Initiation Date:
30 July 2016

Participant(s):
KB3GMU, N3FB, WB4GCS

Initial Symptoms:
Initial measurement of filter N3SH40-3 showed poor return loss and poor passband performance. Visual inspection showed damage to at least one inductor.

Actions:
This filter is much more complex than the other N3SH filters and has custom toroidial inductors, so it was returned to the manufacturer for repair.

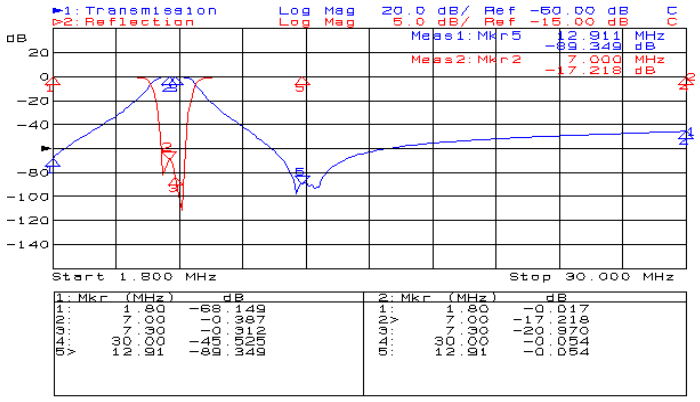
The manufacturer confirmed poor performance and eventually found two bad capacitors. After replacement and slight tuning of the inductors, he measured performance as specified. Manufacturer's notes:

> As you expected, I received your defective 40m BPF today, 05 August 2016. After removing the 40m BPF from the packing box, I opened the aluminum case and closely examined the capacitors, as they are usually the components that fail during an overload.
>
> The input and output capacitors connected to the shunt-to-ground lugs showed no signs of overload and that is typical. The usual capacitor failure occurs to the series capacitors between the input and output UHF solder cups and the two series coils, but I couldn't see any obvious signs of overload UNTIL AFTER I removed both pairs of series capacitors from the UHF solder cups. Then I saw a very small black spot at where the lead of one of the Tusonix 110-pF/2-kV leads entered the capacitor body. This small black spot indicated this capacitor failed because of a current overload.
>
> I replaced both pairs of the series capacitors with a combination of capacitors having the same values as the original capacitors. After that was done, I checked the return loss response that was incorrect in my initial test and after the repair I found it near perfect and was made perfect by squeezing the turns of the two series-connected coils. The stopband attenuation was also in spec.
>
> I confirmed that this 40m BPF was assembled by me based on the internal assembly and the fact that my Tusonix capacitors were used for the series capacitors. I also conclude that the failure of the BPF was due to an overload that caused one of the Tusonix capacitors to fail. Because I was able to replace the failed capacitor from my stock of parts, there will be no charge for the repair, but I would appreciate it if you put a $5 bill in an envelope and mail it to me to cover my cost of returning the filter to you.
>
> I put two RED CAPS on the UHF-threaded parts of the connectors to protect them from dirt, and I recommend you keep them on the connectors until the filter is used again.

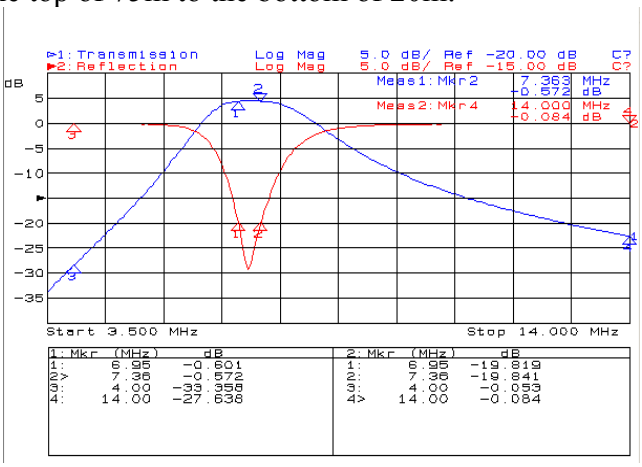
He confirmed that they are a 3-section Cauer (also called Eliptic, after the polynomial used to derive) design, which explains the nice response. A Cauer filter (also known as equi-ripple) can have equal ripple values in both the passband and the stop band, which can be independently set at design time. In addition, no other filter of equal order (number of stages) has a steeper transition from passband to stop band.[1,2] (Reference 1 at the end of the article has a nice graphic comparing various filter designs.)

Observations:
We measured the response.

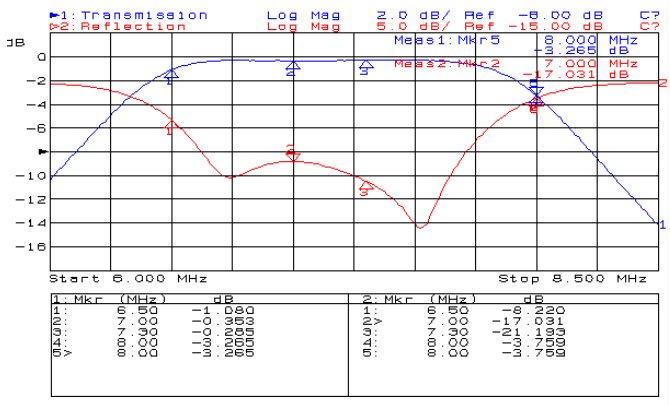
Response across the HF spectrum:



Next, we measured from the top of 75m to the bottom of 20m:



Finally, we took a close look at the passband:



Analysis:
This is a ***nice*** filter!

Hypothesis:
The filter was damaged by overload (excess power) or operation into a non-resonant load, leading to excess voltages and currents, which damaged internal components.

Plan:
Recommend that these filters (W3NQN design from Array Solutions) only be used with resonant antennas or with an antenna tuner downstream of the filter.

Results:
As above

Conclusion:
There are two conclusions from this work:

1. We need to pay attention to filter installation and use (proper bands) to prevent future damage to these filters.
2. Filters of this design are superior to the other N3SH filters.

[1] *Wikipedia* article, Elliptic Filters, *https://en.wikipedia.org/wiki/Elliptic_filter*
[2] *Zverev,* Handbook of Filter Synthesis, John Wiley & Sons, Inc., 1967