Test Report: Yaesu FTDX-3000, S/N 2K020095 (loaned by Bill Trippett W7VP)

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1. **Introduction and Scope:** The following tests were conducted on the FTDX-3000:

   a. MDS (Minimum Discernible Signal): MDS was measured on 20m in CW and SSB modes, to provide a datum point for the DR3 (2-signal 3rd-order IMD dynamic range) test. It was also measured in SSB mode at the NPR (noise power ratio) notch frequencies in the 160, 80, 60 and 40m bands as required for the calculation of NPR. A final measurement was performed on 60m CW.

   b. DR3 (2-signal 3rd-order IMD dynamic range) was measured using test signals at 14010 and 14012 MHz (2 kHz spacing). Two test cases were run, at 500 and 250 Hz IF bandwidth with 600 and 300 Hz roofing filters selected respectively.

   c. NPR (noise power ratio) was measured at 1940, 3886, 5340 and 7600 kHz in SSB mode with 2.4 kHz IF bandwidth. A check measurement was run at 5340 kHz in CW mode, with 500 Hz IF bandwidth, to determine the significance of passive IMD in the narrow 1st-IF roofing filter.

2. **Tests and Results:**

Test 1: MDS (Minimum Discernible Signal): This 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: ATT off, DNR off, NB off, DNF off, Contour off. AGC Slow.

Table 1: MDS.

				MDS dBm		
Freq. kHz	Mode	Roof Flt	IF BW	IPO	AMP 1	AMP 2
14010	CW	300 Hz	250 Hz	-128	-140	-144
14010	CW	600 Hz	500 Hz	-125	-137	-140
1940	LSB	3 kHz	2.4 kHz	-121	-133	-135
3886	LSB	3 kHz	2.4 kHz	-120	-132	-135
5340	LSB	3 kHz	2.4 kHz	-119	-131	-134
5340	CW	600 Hz	500 Hz	-123	-136	-140
5340	CW	300 Hz	250 Hz	-126	-138	-141
7600	LSB	3 kHz	2.4 kHz	-119	-131	-134

Test 2: DR3 (2-signal 3rd-order IMD dynamic range): The purpose of this test is to determine the range of signals which the receiver can tolerate while essentially generating no spurious responses.

In this test, two signals of equal amplitude Pi and separated by a known offset Δf are combined and injected into the receiver input. If the test signal frequencies are f_1 and f_2, the offset $\Delta f = f_2 - f_1$ and the 3rd-order intermodulation products appear at $(2 f_2 - f_1)$ and $(2 f_1 - f_2)$.

The two test signals are combined in a passive hybrid combiner and applied to the receiver input via a step attenuator. The receiver is tuned to the upper and lower 3rd-order IMD products ($2f_2 - f_1$ and $2f_1 - f_2$ respectively) which appear as a 700 Hz tone in the speaker. The per-signal input power level P_i is adjusted to raise the noise floor by 3 dB, i.e. IMD products at MDS. The P_i values for the upper and lower products are recorded and averaged.

Note: If the audio output drops by less than 3 dB when one of the test signals is removed, the measurement is noise-limited (indicated by NL in the table.)

$DR_3 = P_i$ - MDS. Calculated IP_3 = (1.5 * DR3) + MDS

Test Conditions: f_1 = 14.010 MHz, f_2 = 14.012 MHz, CW mode, IPO, ATT off, DNR off, NB off, DNF off, Contour off. AGC Slow. CW Pitch = 700 Hz. DR_3 in dB; IP_3 in dBm. NL = reciprocal mixing noise limited.

Table 2: DR3 and IP3

f_1 kHz	f_2 kHz	Δf kHz	MDS dBm	Roof Flt	IF BW	Preamp	P_i dBm	DR_3 dB	IP_3 dBm	NL
14010	14012	2	-128	300 Hz	250 Hz	IPO	-45	84	-2	Y
14010	14012	2	-125	600 Hz	500 Hz	IPO	-45	80	-5	Y
14010	14012	2	-137	600 Hz	500 Hz	AMP 1	-58	80	-17	Y

Test 3: 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 the following selectable filter pairs (bandstop & band-limiting filters):

Table 3: Noise Generator Filter Pairs

Bandstop filter f_0 kHz	Band limiting filter kHz	B_{RF} kHz	BWR dB
1940	60 - 2048	1985	29.2
3886	60 - 4100	4037	32.3
5340	60 - 5600	5537	33.6
7600	316 - 8100	7781	35.1

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

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 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 kHz (noise source band-limiting filter)

B_{IF} = receiver IF filter bandwidth in kHz

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

Test conditions: Receiver tuned to bandstop filter centre freq. f_0 + 1.5 kHz, 3 kHz roofing filter, IF BW = 2.4 kHz (Check measurements are made in CW mode with 600 Hz roofing filter and 500 Hz IF BW, and also with 300 Hz roofing filter and 250 Hz IF BW.)

Table 4. Noise Power Ratio (NPR)

					IPO		AMP 1		AMP 2	
f_0 kHz	BWR dB	Mode	Roof	B_{IF} kHz	P_{TOT} dBm	NPR dB	P_{TOT} dBm	NPR dB	P_{TOT} dBm	NPR dB
1940	29.2	LSB	3.0	2.4	-16.2	75.3	-27.4	76	-30.2	73.3
3886	32.3	LSB	3.0	2.4	-14.6	72.8	-29.4	69.0	-31.8	70.6
5340	33.6	LSB	3.0	2.4	-12.7	72.4	-27.3	69.8	-30.5	66.6
5340	40.4	CW	0.6	0.5	-13.0	69.3	-27.4	67.9	-30.3	69.0[1]
5340	43.4	CW	0.3	0.25	-12.0	70.3	-26	68.3	-30.3	67[1]
7600	35.1	LSB	3.0	2.4	-14.2	69.4	-29.1	72.5	-31.2	73.4

Notes: 1. It is evident that the 0.6 and 0.3 kHz roofing filters do not degrade NPR.

3. **Conclusions:** It will be seen from Table 2 (DR3) that the 2 kHz DR3 values obtained are close to the 82 dB figure obtained by Rob Sherwood NC0B. **(Ref. 2)** There is a 4 dB improvement with the 300 Hz roofing filter/250 Hz IF selected; this is to be expected.

   The results in Table 3 (NPR) are in the "lower mid-range" of the NPR test data presented in Tables 1 and 1a of **Ref. 1.** It will also be noted that no NPR degradation occurs with the 600 and 300 Hz roofing filters selected.

4. **References:** 1. "Noise Power Ratio (NPR) Testing of HF Receivers", A. Farson VA7OJ/AB4OJ.
   http://www.ab4oj.com/test/docs/npr_test.pdf

   2. "Receiver Test Data", Rob Sherwood NC0B.
   http://www.sherweng.com/table.html