VHF Filters Without Exotic-Expensive Trimmer Capacitors.

Wes Hayward, w7zoi, 10 Nov 2014

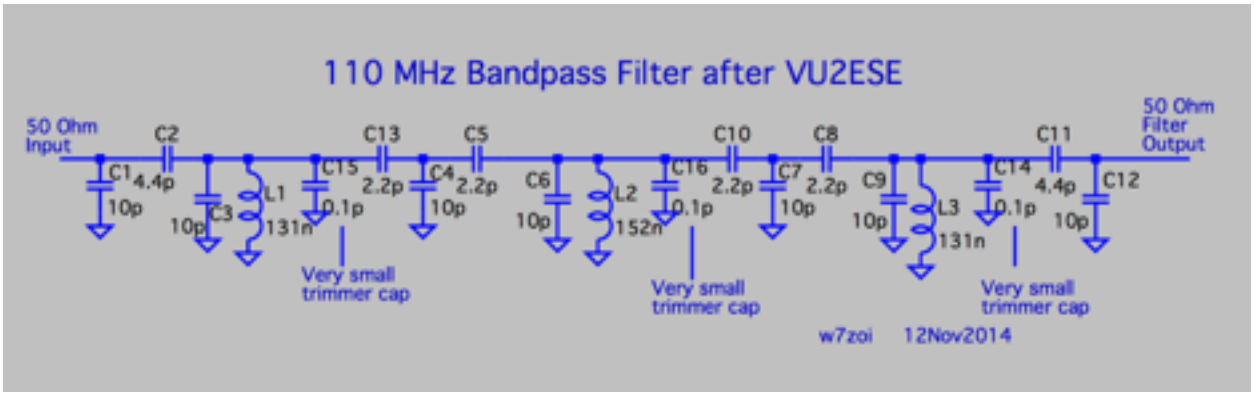
A major problem encountered when one builds a VHF bandpass filter is resonator tuning. The usual filter is tuned with trimmer capacitors with one required for each tuned circuit. Commercial parts usually work well, but they can be difficult to find and very expensive. Clearly, other solutions are of interest. This note presents some possible solutions based upon correspondence I've had with two amateur radio friends: Ashhar Farhan, VU2ESE, and Bob Kopski, K3NHI. Farhan tunes the inductors while Bob builds his own trimmer caps.

> This note will outline some filters built by these experimenters. The information is intended to suggest avenues for experimentation rather than to present detailed, step-by-step instructions. **The details are left to the experimenter.** We assume that the builder will also do both design work, perhaps on a computer, followed by appropriate measurements.

An Inductor-tuned Filter with SMT Capacitors— from VU2ESE.

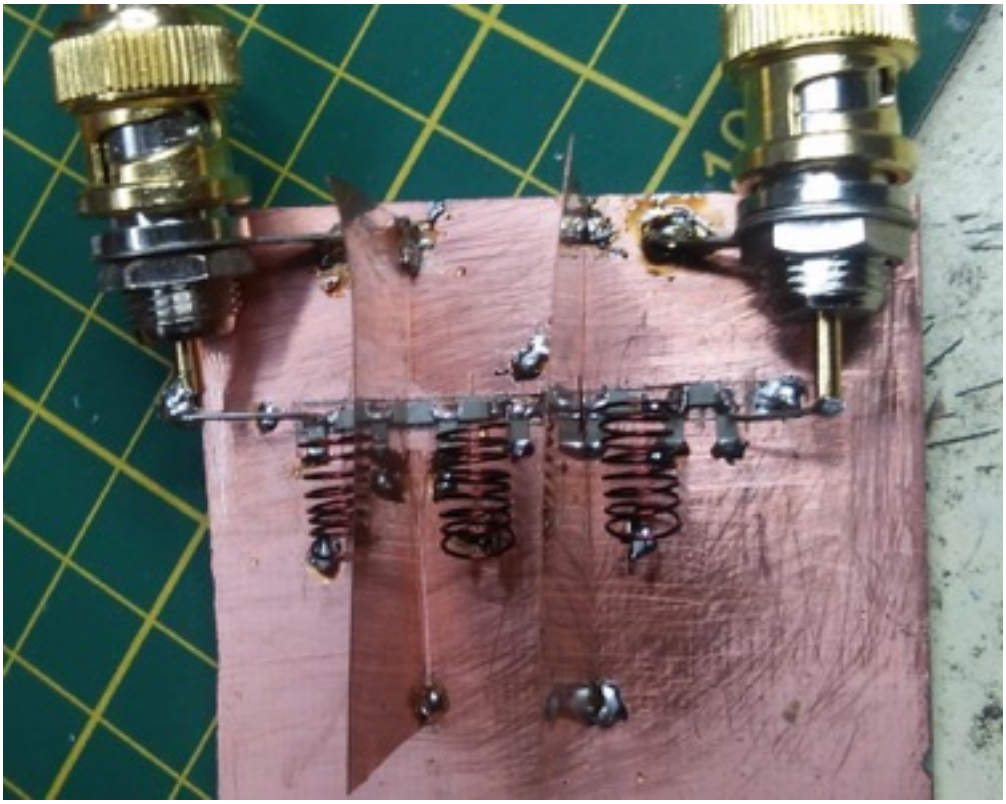
Farhan needed a bandpass filter at 100 MHz for one of his projects. He ended up with a circuit using surface mounted capacitors and air core inductors using a relatively small wire size. The filter was tuned to the desired center frequency by stretching and compressing the inductor turns. A second feature of Farhan's filter design is the use of a restricted number of capacitor values: He only used values of 2.2 and 10 pF.

Farhan described his filter to me in an email along with a photo and schematic. I then did some analysis with GPLA. GPLA is the filter analysis program included in LADPAC, a collection of computer tools that accompanies **Experimental Methods in RF Design** (ARRL, 2003, available from the publisher.) The schematic of my version of this filter is shown below. Farhan's 100 MHz design was modified for a center frequency of 110 MHz to make it fit with the 1998 Spectrum Analyzer. The end loading has been modified slightly, but the constraint of using only two capacitor values has been retained.



The 4.4 pF capacitors at the filter ends consist of two parallel 2.2 pF parts. Farhan's original 100 MHz filter used single 2.2 pF in those positions. The coupling between resonators originally

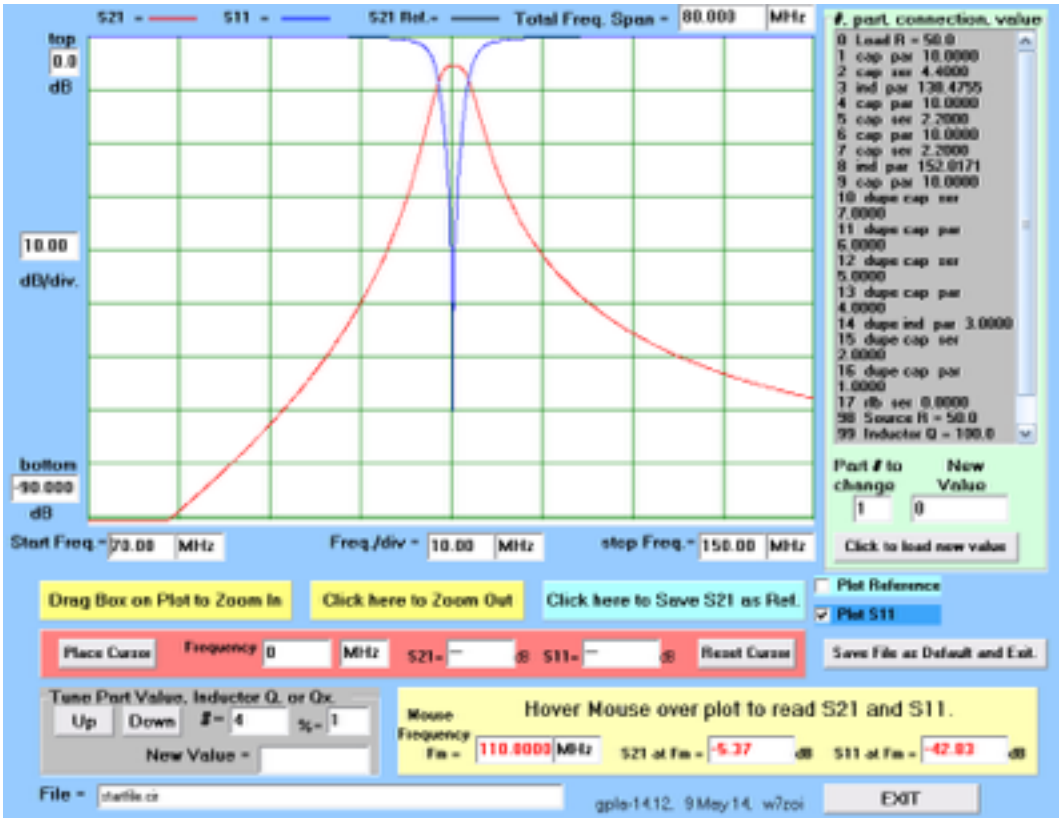
called for a value of about 0.3 pF. This was realized with a replacement network consisting of two capaictors of 2.2 pF value with a third at 10 pF. See the sidebar in EMRFD, page 3.15. Traditional bandpass filter design usually uses equal valued inductors, but this is not required. This example uses equal end inductors with a center L that is 16% larger. A photo of Farhan's 100 MHz filter is shown below.



Farhan's filter includes shields between resonators. The top surface is a ground plane.

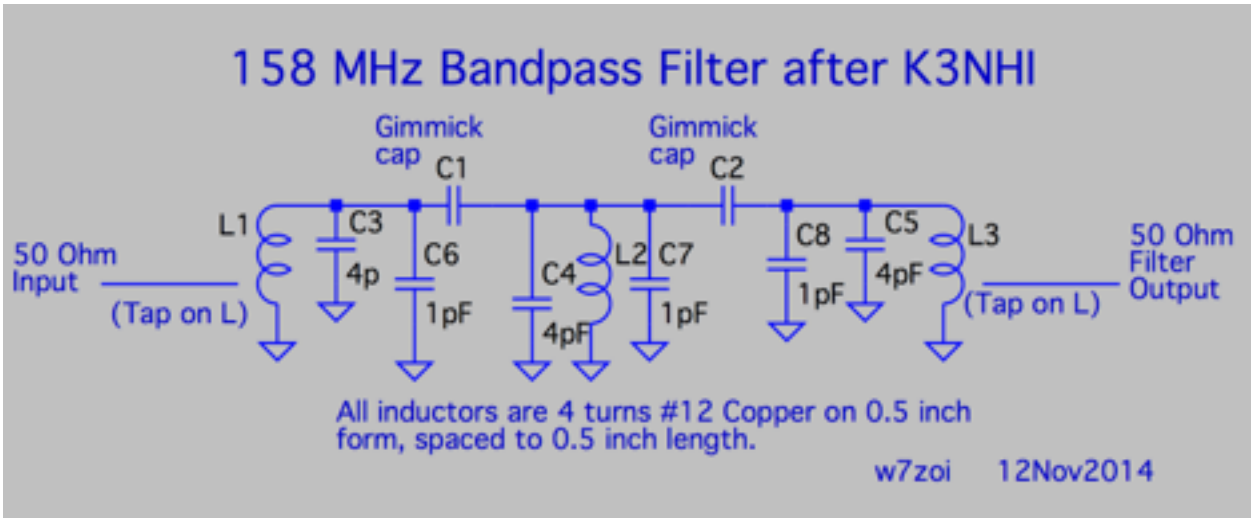
An alternative to the 0.3 pF three capacitor coupling network would be a gimmick capacitor as is done in other filters on this site. The schematic above shows trimmer capacitors. These are small wires that could be included as a "fine tune" element for each resonator. A small piece of stiff wire of about 1 cm in length is attached to the “hot” end of each coil with the wire suspended above the ground plane. The wire position would then be adjusted with a toothpick or similar non-metallic tool. (This is just a thought--I've not tried it yet.)

The calculated response of the 110 MHz version of this filter is shown below, assuming an inductor Qu of only 100. Note that high Q capacitors are best for this circuit.



Filters with Home-brew Variable Capacitors — from K3NHI.

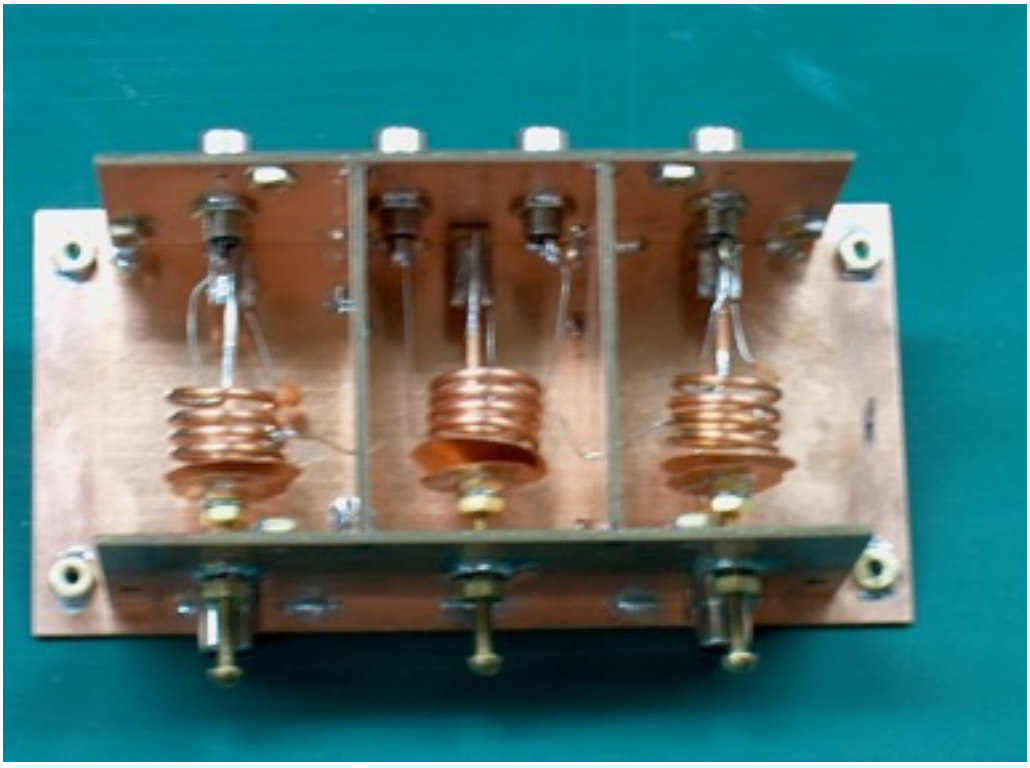
The schematic for Bob's filter is shown below. While the schematic is much like Farhan's filter, the two circuits are really very different.



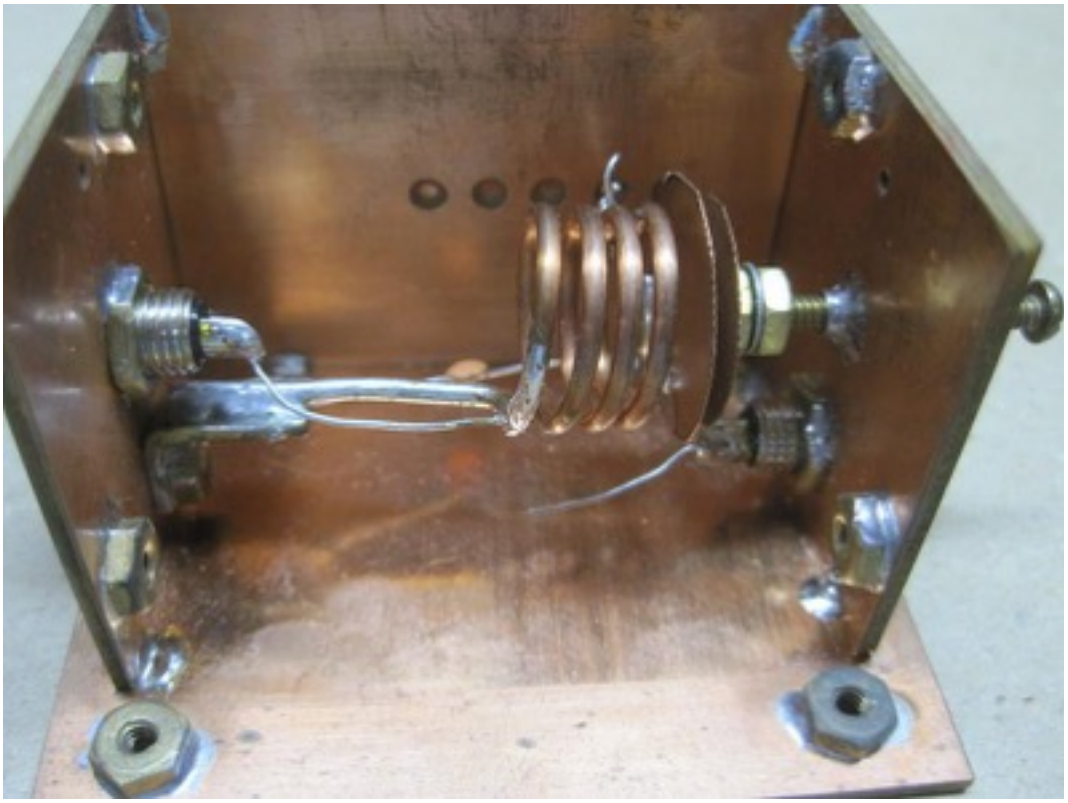
The 50 Ohm coax connectors attach to the filter by way of taps that are a fraction of a turn from the grounded ends of the end coils. The two taps are identical. The tap positions and the two gimmick coupling capacitor values (also equal) are experimentally adjusted for the desired filter performance. The photos below show the details of Bob's filter.

Outside.

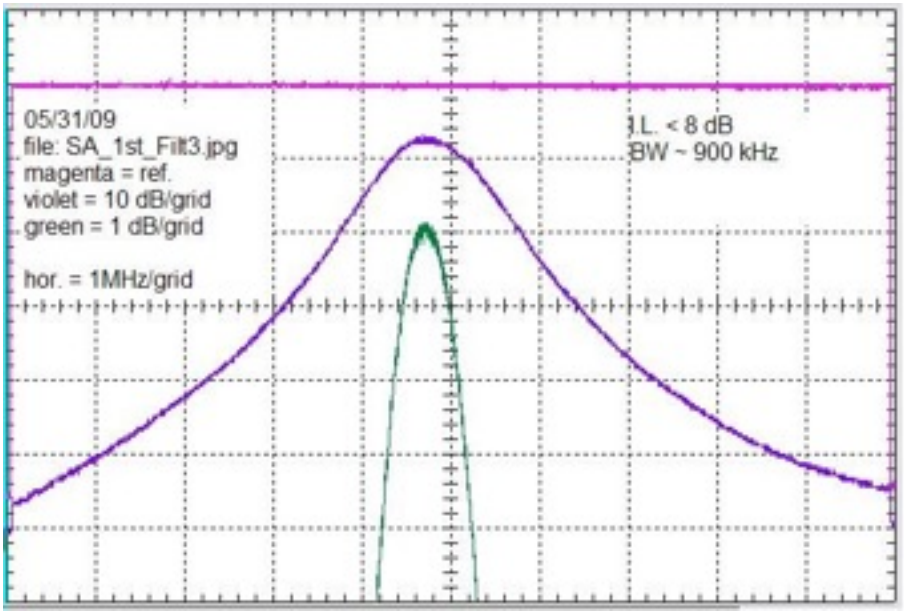
Bob usually uses RCA connectors for RF connections to the modules in his equipment.



Shields are used between filter sections. Not shown is an extra “lid” that goes over the center resonator.



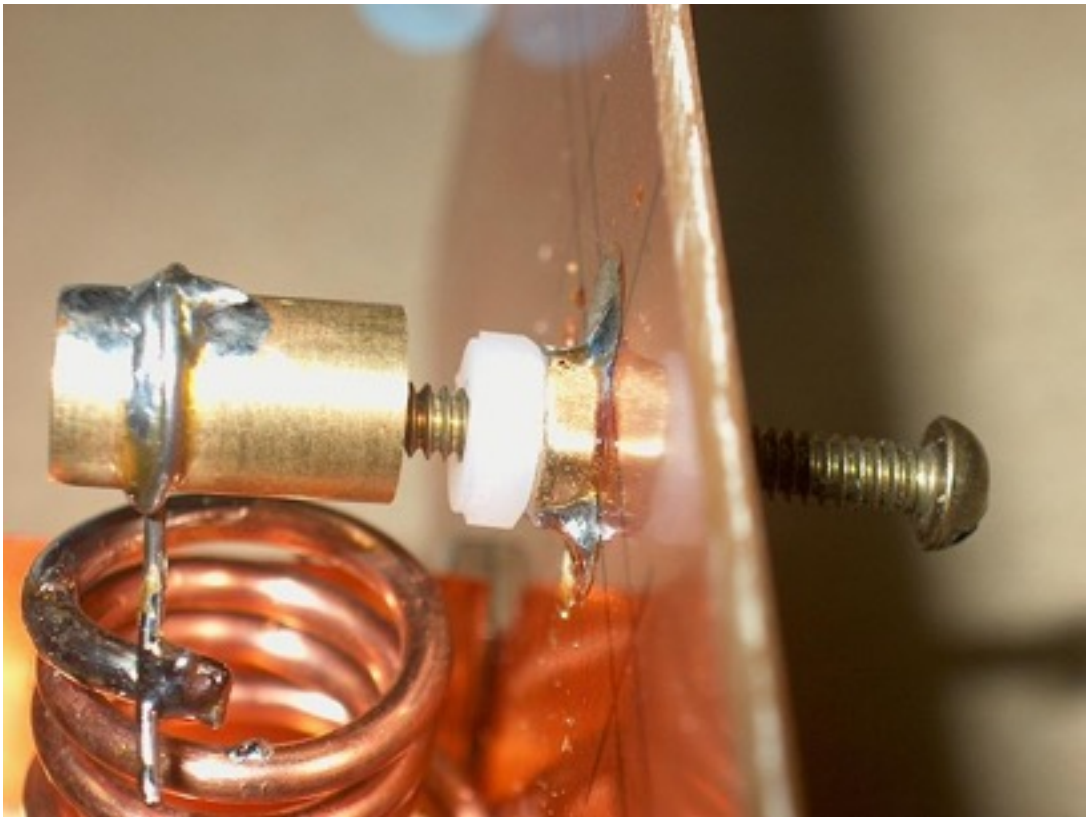
The photo above shows one of the end resonators. The 4 turn coil has one lead extended where it solders to a aground lug. The other coil end has a capacitor disc (about 3/4 inch OD) soldered to it. A similar disc attaches to a machine screw that extends through the grounded wall. A wire from the coax connector taps the first turn of the inductor. The trimmer cap is shown as 1 pF in the schematic, an approximate value. The next figure is a sweep of the filter. The bandwidth is just under 1 MHz while the filter insertion loss is under 8 dB. These values are consistent with a resonator Q of about 400.



Several extra coax connectors are shown in Bob’s filter. These were used with wire “probes” attached as a means of measuring

each resonator when excited with RF. The extra loss is small if the probe wire length is kept small. The use of such probes is central to the “Dishal” method. See Chapter 9 of the classic Zverev book, “**Handbook of Filter Synthesis**.”(Wiley, 1967. Long out of print, but available in a proper library.)

Bob has also experimented with home-brew piston capacitors. One is shown in the next figure.



A small piece of brass tubing is attached to the “hot” end of an inductor. A grounded brass machine screw then extends into the tubing, adjusting the capacitance. While this scheme worked well for Q and a useful capacitance variation of around 1 pF, Bob reports that the capacitor was microphonic. Slight vibrations resulted in unstable filter performance, suggesting the need for further experimentation.

Many thanks to Farhan, VU2ESE, and to Bob, K3NHI, for sharing their ideas with us. Now I’m off to the lab to try some of these schemes.