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QST Issue: May 2000
Title: A No-Tune 2-Meter Bandpass Filter
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By Zack Lau, W1VT

A No-Tune 2-Meter Bandpass Filter

A homebrew solution to annoying intermod.

Here is a solution to a common problem—strong pager signals interfering with 2-meter signals. Wideband receivers rarely have enough filtering to reject pagers signals just above the 2-meter amateur band, resulting in strong intermodulation products, or *intermod*.

My solution is a sharp bandpass filter in the form of tuned circuit made entirely of coaxial cable. This is similar to microwave printed circuits, where the frequency is too high to effectively use ordinary capacitors and inductors. Inductors and capacitors work quite well—if you have the test gear to tune them. I found that semi-rigid cable could be cut accurately enough to eliminate the need for tuning.

The design shown in Figure 1 uses sections of UT-141A semi-rigid coax cable for the circuit elements. This Teflon cable has a solid copper jacket that can be cut accurately to length with a sharp hobby knife and a steel rule. It can also be bent around ³/₄-inch PVC pipe to form compact coils, which reduces the size of 28-inch resonators. Coax cable is also self-shielding—you don't need to buy an expensive box to shield the filter from RF. These days, a good box could cost more than the electronics inside it!

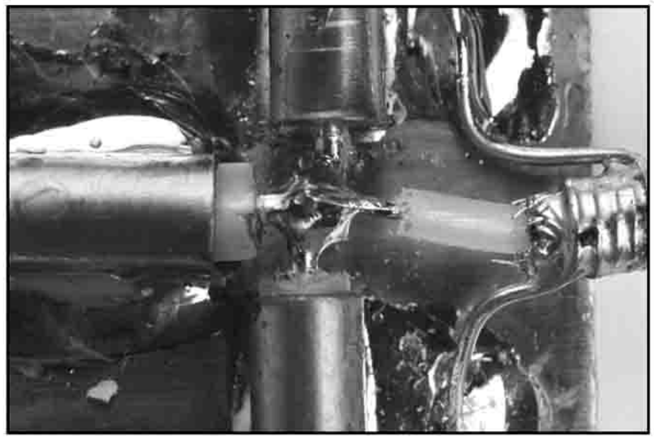
The principle of operation is rather simple—a half wavelength of coax shorted at each end forms a resonant circuit. By tapping into the resonator, energy can be introduced and extracted. Tapping closer to ground reduces the coupling, while tapping closer to the center point increases the coupling.

Thus, the bandwidth of the filter can be adjusted by changing the distance of the tap points from the grounded ends of the resonator. Filters using a pair of resonators have a good compromise between performance and complexity. "The Double-Tuned Circuit: An Experiment's Tutorial," in the December 1991 *QST*, by Wes Hayward, W7ZOI, is an excellent reference for understanding filters with two resonators.

To optimize the rejection of signals just above 148 MHz, I used the same tap points for both the input and output of each resonator. This maximizes the attenuation on the high side of the passband—perfect for rejecting unwanted pager signals around 153 MHz. As a bonus, fewer tap points simplify construction. A more symmetrical passband can be obtained by tapping into the half wave resonator at one end and coupling through the other end. You might want to do this with a 70-cm filter used in a transverter, despite the greater complexity. This would result in greater attenuation of the unwanted low-side local oscillator and image.

With tap points set for the desired bandwidth, I adjusted the passband response by varying the length of the coupling cable. This is tedious to do on the bench, but rather easy with a computer simulation. I used *ARRL Radio Designer* to design the filter—tweaking the element lengths until I achieved a design that looked good. *Radio Designer* is also good for looking at other design possibilities. I explored the idea of making a notch filter out of UT-141A, but none of the designs were worth building.

A significant disadvantage of transmission line filters is



A close up of the T-junction connected to 50-Ω Teflon coax.

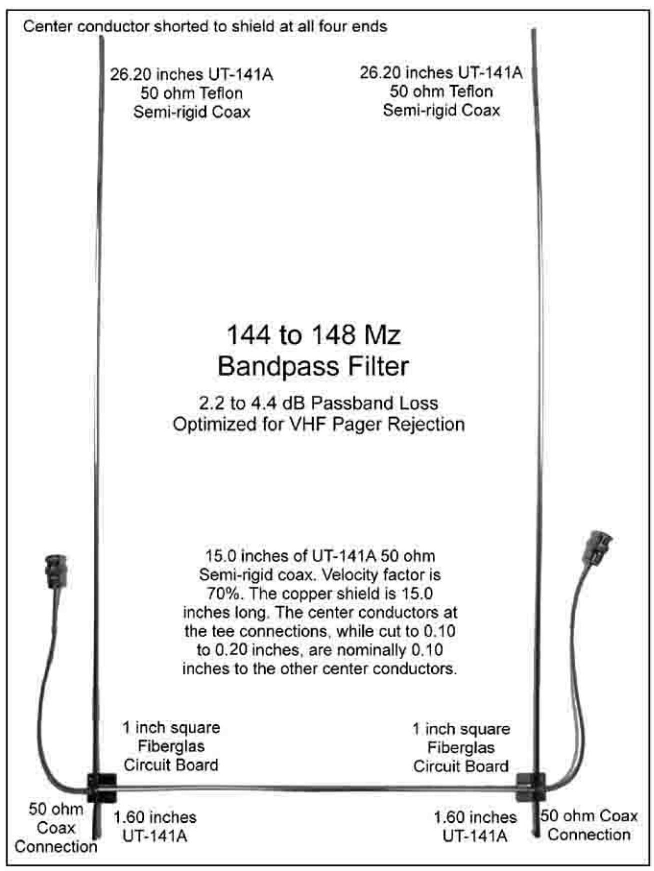


Figure 1—A view of the 2-meter no-tune bandpass filter showing the dimensions and wiring.

Here you can see how the center conductor is grounded to the shield.

harmonic responses. A half-wavelength filter is also resonant on its harmonics. This means that harmonic rejection is quite poor. A more conventional filter is suggested if you need good rejection above 170 MHz. Alternately, a low pass filter could be used in conjunction.

Construction

The semi-rigid cable is available from Down East Microwave and RF Connection.[1] I'd buy at least a couple extra feet for practice and errors. To work well, the cable shields should be cut with an accuracy of 1/16 inch. However, the 15-inch cable isn't as critical—the performance is still good with a 1-inch error. With practice, this can be done by placing the cable on a large flat surface and rolling straight lengths of cable under a sharp knife. I used an X-Acto knife with a new blade. You don't have to cut the cable all the way through—copper will break along a score line. A good steel rule will help insure accuracy. I strongly recommend some sort of eye protection when working with very sharp knives.

The dimensions shown in Figure 1 (26.20, 15.00 and 1.60 inches) are the lengths of the copper shields. The cable is most easily cut when there are a few inches on either side, but as little as 1/2 inch of extra cable will work. A pair of pliers is useful for grasping short lengths of cable. As you cut through the dielectric avoid nicking the center conductor—it will weaken the cable and make it much harder to bend without breaking. If you do nick the conductor, use it on the side that isn't bent.

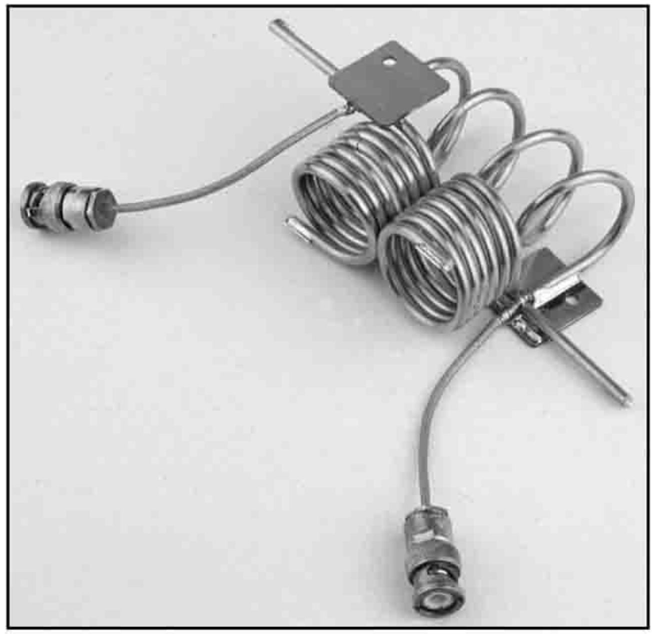
I also looked into ways of cutting the cable that required less skill. I made two cutting guides. They were both sections of brass rod with #27 (0.144) inch holes drilled down the center. The first was made out of 3/8-inch rod—thick enough to tap with set screws to firmly hold the cable. The second was made out of 1/4 inch rod—I just taped it to the coax. I wouldn't go through all this trouble just to make one filter, but making some tools might be a good idea if you plan a lot of microwave construction. UT-141A is a popular cable for connecting microwave subassemblies.

It doesn't hurt to measure twice, even after you have cut the cable shield. If you discover that you've made a mistake, and if you haven't cut the dielectric yet, you might be able to solder the cable back together. Tin the shield, wrap some copper foil over it, and solder the copper foil to the cable. Not as pretty, but still useable. Just 1/2 inch of center conductor is plenty for the shorted ends.

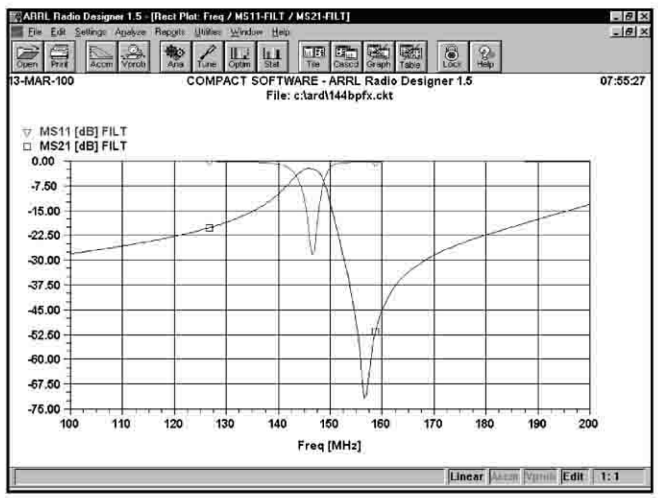
I used an unetched copper and Fiberglas circuit board to solder the three coax connectors together in a **T**-junction. It is a poor heat conductor compared to solid metal—you can solder additional pieces of coax to it without the first melting off. The Teflon may swell up. If this happens you can cut it back with a sharp knife. If you wish, you could use copper foil to cover the **T**-junctions and coax cable ends. However, the exposed "antennas" are so small that I doubt there will be much to be gained by shielding the connections.

I used RG-316/U Teflon coax to connect to the filter **T**-junctions. More common RG-174/U or RG-58/U can also be used, but Teflon coax is less likely to melt and short out.

[1]http://www.therfc.com/coax.htm; http://www.downeastmicrowave.com.



A view of the filter with the resonators coiled up to save space.



Insertion and return loss plots of the bandpass filter generated by *ARRL Radio Designer*. MS21 is the insertion loss and MS11 is the return loss.

Using the Filter

The loss of this filter is a bit high to leave in during transmit—3 dB loss is half your transmit power. Also the SWR, while acceptable from 146 to 147 MHz, isn't too good at the band edges. A common solution is to use a relay to bypass the filter. The 2-meter brick amplifier in the *2000 ARRL Handbook* can be easily adapted to use this filter. Just cut "coax A" in Figure 13.57 on page 13.47 and insert the filter. The amplifier circuit can be adapted to merely bypass the filter, without adding an amplifier.

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