A Filter for the Dual-band 10 & 24 GHz Feedhorn for Offset Dishes

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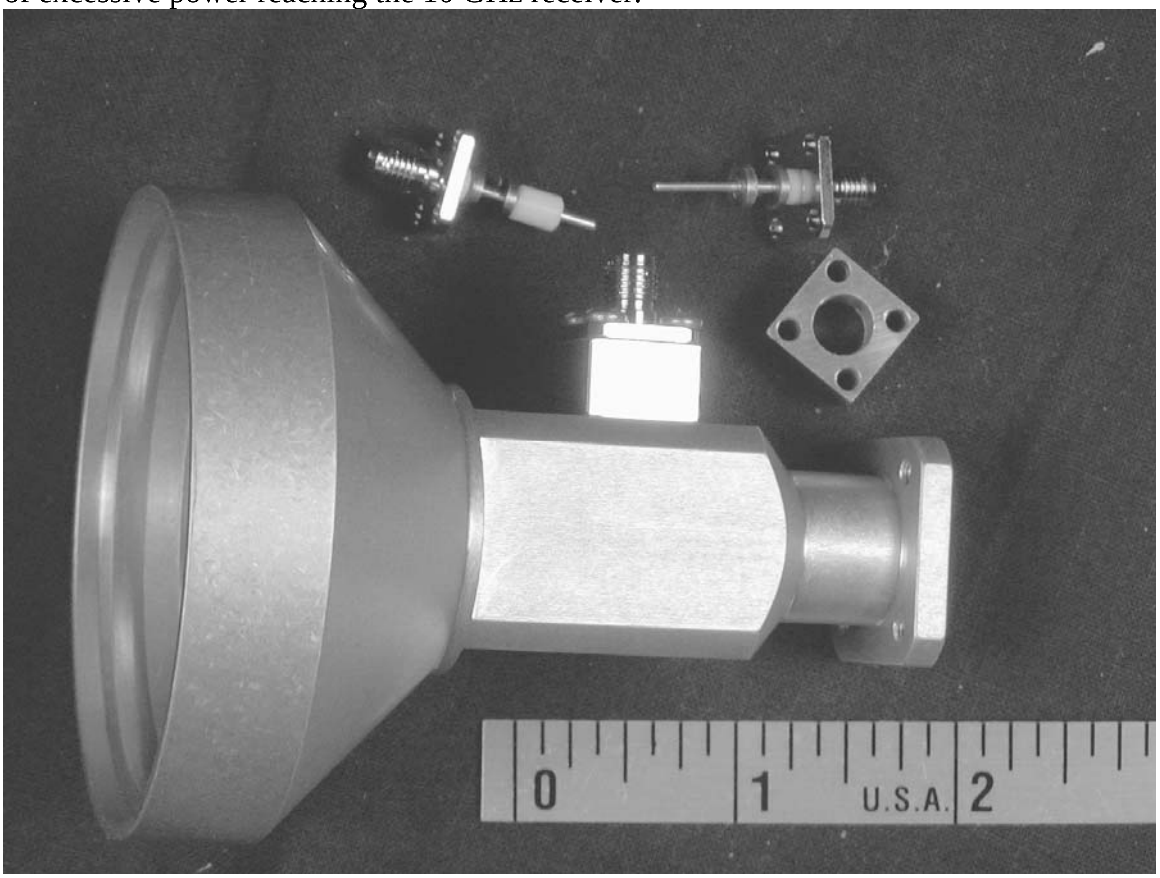
The dual-band feedhorn for 10 and 24 GHz by AD6FP and AA6IW[1] has proven very popular – if all of them were on the air, 24 GHz would be a very active band. The one shortcoming of this feedhorn is the isolation between ports. While it is excellent at 10 GHz, since the waveguide of the 24 GHz port is well beyond cutoff, it is only about 9 dB at 24 GHz. With a number of medium-power 24 GHz amplifiers in use, there is a danger of excessive power reaching the 10 GHz receiver.



In my own setup, I have used a surplus 8-12 GHz bandpass filter on the 10 GHz port, which provides adequate rejection of the 24 GHz power, protecting the 10 GHz front end. These filters are not common, so a reproducible solution was needed.

This is not a hard problem – all that is needed is a low-pass filter to separate two widely separated frequencies, passing 10.368 GHz and rejecting 24 GHz. The cutoff frequency could be anywhere in between. It does not need to be a very good filter, since we don't care about other frequencies, just two narrow bands.

The first thought was that a simple stub, resonant at 24 GHz, would probably provide adequate rejection. However, it would also cause a mismatch at 10 GHz. An old microwave trick is that two identical mismatches, separated by a quarter-wavelength, will cancel. So the mismatch could be removed by a second stub, ¼ λ away at 10.368 GHz. A quick simulation using the free Student Version of Ansoft Designer software[2] showed at least 30 dB rejection at 24 GHz, but the rejection notch and the 10 GHz passband were both pretty narrow, so dimensions would be pretty critical. Finally, I couldn't figure out a way to make it without a bit of machining.

Mechanically, it would be better if the filter were a coaxial structure, in line with the SMA connector. One form of microwave low-pass filter uses alternating sections of high- and low-impedance transmission line, or thin and fat coax. Other versions replace the low-impedance sections by capacitors or stubs. I played around with variations on this theme and found a combination that might work – thin disks, spaced about a ¼ λ. The disks might be considered capacitors, or as stubs of radial transmission line, but the step from thin center conductor to disk is also a capacitor. Properly accounting for all the stray capacitances took some fiddling of dimensions using Ansoft HFSS[2], a 3D electromagnetic simulator, to come up with a good combination of 24 GHz rejection with low loss and VSWR around 10 GHz. The calculated performance is shown in Figure 1 shows about 23 dB rejection.

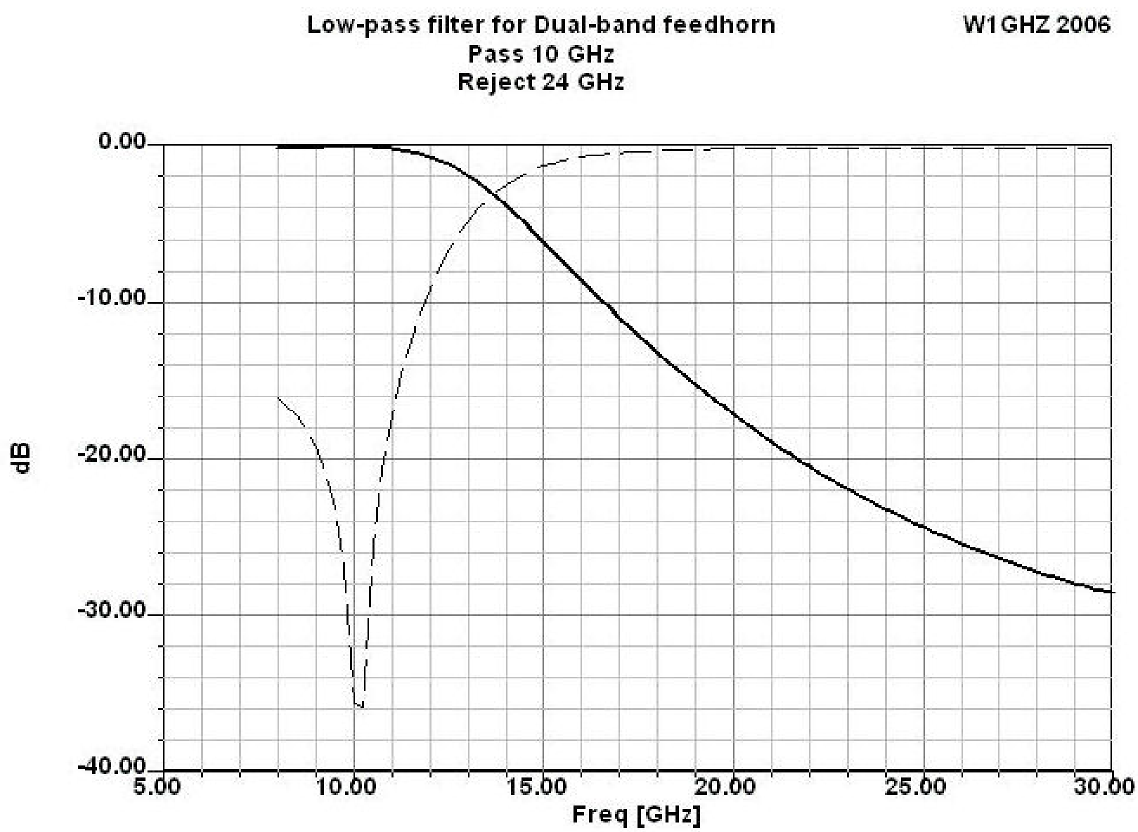


Figure 1

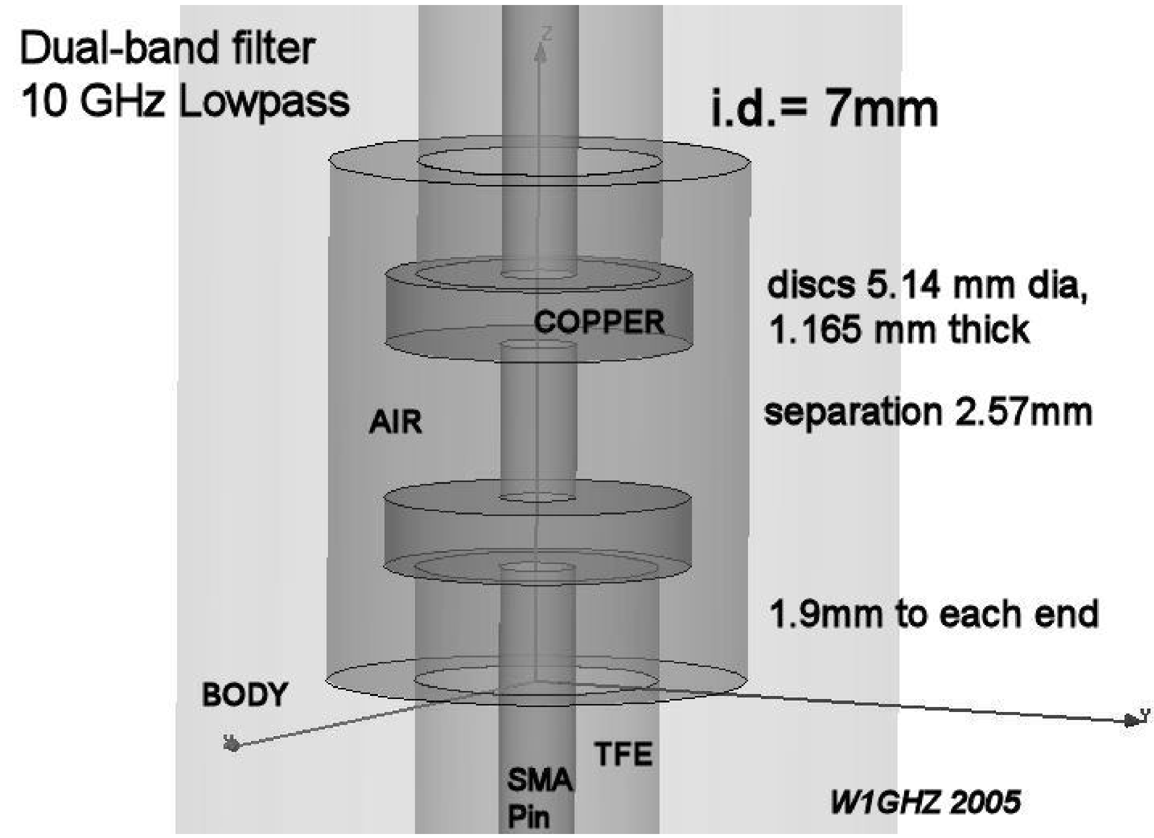


Figure 2

The dimensions of the filter are sketched in Figure 2. Construction is intended to be simple: take a long-pin SMA connector, cut off the Teflon insulator square at the point where the first disc sits, slide on the two disks, space carefully, and solder. Replace the rest of the Teflon, then trim it so that only the bare probe protrudes into the horn.

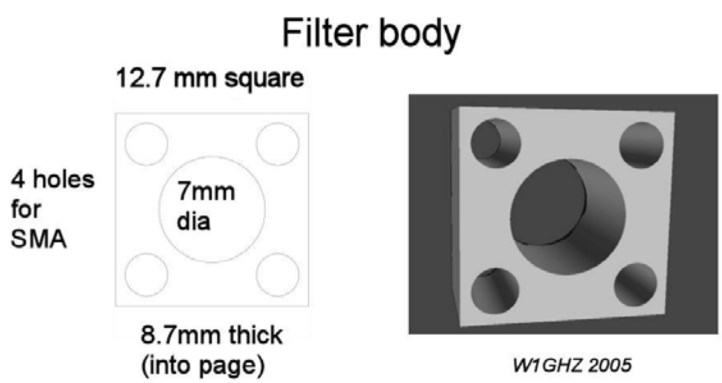
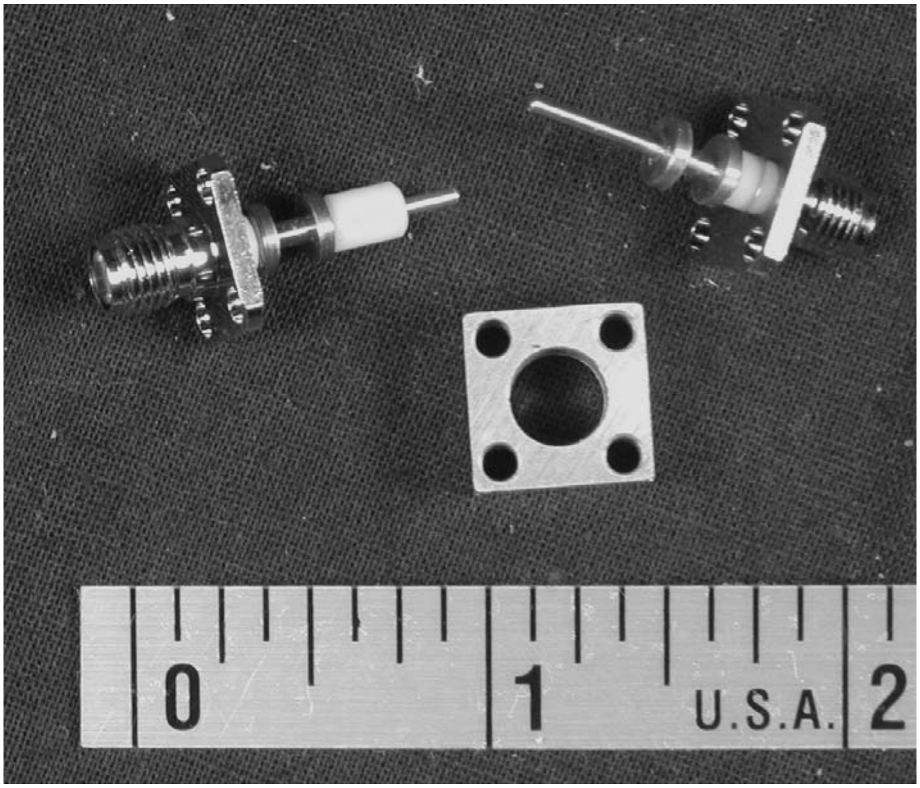


Figure 3

The connector assembly sits in a block shown in Figure 3. Using standard long-pin SMA connectors and the block thickness shown, the probe length is exactly right for the horn.

The completed filter is shown in the photos ready for assembly below and installed on the new one-piece version of the dual-mode feedhorn above.



The test results were good: 24 GHz rejection on two prototypes was 31 and 32 dB. Since we predicted 23 dB from the filter and measured 9 dB for the feedhorn alone, this meets our expectations. VSWR at 10 GHz was slightly better than without the filter, and unaffected at 24 GHz.

Loss is more difficult to measure, since only one end has a connector. Two feedhorns without filters were butted together, then one replaced by a feedhorn with a filter; the difference in loss was small. Another check was to measure the return loss with a metal plate shorting the horn aperture – also small. These are only rough measurements, but the loss of the filter is probably less than ½ dB.

This filter performs as designed, should be easy to reproduce, and provides adequate protection for a 10 GHz LNA from medium-power 24 GHz amplifiers, up to at least the 3-watt level. We hope to have kits available in the near future.

References:

1. Gary Lauterbach, AD6FP, and Lars Karlsson, AA6IW, "Dual-Band 10/24 GHz Feedhorns for Shallow Dishes," *Proceedings of Microwave Update 2001*, ARRL, 2001, pp. 181-190.
2. www.ansoft.com