# *IC-R8500 Test Report*

## By Adam Farson VA7OJ/AB4OJ

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**Figure 1: The Icom IC-R8500.**


***Introduction:*** This report presents results of an RF lab test suite performed on the IC-R8500 receiver. Basic performance tests were conducted in the HF, VHF and UHF ranges up to 1.2 GHz. (The receiver covers 100 kHz – 2 GHz.)

***List of tests conducted:***

1. MDS (Minimum Discernible Signal)
2. 12 dB SINAD Sensitivity (FM)
3. Audio Output for 10% THD
4. Noise Figure (50 MHz & higher)
5. RMDR (Reciprocal Mixing Dynamic Range)
6. NPR (Noise Power Ratio)
7. FM IMD Rejection at 20 kHz Spacing (EIA Method)

## Performance Tests on IC-R8500 S/N 3202015

**As performed in my home RF lab, Dec. 9 – 14, 2015.**

***1: MDS (Minimum Discernible Signal)*** is a measure of ultimate receiver sensitivity. In this test, MDS is defined as the RF input power which yields a 3 dB increase in the receiver noise floor, as measured at the audio output.

***Test Conditions:*** 2.2 kHz SSB**,** ATT off, APF off, AGC normal.

**Table 1: MDS dBm.**

| f MHz | 3.6 | 14.1 | 28.1 | 50.1 | 144.1 | 222.1 | 432.1 | 900.1 |
|---|---|---|---|---|---|---|---|---|
| MDS dBm | -133 | -133 | -132 | -132 | -134 | -128 | -135 | -127 |

***1a: AM Sensitivity.*** An AM test signal with 30% modulation at 1 kHz is applied from a communications test set to the RF input. The PHONES jack is connected to the test set's audio input. The RF input power which yields 10 dB (S+N)/N is recorded (Table 2).

***Test Conditions:*** AM, ATT off, NB off, AGC normal..

**Table 2: AM Sensitivity dBm.**

| f MHz | 0.9 | 3.6 | 14.1 | 52.1 | 121.1 | 399.1 |
|---|---|---|---|---|---|---|
| Sens dBm | -105 | -117 | -117 | -117 | -116 | -120 |

***Notes:***

1. Very clean demodulation; full quieting at -80 dBm (preamp off).

***2. 12 dB SINAD FM sensitivity:*** In this test, a distortion meter is connected to the external speaker jack, and an FM signal modulated by a 1 kHz tone with 3 kHz peak deviation is applied to the RF input. The input signal power for 12 dB SINAD is recorded (Table 3). AFC is off.

**Table 3: FM 12 dB SINAD Sensitivity dBm.**

| f MHz | 29.6 | 53 | 147 | 223 | 446 | 915 |
|---|---|---|---|---|---|---|
| Sens. dBm | -121 | -119 | -121 | -123 | -114 | -119 |

***2a. 12 dB SINAD WFM sensitivity.*** Here, the modulating frequency is 1 kHz and the peak deviation is 45 kHz. AFC is off.

**Table 4. WFM 12 dB SINAD Sensitivity dBm.**

| f MHz | 101.5 |
|---|---|
| Sens. dBm | --111 |

***3. Audio Power Output & THD:*** In this test, an audio distortion analyzer is connected to the external speaker output. An 8Ω resistive load is connected across the analyzer input. A fully-quieted FM test signal modulated at 1 kHz is applied to the antenna input. The audio voltage corresponding to 10% THD is then measured, and the audio output power calculated.

***Test Conditions:*** 147.000 MHz FM, -73 dBm, ATT off, AFC off.

***Test Result:*** Measured audio output voltage = 4.16V rms. Thus, audio power output = $(4.16)^2/8$ ≈ **2.2W in 8Ω**. (Spec. is 2W).

**4. Noise Figure:** In this test, a calibrated noise source is connected to the antenna port via a precision DC - 2 GHz step attenuator. First, the antenna port is terminated in 50Ω and a 0 dBr receive audio reference set. Then, the noise source is connected and the noise loading adjusted for a +3 dBr audio level. The attenuator setting is noted.

As the noise source is calibrated, its noise power density PSD (in dBm/Hz) is known. Noise figure NF is derived as follows:

$$NF \approx PSD - ATT + 174$$

where PSD = -82 dBm/Hz
ATT = attenuator setting in dB
Boltzmann's constant = -174 dBm/Hz

***Test Conditions:*** 2.2 kHz SSB, AGC normal, ATT off, APF off.

**Table 5. Noise figure in dB.**

| Freq. MHz | 50.1 | 144.1 | 222.1 | 432.1 | 900.1 | 1240.1 |
|---|---|---|---|---|---|---|
| Measured NF | 9 | 6 | 13 | 5 | 13 | 10 |
| NF calc. from MDS | 8.6 | 6.6 | 12.6 | 5.6 | 13.6 | - |

***5: Reciprocal Mixing Noise*** occurs in a superheterodyne receiver when the noise sidebands of the local oscillator (LO) mix with strong signals close in frequency to the wanted signal, producing unwanted noise products at the IF and degrading the receiver sensitivity. Reciprocal mixing noise is a measure of LO spectral purity**.**

In this test, a strong "undesired" signal is injected into the receiver's RF input at a fixed offset from the operating frequency. The RF input power is increased until the receiver noise floor increases by 3 dB, as measured at the audio output. Reciprocal mixing dynamic range (**RMDR**), expressed as a figure of merit, is the difference between this RF input power and measured MDS. The higher the RMDRvalue, the better.

***Test Conditions:*** 2.2 kHz SSB, ATT off, APF off, AGC normal, negative offset.
Reciprocal mixing *in dB* = input power – MDS *(both in dBm).*

**Table 5: Reciprocal Mixing Dyn. Range dB.**

| | **f MHz** | | | |
|---|---|---|---|---|
| **Δf kHz** | **14.1** | **50.1** | **144.1** | **432.1** |
| 1 | 69 | 47 | 46 | 36 |
| 2 | 81 | 52 | 52 | 46 |
| 3 | 86 | 55 | 56 | 50 |
| 5 | 81 | 60 | 60 | 55 |
| 10 | * | 67 | 67 | 62 |
| 20 | * | 73 | 74 | 68 |

* *Not measured due to spurs at high test signal levels.*

***6. Noise Power Ratio (NPR):*** An NPR test was performed, using the test methodology described in detail in ***Ref. 1***. The noise-loading source used for this test was a noise generator fitted with bandstop (BSF) and band-limiting filters (BLF) for the test frequencies utilized.

The noise loading $P_{TOT}$ was increased until the audio level measured at the external speaker jack increased by 3 dB. $P_{TOT}$ was read off the attenuator scale on the noise generator, and NPR was then calculated using the formula

$$NPR = P_{TOT} - BWR - MDS$$

where $P_{TOT}$ = total noise loading in dBm for 3 dB increase in audio output

BWR = bandwidth ratio = $10 \log_{10} (B_{RF}/B_{IF})$

$B_{RF}$ = RF bandwidth or noise bandwidth in kHz (noise source band-limiting filter)

$B_{IF}$ = receiver IF filter bandwidth in kHz

MDS = minimum discernible signal (specified at $B_{IF}$), measured at 2.2 kHz SSB prior to NPR testing

***Test Conditions:*** Receiver tuned to bandstop filter centre freq. $f_0 \pm 1.5$ kHz, 2.2 kHz SSB, ATT off, APF off, AGC Normal. Test results are presented in **Table 6.**

**Table 6: NPR Test Results.**

| DUT | BSF kHz | BLF kHz | MDS dBm | $P_{TOT}$ dBm | BWR dB | NPR dB |
|---|---|---|---|---|---|---|
| IC-R8500 | 534 | 12…552 | -119 | -26.5 | 23.9 | 69 |
| | 1248 | 60…1296 | -122 | -26.6 | 27.9 | 68 |
| | 1940 | 60…2044 | -131 | -23.0 | 29.5 | 79[1] |
| | 3886 | 60…4100 | -132 | -36.4 | 32.6 | 64 |
| | 5340 | 60…5600 | -132 | -36.4 | 34 | 64 |
| | 7600 | 316…8160 | -132 | -36.4 | 35.5 | 68 |
| | 11700 | 0…13000 | -132 | -23.0 | 37.7 | 71 |

**Notes: 1.** 1940 kHz NPR higher due to narrow (1.6 – 2 MHz) RF BPF.

***7. FM IMD Rejection at 20 kHz Spacing, EIA Method:*** The purpose of this test is to determine the range of signals which the receiver can tolerate in the FM mode while producing no spurious responses greater than the SINAD level.

Two test signals $f_1$ and $f_2$, of equal amplitude and spaced 20 kHz apart, are applied to the antenna port. The signal 40 kHz removed from the IMD3 product being measured is modulated at 1 kHz, with 3 kHz deviation. The receiver is tuned to the IMD3 products $(2f_1-f_2)$ and $(2f_2-f_1)$. The test signal levels are then increased simultaneously by equal amounts until the IMD3 product reads 12 dB SINAD. The IMD product levels for the upper and lower IMD3 products are averaged; IMD rejection = average IMD3 product amplitude minus 12 dB SINAD sensitivity.

***Test Conditions:*** ATT off, APF off, AGC normal, AFC off.

***6m, I:*** FM, $f_1$ = 53.000 MHz modulated at 1 kHz, peak deviation = 3 kHz.
$f_2$ = 53.020 MHz, modulation off.

***6m, II:*** FM, $f_1$ = 53.000 MHz, modulation off, $f_2$ = 53.020 MHz, modulated at 1 kHz, peak deviation = 3 kHz.

***2m, I:*** FM, $f_1$ = 146.000 MHz modulated at 1 kHz, $f_2$ = 146.020 MHz, modulation off.

***2m, II:*** FM, $f_1$ = 146.000 MHz, modulation off, $f_2$ = 146.020 MHz, modulated at 1 kHz, peak deviation = 3 kHz.

***1.25m, I:*** FM, $f_1$ = 223.000 MHz modulated at 1 kHz, peak deviation = 3 kHz. $f_2$ = 223.020 MHz, modulation off.

***1.25m, II:*** FM, $f_1$ = 223.000 MHz modulation off, $f_2$ = 223.020 MHz, modulated at 1 kHz, peak deviation = 3 kHz.

***70cm, I:*** FM, $f_1$ = 446.000 MHz modulated at 1 kHz, peak deviation = 3 kHz. $f_2$ = 446.020 MHz, modulation off.

***70cm, II:*** FM, $f_1$ = 446.000 MHz modulation off, $f_2$ = 446.020 MHz, modulated at 1 kHz, peak deviation = 3 kHz.

**Table 7. FM IMD rejection at 20 kHz spacing.**

| Frequency MHz | IMD rej. dB |
|---|---|
| 53 | 96 |
| 146 | 87 |
| 223 | 90 |
| 446 | 96 |

***7a. Two-Tone 3rd-Order Dynamic Range ($DR_3$) & Third-Order Intercept ($IP_3$).*** The purpose of this test is to determine the range of CW signals which the receiver can tolerate while essentially generating no spurious responses.

As the DUT was not fitted with a 500 Hz CW filter, this test was omitted.

***8. References:***


1. Noise Power Ratio (NPR) Testing of HF Receivers: http://www.ab4oj.com/test/docs/npr_test.pdf



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**Adam Farson, VA7OJ/AB4OJ**
e-mail: farson@shaw.ca
*http://www.ab4oj.com/*

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