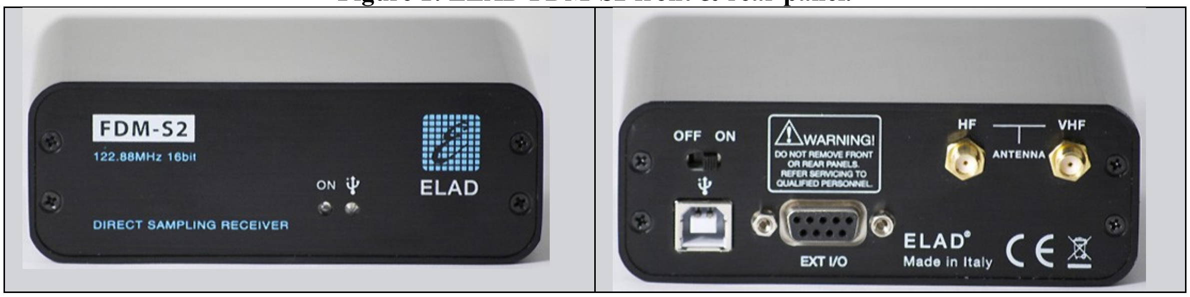
ELAD FDM-S2 Test Report

By Adam Farson VA7OJ/AB4OJ

Iss. 1, August 18, 2014**.**

Figure 1: ELAD FDM-S2 front & rear panel.



Introduction: This test report presents results of a number of RF lab tests performed on an ELAD FDM-S2 direct-sampling SDR receiver loaned by Tadeusz "Ted" Pater VE7VIB.

Software version: FDM-SW2, v1.28.

Performance Tests conducted in my home RF lab, June 24 – August 6, 2014.

A. Receiver Tests

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: CW, B = 500 Hz, ATT off, NR off, NB off, ANF off, AGC slow.

Table 1: MDS in dBm.

3.6 MHz	14.1 MHz	50.1 MHz	144.1 MHz
-133	-133	-132	-130

2: Reciprocal Mixing Noise occurs in a direct-sampling SDR receiver when phase noise generated within the ADC mixes 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 in a direct-sampler is an indicator of the ADC clock's spectral purity**.**

In this test, a signal generator with low phase noise is connected via a 3 dB pad, a narrow bandstop filter and a 0-110 dB step attenuator to the DUT (ANT 1). The noise floor is read on the DUT S-meter in CW mode (500 Hz) with ANT 1 terminated in 50Ω. The signal generator is tuned for maximum null; next, the DUT is tuned to this frequency (f_0). The null should be at the noise floor. The bandstop filter reduces the signal source's close-in phase noise.

The signal generator is now set to f_0 - offset and output P_i increased to raise detected noise by 3 dB. Reciprocal mixing dynamic range (RMDR) = P_i – MDS.

Bandstop filter parameters: 4-pole crystal filter, centre freq. 9.830 MHz, passband insertion loss 0.6 dB, stopband attenuation > 80 dB, bandwidth at max. attenuation 300 Hz. ***Note:*** The residual phase noise of the measuring system is the limiting factor in measurement accuracy.

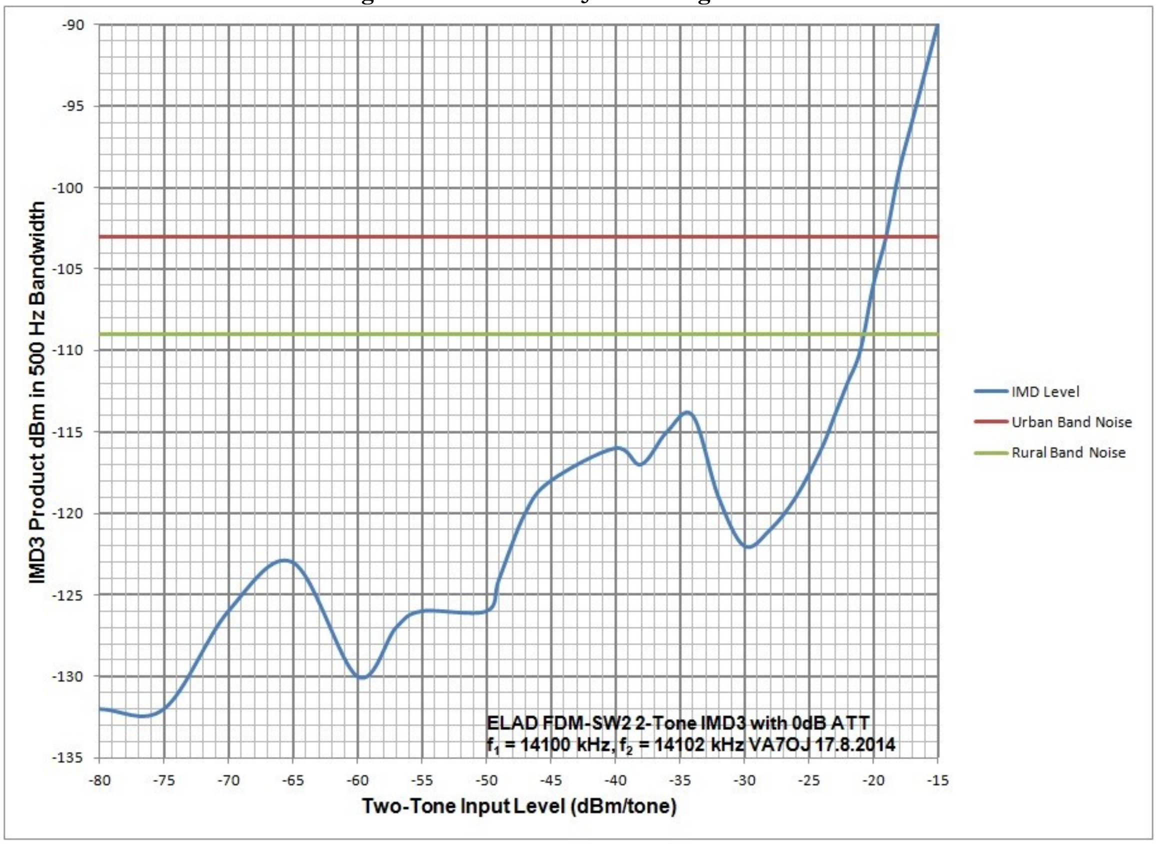
Test Conditions: 9.830 MHz, 500 Hz CW, B= 500 Hz, ATT off, NR off, NB off, ANF off, negative offset. RMDR *in dB* = input power (P_i) – MDS *(both in dBm)*. Here, MDS = -134 dBm at 9.830 MHz.

Table 2: RMDR in dB.

Offset kHz	P_i dBm	RMDR dB
1	-26	108
2	-24	110
3	-22	112
5	-20	114
10	-18	116

3. Two-Tone IMD$_3$ (IFSS, Interference-Free Signal Strength) tested in CW mode (B = 500 Hz), ATT = 0 dB. Test frequencies: f_1 = 14100 kHz, f_2 = 14102 kHz. IMD$_3$ products: 14098/14104 kHz. IMD$_3$ product level was measured as absolute power in a 500 Hz detection bandwidth at various test-signal power levels, with ATT off. The ITU-R P-372.1 band noise levels for typical urban and rural environments are shown as datum lines.

Figure 2: 2-tone IMD$_3$ vs. test signal level.



Note on 2-tone IMD_3 test: This is a new data presentation format in which the amplitude relationship of the actual IMD_3 products to typical band-noise levels is shown, rather than the more traditional DR_3 (3^{rd}-order IMD dynamic range) or SFDR (spurious-free dynamic range). The reason for this is that for an ADC, SFDR referred to input power rises with increasing input level, reaching a well-defined peak ("sweet spot") and then falling off. In a conventional receiver, SFDR falls with increasing input power.

If the IMD_3 products fall below the band-noise level at the operating site, they will generally not interfere with desired signals.

The SFDR behaviour of an ADC invalidates the traditional DR_3 test for a direct-sampling SDR receiver. Our goal here is to find an approach to SFDR testing which holds equally for SDR and legacy receiver architecture. See ***Reference 4.***

4. Two-Tone 2^{nd}-Order Dynamic Range (DR_2). The purpose of this test is to determine the range of signals far removed from an amateur band which the receiver can tolerate while essentially generating no spurious responses within the amateur band.

In this test, two widely-separated signals of equal amplitude P_i are injected into the receiver input. If the signal frequencies are f_1 and f_2, the 2^{nd}-order intermodulation product appears at $(f_1 + f_2)$. The test signals are chosen such that $(f_1 + f_2)$ falls within an amateur band.

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 IMD product $(f_1 + f_2)$ which appears as a 600 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 product at MDS. The P_i value is then recorded. $DR_2 = P_i$ - MDS.

Test Conditions: f_1 = 6.1 MHz, f_2 = 8.1 MHz. IMD product at14.2 MHz. CW, B = 500 Hz, AGC slow, ATT off, NR off, NB off, CW neutral, ANF off. DR_2 in dB. Measured MDS =133 dBm at 14.2 MHz.

Table 3: DR_2. f_1: 6.1 MHz. f_2: 8.1 MHz.

MDS dBm	P_i dBm	DR_2 dB[1]
-133	-83	50

Notes on DR2 test: 1. An external preselector will improve DR_2 significantly.

5. Noise Power Ratio (NPR): An NPR test is performed, using the test methodology described in detail in ***Ref. 2***. The noise-loading source used for this test is a noise generator fitted with bandstop (BSF) and band-limiting filters (BLF) for the test frequencies utilised.

The noise loading P_{TOT} is applied to ANT1 and increased until ADC clipping just commences, and then backed off until no clipping is observed for at least 10 seconds. NPR is then read off the spectrum scope by observation. (NPR is the ratio of noise power in a channel outside the notch to noise power at the bottom of the notch.)

Test Conditions: Receiver tuned to bandstop filter centre freq. $f_0 \pm 1.5$ kHz, SSB, B = 2.5 kHz, ATT off, NR off, NB off, ANF off, AGC slow. Test results are given in **Table 4.**

Table 4: NPR Test Results.

DUT	BSF kHz	BLF kHz	P_{TOT} dBm	BWR dB	NPR dB[2]	Theor. NPR[1]
FDM-S2	1940	60…2044	-19.5	29.0	71	80
	3886	60…4100	-18	32.1	74	76.9
	5340	60…5600	-19.5	33.4	71	75.6
	7600	316…8160	-19.5	34.9	71	74.1

Notes on NPR test:

1. Theoretical NPR was calculated for the LTC2208-16 ADC using the method outlined in ***Ref. 3.*** The theoretical NPR value assumes that B_{RF} is not limited by any filtering in the DUT ahead of the ADC, and that the net gain between the antenna port and the ADC is 0 dB.

2. An external preselector will improve NPR by several dB.

6. References:

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

7. Acknowledgements: I would like to thank Tadeusz "Ted" Pater VE7VIB for making this ELAD FDM-S2 available to me for testing and evaluation.

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

Iss. 1, August 18, 2014.