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Subject: R-390A 10 dB S+N/N AM Sensitivity
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There has been a lot of confusion about how to measure the AM sensitivity of an R-390A. Unfortunately the manuals have contributed to this confusion. The 1970 Navships 0967-063-2010 manual has a sensitivity measuring procedure on pages 4-2 and 4-3 which involves setting the signal generator (URM-25D) to minimum output. This is equivalent to the method of turning the signal generator on and off which is used at several web sites to find the 10 dB S+N/N ratio. However, the Navships manual does not mention a 10 dB S+N/N ratio, but rather a 10 dB rise, which it is. What the Navships and web sites measure is the 10 dB S+N1/N2 where N2 is the no-signal receiver noise, and N1 is the noise due to the signal and receiver. Also, the 50 ohm impedance of the signal generator is not matched to the 125 ohm nominal (100 - 300 ohms) antenna input impedance (through a UG-636A/U and UG-971/U) of the R-390A. Consequently, the signal generator reading is not the number of microvolts that appears across the R-390A antenna input. The Army manual TM 11-5820-358-35 gives a Sensitivity Test, not a procedure for measuring the 10 dB S+N/N ratio. The earlier Army manual TM 11-856A in paragraph 166 has what it calls an AM Sensitivity measurement procedure. However, there are at least two things wrong with it: (1) a DA-121/U attenuator (8.9 dB) two way match (52.2 ohms to 128.8 ohms) is used between the URM-25D and R-390A, and (2) the 0.8 volt noise indication in step (f.) is not maximized with the antenna trimmer, nor is its value checked after the signal generator is adjusted for 2.5 volts, as it must be.

Here is a correct method for measuring the AM sensitivity of an R-390A.

I measured the real component of the R-390A antenna input impedance by connecting a 250 ohm 2 watt Clarostat composition pot in the signal path, and used a UG-971/U (twinax to C) and UG-636AU (C to BNC). The 10X scope probe was connected across the 636. The 25D was set to some convenient value that could be seen on the scope. The signal was peaked (as seen on the scope) using the 390A antenna trimmer. The pot was adjusted so that the scope read half the open circuit voltage (the voltage from the antenna input side of the pot when disconnected from the antenna input). The value of the pot was read using an accurate voltmeter, call this value R1. The R-390A antenna input resistance is $R = R1 + 50$ at that frequency.

I may have gotten the high end numbers a little too high previously. My scope method is probably not all that accurate because there is quite a bit of uncertainty as to the half the open circuit voltage. A true RMS voltmeter might be better. Now I am getting 180 - 220 ohms for the high values. Previously I got up to 300 ohms. The low values still come in around 90 - 100 ohms. Low values were found at 1.001, 1.999, and 3.999 MHz. High values were found at 1.5, 4.5, and 5.5 MHz.

I used a TEK 2465B (cal traceable to NIST), and a rebuilt (by me) URM-25D (cal by me using my 2465B and a precision 50 ohm terminator).

I used 2 feet of RG-58A/U to connect the 25D to the 390A, and a BNC T connector adapter with a short stub coming out of one of the females of the BNC T for clipping the 10X probe to. I measured the voltage across the 390A antenna input (UG-971/U and UG-636A/U) to get a correction factor to multiply the 25D reading by. Then I measured the S+N/N ratio as if the impedances were matched (which they weren't).

My method for measuring sensitivity for a 10 dB S+N/N ratio involves turning the modulation ON and OFF (NOT turning the signal generator ON and OFF or tuning the R-390A away from and back to the signal generator). I could use a volt meter on the diode load, but it is more convenient and about as accurate to use the LINE LEVEL meter. I adjust the meter and signal generator repeatedly if necessary, peaking the ANT TRIM at each resetting of the signal generator output level, until the meter reads 0 VU with modulation on, and the meter reads -10 with modulation off.

At 4.5 MHz, with the antenna input resistance measured as 187 ohms, using the 4 kHz BW, and a correction factor of $cf = 1.57$ ($cf = 2R/(R + 50)$, where R is the measured antenna input resistance of the R-390A at the frequency where the measurement is being taken), with AGC off, and 30% modulation, I got a reading of 0.5 microvolts on the 25D for a 10 dB S+N/N ratio. Using the correction factor, the voltage across the UG-636A/U was deduced to be 0.785 microvolts. So the input power was $P = (0.785)^2 \times E-12/187 = 3.3 \times E-15$ watts, or -114.8 dBm. The sensitivity looks a lot better when you convert it to dBm. If you had a 50 ohm receiver with a -114.8 dBm sensitivity for a 10 dB S+N/N ratio, that would be 0.41 microvolts. Not shabby. Note that this is also quite close to the uncorrected 0.5 microvolt measurement above.

I also used a broadband matching transformer and got a slightly better sensitivity, namely -115.2 dBm. This suggests that matching with a broadband transformer does not change the results very much.

My R-390A was a bit weak at the top end of the 4 MHz band, coming in at -109 dBm at 3.9 MHz. Maybe I need to go in there and up the 2 pF coupling capacitor in the double tuned circuit between the RF amp and MIXER? We'll see.

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