Test Report for IC-7851

July 1 and September 21-22, 2015; June 10, 2016

by Adam Farson VA7OJ/AB4OJ (Iss. 3)

The following are the results obtained from lab tests which the author conducted on Icom IC-7851 S/N 02001019, kindly loaned by Allan Buckshon VE7SZ. The installed firmware versions were V1.01 for the receiver tests and V1.11 for the transmitter tests. The baseline configuration for all receiver tests was MAIN Receiver, NR/NB/ATT/Notch off, AGC Slow. **Note:** NPR with 1.2 kHz roofing filter was measured on IC-7851 S/N 02001089, kindly loaned by Icom Canada.

A. Receiver Tests (July 1, 2015):

1. **MDS (Minimum Discernible Signal).** Test setup: Marconi 2018A signal generator, 20 dB pad, DUT ANT1 input. HP 339A distortion meter at EXT SP jack as level meter.

2. **NPR (Noise Power Ratio).** Test setup: Wandel & Goltermann RS-50 and RS-25 noise generators (fitted with filters per Table 2), 75/50Ω RF transformer, DUT ANT1 input. DUT set to LSB for all test frequencies except 5340 kHz (USB). 2.4 kHz IF filter selected. Noise loading adjusted for 3 dB increase in audio output at EXT SP jack, as read on HP 339A. NPR derived by calculation.

3. **RMDR (Reciprocal Mixing Dynamic Range).** Test setup: Marconi 2018A signal generator, 3 dB pad, 9830 kHz bandstop filter, 0-110 dB step attenuator, DUT ANT1 port. HP 339A distortion meter at EXT SP jack as level meter.

4. **DR3 (2-Tone 3rd-Order IMD Dynamic Range).** Test setup: Marconi 2018A and 2019 signal generators, MCL ZHL-32A buffer amplifiers, MCL low-pass filters appropriate for band tested, 20 dB pads, MCL ZSC-2-1W combiner, 0-110 dB step attenuator, DUT ANT1 input. Test signal level adjusted for 3 dB increase in audio output at EXT SP jack, as read on HP 339A.

5. **Roofing-filter bandwidth:** As for 1.

6. **Spectrum scope RBW:** As for 1.

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1. **MDS (Minimum Discernible Signal)** tested on 14.1 MHz in CW mode (500 Hz), Preamp off, 1 and 2 in turn. Roofing filter: 15, 6, 3 and 1.2 kHz in turn. The MAIN receiver is tuned to f_0 = 14.1 MHz and a test signal applied. For each preamp/roofing filter combination, the input power P_i required to raise audio output noise level by 3 dB is noted. P_i = MDS. NR/NB/ATT/Notch off, AGC Slow for all tests. Refer to Table 1.

   A variant of MDS is also measured in SSB mode (2.4 kHz) at each of the four NPR test frequencies in turn, for use in calculating NPR. The measured MDS values and roofing-filter correction values are given in Table 2.

Table 1: Minimum Discernible Signal (MDS).

	14.1 MHz, 500 Hz CW			
Roof Flt kHz	15	6	3	1.2
Preamp Off	-126	-125	-125	-117
1	-138	-137	-137	-129
2	-142	-141	-141	-136

2. **NPR (Noise Power Ratio)**, tested in SSB mode (2.4 kHz) with Preamp off, 1 and 2 and with 15, 6 and 3 kHz roofing filters, and in CW mode (500 Hz) with 1.2 kHz roofing filter. MAIN Receiver A tuned to notch centre. Noise loading P_{TOT} adjusted for 3 dB increase in audio output. 1.2 kHz roofing filter calibrated prior to test. NPR calculated per Appendix 1. See Table 2.

Table 2: NPR test data (1940, 3886, 5340, 7600 kHz).

DUT	BSF kHz	BLF kHz	Config	MDS dBm	P_{TOT} dBm	BWR dB	NPR dB
IC-7851	1940[1]	60…2044	Preamp off R15	-122	-4.8	29.2	88
			R6		-4.3		88
			R3		-3.7		89
			R1.2[4]	-120	-0.4	36	84
			Preamp 1 R15	-134	-14	29.2	91
			R6		-13.8		90
			R3		-13.9		89
			R1.2[4]	-133	-12.8	36	84
			Preamp 2 R15	-136	-21.1	29.2	86
			R6		-21		86
			R3		-20.4		86
			R1.2[4]	-139	-20.3	36	83
			Digi-Sel R15	-125	-5.3	29.2	91
			R6		-4.6		90
			R3		-4.3		90
			R1.2[4]	-123	-0.5	36	87
	3886[2]	60…4100	Preamp off R15	-123	-4.7	32.3	86
			R6		-4.3		84
			R3		-4.0		83
			R1.2[4]	-121	+1.3	39.1	83
			Preamp 1 R15	-135	-13.8	32.3	89
			R6		-13.1		87
			R3		-12.2		87
			R1.2[4]	-133	-10.5	39.1	83
			Preamp 2 R15	-137	-19.6	32.3	85
			R6		-20.1		83
			R3		-19.9		84
			R1.2[4]	-139	-19	39.1	83
			Digi-Sel R15	-122	-5.5	32.3	84
			R6		-5.8		82
			R3		-5.7		82
			R1.2[4]	-123	+1.5	39.1	84
	5340[2]	60…5600	Preamp off R15	-123	-3.9	33.6	85
			R6		-2.9		85
			R3		-2.3		85
			R1.2[4]	-121	+1.8	40.4	82
			Preamp 1 R15	-135	-13.4	33.6	88
			R6		-12.4		88
			R3		-11.7		87
			R1.2[4]	-133	-10.3	40.4	82
			Preamp 2 R15	-137	-19.9	33.6	83
			R6		-19.6		84
			R3		-19.2		84
			R1.2	-139	-16.7	40.4	82
			Digi-Sel R15	-122	-4.2	33.6	84
			R6		-4.0		82
			R3		-3.4		83
			R1.2[4]	-122	+1.6	40.4	83

BSF: Bandstop (Notch) Filter. **BLF:** Band Limiting (Bandpass) Filter.

Table 2a: NPR test data (7600, 11700 kHz).

DUT	BSF kHz	BLF kHz	Config	MDS dBm	P_{TOT} dBm	BWR dB	NPR dB
IC-7851	7600[3]	316…8160	Preamp off R15	-123	-2.6	35.1	85
			R6		-2.1		85
			R3		-1.5		85
			R1.2[4]	-121	+1.7	42	81
			Preamp 1 R15	-134	-11.0	35.1	88
			R6		-10.2		88
			R3		-10.0		87
			R1.2[4]	-133	--8.1	42	82
			Preamp 2 R15	-137	-19.9	35.1	83
			R6		-19.6		84
			R3		-19.2		84
			R1.2[4]	-133	-15.9	42	81
			Digi-Sel R15	-123	-2.5	35.1	85
			R6		-2.2		84
			R3		-1.9		85
			R1.2[4]	-124	0	42	82
	11700[1]	0…13800	Preamp off R15	-122	-1	37.6	83
			R6		+0.3		83
			R3		+0.5		83
			R1.2[4]	-120	+0.1	44.4	76
			Preamp 1 R15	-134	-9	37.6	87
			R6		-8.3		86
			R3		-8.2		86
			R1.2[4]	-134	-8.4	44.4	81
			Preamp 2 R15	-137	-16.6	37.6	82
			R6		-16.5		82
			R3		-16.6		81
			R1.2[4]	-139	-16.3	44.4	78
			Digi-Sel R15	-120	+0.6	37.6	83
			R6		+1.6		83
			R3		+1.8		82
			R1.2[4]	-120		44.4	78
BSF: Bandstop (Notch) Filter.				**BLF:** Band Limiting (Bandpass) Filter.			

Notes on NPR test:

1. MDS shown for R15. Correction factors: R6: +1 dB. R3: +2 dB.
2. MDS shown for R15. Correction factors: R6: +2 dB. R3: +2 dB.
3. MDS shown for R15. Correction factors: R6: +1 dB. R3: +1 dB.
4. MDS stated separately for R1.2 (measured on different DUT).

3. **RMDR (Reciprocal Mixing Dynamic Range)**.

Test Procedure: Signal generator frequency (f_0) tuned for max. null in audio output measured at EXT SP jack; DUT tuned to f_0 = 9830.24 kHz. Signal generator then tuned to $f_0 - \Delta f$ and output P_i increased to raise audio output by 3 dB.

Test Conditions: DUT in CW mode, B = 500 Hz. 1.2 kHz roofing filter selected. Preamp off. Measured MDS = -119 dBm. RMDR = P_i – MDS. Phase noise = -(27 + RMDR) dBc/Hz. See Table 3.
Note: The residual phase noise of the measuring system is the limiting factor in measurement accuracy.

Table 3: Reciprocal Mixing Dynamic Range (RMDR) at 9830 kHz.

Δf kHz	P_i dBm	RMDR dB	Phase noise dBc/Hz
1	-5	114	-141
2	-2	117	-144
3	-2	117	-144
5	-2	117	-144
10	-1	118	-145
20	+6	125	-152
MDS = -119 dBm			

4. **DR3 (Two-Tone 3[rd]-Order IMD Dynamic Range)** tested in CW mode (B = 500 Hz), Preamp off, 1.2 and 3 kHz roofing filters. Test frequencies 14100/14101, 14100/14102 and 14100/14120 kHz. The receiver is tuned to the lower and upper IMD products in turn; the test signal level P_i is adjusted for a 3 dB increase in audio output at the EXT SP jack. DR3 = Pi – MDS. DR3 is measured with the 1.2 and 3 kHz roofing filters in turn. The results are given in Table 4.

At 20 kHz spacing, DR3 is 3 dB worse with the 1.2 kHz roofing filter than with the 3 kHz filter. This is due to passive IMD (PIM) in the 1.2 kHz roofing filter at the high test signal levels used.

Table 4: DR3 Test Data.

Roof kHz	Spacing kHz	f_1 kHz	f_2 kHz	Lower IMP kHz	Upper IMP kHz	P_i dBm	MDS dBm	DR3 dB
1.2	1	14100	14101	14099	14102	-30	-117	87
	2		14102	14098	14104	-20		97
	20		14120	14080	14140	-13		104
3	1	14100	14101	14099	14102	-37	-125	88
	2		14102	14098	14104	-30		95
	20		14120	14080	14140	-18		107

5. **Roofing filter bandwidth (approximate),** tested at 14.200 MHz, WIDE, in AM mode (B = 10 kHz), Preamp off. A CW test signal is applied at the S9 level (-73 dBm nominal). With the receiver tuned to the centre frequency, the S-meter readings for 3 and 20 dB reductions in signal level are recorded. This procedure is useful for checking roofing filters with B <10 kHz.

The receiver is then de-tuned above and below the centre frequency for a 3 dB and 20 dB drop in signal level as read on the S-meter, and the frequency offsets recorded. The -3 dB and -20 dB bandwidths are equal to the sum of the respective offsets.

Note: It is clear that DR3 is not phase-noise limited. Small differences in DR3 per Table 4 suggest passive IMD in the roofing filters as a limiting factor in IMD performance.

Table 5: Roofing Filter Bandwidths.

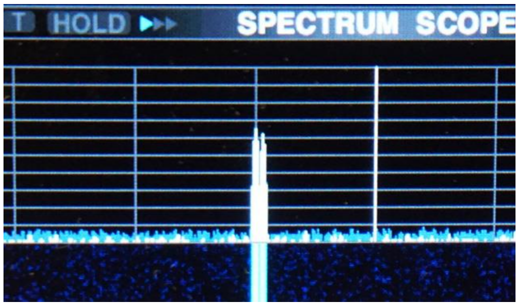
Nominal BW kHz	Meas. -3 dB BW kHz	Meas. -20 dB BW kHz
1.2	≈ 1.32	≈ 3.2
3	≈ 4.9	> 10

6. **Minimum Spectrum Scope Resolution Bandwidth (RBW).** In a spectrum analyser, the resolution bandwidth (RBW) determines how far apart in frequency two (or more) signals must be to be resolved into separate and distinct displays on the screen.

   Test Conditions: Scope settings: Span = ± 2.5 kHz, VBW = Narrow, Averaging = 2, Scope ATT = 0 dB, preamp off. Calibration Marker is on.

   To measure RBW, a test signal is injected into the antenna input at a level sufficient to produce a spike whose vertical amplitude is equal to that of the Calibration Marker. Initially, the test signal is approx. 10 kHz above the selected Marker spike. (Example: Marker at 14100 kHz; test signal at 14110 kHz.) The test signal is moved closer to the Marker spike until two distinct spikes are ***just*** observable. RBW is the frequency difference between the test signal and the Marker. Measured RBW = 30 Hz at 2.5 kHz span. (f_1 = 14100 kHz, f_2 = 14100.030 kHz)

Figure 1: Example of 30 Hz spectrum scope RBW.



B. Transmitter Tests (September 21-22, 2015)

7. **CW Power Output.** In this test, the RF power output into a 50Ω load is measured on all amateur bands in RTTY mode, at n AC mains supply voltage of 120V. An HP 8482A power sensor and 437B power meter are connected to ANT1 via a 50 dB high-power attenuator. AM carrier output is checked at 14.1 MHz.

Test Conditions: RTTY, freq. per Table 7, RF PWR at 100%, Power Limit ON, 200W.

Table 7: CW Power Output.

Freq. MHz	P_O W	AM Carrier
1.9	215	
3.6	215	
7.1	215	
10.11	215	
14.1	216	54.2
18.1	215	
21.2	215	
24.9	216	
28.3	215	
50.1	212	

8. **RF PWR readout & P_O scale tracking.** Measured RF power output is compared with the on-screen RF PWR setting readout and P_O meter scale. Refer to Table 8.

Table 8: RF PWR readout & P_O scale tracking.

Freq. MHz	Measured P_O W	P_O meter	RF PWR readout
14.1	200	191	190
	100	96	110
	50	48	55
50.1	100	99	85

9. **SSB Peak Envelope Power (PEP).** Here, a Tek 455 oscilloscope is terminated in 50Ω and connected to ANT1 via a 50 dB high-power attenuator. At 200W CW, the scope vertical gain is adjusted for a peak-to-peak vertical deflection of 6 divisions.

Test Conditions: 14.1 MHz, USB mode, Heil HC-5 dynamic mic connected, RF PWR set for P_O = 200W CW, compression 6 dB, TBW MID (default), SSB TX Bass = 0 dB, SSB TX Treble = 0 dB. Mic Gain set for mid-scale ALC reading on voice peaks.

Speak loudly into the microphone for max. PEP output. Figures 2 & 3 show the envelope for 200W PEP, without and with compression respectively. ±3 vert. div. = 200W. 5 ms/horiz.div.

Note: No sign of ALC overshoot at 200W PEP, with or without compression.

Figure 2: 200W PEP speech envelope, no compression.

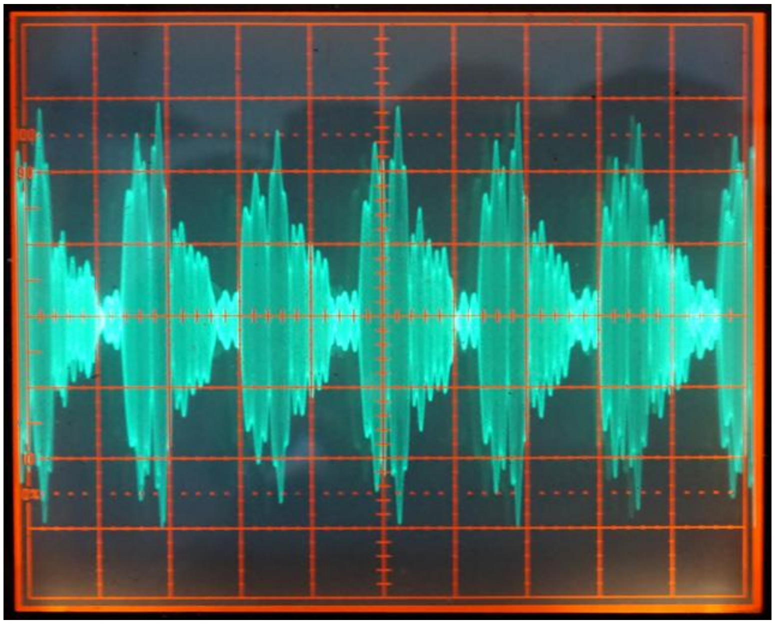
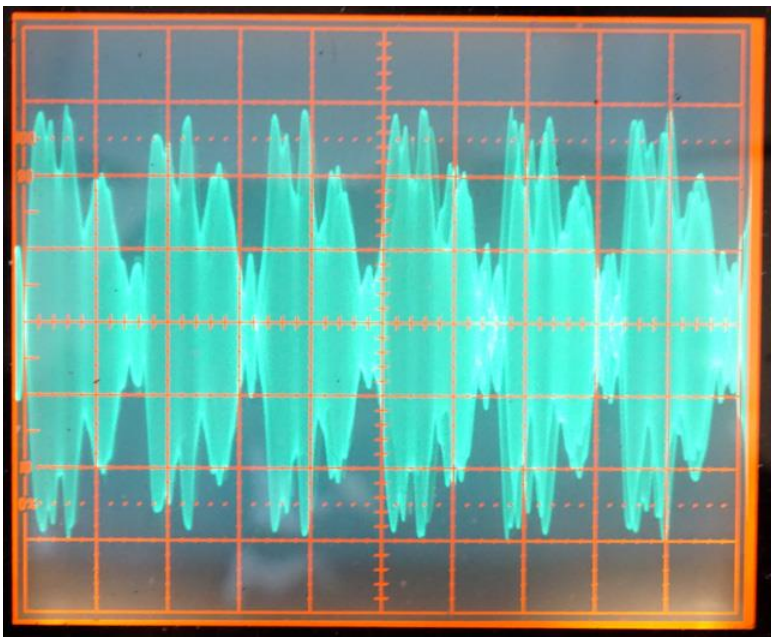


Figure 3: 200W PEP speech envelope, 6 dB compression.

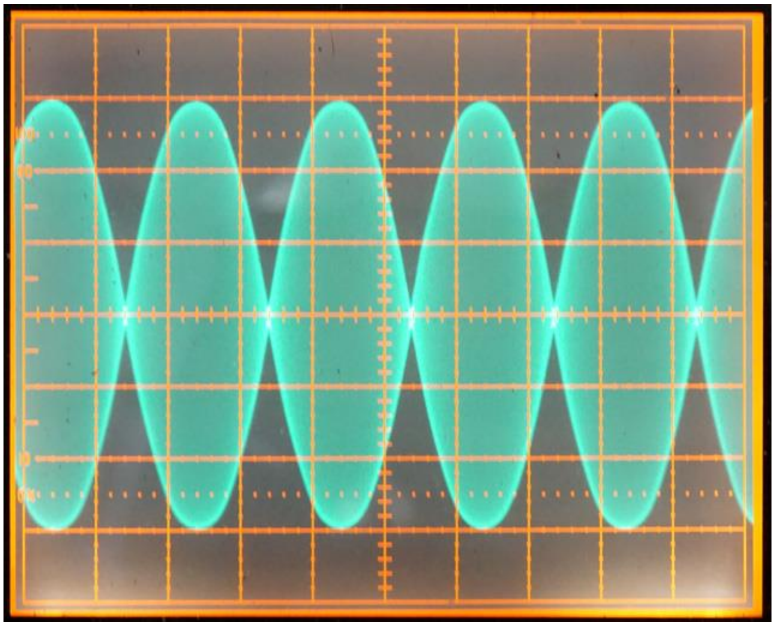


10. **ALC Compression Check.** In this test, a 2-tone test signal is applied to A ACC1 Pin 4 (MOD IN) from an HP/Agilent 8935 test set. The terminated oscilloscope is connected to ANT1 via a 50 dB high-power attenuator.

Test Conditions: 14100 kHz USB, RF PWR set for P_O = 200W CW, compression off. Test signal: 2-tone. Transmit Filter 200-2900. Test tones: 700 and 1700 Hz, at equal amplitudes. ±3 vert. div. = 200W. 5 ms/horiz.div.

Test Result: No flat-topping of the 2-tone envelope was observed (see Figure 4.)

Figure 4: 2-tone envelope, 200W PEP.

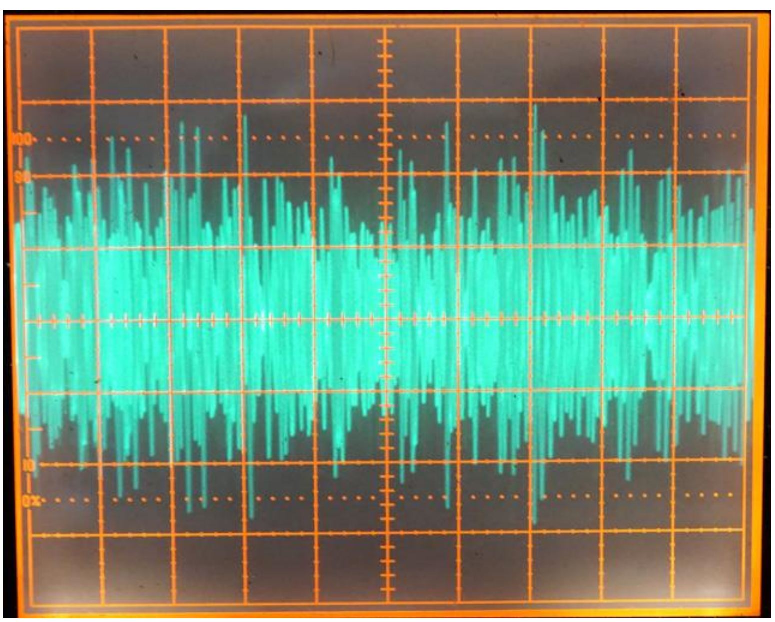


11. **ALC Overshoot Test with White Noise.** In this test, white noise is applied applied to A ACC1 Pin 4 (MOD IN) from an HP 8935 test set. The terminated oscilloscope is connected to ANT1 via a 50 dB high-power attenuator.

Test Conditions: 14.1 MHz USB, COMP off, DATA OFF MOD = USB, USB MOD Level = 50% (default). Test signal: Gaussian noise. Default MID TBW (default value) selected. Set RF Power for P_O = 200W CW (±3 vert. div.) 5 ms/horiz. div. Select USB, then adjust noise source output level for mid-scale ALC reading.

Test Result: No ALC overshoot was observed (see Figure 5.)

Figure 5. ALC overshoot test with white noise.



12. **Subjective TX audio test:** In this test, a headset is plugged into the microphone and headphone jacks and a transmitted SSB signal is monitored with MON active.

Test Procedure:

a. Set COMP ON, COMP control for 6 dB compression on voice peaks.
b. Adjust Mic Gain for mid-scale ALC reading.
c. Transmit alternately with COMP off and on. Observe that COMP gives monitored TX audio more audible "punch" and penetrating power.

13. **Transmitter 2-tone IMD Test.** In this test, a 2-tone test signal is applied from the HP 8935 test set to A ACC1 Pin 4 (MOD IN). An HP 8563E spectrum analyser is connected to ANT1 via a 60 dB high-power attenuator.

Test Conditions: Bands/modes per Table 9, compression off. Test signal: 2-tone. TBW: MID (default). Test tones: 700 and 1700 Hz, at equal amplitudes. RF PWR set for P_O = 200W CW (200W & 50W on 14.1 MHz).

Adjust test tone levels to display test tones at -6 dBc on spectrum analyser. Figures 6 through 10 show the two test tones and the associated IMD products for each test case. **Note:** IMD values stated in Table 9 are in dBc (0 dBc = amplitude of one of two equal test tones). To obtain IMD expressed in dB below 2-tone PEP, subtract 6 dB from the value stated in Table 9. *Example: -29 dBc = 35 dB below 2-tone PEP.*

Table 9. 2-tone TX IMD.

2-tone TX IMD Products at Rated P_o					
IMD Products	Rel. Level dBc (0 dBc = 1 tone)				
Freq. MHz	1.9	3.6	14.1	28.3	50.1
IMD3 (3rd-order)	-30	-30	-29	-37	-31
IMD5 (5th-order)	-44	-44	-43	-42	-46
IMD7 (7th-order)	-52	-45	-44	-51	-57
IMD9 (9th-order)	-57	-62	-66	-71	-71
Subtract 6 dB for IMD referred to 2-tone PEP					

14. **Transmitter Noise IMD Test.** This test is similar to Test 13, except that a white-noise baseband is applied from the HP 8935. Spectrograms are captured at 200W and 50W PEP, as shown in Figure 11. Note that the IMD skirts are steeper at the lower power level.

Test Conditions: 14.1 MHz USB, COMP off, DATA OFF MOD = USB, USB MOD Level = 50% (default). Test signal: Gaussian noise. Default MID TBW (default value) selected. Set RF Power for P_O = 200W CW. Select USB, then adjust noise source output level for mid-scale ALC reading. Repeat test with P_O = 50W.

Figure 6: Spectral display of 2-tone IMD at 1.9 MHz, 200W PEP.

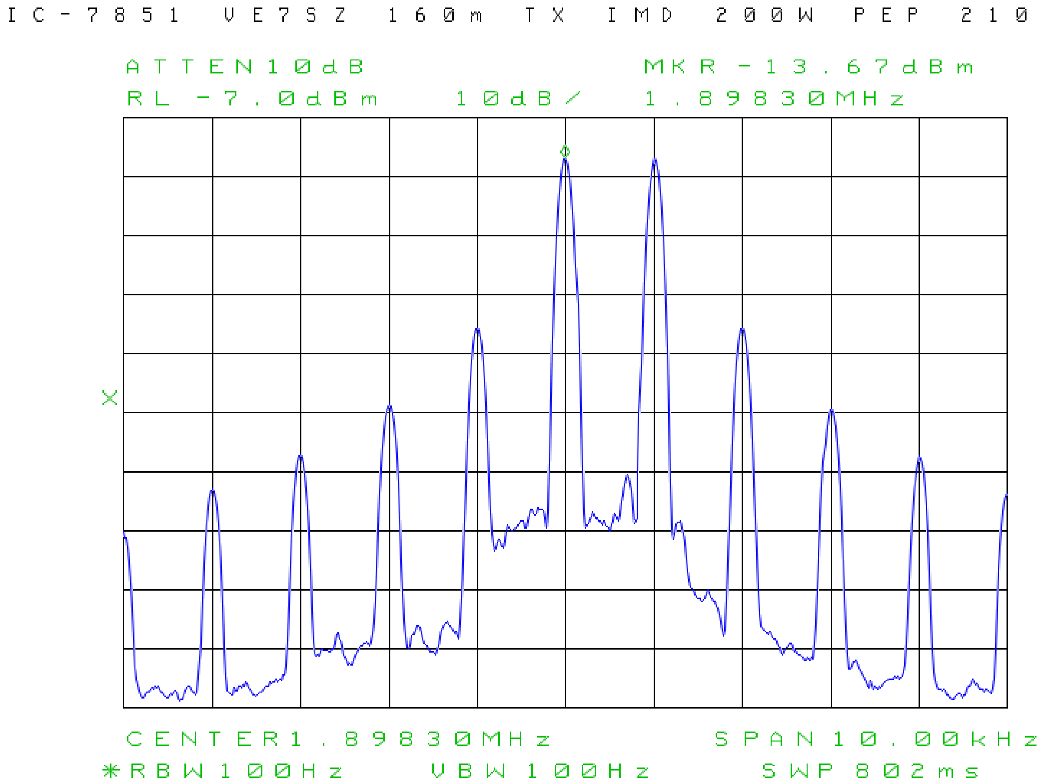


Figure 7: Spectral display of 2-tone IMD at 3.6 MHz, 200W PEP.

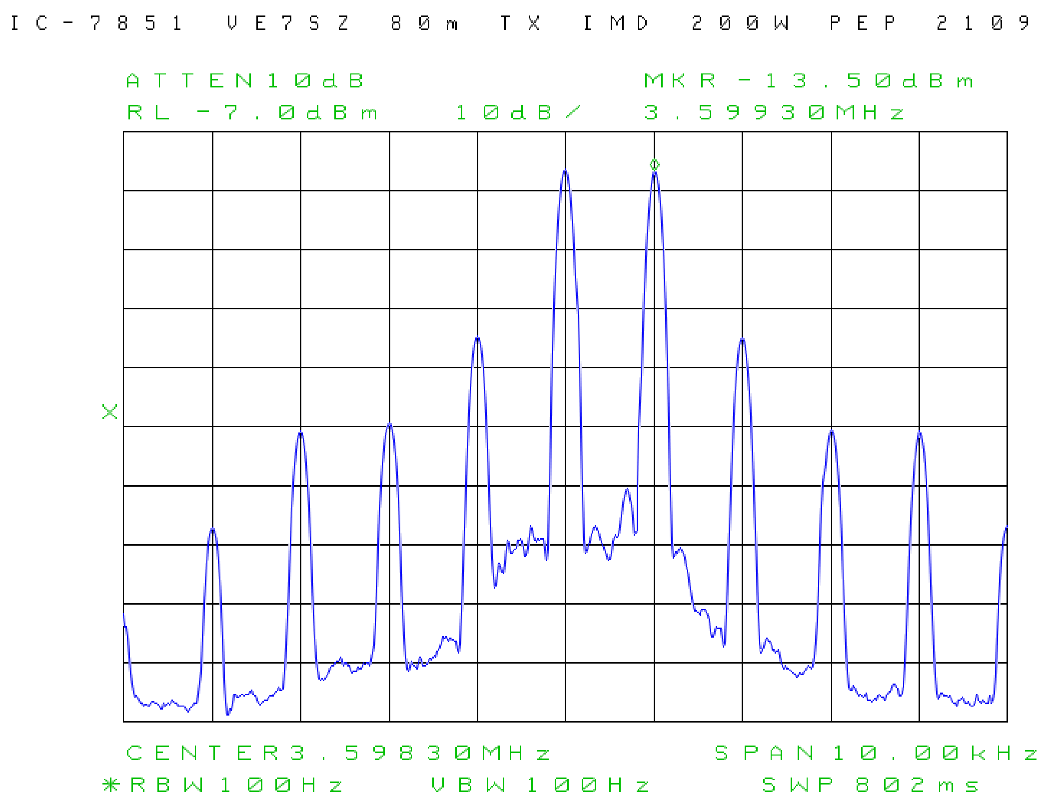


Figure 8: Spectral display of 2-tone IMD at 14.1 MHz, 200W & 50W PEP.

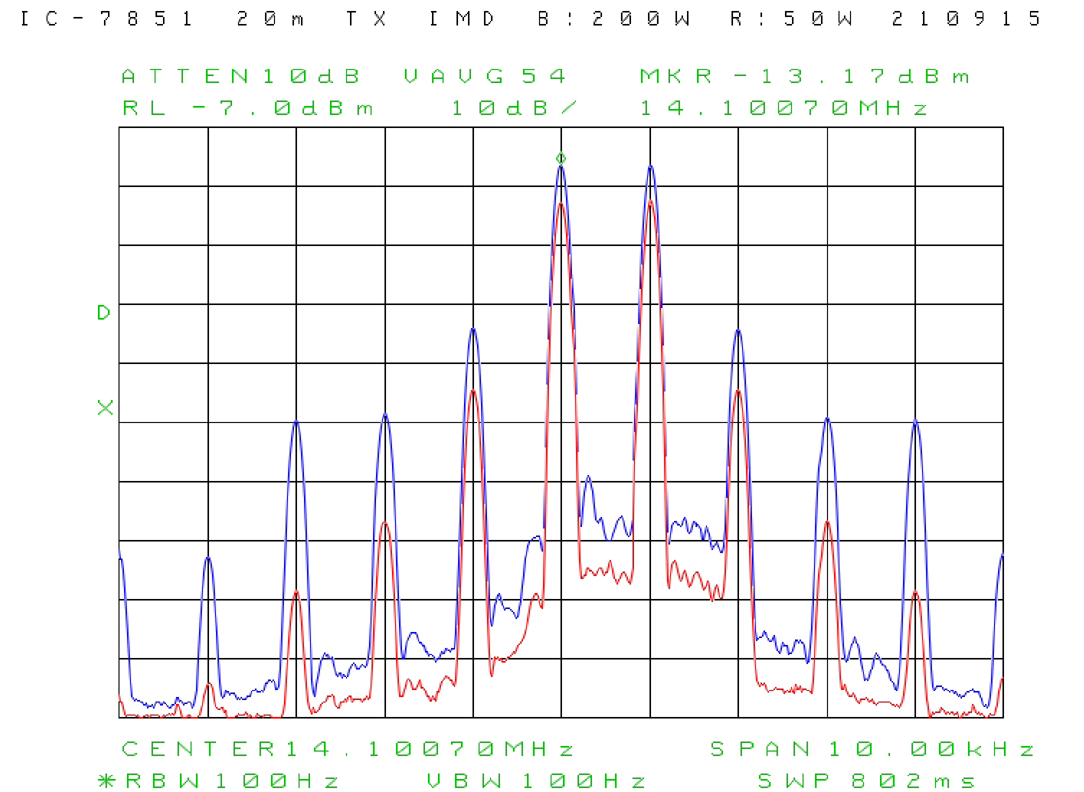


Figure 9: Spectral display of 2-tone IMD at 28.3 MHz, 200W PEP.

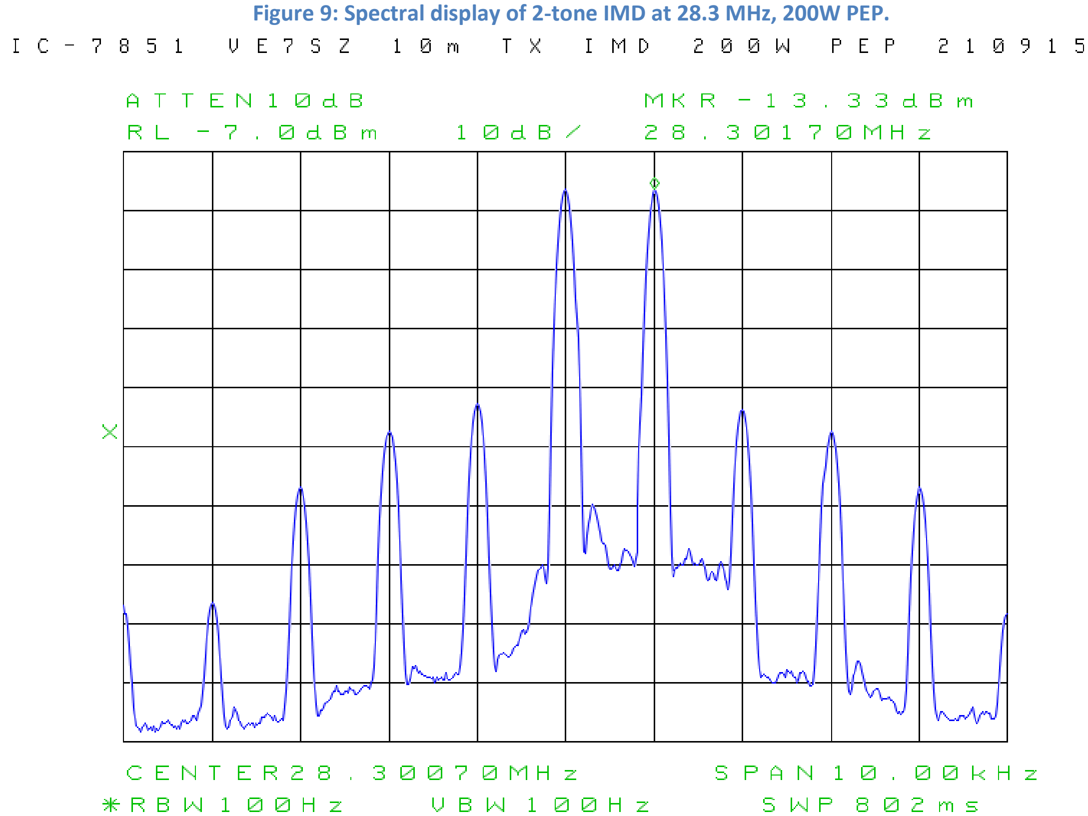


Figure 10: Spectral display of 2-tone IMD at 28.3 MHz, 200W PEP.

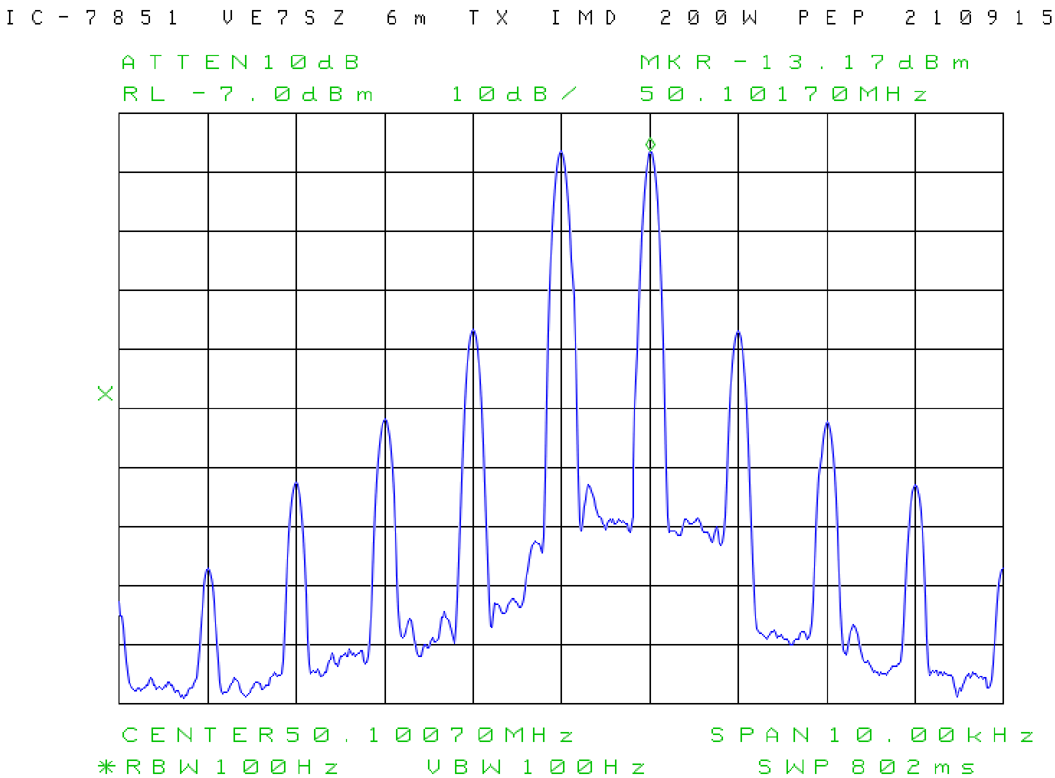
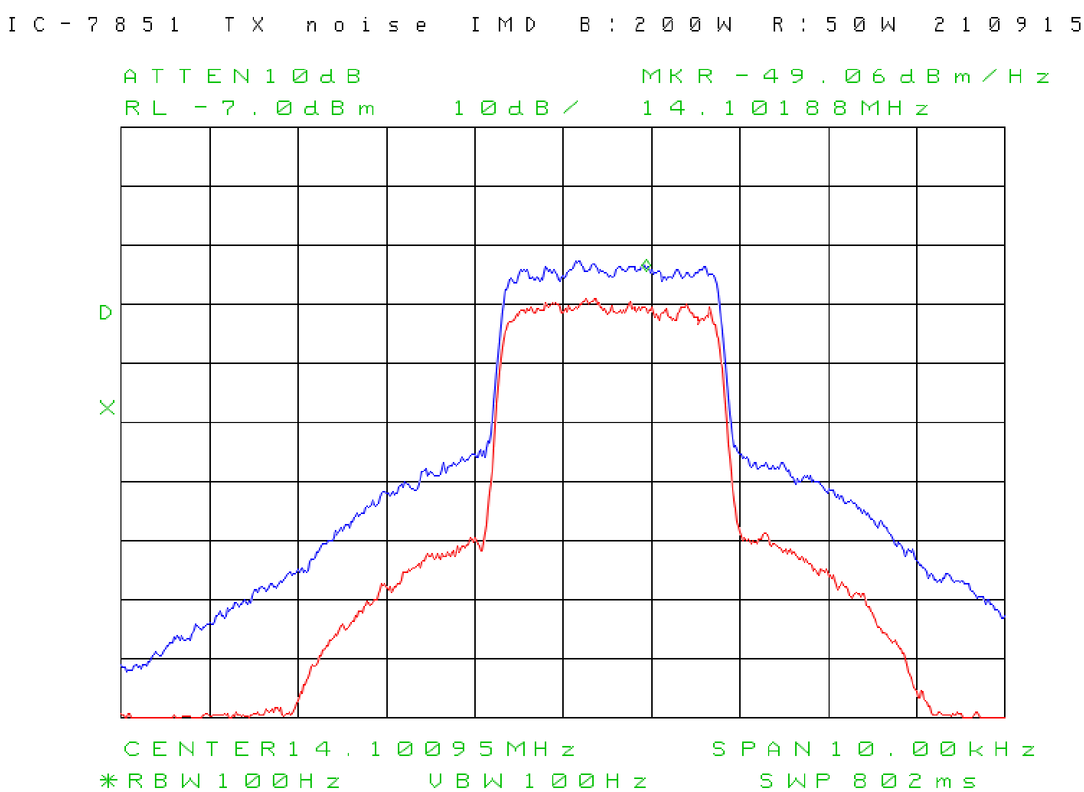


Figure 11: Spectral display of white-noise IMD at 14.1 MHz, 200W & 50W PEP.



15. **Transmitter harmonics & spectral purity.** Once again, the spectrum analyser is connected to ANT1 via a 60 dB high-power attenuator. Harmonics are measured using the HP 85672A spurious response utility.

Test Conditions: 3.6, 14.1 and 50.1 MHz, RTTY mode, 100W to 50Ω load. Harmonic data are presented for all frequencies tested (Figures 12 through 14) and spur sweeps in Figures 15 through 17. It will be seen that harmonics are well within specifications. Spurs are within the -60 dBc limit specified in FCC Part 97.307(e).

Figure 12.

IC-7851 VE7SZ 80m harmonics 100W CW 210915

HARMONIC MEASUREMENT RESULTS

FUNDAMENTAL SIGNAL: 3.600 MHz
-10.7 dBm

HARMONIC	LEVEL dBc	FREQUENCY
2	-82.7 *	7.200 MHz
3	-73.7	10.80 MHz
4	-95.0 *	14.40 MHz
5	-86.8	18.00 MHz
6	-96.3	21.60 MHz
7	-99.3 *	25.20 MHz
8	-101.3 *	28.80 MHz

* MEASURED LEVEL MAY BE NOISE OR LOST SIGNAL.

TOTAL HARMONIC DISTORTION = 0 %
(OF HARMONICS MEASURED)

Figure 13.

IC-7851 VE7SZ 20m harmonics 100W CW 210915

HARMONIC MEASUREMENT RESULTS

FUNDAMENTAL SIGNAL: 14.10 MHz
-9.8 dBm

HARMONIC	LEVEL dBc	FREQUENCY
2	-85.7 *	28.20 MHz
3	-86.5	42.30 MHz
4	-107.0 *	56.40 MHz
5	-109.5 *	70.50 MHz
6	-107.7 *	84.60 MHz
7	-100.3	98.70 MHz
8	-103.5 *	112.8 MHz

* MEASURED LEVEL MAY BE
NOISE OR LOST SIGNAL.

TOTAL HARMONIC DISTORTION= 0 %
(OF HARMONICS MEASURED)

Figure 14.

IC-7851 VE7SZ 6m harmonics 100W CW 210915

HARMONIC MEASUREMENT RESULTS

FUNDAMENTAL SIGNAL: 50.10 MHz
-9.8 dBm

HARMONIC	LEVEL dBc	FREQUENCY
2	-88.5 *	100.2 MHz
3	-87.0 *	150.3 MHz
4	-95.5	200.4 MHz
5	-99.7 *	250.5 MHz
6	-105.2 *	300.6 MHz
7	-101.7 *	350.7 MHz
8	-106.2 *	400.8 MHz

* MEASURED LEVEL MAY BE
NOISE OR LOST SIGNAL.

TOTAL HARMONIC DISTORTION= 0 %
(OF HARMONICS MEASURED)

Figure 15.

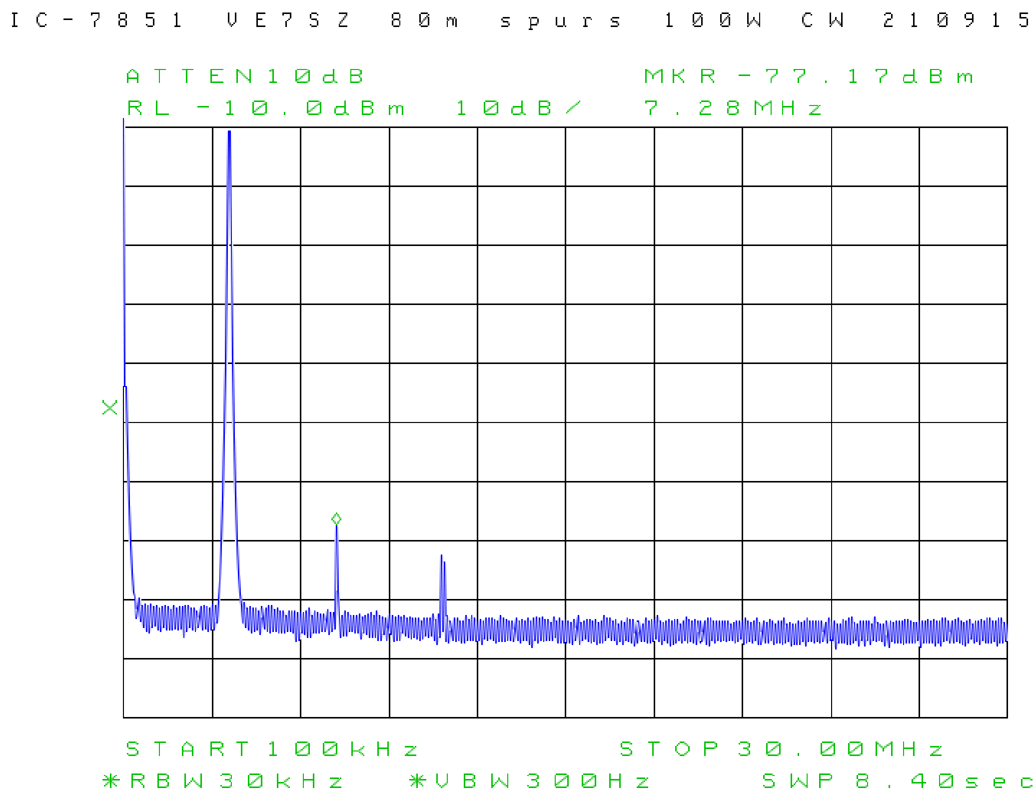


Figure 16.

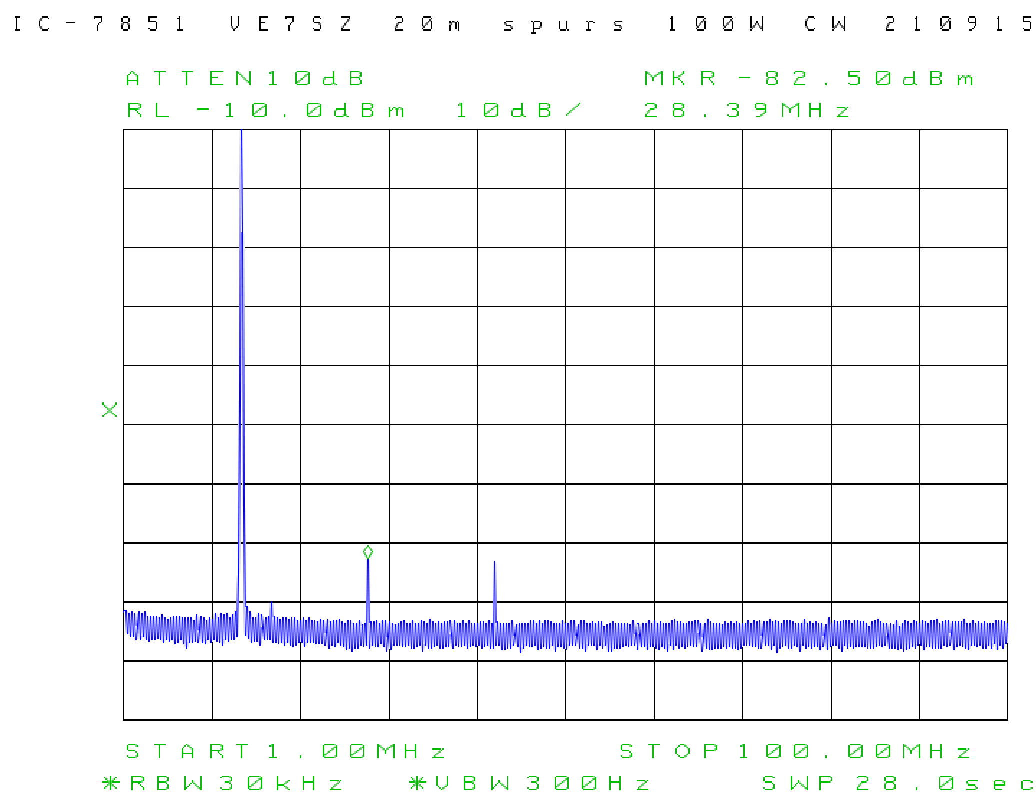
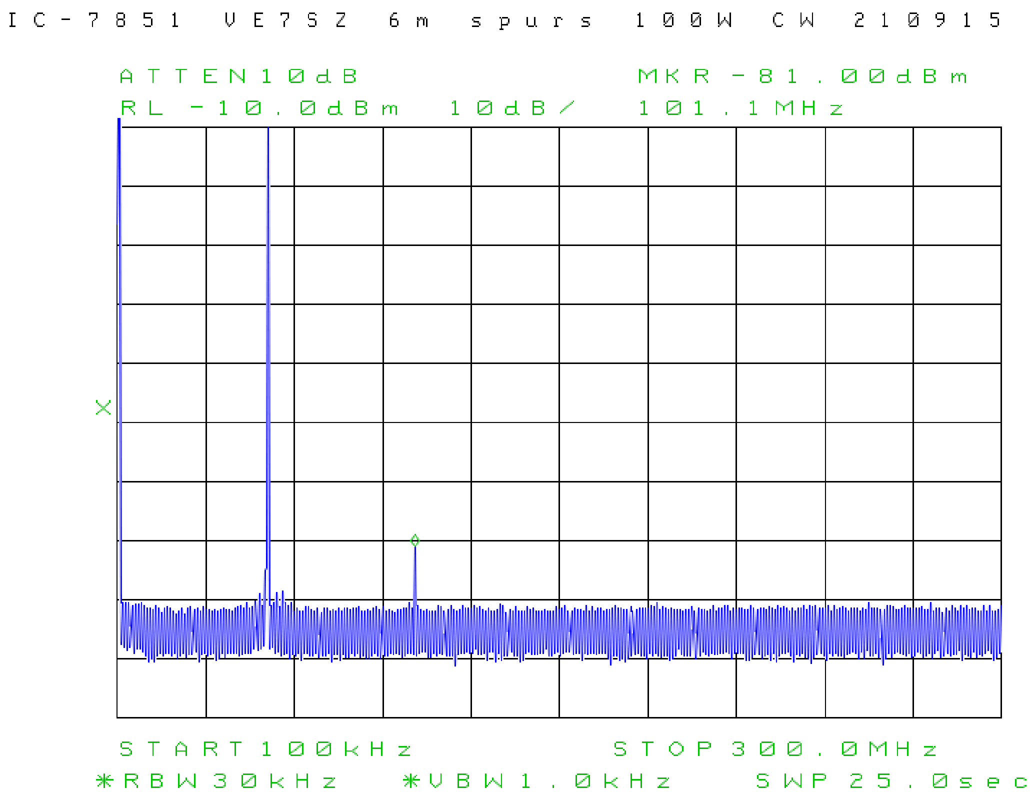


Figure 17.


IC-7851 VE7SZ 6m spurs 100W CW 210915
ATTEN 10dB
MKR -81.00dBm
RL -10.0dBm 10dB/
101.1MHz
START 100kHz
STOP 300.0MHz
*RBW 30kHz
*VBW 1.0kHz
SWP 25.0sec

16. **AM sidebands and THD with single-tone modulation.** As in Test 15 above, the spectrum analyser is connected to ANT1 via a 50 dB high-power attenuator. RF PWR is adjusted for 50W resting carrier. A 1 kHz test tone is applied from the HP 8935 test set to A ACC1 Pin 4 (MOD IN). AM sidebands are measured using the HP 85672A spurious response utility.

Test Conditions: 14100 kHz AM, 50W carrier output, AM TX Bass = 0, AM TX Treble = 0. Adjust test tone level for -7 dBc test tone level (90% modulation.) Figure 18 shows the carrier and sideband levels. Calculated THD < 5%.

Figure 18: AM Sidebands for 90% Modulation, 1 kHz test tone.

```
IC-7851 VE7SZ 50W AM SB 90% mod.210915

DISCRETESIDEBANDSEARCHRESULTS

CARRIERFREQ:    14.10MHz
CARRIERPOWER:   -13.0dBm

OFFSETFREQ     - OFFSET    + OFFSET
                 dBc         dBc
-----------    --------    --------
  .998kHz        -7.2        -7.5
 1.997kHz       -32.0       -32.3
 2.996kHz       -44.0       -44.0
 4.004kHz       -56.8       -57.0
 5.003kHz       -51.3       -51.5

FOUND:  5 SETS OF SIDEBANDS
```

17. **Spectral display of CW keying sidebands.** The spectrum analyser is connected to ANT1 via a 60 dB high-power attenuator. A series of dits is transmitted at 48 wpm from the DUT's internal keyer.

Test Conditions: 14.1 MHz CW, 50W output to 50Ω load. Keying speed 48 wpm (max.) using internal keyer. CW weight = 1:3:1 (default). Rise time = 6, 4 (default) & 2 ms. Spectrum analyser RBW is 10 Hz, video-averaged; sweep time < 4 sec. Figures 19 and 20 show the transmitter output ±5 kHz from the carrier at 4 and 6 ms rise times.

Figure 19: Keying sidebands at 48 wpm, Rise Time 6 & 4 ms, Weight = 1:1:3, 14.1 MHz, 50W.

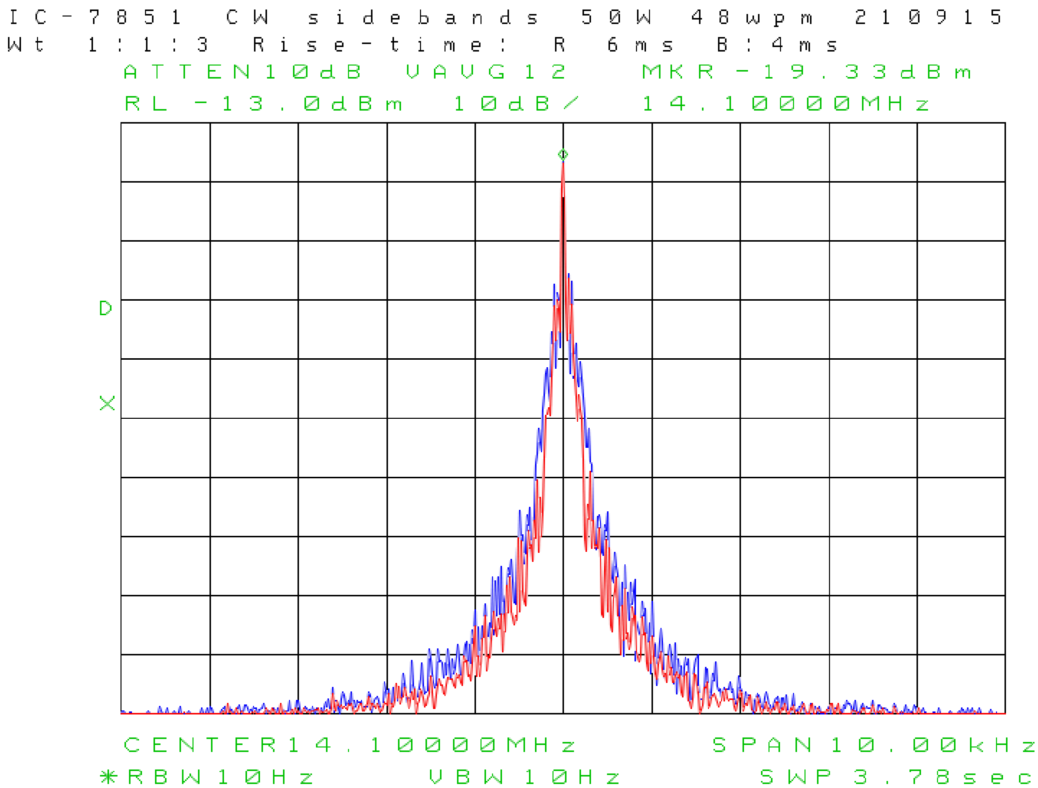
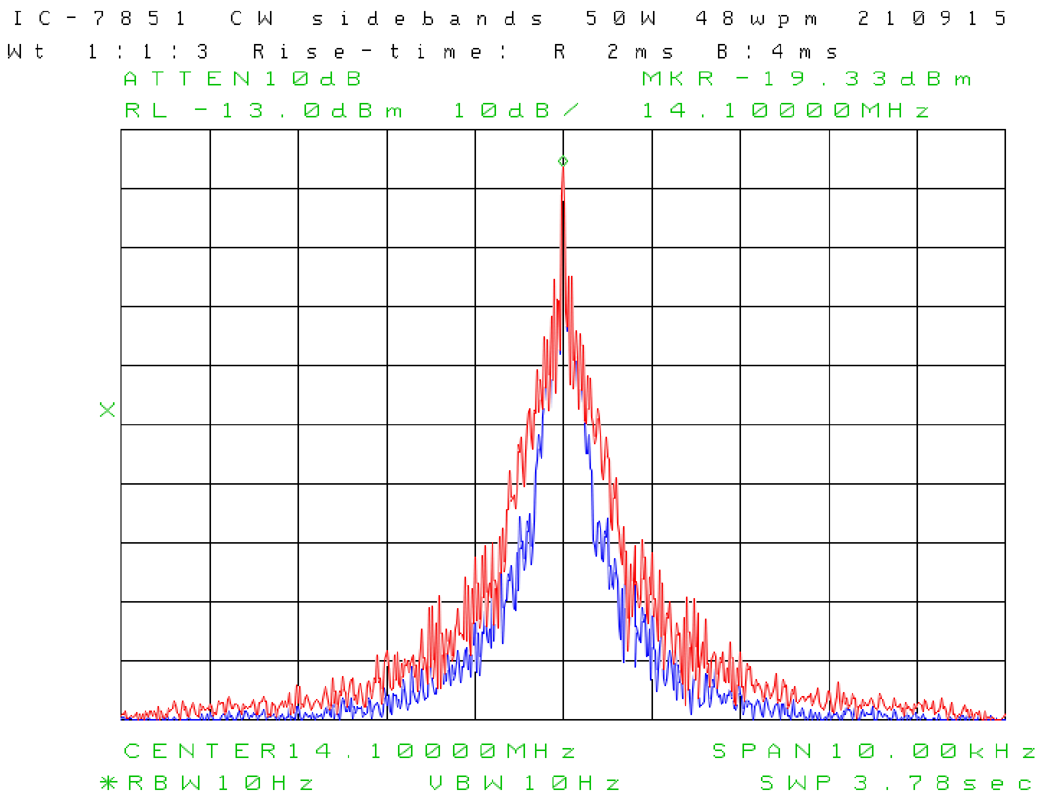


Figure 20: Keying sidebands at 48 wpm, Rise Time 2 & 4 ms, Weight = 1:1:3, 14.1 MHz, 50W.



18. **CW keying envelope.** The oscilloscope is terminated in 50Ω and connected to ANT1 via a 50 dB high-power attenuator. A series of dits is transmitted from the internal keyer at 48 wpm.

Test Conditions: 14.1 MHz CW, 50W output to 50Ω load. Sweep rate = 10 ms/hor. div. ±3 vert. div. = 50W. Keying speed 48 wpm (max.) using internal keyer. CW weight = 1:3:1 (default). Rise time = 6, 4 (default) & 2 ms. The keying envelope is shown in Figures 21 through 23.

Figure 21: Keying envelope at 48 wpm, 1:3:1 weight, rise time 6 ms.

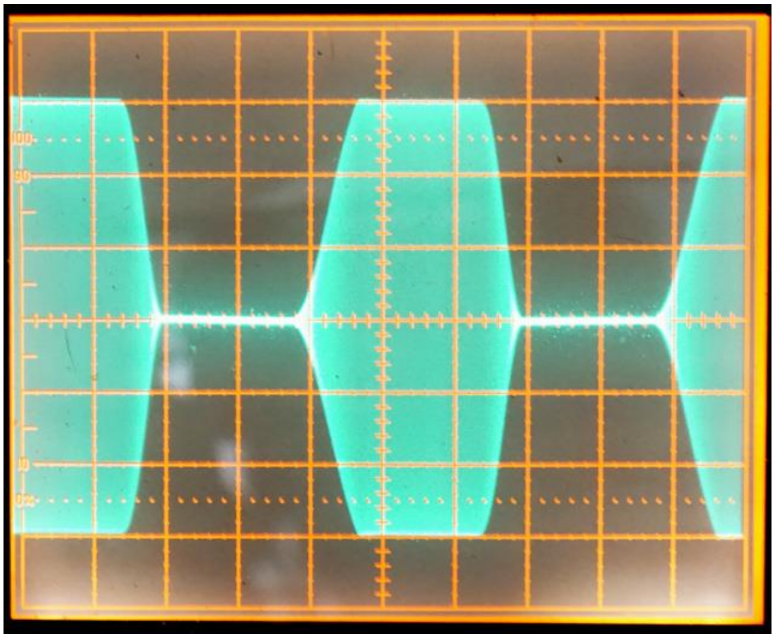


Figure 22: Keying envelope at 48 wpm, 1:3:1 weight, rise time 4 ms.

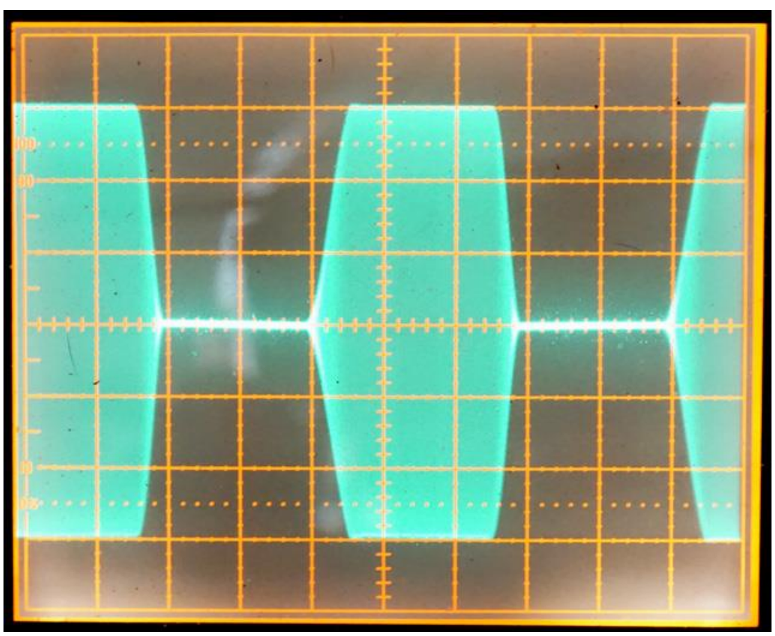
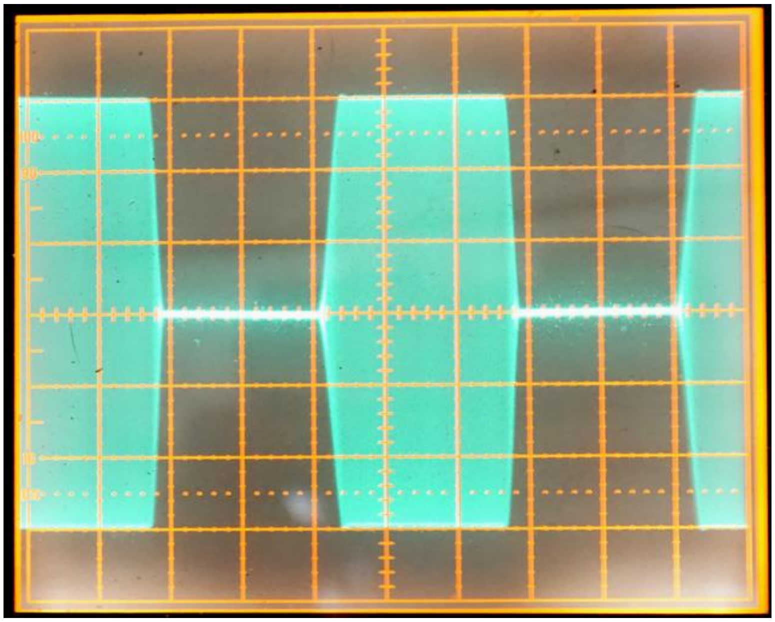


Figure 23: Keying envelope at 48 wpm, 1:3:1 weight, rise time 2 ms.



19. **Comments on receiver test results:** The **NPR** test data (Test 2) show an improvement of several dB over the IC-7700 and IC-7800, mostly attributable to the IC-7851's 30+ dB RMDR improvement over earlier designs. NPR values ≥ 90 dB approach the measurement limits of the instrumentation. It will be noted that with the 1.2 kHz roofing filter selected, NPR is a few dB lower than with the other roofing filters. This is suggestive of PIM in the 1.2 kHz filter under high noise loading.

RMDR (Test 3) is the highest I have ever measured in a superhet receiver; it is close to Icom's advertised value, and is comparable to that of the best direct-sampling SDR's. This is a function of the new LOCAL Unit (synthesiser) design. As the IC-7851 receiver's dynamic range is now no longer phase-noise limited, passive IMD (PIM) in front-end components such as roofing filters, inductor cores etc. is likely to be the major limiting factor in ultimate receiver performance.

DR3 (3rd-order IMD dynamic range, Test 4) is 15 – 20 dB higher than that of earlier designs. Again, this is among the highest I have ever measured in a superhet. The serious contester or DX'er will no longer be handicapped by IMD products or phase noise in his own receiver.

The measured bandwidth of the **1.2 kHz roofing filter** (Test 5) is very close to the filter specification. This filter will greatly improve close-in dynamic performance on a crowded band, as it will enable the operator to benefit from a combination of excellent close-in dynamic range and image/1st IF rejection.

The **measured 30 Hz spectrum scope RBW** (Test 6) allows reasonably accurate assessment of IMD and spurs on received signals, as well as facilitating the identification of closely-spaced transmissions. In general, the IC-7850 display, with LED backlighting, is far superior to its predecessors. Dual Main/Sub spectrum scopes and other enhancements make the display one of the most appealing features of the IC-7850.

20. **Comments on transmitter test results: CW Power Output** (Test 7) was comfortably above the IC-7851's design rating, and was easily controllable. The Power Limit table is a new IC-7850/7851 feature allowing a preset power output to be configured independently for voice and data modes on each band. During testing, all entries were set at 200W. The transmitter was absolutely stable at full output; no overheating, PA standing current creep or other anomaly was observed. The P_O meter scale tracked measured P_O to within 5%.

    SSB Peak Envelope Power (Test 9) showed full rated PEP output on SSB voice audio, with a significant gain in "talk power" with compression on. There was no evidence of ALC overshoot during voice transmission.

    ALC Compression and **ALC Overshoot** (Tests 10 & 11) showed a clean 2-tone envelope with no trace of flat-topping or ALC overshoot spikes.

    Transmitter 2-tone IMD (Test 13) yielded results equal to to or better than those obtained on the IC-7700 and IC-7800. Worst-case IMD was well within the -25 dBc ITU-R guideline per Recommendation SM.326-7, Section 1.2.3. At 50W PEP output, e.g. when driving an amplifier, the 5^{th}- and higher-order IMD products are reduced even further. This can also be seen in Figure 8 and in Test 14 **(Transmitter Noise IMD).**

    The results of Test 15, **Transmitter harmonics & spectral purity,** are well within the -60 dBc limit specified in FCC Part 97.307(e). Test 16, **AM sidebands and THD with single-tone modulation**, shows a correct carrier/sideband amplitude relationship at 90% modulation, with THD < 5%.

    Spectral display of CW keying sidebands (Test 17) indicates 4 or 6 ms as the optimum rise time choice for reasonably "hard" CW keying combined with acceptable occupied bandwidth (2 kHz at -70 dBc). **CW keying envelope** (Test 18) illustrates the RF keying envelope for 6, 4 and 2 ms rise times.

    It should be noted that I did not measure **Transmitter Composite Noise,** as the IC-7850's phase noise is below my spectrum analyser's noise floor.

    Conclusion: Although the IC-7851 is admittedly costly, the above test effort has led me to conclude that it is the very best conventional HF transceiver I have tested to date. Its ergonomics, "feel" and overall handling reflect an ultra-refined version of the familiar Icom user interface. One new feature which greatly facilitates diversity reception is Main/Sub VFO Tracking. When activated, Tracking enables the operator to tune both receivers synchronously and simultaneously by rotating the Main tuning knob.

21. **Acknowledgements:** I would like to thank my friend Allan Buckshon VE7SZ for his kindness and generosity in loaning me his IC-7851 for the above tests.

22. **References:** 1. http://www.ab4oj.com/test/docs/npr_test.pdf

Adam Farson VA7OJ/AB4OJ, September 25, 2015.

Appendix I: Description of NPR Test Procedure.

Noise Power Ratio (NPR) Test: An NPR test is performed on the DUT Main Receiver, using the test methodology described in detail in **Reference 1.** The noise-loading source used for this test is a Wandel & Goltermann RS-50 notched-noise generator fitted with the following selectable filter pairs (bandstop & band-limiting filters):

Table 6: Noise Generator Filter Pairs

DUT Mode	Bandstop filter f_0 kHz	Band-limiting filter kHz	B_{RF} kHz	BWR dB 2.4 kHz B_{IF}	BWR dB 500 Hz B_{IF}
LSB	1940	60 - 2048	1985	29.2	
LSB	3886	60 - 4100	4037	32.3	
USB	5340	60 - 5600	5537	33.6	
LSB	7600	316 - 8100	7781	35.1	
USB	11700	0-13800	13797	36.7	44.1

For bandstop filters: Notch depth ≈ 100 dB. Bandwidth at bottom of notch ≈ 3 kHz.

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

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

where P_{TOT} = total noise power 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 Hz (noise source band-limiting filter)

B_{IF} = receiver IF filter bandwidth in Hz = 2400 Hz

MDS = minimum discernible signal (specified at B_{IF})

Test Conditions: Receiver tuned to bandstop filter centre freq. f_0 ± 1.5 kHz, IF BW = 2.4 kHz USB/LSB, ATT off, NR off, NB off, AGC Slow. Measure MDS first with signal generator, then NPR with noise generator.

References:

1. "Noise Power Ratio (NPR) Testing of HF Receivers" http://www.ab4oj.com/test/docs/npr_test.pdf
2. "Theoretical maximum NPR of a 16-bit ADC" http://www.ab4oj.com/test/docs/16bit_npr.pdf
3. "HF Receiver Testing: Issues & Advances" http://www.nsarc.ca/hf/rcvrtest.pdf

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