higher the better the stereo separation (another mic derives bias from the same rail). Apparently higher values also lower distortion, and the best bias power circuits involve actually breaking a trace on the electret capsule to allow the use of both a drain & source resistor, but I□m not going that far.

The leftmost 2.2uF cap blocks the bias voltage from the input. In conjunction with the following 27k resistor it forms a high pass filter, but cutoff is essentially near DC.

The input impedance is set by the two 27k resistors and the 10k resistor. The +ve rail is also connected to ground as far as the AC signal is concerned because of the power supply cap. So there are two 27k resistors in parallel, making 13.5k, in parallel with the 10k, making about 6k or so for the input impedance. But if you're making it proper dual supply, you don't need the upper 27k resistor, as the input doesn't have to be biased mid rail anymore.

The feedback loop has two resistors 27k & 1k5 from the inverting input to ground. When they are both in circuit, the gain is a bit under 2 ((28.5/33)+1). The 27k resistor can be bypassed with a switch, then only the 1k5 sets the gain, to 23 ((33/1.5)+1).

The 10uF cap in the bottom half of the feedback loop reduces DC gain to ~1. The value isn't very important. If any DC input offset were amplified it would create a larger output offset, pushing the output toward one of the rails and reducing headroom. (At a gain of 23 with the expected input levels it probably doesn't matter.)

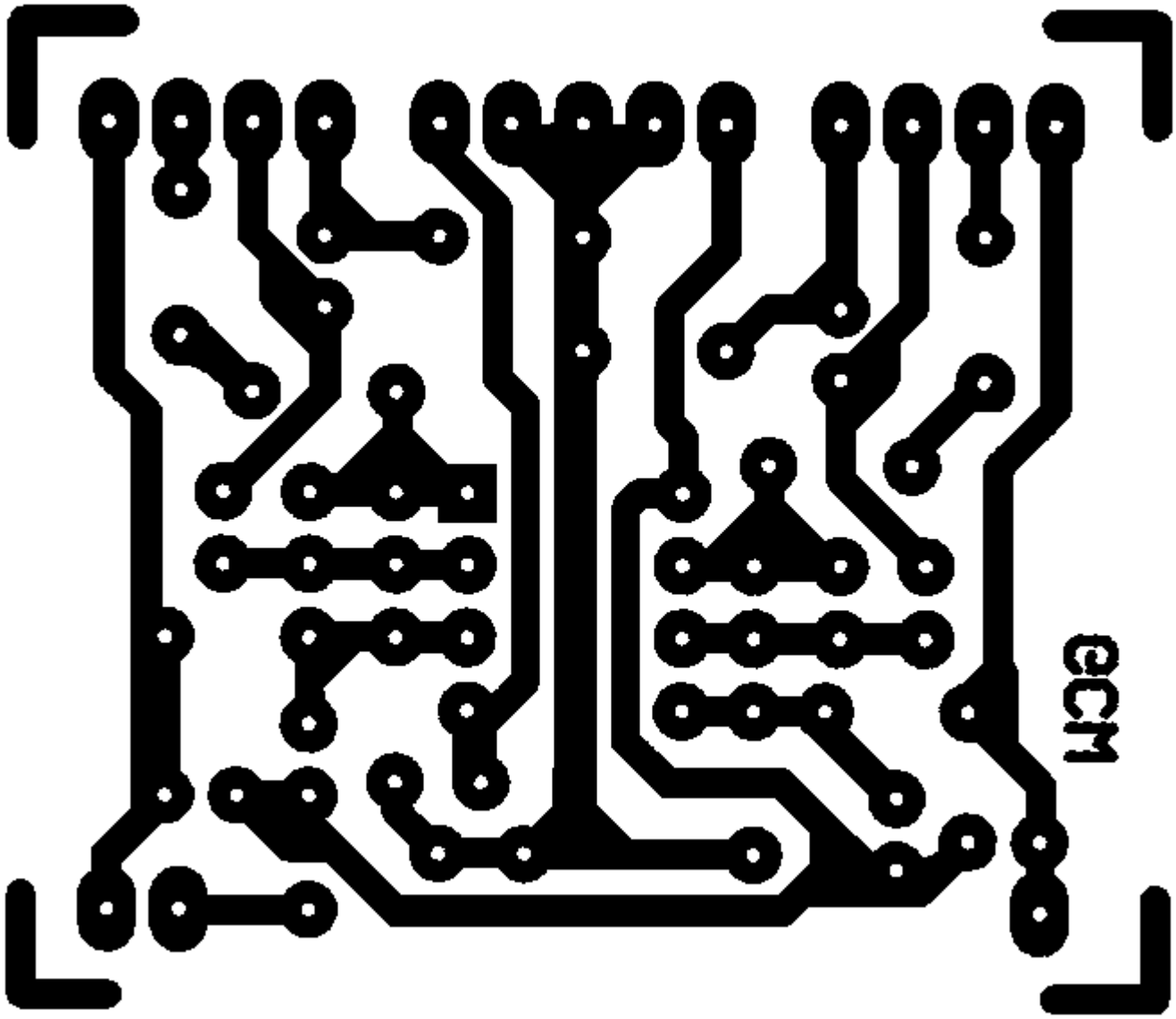
The optional 2pF cap in relation to the 33k resistor sets the high frequency rolloff. The cutoff frequency is in the 100□s of kHz. It has to go further than 20kHz to keep the phase shift at audio frequencies small, and also because output starts falling long before cutoff. The op-amps cannot maintain enough gain at these frequencies anyway and their output will already be falling, but the cap makes the circuit more stable, though it will probably work without it. There will probably be 2pF of capacitance just from the PCB traces, and op-amps tend to be fairly well compensated these days so it□s really not needed. I think in retrospect this cutoff frequency should be much lower, say 30kHz-50kHz.

The 100ohm resistors are there partly to limit current to protect the op-amp if the output is shorted, but the op-amps have internal protection anyway. They mainly allow the op-amp to drive capacitive loads (long/cheap cables) without oscillation.

The 2.2uF cap on the output blocks DC and the value is not specially important. It forms a highpass filter with the 10k pot, the cutoff is virtually at DC.

If you think you might accidentally start connecting the battery the wrong way round, you'd better put a diode in series with the battery clip, or you'll smoke your ic. Put your ic in a socket too just in case you do want/need to change it. You could try several dual op-amps against each other, they're all direct plug in replacements.

The PCB Board



I've not made a stuffing diagram yet, and I probably won't. If you follow the legs from the ic, the components can really only go in one way. Pin 1 is the square hole. Not all of the holes are necessarily used, it depends whether you make it single supply or dual supply and if you include the hf roll-off caps or not. I doubt that anyone will use

this circuit layout, but if you do, and you have any questions, please email me. You might want to email me anyway, because there are a couple of (what I shall euphemistically term) issues with this board. It works fine, but having made it, I can see places where it could certainly be improved.

In response to a couple of emails, I updated this a bit. Basically I just changed a couple of holes to fit 0.2" leg spacing on the output capacitors. If I was doing it again from scratch I would try to keep the input tracks further away from the output tracks, but I haven't noticed any instability in this board.

Size - well it's obviously 1mil pin spacing. I scanned it at 300dpi, and that was a double size image. So if you printed it out at 300dpi, then told the lithographer to reduce it by a factor of two, it should come out the right size. But don't take my word for it, check it. When you've printed it out, measure the pin spacing.

References

I found these books very useful. Walter Jung also wrote the famous *Op-Amp Cookbook*. It's a good book too, but for audio his *Audio IC Op-Amp Applications* is much more focused and relevant. Don Lancaster's *Active-Filter Cookbook* is amazing. Really great basic op-amp info as well as filter design. Makes filter concepts really simple if (like me) you've been confused by other books before.

If you're in Australia or NZ, the Dick Smith catalog is a great cheap source of info too.

Berlin, Howard M., 1977, *Design of Op-Amp Circuits with Experiments*, Indianapolis, Howard W. Sams & Co.

Jung, Walter G., 1975, *Audio IC Op-Amp Applications*, Indianapolis, Howard W. Sams & Co.

Lancaster, Don, 1975, *Active-Filter Cookbook*, Carmel Indiana, SAMS Prentice Hall Computer Publishing

Malmstadt, H., Enke, C., Crouch, S., 1981, *Electronics and Instrumentation for Scientists*, Menlo Park CA, Benjamin/Cummings

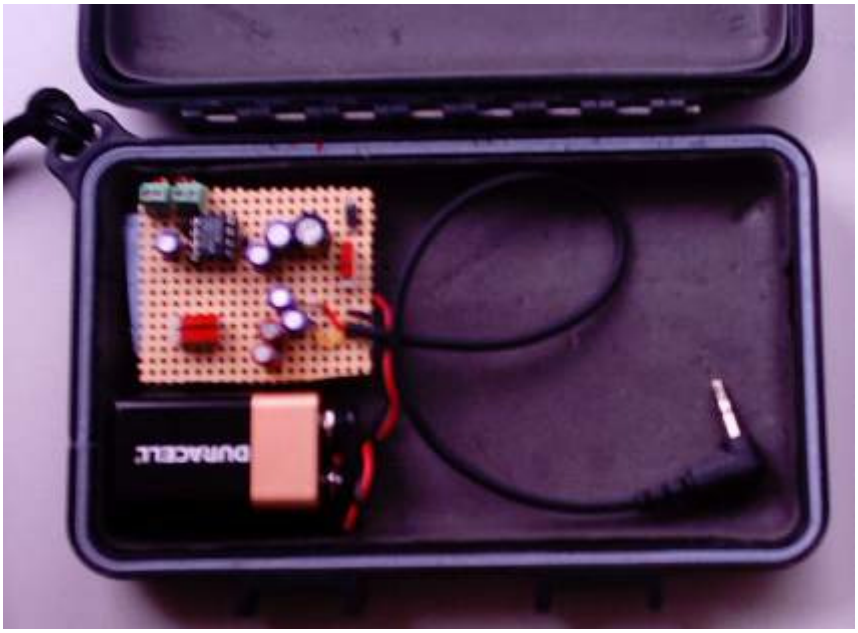
Claimer

If you build this or something like it and harm your MD recorder, I will snicker. Do be careful.

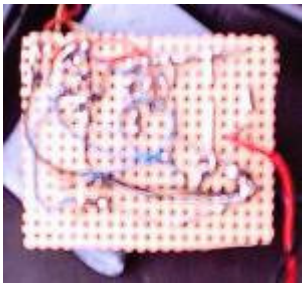
Photos Of Real Live Preamps

If you've a photo of your preamp, I'd certainly be interested to see it.
Send me a picture/description.

Tom's Preamp



I built the thing out of NE5532s in the end... Took an age to do, as all the other components were SMT to fit it onto a really tiny board which'll fit inside one of those Otter Boxes along with the MD unit...



I don't think the numerous SMD components are even visible on the underside shot due to the focus being so poor, but I've included it anyway.

As for layout, well, I tend to make it up as I go along... effectively, the underside could be quoted as 3-layer... :)

As for the components used... all the resistors are SMD 1% bulk metal films. Power decoupling is 220uF/25V FC+10uF/25V Oscon. Coupling caps are all 2.2uF/25V Oscon except for the blocking ones on output which are Elna Starget 10uF/35V.

- Tom.

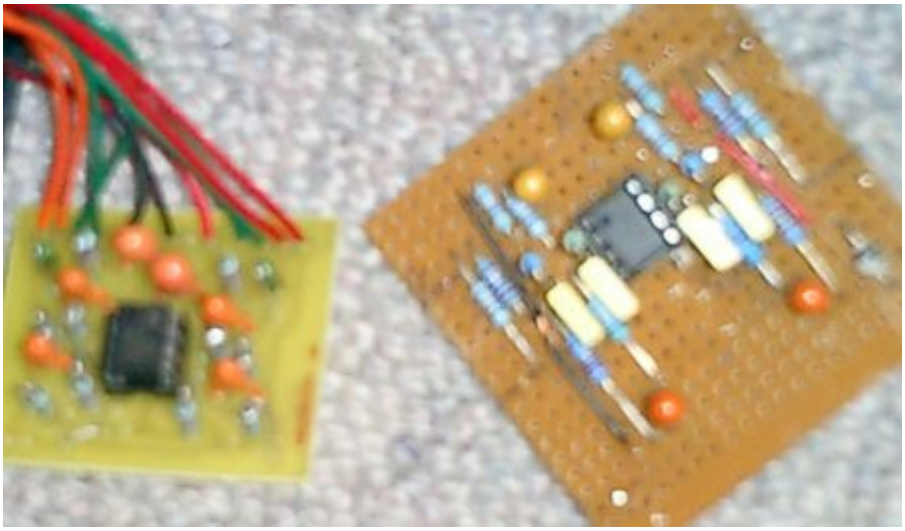
Eric's Preamp

Thanks for the preamp circuit. I scaled your circuit design (407 dpi) and printed it onto toner transfer medium, ironed it onto a copper-clad and built one today. Here's a photo for your collection.

It works nicely tucked into an Altoids tin. Nice sheilding I guess. I used a TL072 and shorting jumpers for the gain control. No fancy components, just carbon resistors and electrolytic caps. I didn't have 2pf caps for the feedback bypass so I used 5 pf and that seems to work fine.

The pre-amp is working well. I've used it with a mini-disc and an Archos Jukebox recorder and a pair of home-made binaural mics to do environmental recordings. Got some great thunder a while back...

My Preamp



Saving the worst for last. Here's a couple of really fuzzy shots of my preamps. On the left, the semi-final version using the PCB, much as described on the other page.

On the right, my prototype, built on veroboard. If the spare tracks around the outside were trimmed it actually wouldn't be much bigger than the PCB version. You may be able to spot that there are two input capacitors on the veroboard version. That's because I was playing about with a switchable input filter, for a selectable bass cutoff, as seemed to be popular on some battery boxes. But it seemed to have essentially no effect to me, I guess being a one pole filter and all, so I left it to its own devices.

...I started with your pcb and the ckt worked great. But my caps didn't fit, were hanging out, so I decided to redo the wiring so those w/o pcb equipment could build it.

The point to point wiring was tedious, and it took me two full evenings to wire it, where I normally could have stuffed the board in an hour. Next time for me, it's pcb only!

Enjoy the photos. I appreciate the ckt. I'd built a previous 5532 preamp that I still use and it has much fewer parts...

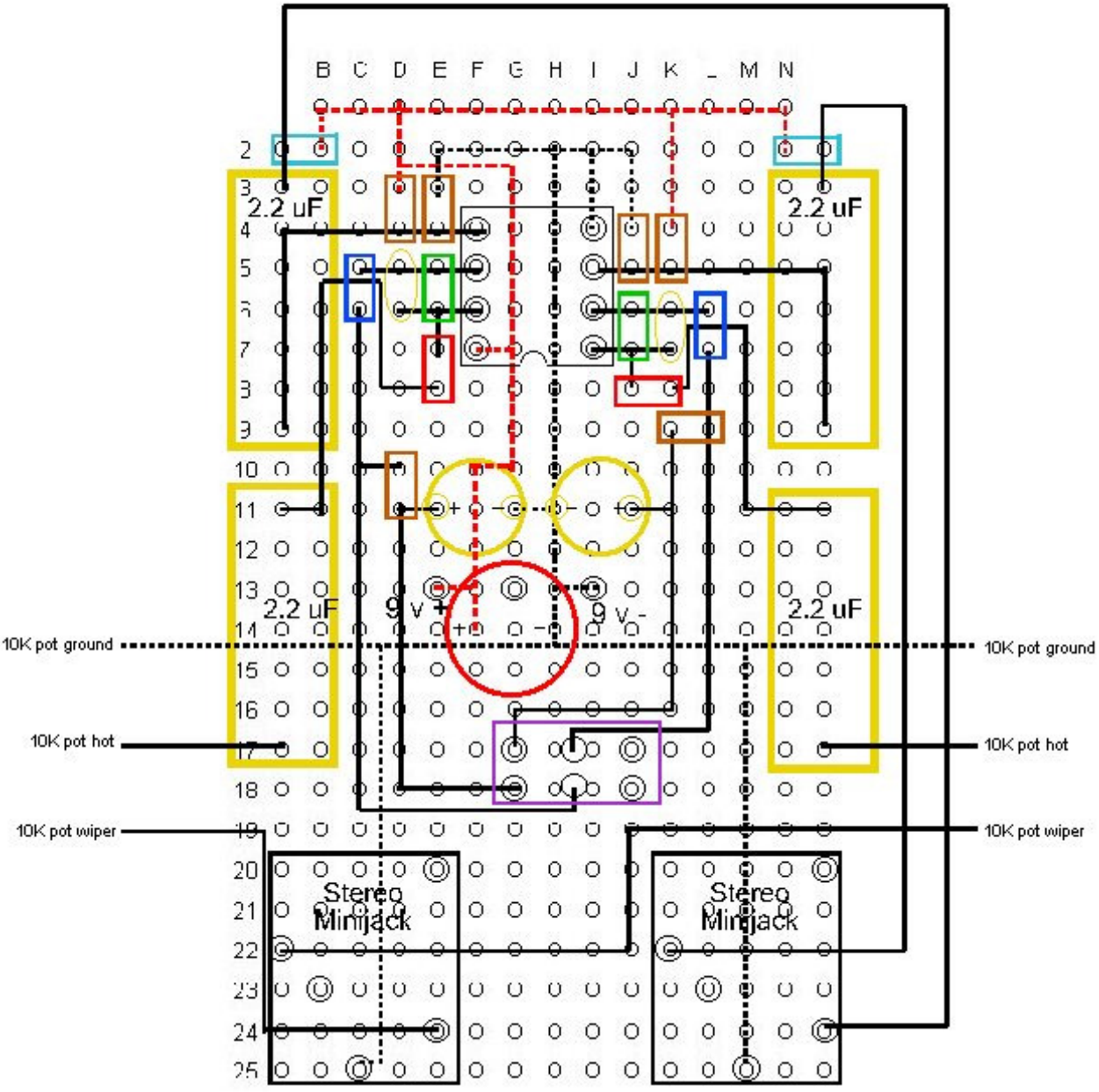
...I eliminated the 2 pf, just left them in the old board. But you'll see that I included them in the wiring diagram (also note that I'm giving you proper credit!)

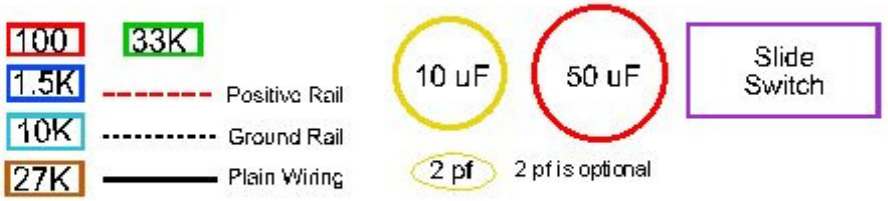
Best wishes,

Tom Polk

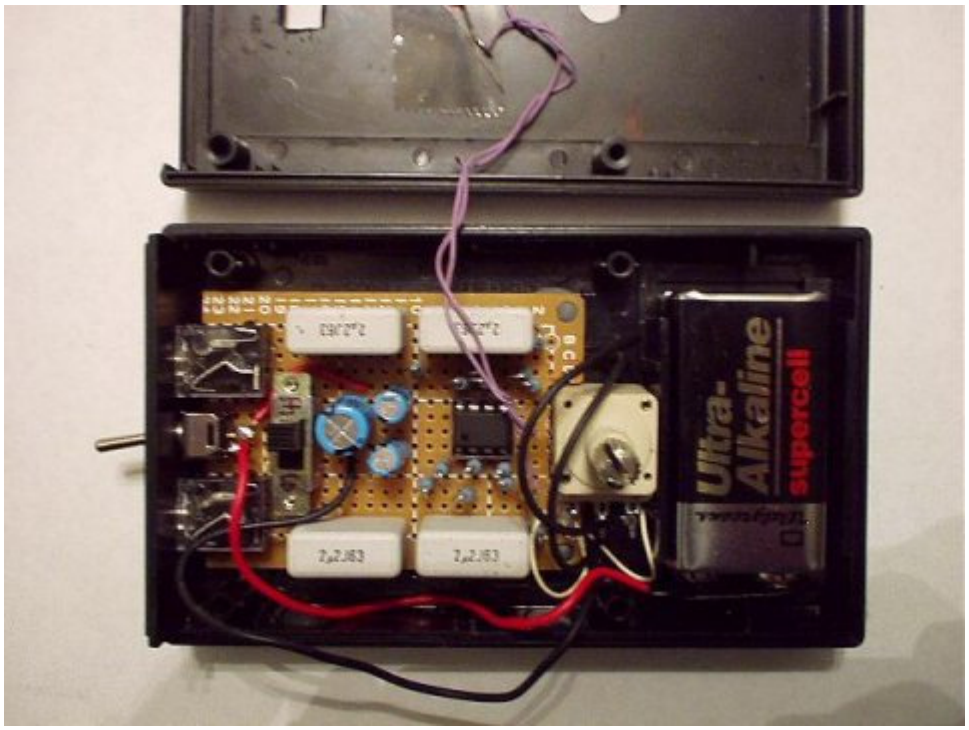
http://www.tompolk.com/

Top Side View





Schematic and description at
http://www.geocities.com/ferocious_1999/md/micpreamp2.html
This wiring and drawing by Macrohenry


Ultra-
Alkaline
supercell