Network Sciences/ACØC Roofing Filter for the Yaesu FT-2000

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ARRL Test Engineer Bob Allison, WB1GCM, asked if I would be willing to install an aftermarket roofing filter in the Yaesu FT-2000 transceiver at W1AW. It's a 2.4 kHz roofing filter for the 69.45 MHz IF in the Yaesu FT-2000 or FT-950. Manufactured by Network Sciences (NS) and marketed by Jeff Blaine, ACØC, the filter is designed to improve the radio's close-in strong signal performance. In the FT-2000 Product Review, the Lab measured IMD dynamic range of 64 dB at 2 kHz spacing with the stock 3 kHz roofing filter.[5] A later FT-2000D (200 W model) reviewed in October 2007 measured 69 dB. Serious contesters and DXers listening to weak signals on bands crowded with strong nearby signals often want better performance. We've measured 80 dB or more with other radios in the FT-2000's price class, and at the high end Yaesu's FTDX5000 measured 104 dB in the Lab.

This review will describe my experiences with the filter installation and the results of Bob's testing in the Lab before and after modification. I've worked with surface mounted devices (SMD) and tight PC boards in the past and haven't had a problem tearing into a piece of equipment if necessary. Check out the installation instructions online at **www.ac0c.com**. If the modification looks useful but the installation is a bit much, ask an experienced friend for help or consider contacting one of the installers listed on the website.

Where to Begin

Read all the instructions carefully a couple of times before you break out the soldering iron. The step-by-step instructions are well-written, well illustrated and fairly concise. Because of the complexity, having a good understanding of what you may encounter in this process will go a long way in making the installation go smoothly.

As with most aftermarket modifications of this nature, the NS FT-2000 filter installation requires not just a steady hand, fine pointed tweezers and small hand tools, but also a really good eye. The PCB traces are *extremely* small and the area of the radio in which you need to work is very cramped.

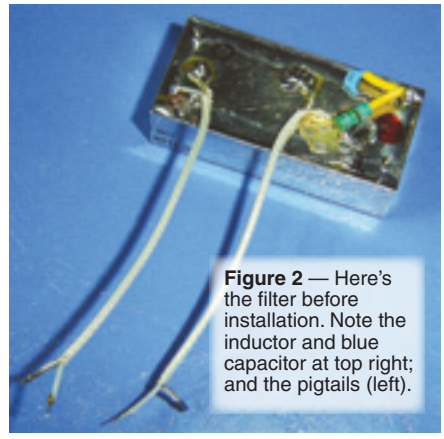

Figure 2 — Here's the filter before installation. Note the inductor and blue capacitor at top right; and the pigtails (left).

Therefore, having a good magnifying glass and a very sharp hobby knife is a must. A low-wattage soldering iron — either modified for SMD work or one designed for the task — is also required. It's also been suggested that having a good digital camera at the ready may assist in some aspects of the installation.

Installing the Filter

The installation of the NS filter requires removing a surface mounted resistor, cutting a PCB trace, soldering the filter input and output to the PCB and then tack soldering the filter case to keep it from floating around in the radio.

Before you open the radio, prepare the filter. This entails making two very short coaxial pigtails, as well as mounting components for a small LC filter input matching network. See Figure 2. The input of the filter is marked, so there's no need to guess which end is which.

While making the pigtails, take care not to damage the center conductor. The center conductor wire is extremely small and fragile. I found it easier to use the hobby knife instead of a wire stripper to remove the jacket and strip the center conductor. Fine tweezers assisted with the bending of the center conductor as well as with the installation.

While the capacitor is connected between the filter's input and ground, the inductor is "floating," in that one end is attached to the filter input and the other is used to make the connection to the radio via one of the coaxial pig tails. I used a small bit of hot glue to hold the components in place.

A word about the capacitor: Although you want to make all the component leads as short as possible, you *might* need to remove this capacitor. (More on this later.) The filter will be accessible once it's completely installed. Therefore I suggest you leave just a little extra bit of length on a capacitor lead in the event you need to clip it out of circuit. See Figure 3.

Once the filter is ready, open the radio. This requires removal of the rig's outer casing (both top and bottom halves) and the protective bottom shield. There are a number of screws removed in this process — don't lose them. Place the radio on a soft surface to protect it. I have a soft electrostatic discharge (ESD) mat that protects the radio not only externally, but also diminishes the possibility of ESD damage.

Before doing any work within the radio, I placed a sheet of paper over those sections near the area where I would be working to protect them from accidental damage or dropped solder or wire bits. Painter's tape does a good job of holding the paper without leaving behind a sticky mess.

What to Watch Out For

According to the instructions, the filter should have the coax pigtails attached *before* connection is made to the radio although that's not set in stone. I found that during installation the filter got in the way. The pigtails are rather short, so when it came to making the solder connections to the PCB, it was all I could do to keep the filter out of the way and not block the soldering iron.

Granted, others have installed the filter using the step-by-step process and didn't experi-

Bottom Line

The Network Sciences roofing filter from ACØC made a noticeable improvement in W1AW's FT-2000 transceiver's close-in strong signal handling performance. Installation requires the proper tools and a steady hand.

[5]J. Hallas, W1ZR, "Yaesu FT-2000 HF and 6 Meter Transceiver," Product Review, *QST*, Feb 2007, pp 72-78. Reviews of all the Yaesu radios mentioned here are available to ARRL members online at **www.arrl.org/product-review**.

Table 3
NS Roofing Filter Modification for the Yaesu FT-2000 from ACØC

Parameter	Measured in the ARRL Lab	
Noise floor (MDS), 500 Hz bandwidth	*6 dB attenuator/preamp off/1/2*	
Unmodified	–121/–127/–136/–141 dBm	
Modified	–121/–127/–136/–141 dBm	
Blocking gain compression:	*6 dB attenuator/preamp off/1/2*	
Unmodified, 20 kHz offset	125/126/125/122 dB	
Modified	131/133/132/129 dBm	
	5/2 kHz offset	
Unmodified, preamp off	112/94 dB	
Modified, preamp off	122/109 dB	
Reciprocal mixing dynamic range:	*20/5/2 kHz offset*	
Unmodified, 20/5/2 kHz offset	102/87/76 dB	
Modified, 20/5/2 kHz offset	102/89/77 dB	
ARRL Lab Two Tone IMD Testing	*Measured IMD DR*	*Calculated IP3*
	20/2 kHz offset	*20/2 kHz offset*
Unmodified, preamp off, 6 dB attenuator	98/70 dB	+26/–16 dBm
Modified, preamp off, 6 dB attenuator	98/83 dB	+26/+5 dBm
	20/5/2 kHz offset	*20/5/2 kHz offset*
Unmodified, preamp off	99/94/70 dB	+20/+16/–19 dBm
Modified, preamp off	99/95/80 dB	+22/+16/–7 dBm
	Preamp 1/2	*Preamp 1/2*
Unmodified, 20 kHz offset, preamp on	97/95 dB	+10/–1 dBm
Modified, 20 kHz offset, preamp on	97/96 dB	+11/+2 dBm

Price: $310 postpaid in the US; $329 uninsured and $350 insured outside the US.

Notes: FT-2000 transceiver serial number 6K050057. Data taken at 14 MHz. "Unmodified" measurements taken with stock 3 kHz roofing filter. The "IP3" column is the calculated third-order intercept point determined using –97 dBm reference.

ence any issues. Try a dry run. If the filter hinders your access to the PCB, I suggest removing the coax pigtails from the filter. Make the connections to the PCB first, tack-solder the filter in place as per the instructions and then solder the pigtails to the filter. Regardless of how you do it, keep in mind the mechanical stress you may place on the pigtails and their PCB connections. Make any necessary bends in the coax pigtails before you solder them to the PCB.

Okay, so you've prepared the filter and carefully followed the installation instructions and it's installed and ready to go. What's next? Power up the FT-2000 and check for smoke!

Assuming you did everything right and took your time, at a minimum you should hear audio coming out of the radio's speaker. If you do not, then it is possible that somewhere along the line the signal has gotten lost. Given the complexity of the connections, I would suggest you check the area near transformer T1040. Since this is the most critical solder joint, this is where a problem may occur.

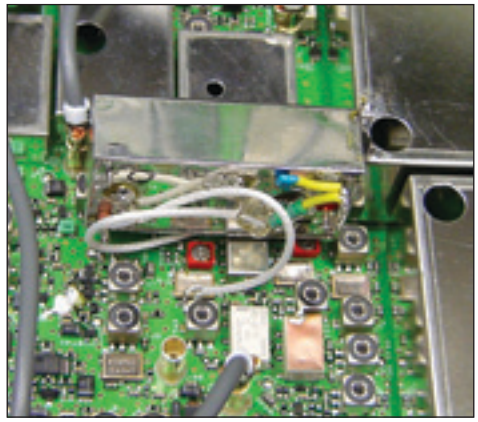

Figure 3 — Initially we installed the filter as shown here. It didn't perform as expected, and we learned that the leads were too long and the capacitor was not needed with our radio.

Filter Performance

Prior to the filter installation, Bob Allison conducted MDS, third order IMD, blocking gain compression and reciprocal mixing dynamic range tests on the FT-2000 to obtain some baseline measurements. After the filter installation, he conducted these tests again. He found the MDS on 14 MHz dropped by 2 dB. Blocking was improved and reciprocal mixing stayed about the same. The AM audio bandwidth was reduced a bit, but this was expected. However, Bob had gotten some unexpected IMD test results. The IMD dynamic range at 5 kHz spacing was actually worse than with the stock filter and there was little improvement at 2 kHz spacing. We contacted Jeff and asked for advice. We included photographs of the install.

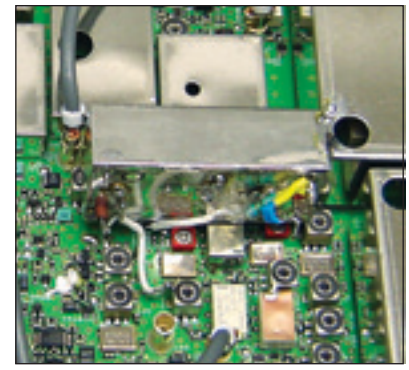

Figure 4 — In the final installation, the leads are shortened and moved apart more, and one side of the capacitor is lifted.

Jeff's first recommendation was to shorten the coax pigtails much more than they already were. The pigtails were also parallel to each other. They need to be as far away from each other as is physically possible.

The other issue was the capacitor in the LC matching network. Jeff has received reports that some hams had better receive performance by not using the capacitor. While there is not a lot of information available as to why this may be an issue, it might be due to the radio itself. It may very well be that this filter — with the capacitor — will work just fine on older FT-2000s, but not on newer ones (based on construction and release dates). This is attributed to enhancements or updates made to the newer FT-2000s that are not in the older units.

Based on Jeff's recommendations, I made the coax pigtails even smaller and snipped one lead of the capacitor (as shown in Figure 4). The test results were much better, as shown in Table 3. IMD dynamic range improved to 80 dB at 2 kHz spacing with the preamp off, and to 83 dB with the 6 dB attenuator in line. Blocking dynamic range at 2 kHz spacing went from 96 dB to 109 dB.

Final Thoughts

Clearly the Network Sciences roofing filter improves our FT-2000's strong signal handling performance. Serious contesters or DXers who own an FT-2000 may want to consider the new filter, especially if they are experiencing IMD issues on crowded bands.

Available from Jeff Blaine, ACØC, 15922 West 91st Ter, Lenexa, KS 66219; **www.ac0c.com**; **jeff@ac0c.com**.