R-390A Measuring Signal to Noise Ratio
3/18/2022, Larry Haney

The 1970 (and most other years) Navy Tech Refs procedure for this is to use the unbalanced antenna input (which is normally the high impedance input) for providing the signal into the rx for doing the sensitivity measurement (which is the same as s/n ratio measurement). But, the Navy Tech Refs are assuming that all R-390As that were installed on ships have Field Change 5 from Nov. 1966 installed on them. The change document can be found on our website at the fifth entry from the bottom of the Navy References documentation. That change moved the MB connectors around on the antenna relay such that the Unbalanced C antenna connector on the back of an R-390A is now connected to the low impedance balanced winding on the input of the antenna transformer. Unfortunately, not all R-390As in use by the Navy had this change installed on them. And, by now, most do not have it on anymore because the Twinax shorting connector required to make Field Change 5 work, have been removed and lost. It is unfortunate that the Navy Tech Refs did not include instructions to do the test one way or the other depending on whether Field Change 5 was installed or not.

The other thing that the Field Change 5 did was to change the manual to specify use of the MX-1487 impedance adapter instead of the DA-121. This is not good because it is a 50 ohm shunt across the RF output of the sig gen. This makes the impedance that the sig gen sees in the connection to the rx too low. The correct impedance matching unit is the DA-121 or an 83 ohm shunt adapter.

So, if your R-390A still has Field Change 5 installed on it, still use my recommended procedure below, but connect the sig gen to the C connector.

Because the R-390A Y2K R3 Tech Ref is based on the 1985 Navy Tech Ref, Its documented sensitivity measuring procedure is very similar to the 1970 Navy Tech Ref, so Field Change 5 needs to be on the rx in order for it to work.

If it is not connected correctly, this measurement procedure is missing a valuable section of hardware by measuring from the unbalanced input. At this input point, the low impedance input (balanced) tuned antenna transformer, antenna relay, and band switch contacts are not tested. These 3 items are very important for users that connect coax or a real balanced line to their rx, which is a very high percentage of connections.

The only time it is correct to use the unbalanced input (high impedance) for an antenna connection, is when it is connected to a whip with a short coax, or to a random length wire with a short or no coax. Connecting a coax to the 'unbalanced' input longer than 15 or 20 feet applies too much capacitance to the circuit. This impairs the 'Q' of the circuit and seriously impairs its filtering effect (rejection of unwanted signals).

The TM-11-856A (January 1956 Army Tech Ref (and other years)) does it right as far as connecting the signal generator to the rx, using the balanced input with an appropriate impedance matching device, DA-121. Just make sure that the Navy Field Change 5 is not installed. But, on the other hand, the Navy manuals procedure does a very good thing and uses the line level meter for the output part of the measuring procedure, instead of an external meter. This is a good improvement and is in my procedure.

There is just one little problem, though. The recommended impedance matching unit (DA-121) has a 9.1 db loss (or 55%) and this needs to be taken into consideration when calculating the actual signal level into the rx. In order to avoid this calculation, I use a different matching device – one where the input is tied directly to the output and an 83 ohm resistor is connected from the center contact to ground. This matches 125 ohms to 50 ohms and the voltage into the rx is what's read on the signal generator meter. Now I understand that the impedance on the input of the rx varies depending on frequency, but this is close enough most of the time. Even using the DA-121, this issue is not fully resolved (the impedance the signal generator sees is still not always 50 ohms).

Now for the output measuring part of the SNR measurement. There must be an audio db measuring meter on the audio output in order to see what the noise sound level is at the measuring time. The Army Tech Refs use an external db meter connected to the local audio out. This is fine and it does work, but using the built in line level meter also works just fine. I see no reason to not use the line meter, so that is what I use and recommend. Of course, you would want to have previously verified that its reading is close to correct. And, that is easy to do. Just hook up a 600 ohm audio db meter to the line out terminals on the back and compare the two. If they don't match or are off by more than 10%, fixing it is not too difficult.

And now the rest of the story, about why the Navy did Field Change 5. A lot of the R-390As were installed in cabinets that did not have a large clearance behind the rx on shipboard installations. Because most of them used stiff RG-8 as the antenna coax, a straight Twinax connection could not be used, so a 90 degree elbow (such as a UG-970/U, UG-971/U or similar) was used to make room for it to fit. Because of the design of the 90 degree adapters and the Twinax connector, the elbow on the adapter ended up pointing to the left. So, when the stiff coax was connected to it, and a little bit of pressure was applied to the coax in the up or down direction, a lot of force was applied to the key in the Twinax connector, causing them to eventually fail and rotate the insides of the connector. Because of the way the antenna relay is designed, any slight rotation of the contacts could disable the operation of the relay. I believe that reinstalling the R-390As after testing or repair caused a lot of rotational pressure to be applied to the Twinax key.

The correct way to repair this failure is to replace the antenna relay. In order to reduce the high number of antenna relay failures being experienced, the Navy correctly decided to fix the problem by moving the mini coax connectors inside the R-390A so that the C connector is now the input to the low impedance balanced input winding (the primary of the antenna transformer). The reason for doing this is because the 90 degree angled C adapter would rotate without damage and not have the same issue as the Twinax connector.

The lesson for today – if anyone is using a 90 degree adapter that plugs into the Twinax connector, be sure that very little rotational pressure is being applied to it. Most smaller diameter coax (less than 5/16” diameter, RG-8X is 1/4”) should not be a problem.

You will notice that my recommended procedure (which is next) has an addition to it that none of the Tech Refs specify - #8, check for grounding and RF leakage. It is very necessary that this test pass, or you can not obtain a valid measurement.

The other thing that is different is the use of a home made 83 ohm shunt impedance adapter instead of the DA-121 or the MX-1487. This is not required, but does make recording sensitivity measurements a lot easier. I did a lot of comparisons between using the DA-121 and the 83 ohm shunt adapter, and found very little difference, and most of the time there was none. This is a much better value than the 50 ohm shunt the Navy Tech Refs suggest.

My recommended procedure is a combination of the two different methods (the Army Tech Ref or the Navy Tech Ref) as follows:

1. Energize and set receiver controls as follows: Noise Limiter = off, function = MGC, Bandwidth = 8 KC, RF Gain = Max.
2. Connect the RF OUTPUT jack of Signal Generator AN/URM-25( ) to receiver ANTENNA BALANCED Twinax jack using an 83 ohm shunt impedance adapter (or DA-121). Put a 600 ohm resistor across the line out terminals on the back of the rx.
3. Tune the receiver and signal generator to 750 kHz or selected frequency.
4. Turn BFO switch S101 to ON.
5. Set the signal generator controls for CW operation and 10 μV output, and tune the signal generator frequency control for a zero beat with the receiver. To zero beat, turn LINE METER switch S105 to 0, LINE GAIN control R104 for an indication of about -2 db on LINE LEVEL meter M101 and tune the signal generator frequency for the bottom of the dip between two peaks on LINE LEVEL meter M101.
6. Turn BFO switch S101 to OFF.
7. Turn output of signal generator to minimum.
8. Check for proper grounding of sig gen to rx and for RF leakage, once for each frequency. Set the line level meter for about -2 db with the line gain and meter switch. Disconnect the coax from the sig gen at the sig gen. If the change is less than 7 db in the line meter, then all is good. Typical is about 3 db. Reconnect the coax to the sig gen and continue. If the line meter goes down more than that, there probably was RF getting into the coax when it was connected (sig gen is leaking). If it goes up more than that, there probably is RF getting into the rx that should not be there. Sometimes trying a slightly different frequency will bypass an issue. Or, improving the ground connection between the rx and the sig gen. The bottom line is that you can not get an accurate measurement until there is less than 7db difference between connected and disconnected. This value was determined by experimentation.
9. Adjust LINE GAIN control R104 for -10 VU reading on LINE LEVEL meter M10l. The line meter switch may need to be on -10, and that is ok.
10. Adjust the output of the signal generator for 30% modulation at 1000 Hz.
11. Increase the signal generator output until the LINE LEVEL meter M10l reads -5dB and adjust ANT TRIM control C-255 for a peak on the meter.
12. Repeat to Step 7 until no change required.
13. Increase the signal generator output until a 0 VU indication is read on the line level meter.
14. The signal generator output reading is your Sensitivity and should be less than 1.3 μV or 3 uV if you're using a DA-121 adapter (in which case, calculate the actual sensitivity by multiplying the sig gen meter reading by 55%).
15. Repeat the procedure for each of the recommended or selected frequencies at 3 above.