NanoVNA Evaluation of Inexpensive HF Bandpass Filters

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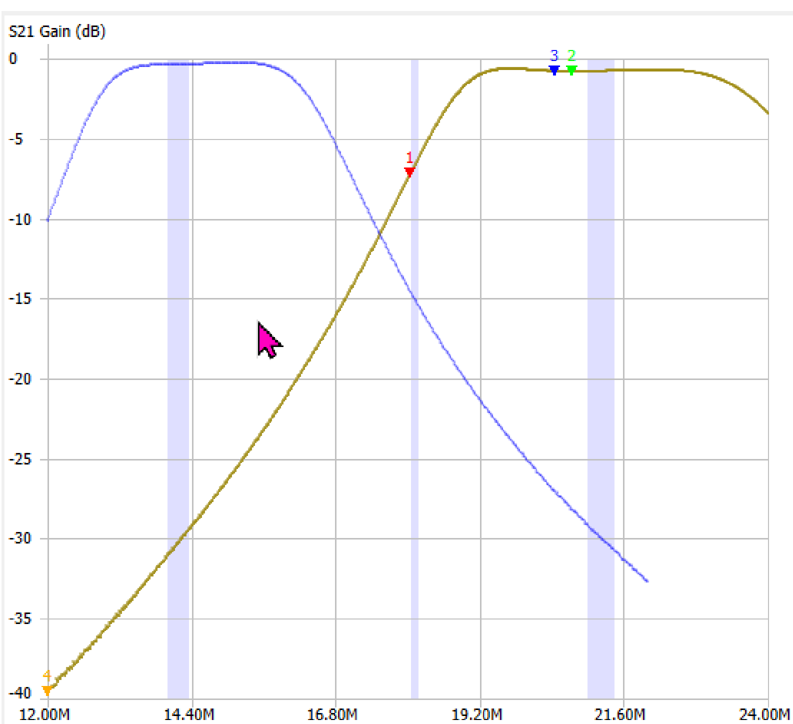
The DETARC Club has two upcoming POTA outings planned in October and Winter Field Day is in January of 2025. At all of these events, multiple HF rigs will be operating with antennas in close proximity. While each rig will be on a different band, interference from strong out-of-band signals has been observed at other, similar DETARC and NARC operations. At DETARC WFD 2024, interference was mostly prevented by placing the antennas such that the large metal shielded them from one another. However, this method cannot be relied on in most situations.

In an attempt to solve this problem especially in POTA operations, I purchased several inexpensive band pass filters (photo below). Three of these made-in-China filters cost $124.24 delivered. The filters are rated for 200W, however the mode or duty-cycle are not specified. I assume that the power rating is for ~20% duty (SSB). The bandwidth, insertion loss and SWR specs are also provided (see table below). I learned about these filters from a YouTube video published by K8MRD. His test and operational results were very promising.

Frequency, MHz	Bandwith, MHz	SWR	Insertion Loss., dB
7	1.2	<1.5:1	<0.5
14	2.4	<1.5:1	<0.5
21	3.6	<1.5:1	<0.5

I set out to verify the performance of 7MHz, 14MHz and 21MHz filters using a NanoVNA and nanovna-saver software. The NanoVNA was calibrated for the frequency range of 5MHz to 25MHz using the typical method. The NanoVNA is limited to 101 points per scan. However, the software can divide a scan into "segments" each with 101 points. This results in much better resolution than for the NanoVNA alone. The software also provides detailed data tables for the markers and does specific analyses, like filters – very helpful my objective. I will not go into detail on how to use the NanoVNA but will focus on the filters' performance.

The figure below shows the frequency responses for the 14MHz (blue curve) and 21 MHz (gold curve) filters. The NanoVNA outputs a small signal from port S1 into the filter. The output from the filter is input to port S2. This known as an S21 or "through" measurement. The curve shows the how much signal gets through the filter. The "hump" shape is characteristic of a bandpass filter. The flat area is called the passband where the signal is attenuated very little. On either side, the signal "rolls off" sharply with a large amount of attenuation.



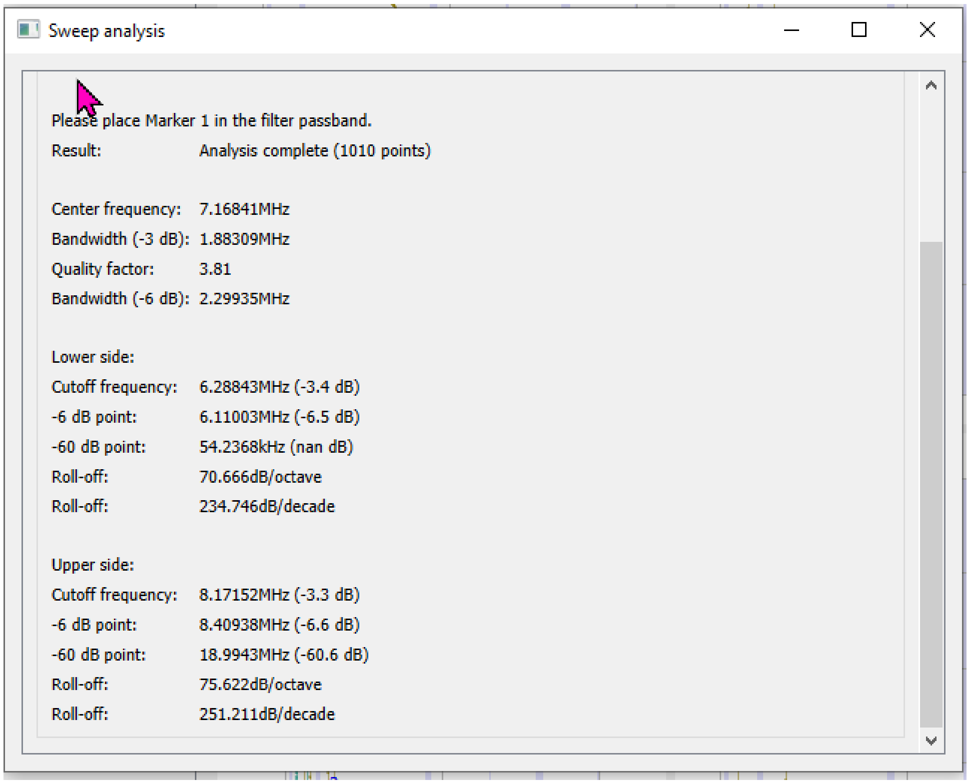
From these curves, we can see that the insertion loss is very small because the passband is very close to the 0dB line (no attenuation). Also, we can see that a 14MHz signal is attenuated by almost 30dB (or 1000 times lower) at 21 MHz. Likewise, a 21MHz signal is attenuated by about the same amount at 14MHz. This means that a 100W transmitter at 14MHz would be received as about 0.1W through the 21MHz by a receiver tuned to 21MHz. This assumes that the antennas have no gain, are omnidirectional and have no obstacles between them. A comparison of the curves for the 7 MHz and 14 MHz filters shows an even larger attenuation of about 45dB. This means that a 100W, 7MHz transmitter would be attenuated by 32,000 times by the 14 MHz filter and vice versa.

From the curves, the measure specification values for the filters that I purchased are shown in the table below. The SWR and insertion loss specs are as stated by the manufacturer. My measured bandwidths however, are significantly larger than those stated by the manufacturer.

Frequency, MHz	Bandwith, MHz	SWR	Insertion Loss., dB
7	1.9	<1.2:1	~0.0
14	3.8	<1.2:1	~0.1
21	5.5	<1.4:1	~0.5

The nanovna-saver software bandpass filter analysis is shown in the figure below. As is typical, the analysis shows the bandwidth at a specific value of attenuation (3 dB down). By looking at the curves, it appears that the manufacturer, simply used the pass band (~0 dB down) to specify the bandwidth. This explains the difference with the manufacturer using a nonstandard way of stating bandwidth to make the filter look better. The nano-saver software also provides other technical values for the filter such quality factor, -6 and -60 dB points, roll-off rates, etc.

My overall assessment is that the attenuation of out-of-band signals is impressive. It seems that these filters will be effective for reducing out-of-band interference. I will report the results of the DETARC October 5th POTA outing at the November NARC meeting.


Sweep analysis
Please place Marker 1 in the filter passband.
Result: Analysis complete (1010 points)
Center frequency: 7.16841MHz
Bandwidth (-3 dB): 1.88309MHz
Quality factor: 3.81
Bandwidth (-6 dB): 2.29935MHz
Lower side:
Cutoff frequency: 6.28843MHz (-3.4 dB)
-6 dB point: 6.11003MHz (-6.5 dB)
-60 dB point: 54.2368kHz (nan dB)
Roll-off: 70.666dB/octave
Roll-off: 234.746dB/decade
Upper side:
Cutoff frequency: 8.17152MHz (-3.3 dB)
-6 dB point: 8.40938MHz (-6.6 dB)
-60 dB point: 18.9943MHz (-60.6 dB)
Roll-off: 75.622dB/octave
Roll-off: 251.211dB/decade