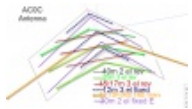


Jeff Blaine, ACØC

NS Filter Installation

Step by Step - Installing the NS Roofing Filter into the FT-2000

Overview

The installation procedure that follows is well tested and will provide excellent results. For hams waiting to see what the final details would look like, I'm happy to say this is it!

The modification is simple in that the real challenge is primarily the exceptionally small board dimensions involved. Complexity is similar to the first Charlie W5VIN Mod.

This installation example is our suggested procedure - but it's not the only possible implementation method. Amateurs with RF design experience and a thorough understanding of the rig's operation may prefer to vary one detail or another. Likewise, individuals with high levels of SMT experience may prefer a differing material set (use SMT instead of leaded packages, for example) or a varied wire dress, etc.

However, for the amateur operator who wishes to follow a known-functional method of installation, the steps outlined below should enable the full use of the filter's capabilities - without necessitating any design work or requiring bench optimization and advanced characterization testing.

Cautions

This example is for illustration purposes only. I cannot be liable for damage to a rig under any circumstances. While it's complete to the best of my knowledge, this page may contain errors, omissions, or use language that is not easily understood especially via translation software.

Only proceed with this modification if you have the required skills to perform the work described below. That includes following proper EOS/ESD precautions and that you have adequate lighting, magnification and soldering implements suitable for the projects scale.

With the legal disclaimer out of the way... The primary risk to your rig is that you accidentally create a short circuit across one of the signal paths. If you have experience working with SMT and a basic understanding of VHF techniques (meaning keep things short, neat, and tidy), it's easy to perform this installation. Because of the very small size of the features on the board, exceptional care must be taken when making the connections. The PCB is a multi-layer arrangement with a ground plane in VERY close proximity to almost every trace. Fortunately, the solder mask is of good quality and with care, inadvertent shorts are not as easy to create as one may fear.

Magnification is important for inspection. If you have marginal magnification but good SMT skill, the operations can be accomplished. However, inspection will be difficult. In this case, it may be helpful to use a digital camera to take a photo of the area with good light and a high pixel count setting - then review the photo on the computer screen where you can zoom in for a better look. I used this approach many times on this and other projects. While it's not fast, it certainly is effective.

Yaesu cautions that lead free solder be used for all connections to the rig. See notes at end for more on this topic.

And as with all SMT PCB, use a hot iron and keep the dwell times as sort as possible.

Read these instructions fully before starting. Compare the drawings with what's found in your rig. And double check your soldering points before making the connection.

The rig should be completely disconnected from any other wires. The soldering iron grounded to the rig. And the operator equipped with an ESD strap.

Installation - in Summary

The installation replaces the existing 3 KHz Yaesu roofing filter with the NS filter.

Access to the main PCB require removal of the top and bottom black outer clamshell coverings (all black colored screws). And removal of a shielding plate from the bottom of the rig.

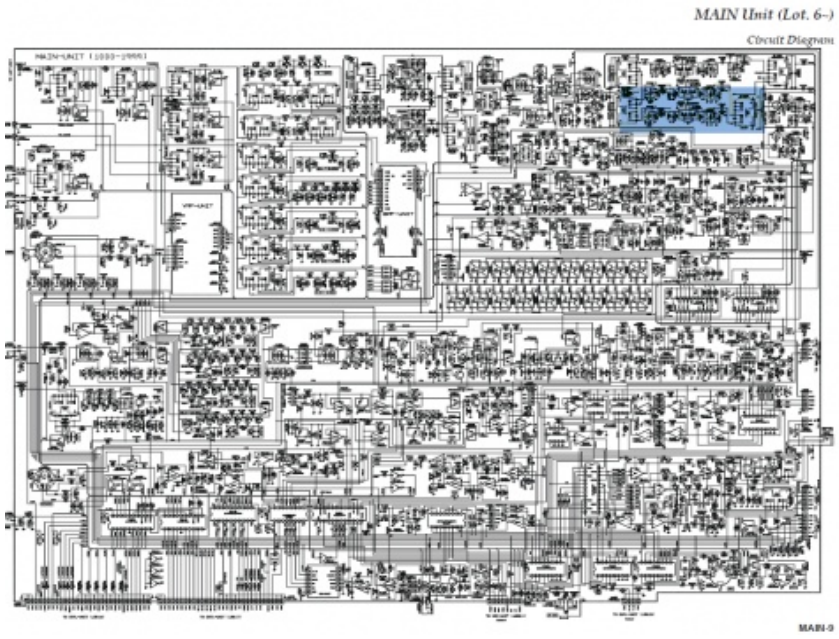
The key installation sections are:

1) NS filter preparation
2) FT-2000 preparation
3) Final assembly of filter into rig

Service Manual Pages for Reference

References below are taken from the latest service manual published, TS-EH025H90D. While it's a great idea to have this document in your library, the drawings below are sufficient to perform the mod successfully.

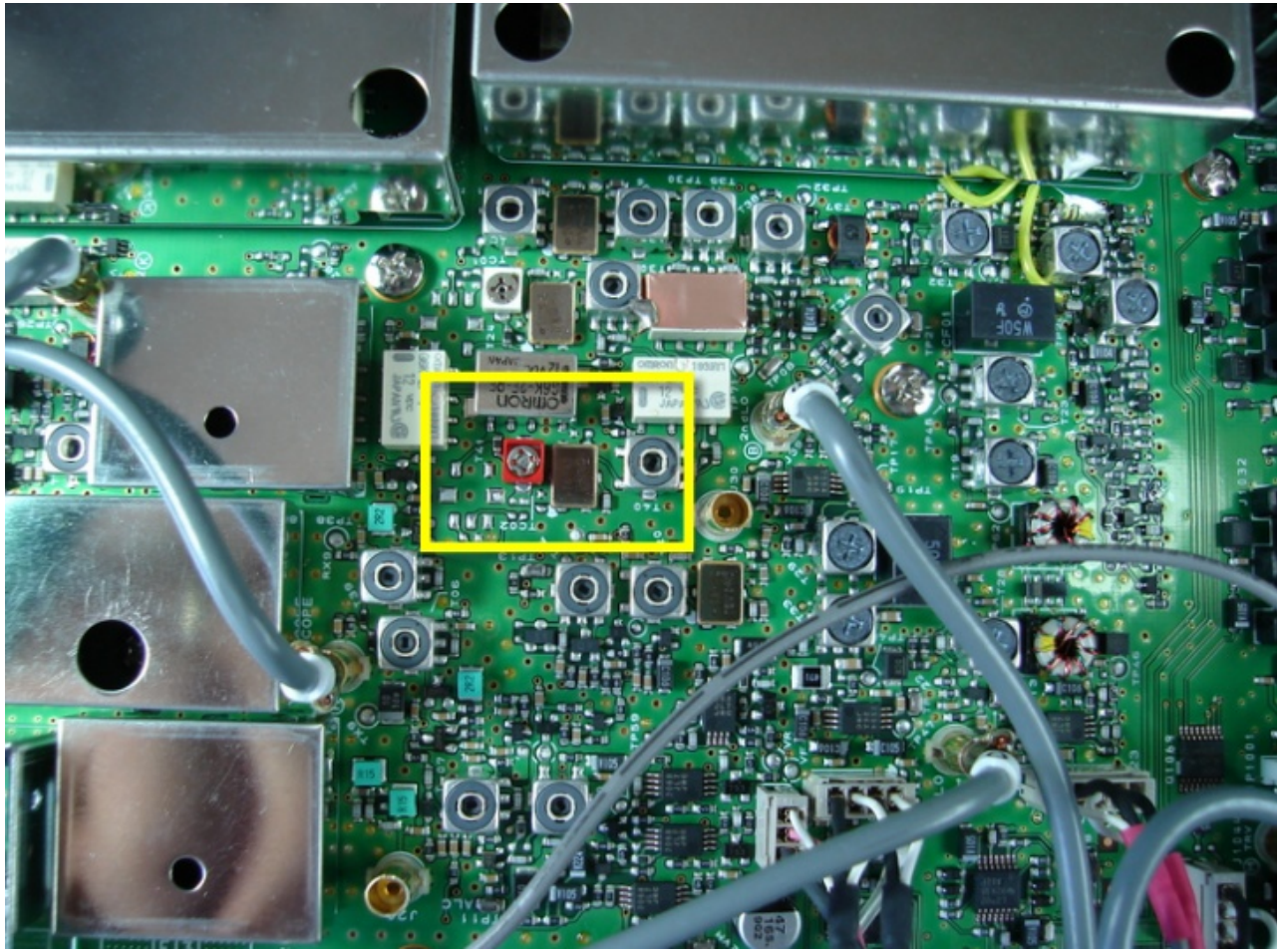
If you want to follow along in your own copy of the TS, the work will take place in this section of the schematic - highlighted here (blue highlight, right-top) - taken from page MAIN-9:



And the component drawings are from this region of the PCB drawing. Section E3 & E4 (blue highlight) - from page MAIN-11.

Finally, the area of interest for this install is found on the main circuit PCB. In this case, the front panel controls are located to the LEFT. Our work will be focused on the part of the PCB in the yellow square. Most rigs will have this red colored trimmer cap and that serves as a very useful "landmark" for helping to orient the pictures to follow. In the pictures following, I have included the red trimmer in most to help with easy orientation.

To gain access to this section of the rig, first remove the outer casing from rig (top half, bottom half) and then the protective bottom shield plate.



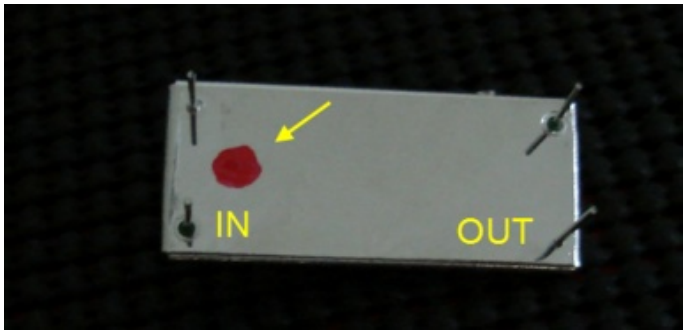
And now for the actual install procedure. Good luck and you will be pleased to know that when complete, your rig will feature a world-class roofing filter capability previously unknown to any up-conversion rig on the market, at any price!

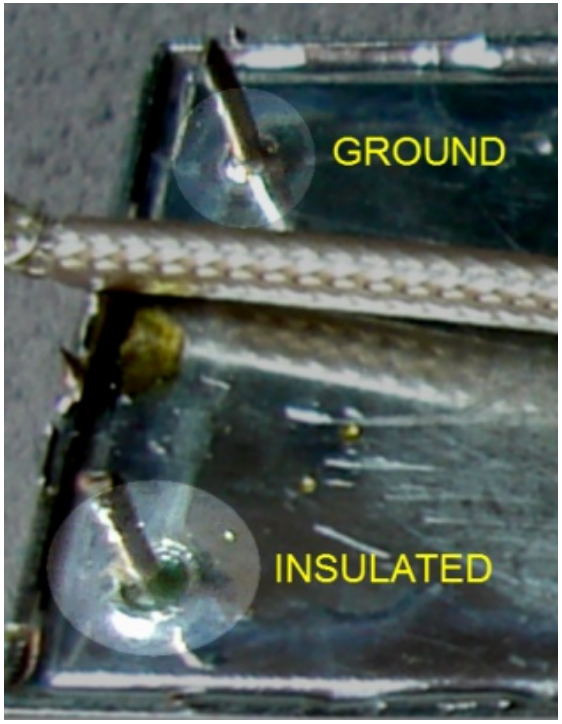
PART 1 - NS Filter Preparation

Overview: The first part, "NS Filter Preparation" involves confirming the filter's orientation, fitting the input L/C parts and attaching the coax jumper to the L/C input network.

FILTER PREP STEP A - FILTER ORIENTATION

The filter has an orientation. To determine which end is the filter's input, reference the RED DOT marking. The end with the RED DOT symbol is the filter's input.





NOTE: The filter has 4 pins on the back. Reference the photo at right of a set of end pins.

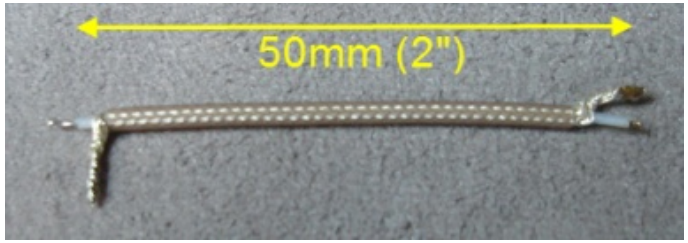
One of the pins on each end is the ground connection. The solder tin connection to the pin and the case is visible.

The insulated or "hot" connection is the pin with the small dark ring surrounding the pin.

If you are unsure, use an ohm-meter to double check. The "hot" connection will measure with NO continuity indicated.

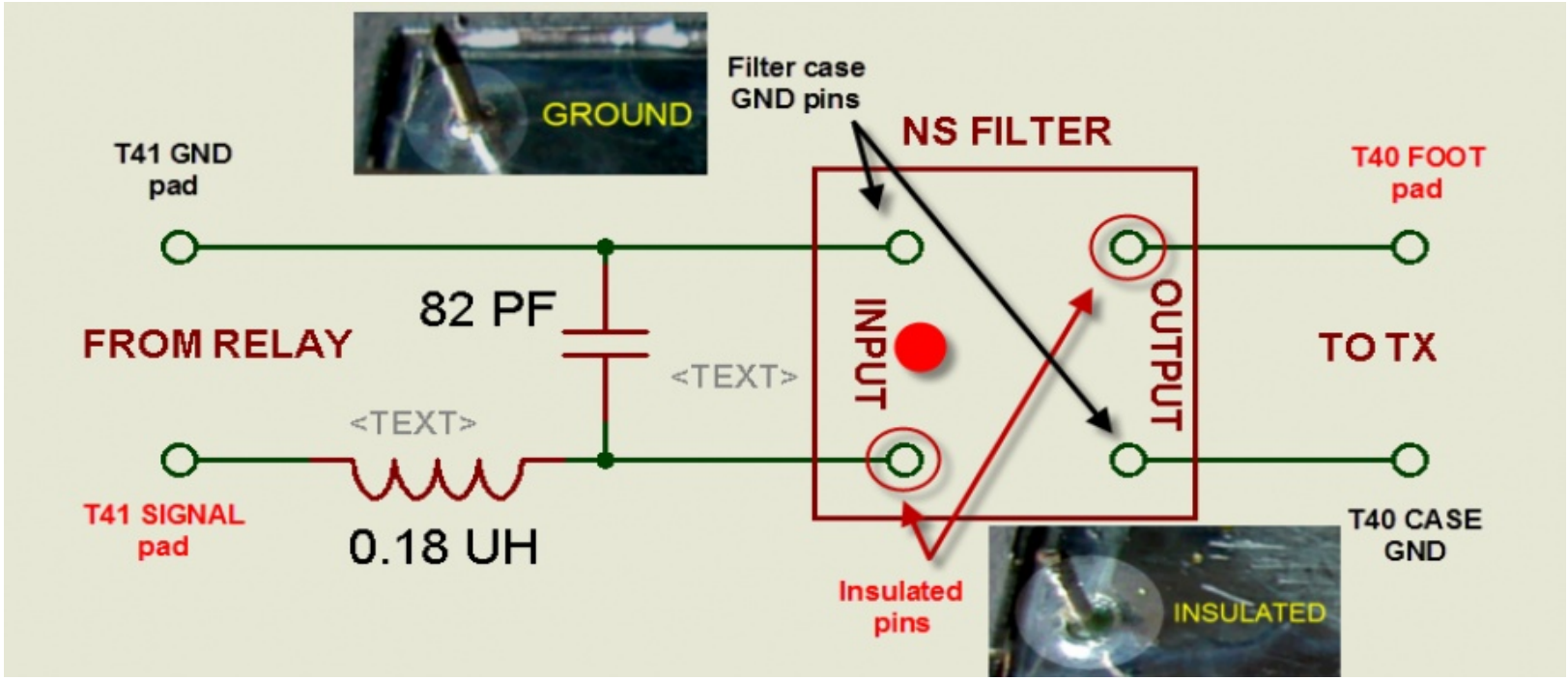
FILTER PREP STEP B - COAX JUMPERS

Cut two lengths of micro-coax about 60-65 mm (2.25") long. The exact length is not critical but this length is convenient as we will see in later pictures. 2" is the minimum length required for a convenient install. Strip about 10mm (1/3") of the insulation from each end and prepare the ends - bending roughly like the picture below.

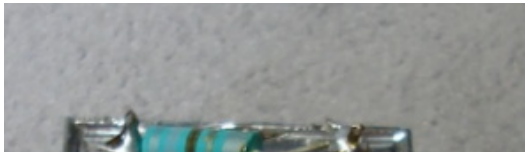


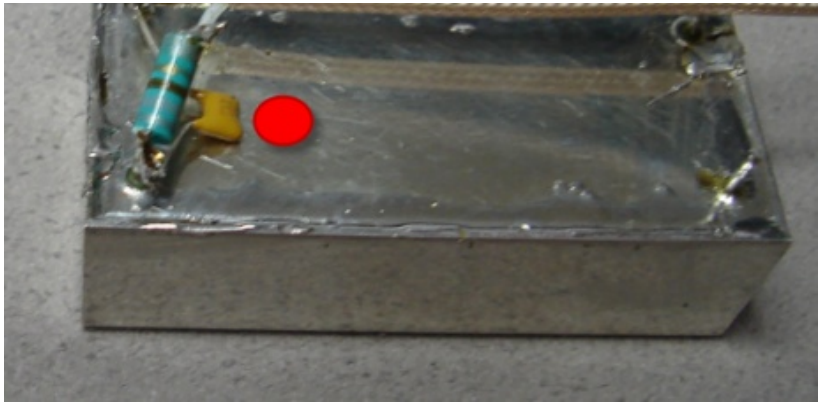
FILTER PREP STEP C. - FILTER INPUT MATCHING NET

On the INPUT side of the filter (the pins adjacent the RED dot), connect the cap and inductor according to this schematic and orientating the parts similar to the photos.

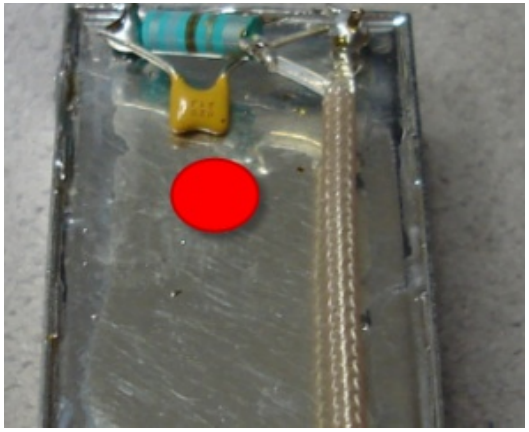


Follow good VHF practices here with wire dress and component lengths - keep things





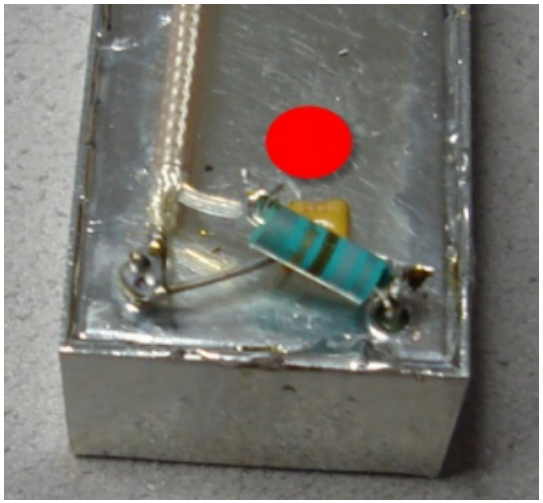
short and close.



Input matching network assembly can be done like this:

1. The capacitor is places across the two input side (red dot end) filter pins first.

2. On the input side "hot" (insulated) pin, connect one lead of the inductor.



3. Finally, one end of our coax jumper is attached to the other side of the inductor.

4. Trim the excess lengths of filter pins, cap, inductor and coax.

Take care to attach the coax ground to the "cold" side grounded filter pin.

Make sure the coax center / inductor solder point does NOT contact the case or that will result in a signal short. A small bit of heat shrink tubing, hot glue or other insulation may be used.

The complete assembly should look something like these photos here.

At this point, the filter preparation is complete.

PART 2 - FT-2000 BOARD PREPARATION

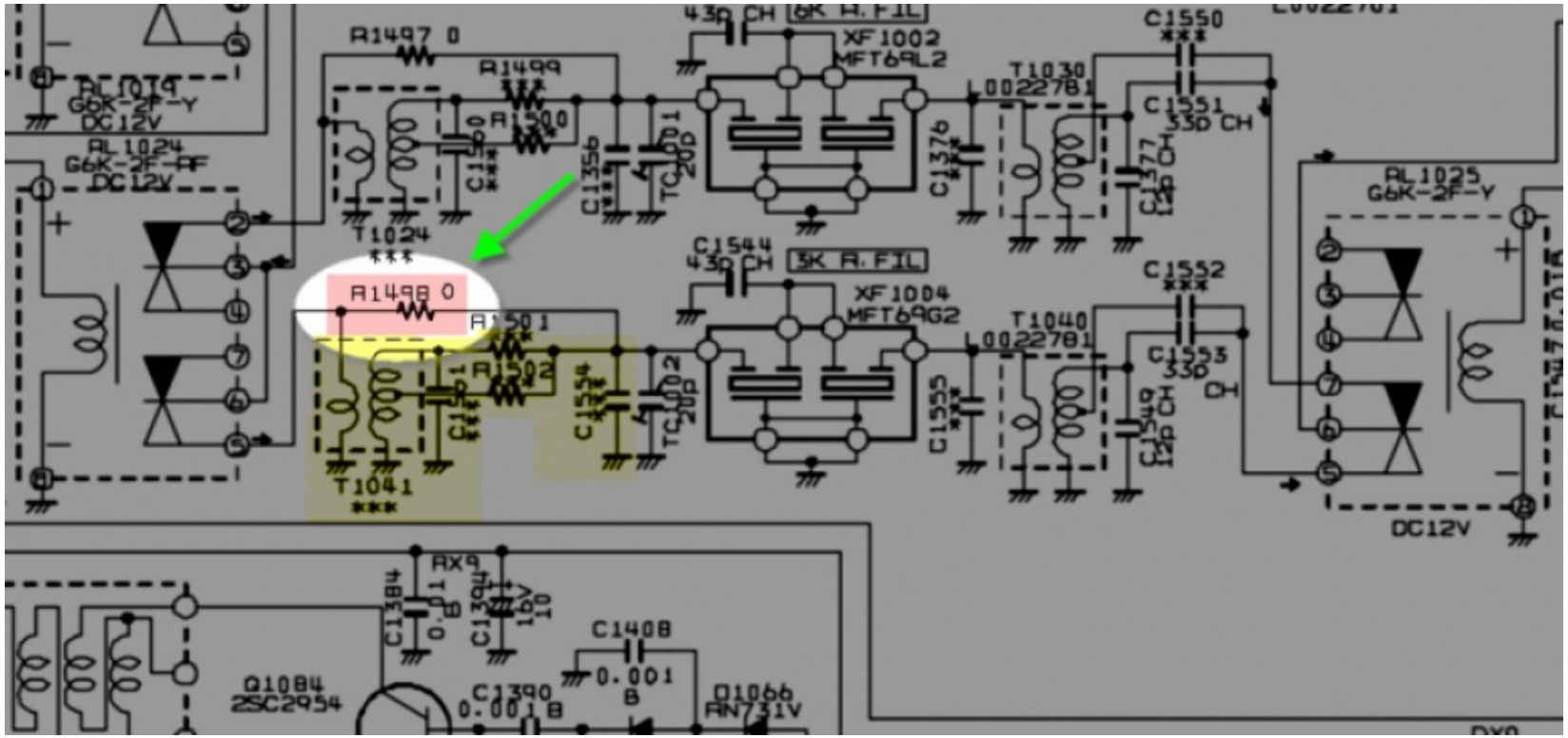
In this section, we make the connections and adjustments to the main rig PCB to accept the filter connection.

FT2000 PREP STEP A - REMOVE R1498

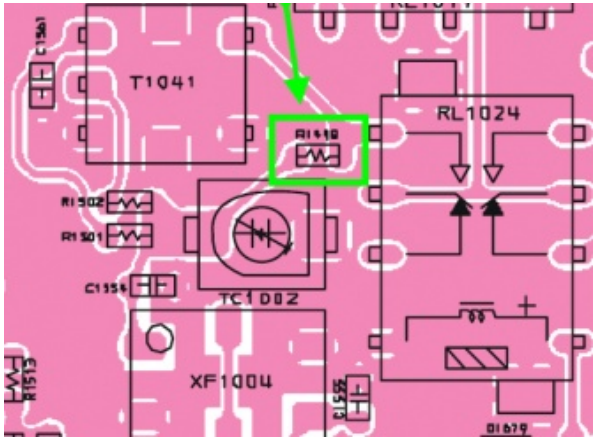
Explanation: Signals from the mixer are routed to either the 3KHz or 6 KHz filter by RL1024. So our first step is to break the connection from this relay to the existing 3 KHz filter. That is done in this install process by removing R1498.

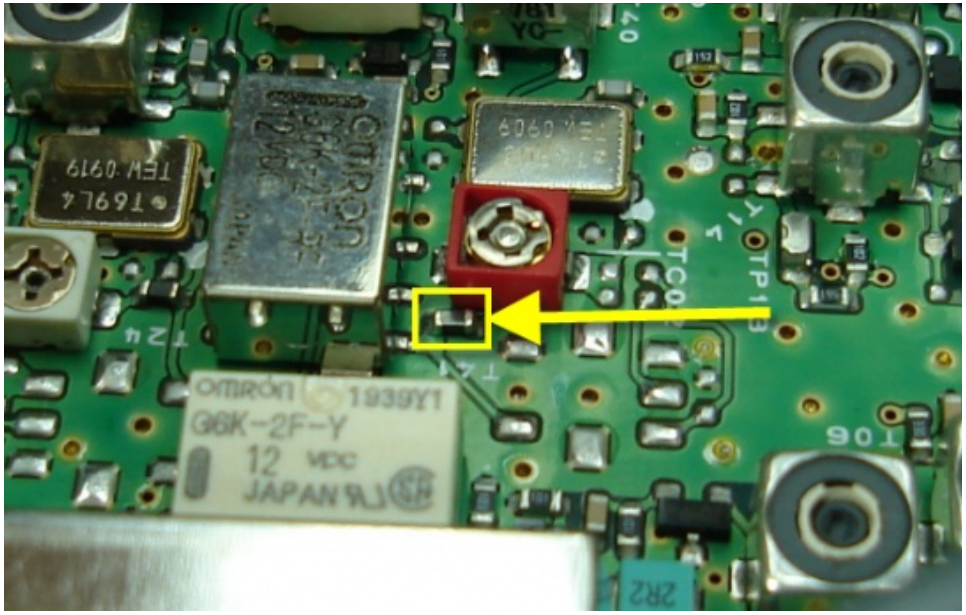
R1498 is a zero-ohm resistor and is part of an input matching network (all the yellow shaded schematic parts) that was not mounted on the final production version of the rig.

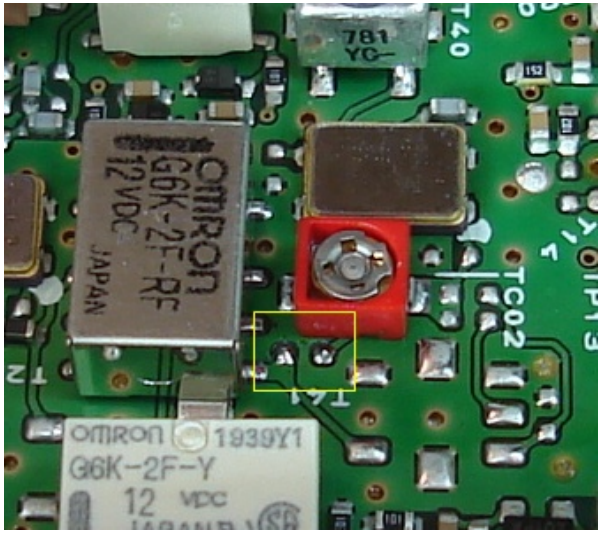
Note: The 3-stars *** marking on the schematic is Yaesu's notation that the part is not mounted in the PCB in manufacture.



Remove R1498 - shown here on the PCB drawing (left) and on the actual PCB (right).







At left, R1498 has been successfully removed.

The pads were cleaned with alcohol to remove the flux so that inspection of the pads could be made. Inspection helps to identify places where a tiny bit of solder may be contacting the surrounding ground plane.

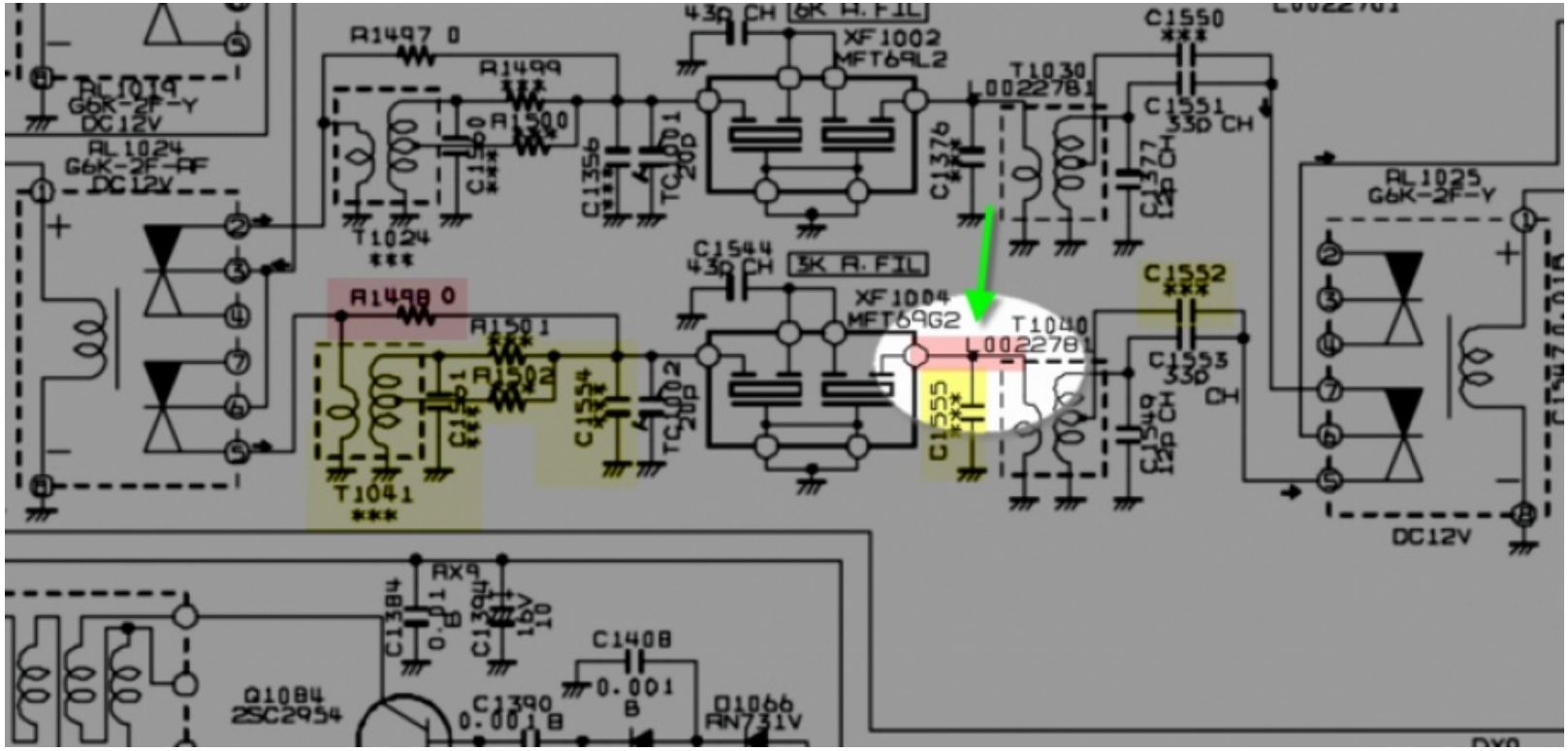
FT2000 PREP STEP B - CUT TRACE @ T1040

Explanation: In this step, we disconnect the existing 3 KHz Yaesu filter from the on-board matching network formed by C1549 and T1040. This is done by cutting the trace that runs from XF1004 to T1040. The PCB is a multi-layer construction so take care to cut only enough of the trace to break the connection.

C1555 does not exist on the board and so the trace is clear of obstructions.

Unfortunately, the clearance between the shield of T1040 and the input lead is small when viewed without magnification. Which makes dealing with T1040 the most delicate part of the installation.

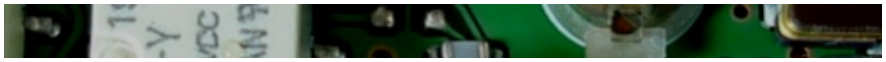
T1040 and C1549 also serve to allow a very precise fine-tune the output matching to the filter, which provides a very well formed passband shape. In addition, the step-up action of T1040 matches the high Z input of the following FET amp. Because of this, no additional matching network is needed on the filter side.

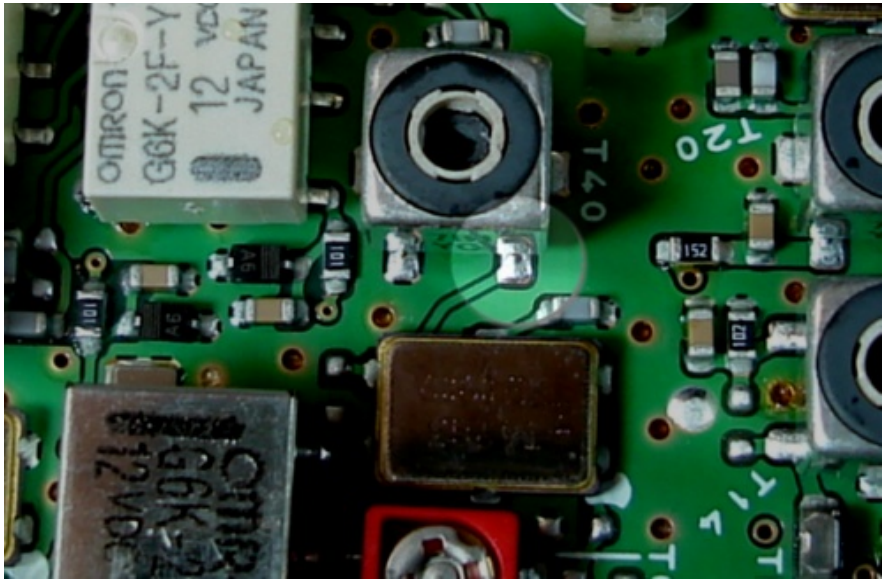


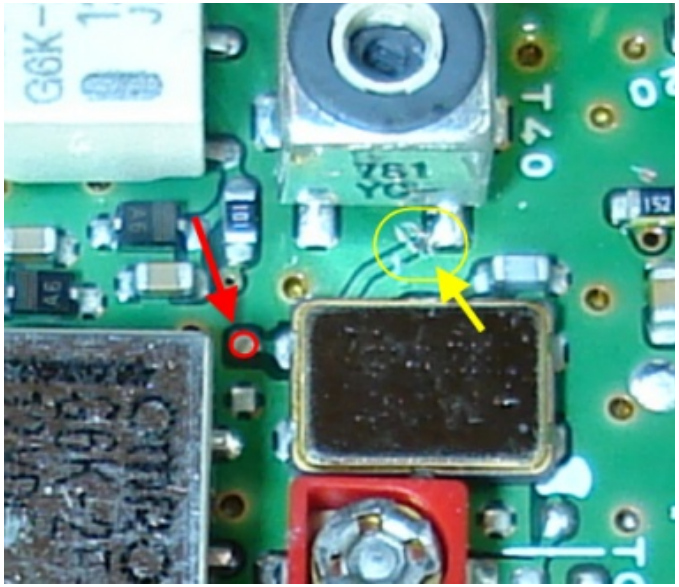
Highlighted in this picture (below) is the input connection "foot" of T1040. We want to cut the trace right at the junction of the trace and the solder joint.

To make the cut, I used a NEW X-acto blade and took about 3 small strokes. On the right, we can see the trace following the cuts.

After each stroke, I tested for continuity between the filter contact point (red circle) and ground. When the trace is cut, there will be no continuity showing between the red-circle solder pad and ground. Do not make more cuts than are needed to see the break in continuity to avoid risk of damage to other PCB layers.







FT2000 PREP STEP C - ATTACH COAX JUMPER TO T1040

Explanation: In this step, we are attaching the coax feed to the input of T1040.

Soldering the tip of the coax to the input requires good magnification, lighting and a very sharp soldering iron tip.

It's easy to create a solder bridge between the foot and the transformer casing. If you do this, it won't damage your rig - but the signal will not pass.

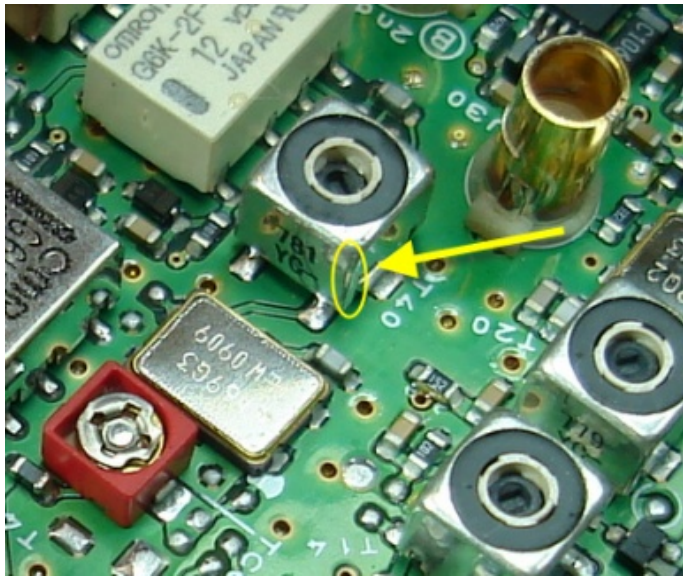
Solder tin the T1040 input pad.

Solder tin the tip of the coax to ensure good wetting between the two.

Trim the amount of exposed center conductor lead on the coax to about 1mm (1/16") as shown in the picture above. This helps to keep the risk of a short to the case low.

Tin the side of T1040 where the PCB lettering says T40 (shown in picture at right).

Solder the center conductor of the coax to the input of pad T1040 (below, inside the highlight circle). Don't add solder unless necessary.



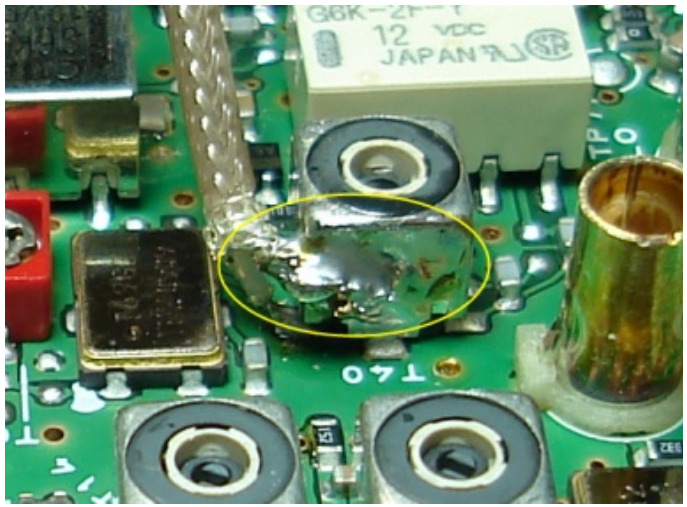
Visually inspect the solder connection very carefully. Reflections from the transformer case can make this difficult - however with enough magnification, the gap between the case and the pad is actually quite large.

The coax jumper will be self-supporting after the center connection is made . Do not move or bend this wire unless necessary - and then only enough to facilitate inspection or to adjust your solder tack.

Note: Unfortunately, an ohmmeter test is not helpful because the primary of T1040 is grounded on the cold end. Tests with an inductance meter like AADE should show a significant non-zero L however and provide confidence in the center connection.

Once you are satisfied that the center coax connection is clean and well made, then lean the shield against the tinned area and solder it to the case of T1040. See picture inside yellow circle (right).

The connection to the case of T1040 serves to provide a strain-relief for later movement of the coax jumper. After making this connection, the wire should be well secured.



PART 3 - FINAL ASSEMBLY

At this point, it's time to put the filter into the rig, confirm operation and secure it's final resting location.

FINAL ASSEMBLY STEP A. CONNECTING FILTER INPUT TO RIG PCB

We begin the final assembly by connecting the coax jumper now leading from the NS filter's input matching net to the PCB.

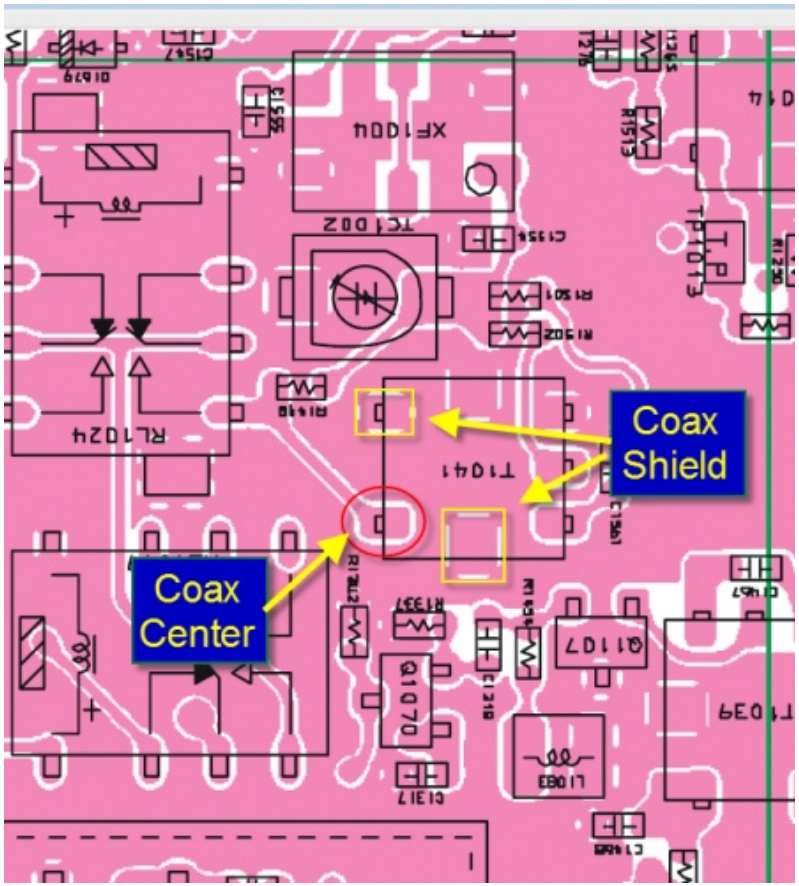
Connection soldering points are shown here in the drawing and picture at right and below.

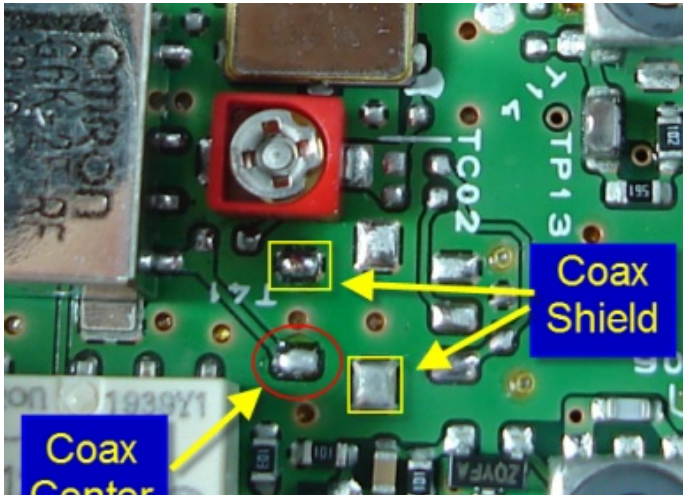
The center coax connection goes to the RED CIRCLE contact point on the PCB.

The coax shield braid can attach to either of the YELLOW BOX contact points.

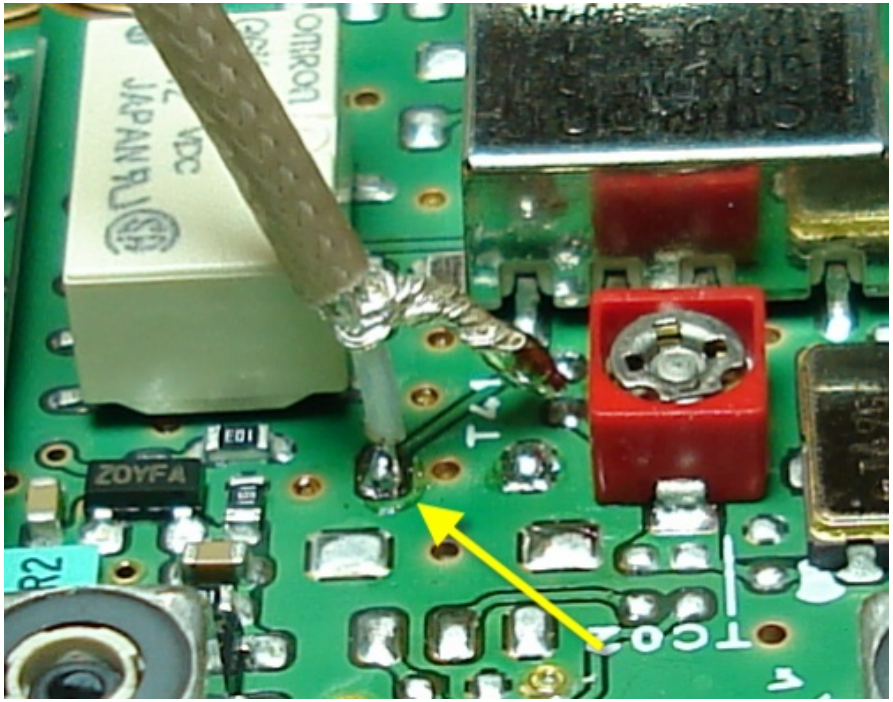
NOTE: I suggest using the larger pad (bottom right yellow box) for the coax shield braid as it's easier to make the connection there.

[In the photos below I used the upper left, but that was to allow a better photograph view of the two leads.]





First, solder the center coax connection point as seen in the photo below being careful to center the conductor on the pad.

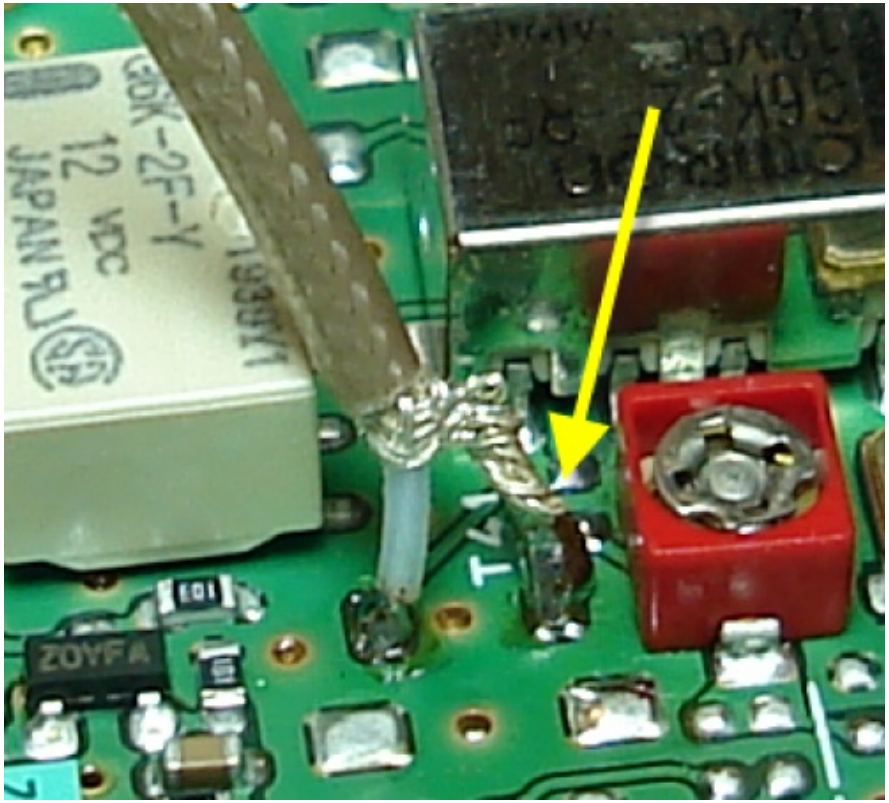


Next, solder the shield to the PCB pad. As with the other coax jumper, this contact point serves as a strain relief for this coax jumper as well so it should be soldered well.

IMPORTANT: The picture shows this wire coming off the board vertically. In fact, the wire will need to lay down under the filter when it's put into position. That's not a problem if the shield solder does not wick up. In the picture here, the solder is mostly at the joint point as indicated

by the yellow wire. However, if the solder wicks up, this coax can be quite stiff and it may not lay down properly.

To ensure it does lay properly, hold the wire with a set of diagnoal pliers. Place the tip of the pliers just above the point where the outer insulation has been removed. And with your other hand, bend the wire toward the RED trimmer cap.



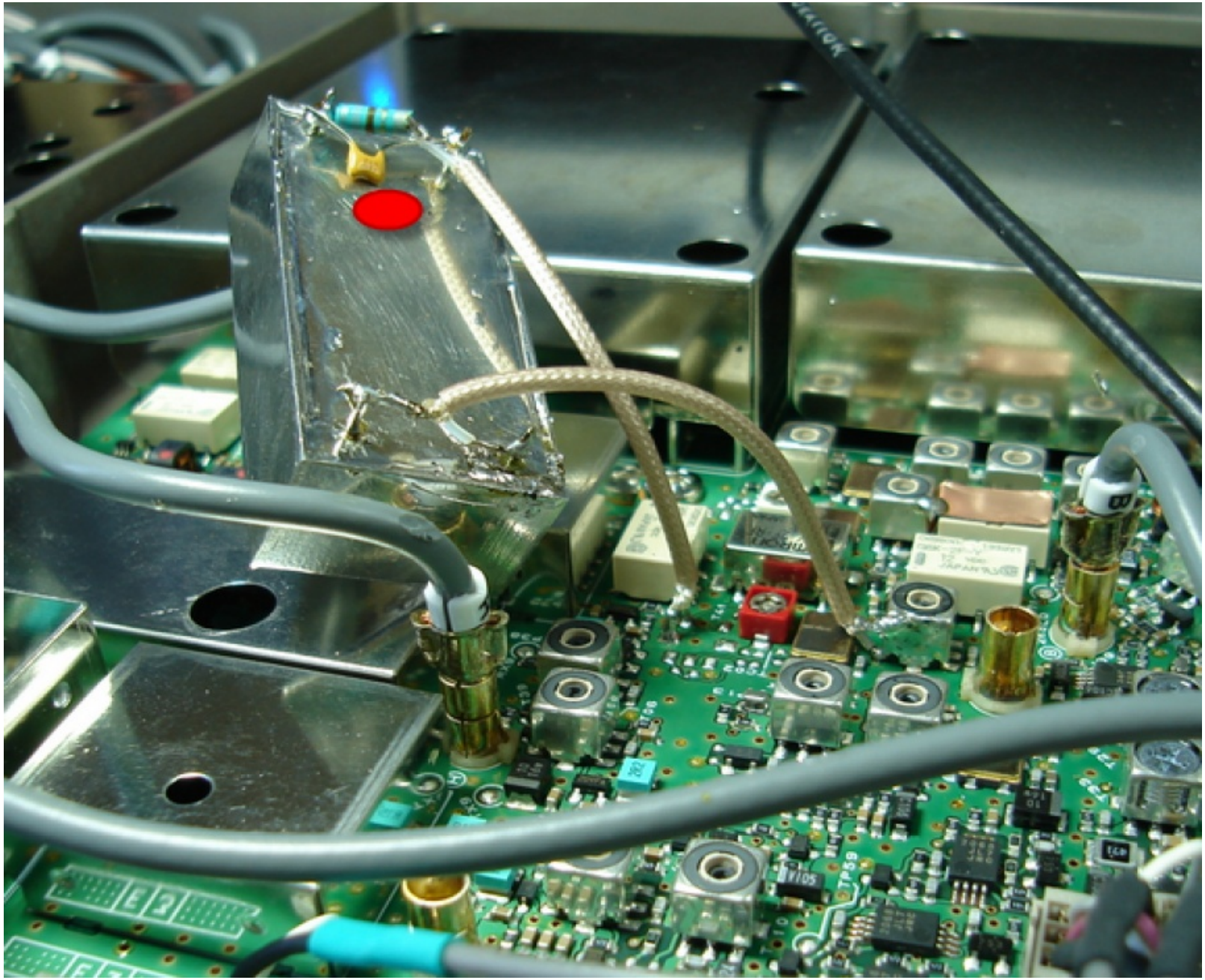
At this point, the assembly should look something like this:

FINAL ASSEMBLY STEP B. CONNECTION OF FILTER OUTPUT TO COAX JUMPER

Solder the filter output pins to the coax jumper connecting to T1040.

Note again which are the cold (grounded) and hot (insulated) filter pins. The coax center is soldered to the hot (insulated) pin.

For a better looking wire dress, you can solder directly to the filter case, near the input pin. However, the the solder-dipped filter case is an excellent heat sink and so a hot iron is required.



FINAL ASSEMBLY STEP D. INITIAL TESTING

Check to ensure no tools or other things are setting on the rig. Then power on the rig along with a temporary antenna (even a short jumper wire will be acceptable).

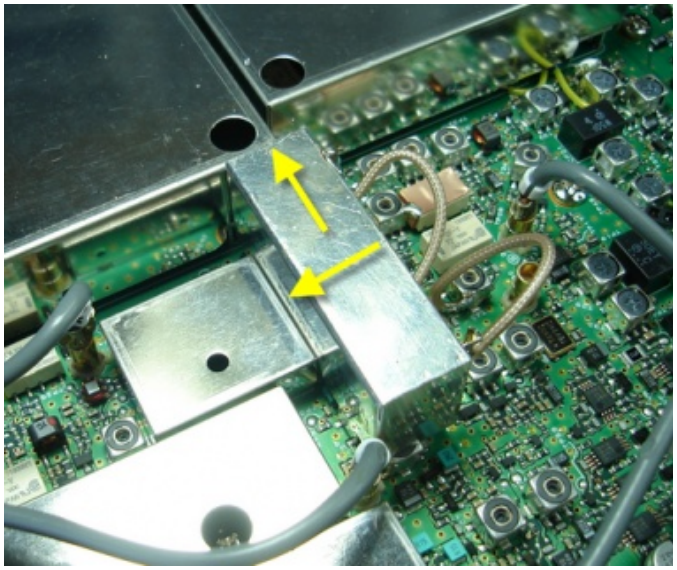
Switch between the various roofing filter positions. Listen to be sure that you have approximately the same AF level from the 6 KHz and 3 KHz switch positions. This confirms that our wiring is made properly.

You will notice some decrease in overall volume as you switch from 15 kHz, to 6 kHz, and again from 6 kHz to the NS filter in the 3 kHz position. [This is related to the noise power (as the bandwidth gets narrower, with the same peak amplitude, the overall volume sounds less) and is normal.]

If the AF level in the 3 KHz roofing filter position is very very low, by comparison to the 6 kHz position, then it's most likely that the T1040 input pin connection has a tiny short to the transformer's case. Examine that connection point carefully and resolder if necessary.

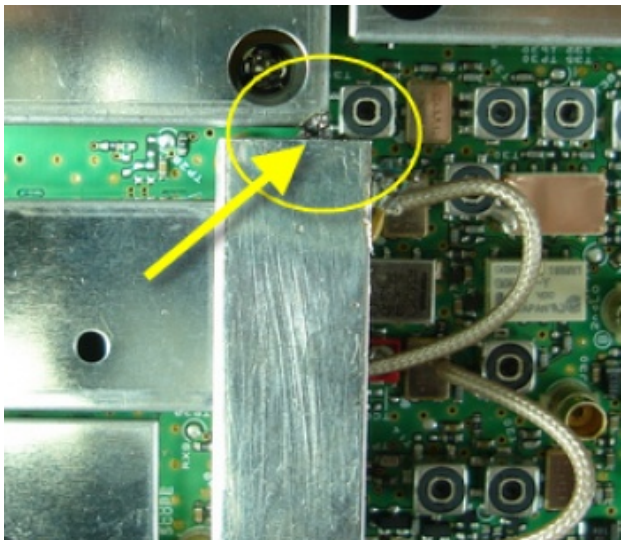
FINAL ASSEMBLY STEP C. MOUNTING FILTER IN FINAL POSITION

Tilt the filter into position as shown below. Allowing the labeled side of the filter and edge to rest against the shield cans noted by the yellow arrows.



Note: Let the coax wires naturally lay in whatever orientation that they would prefer to follow. We want to be very careful with the coax leads out of respect for their delicate solder connections to the PCB. In prior testing, the NS filters' ultimate attenuation performance is unaffected by the wire's proximity or routing.

Other mounting positions are NOT recommended. This position has a negligible impact on the passband response of the other filters shape, allows for short coax connections and provides excellent ultimate attenuation performance in-circuit. However, in bench testing we found that other positions may provide more attenuation and less ultimate attenuation. I strongly encourage the use of this mounting position.

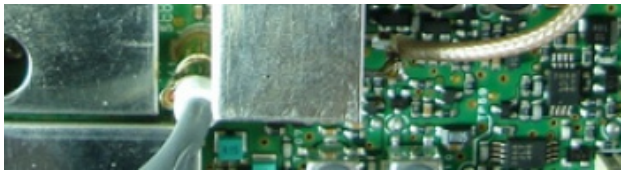


Tack-solder the corner of the shield to the filter as shown. This will require a high -heat soldering iron setting because the shield and the filter case are excellent heat sinks.

The connection serves 2 purposes. While testing does not demonstrate any improved performance, this connection does provide an additional direct chassis connection for the filter ground and is a good idea in theory. And secondly, and more practically, it holds the filter into position while the rig covers are reinstalled!

Do not add other materials onto the top or bottom of the filter. The width of the filter is designed to fit exactly between the board and the shield cover. The clearance is minimal and as a result does not provide any compressive force to the underlying PCB.

If you are using the rig in a high-vibration environment, the I suggest you add one more solder tack between the top (logo side) of the filter and the shield so that the filter is secured in 2 locations.



At this point, the installation of the filter is complete.

ADVICE BY HAMS WHO HAVE INSTALLED THE FILTER

- Use a very hot, very fine-tipped soldering iron. The lead-free solder on the PCB has a higher melting temp - as much as 50C-100C higher - than traditional lead/tin solders. This means a hotter iron is helpful **so the dwell time to make the connection remains short.** To minimize dwell times, solder-tin each wire or connection before making the solder joint. Temperatures too low will cause excessive soldering time and potential delamination of a PCB pad. [AC0C - when doing this install, I personally set my Weller to 850F/450C when working on the rig board - this ensures the solder melts compeletly and quickly - so my connections can be fast.]

- Lead-free solder concerns. Yaesu recommends the use of only lead-free solder in the repair, however many hams don't have lead-free solder available. This lead-free recommendation is driven by the RoHS compliance envionmental certification. However, if maintaining strict RoHS compliance is not a factor, the use of lead-containing solder is functional. I have not seen data that would suggest any drop in reliability when mixing lead-free and lead-containing solder for the connections mentioned here. The important point is that **the solder temperature must be high enough to fully melt the lead-free solder.**

- Check the red dot. The red dot side is where the matching net is installed. And the coax from that matching net goes to the T41 connection side. **NOT** the T40 "small foot" side. If your filter seems to work, but the loss when using the 3 Khz position seems high, check the orientation. [The installation photos have also been updated with enhanced red dots for more easy understanding based on this comment]

- If you have done the original Charlie W5VIN mod, which puts wire jumpers over the zero ohm resistors, the proceedure is unchanged. One of the zero-ohm resistors is removed in the process. If you have not done this mod, it's not necessary with this filter install.

- Yes, access to the 6/15 khz filter trimmers TC01/TC02 will be less convenient by the filter placement. However, I strongly recommend that you DO NOT relocate the filter to another position. The location specified is optimal and repositioning may create capacitive coupling and unanticipated detuning.

- Stress again the need for proper magnification. If the parts look too small after you put your magnification device on the board, then you need to get something with a stronger magnification capability.

- Use multiple light sources to help minimize shadows. A ring magnifying lamp may provide enough, but I find in some cases using one of the small 6-LED hand-held miniture flashlights to be helpful in some cases. Use something to help position the flash light to give extra illumination to the area you are working on.

- Fluxes. Several hams have commented that installers using no-wash type of flux should be careful. These chemicals may be incompatible with the PCB and/or solders used. Rosen-core solders, and rosen type flux is safe. Cleaning the board is optional - and can be done with isopropil alcohol and a old toothbrush. If you chose to use additional flux, apply it sparingly.

- The coax supplied for the installation is of a teflon-type. Which means it has excellent temperature resistance. It also means you must have a very sharp striping tool to ensure a clean cut. You may need to strip the cable a couple of times before getting a nice clean result. As a result, the lengths of coax now being sent are a bit longer to allow for this. The most time-consuming part of the install is generally the coax preparation.
- Short coax lengths and replacement of SMD devices make for a very nice picture - but the performance is the same as with somewhat longer length coax runs and the through-hole components supplied. So don't worry about getting the last few mm of coax length removed - it is far easier to perform this install with coax of adequate length. And remember, once the cover is on the rig, no one will ever know you used an extra 5 mm of coax! :)

- When installing the filter, take care that the filter input side coax and inductor joint does not short against the filter. A bit of heat shrink can be helpful here.

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Comments on Alignment - THIS STEP IS NOT REQUIRED

The Yaesu manual specifies the S-meter calibration sequence to be performed in the 6 KHz position. Generally the insertion loss of the 6 KHz and the new NS filter will be about the same and the S-meter indication will be about the same. The peak audio levels will be very similar as well - in fact, depending on the performance of the Yaesu 3 kHz filter in your rig, you may notice a slight increase in the signal levels when using the new NS filter.

The output filter matching provided with the stock alignment setting will be satisfactory without further adjustment and will be at least as good as the original filter performance.

Unlike rigs of old, there is no need for periodic rig realignment. In fact, its pretty easy to create more problems in the alignment process than there is potential upside benefit. Further, there are errors in the alignment proceedure as published (even in the latest revision E) of the TS...

For individuals with the proper capability, the MCF alignment steps are given on page ALIGNMENT-4 of the service manual and can be followed.

In the case of the 3KHz filter, adjustment is ONLY made to T1040 as TC1002 is not part of the circuit following the NS install.

For individuals with a spectrum analyzer functional at 450 KHz, connection to the 2nd IF as explained in the following link allows real-time examination of the filter passband.

http://www.ac0c.com/main/page_ft2k_roofing_filters_ft2000_rig_plots.html

With tiny adjustments of T1040, precision tuning of the filter's top 3db passband is possible. Adjust the SA so that you are looking at just the top 10db of

the filter response or less. The signal strength alignment in the TS will set T1040 to the correct range. And then with the SA, make sweeps and fine tune T1040 in tiny increments of perhaps 1/10th turn to find the ideal trim point where filter symmetry and passband is optimized.

<<<<<<<< Suggestions? Please direct comments regarding page to jeff -at- ac0c -dot- com. >>>>>>>>