

Tech corner – Your own PCBs, Part 3

In the previous articles, I discussed the design of a two-channel **electret microphone mixer** with an adjustable band-pass filter, and the **subsequent design of its PCB board** using *ExpressPCB Plus*.

This final installment populates the PCBs with SMD 0805 (medium sized) resistors and capacitors, LM358 integrated circuits or sockets, and 0.1" headers. If all goes well, and you have all the parts, this shouldn't take more than a few hours of assembly time. But, wiring up the potentiometers and microphone connectors is a time sink that took me several hours. 3-D printing the box after a few false starts soaked up additional time.

Beginner tools

You probably already have a soldering iron, but you're going to need something small; 5 to 10 watts is more than sufficient.

- You need **the appropriate solder**, the thinner the better
- **Water-soluble flux pen**
- Solder station : adjustable heat is desirable but you can get a low wattage iron from **Home Depot** that will suffice, with patience
- Tweezers. the more the merrier. Sharp points a necessity, keep band aids handy.
- Magnifying glass or microscope : especially if your eyes aren't what they used to be
- **Exacto knife** with sharp points : useful for cutting traces that shouldn't connect, or scraping off solder mask, or making plastic fit
- Wire cutters with flush faces
- Wire strippers : thermal is the best but expensive; for #30 hookup wire, you can use your teeth if your dentist doesn't know
- Rubbing alcohol : to remove the spent flux or Q-tips dipped in the alcohol
- **Solder wick** : copper braid to help remove solder
- Pizza oven : if you don't want to solder small parts

Part placement and soldering order

There's a best order for soldering parts:



1. The thin stuff first. SMDs, smaller through-hole items that don't stick up very far; wait on radial capacitors and headers that stand up straight
2. Work from the inside out
3. Headers and big connectors; it helps if your board will balance on them without tipping over
4. Through-hole parts

First board assembly: design errors

Error #1 : One of the test point labels ended up in copper rather than silk screen. Fortunately, no traces were shorted.

Error #2 : A process error, some through-hole vias had excess solder in them. For example, an 8-pin IC socket had pin #1 nearly full of solder.

Error #3 : -3V on U1 got connected to ground; corrected by Exacto knife

Minor #1 : Some part labels were in the wrong place, a few were missing

Minor #2 : No fixed resistor pads for balance and final gain stage

Substituting parts

Rifling through the junk box and borrowing from friends, I found enough 0603 (small) parts to assemble at least one board until the 0805 parts arrived. This required a microscope for ease of assembly, particularly for older eyes. A reasonable amount of flux that found its way around the board and was removed by an ultrasonic alcohol bath. The two channels are on the left, and the final balance amplifier on the right and the ICs are comfortably seated in their sockets.

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Toaster oven alternative

There's an easier way to solder surface-mount parts. You can still burn your fingers, but you have to try harder. Place flux on the board, put the parts in place, put them in the oven to bake, and you're done. If you're using lead-based solder, you probably want to avoid using the oven for food. You can find many DIY videos on this process by searching for "Using a pizza oven for surface-mount

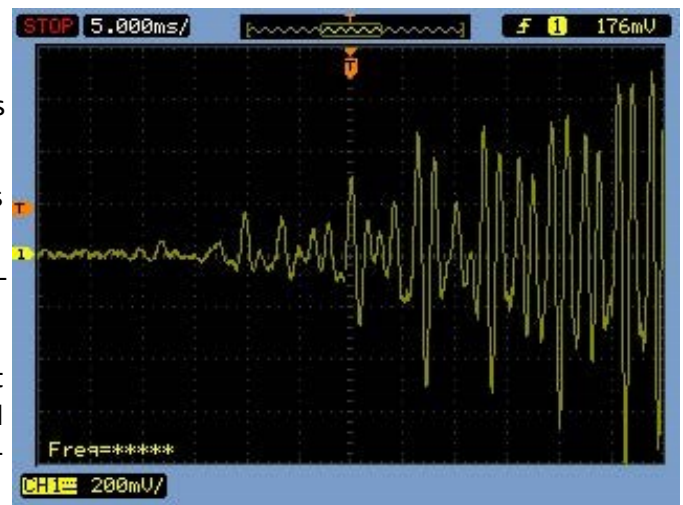
components" on the internet. You'll need either some solder paste or really sticky flux. Put the SMD parts in the right place, place the PCB in the oven until they're melted into place, and you're done. Check the internet for times and temperatures.

Debugging

A few minor problems:

1. Negative was shorted to ground : pin #8 on U1 is grounded, not -Vcc; another Exacto knife fix
2. Op-amp mix-up : TL072 is not the same as LM358...get the right chip!
3. The microphone jack got wired backwards : the PTT got connected rather than the electret

After fixing these problems, to the right is the output from TP4 on channel one volume set to the maximum and saying "One" into the microphone, as reported on an oscilloscope:

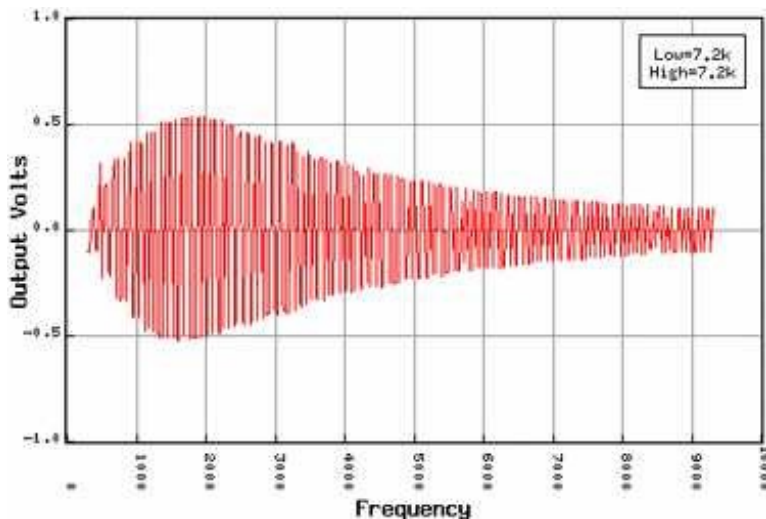


Band-pass

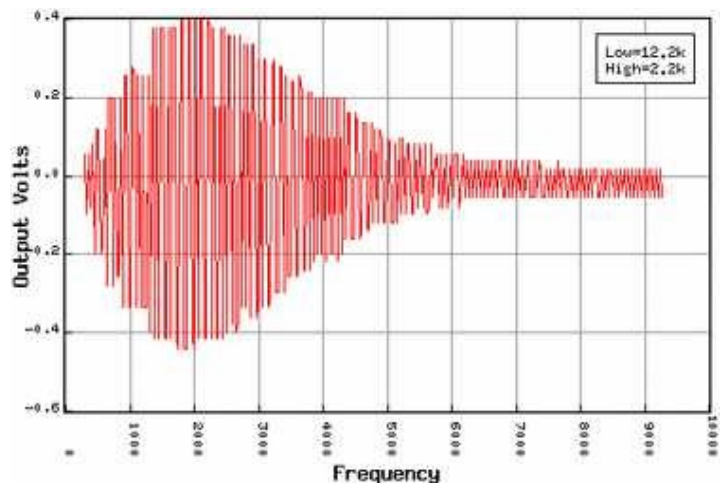
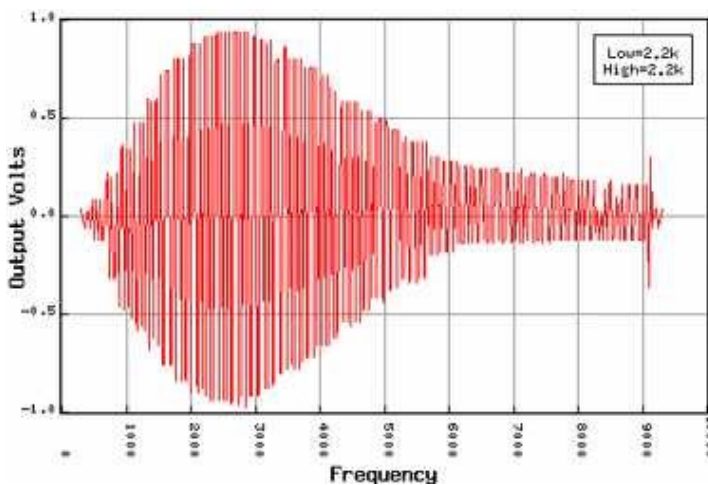
I built a board with a single-channel filter and no microphone pull-up. The first stage gain was set to 100, and two 10-k potentiometers connected for the filter resistor constants. The low-pass filter (high attenuation) capacitor is 0.01 μF and the high pass 0.047 μF . A sweep generator was connected to the microphone #1 input and set at 0.01 volts ranging from 300 hertz to 9300 hertz. I captured the signal by the oscilloscope and plotted the data.

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The band-pass for low/high both set at 7.2-k Ω resulted in a peak amplitude of around 1.6 kHz with a low cut-off at about 1 kHz. The high attenuation is more gradual with most attenuation after 5 kHz:



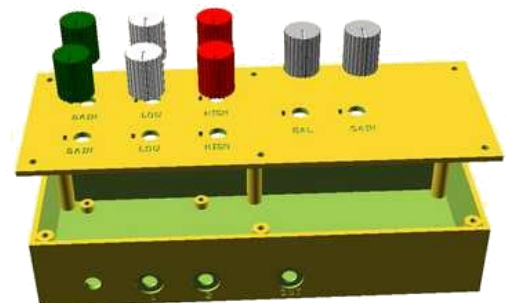
With both potentiometers set to 0 (i.e. 2.2 k Ω because of the two fixed resistors in series), we get more amplitude and sharper cutoffs (left image). Finally, setting the high-pass potentiometer to zero and the low-pass filter to 10 k Ω moves the low end of the band-pass to lower frequencies (right image).



Conclusion: The filter isn't terribly effective, but still cuts out low and high noise to a significant amount.

The wiring harness and the enclosure

After a few false starts, I printed a box for an enclosure, some knobs and face plate for all the potentiometers, a switch, and the microphone 3.5-mm jacks. There are board supports with holes to tap for #4 screws, same for the face plate. The knobs are friction-fit. There's a wiring harness for each set of microphone controls, the balance, final gain and microphone connectors and the battery/switch.



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And with all the screws in place:



The finished product

Does it work?

My transceiver has a 6 pin RJ-11 connector and DTMF keys. I haven't figured out how to test the box on it. My Icom has an 8-pin, screw-on jack, my GMRS base station has a 6-pin RJ-11 connector as well. More time needed to build adapters for each.

Jed Marti KI7NNP