SRL-LLC QS1R Test Report

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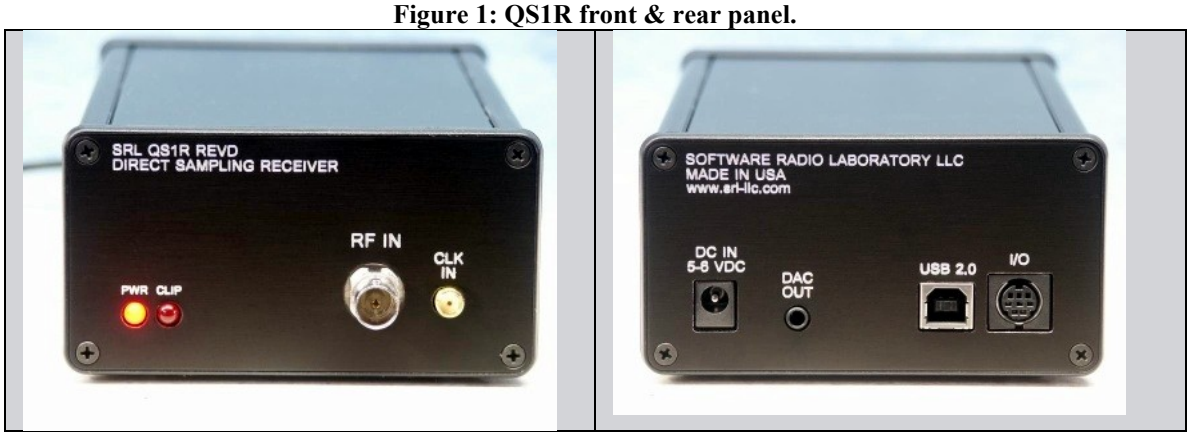
Figure 1: QS1R front & rear panel.



Introduction: This test report presents results of a number of RF lab tests performed on a QS1R Rev. D direct-sampling SDR receiver obtained on loan.

Software version: SDRMaxV, ver. 5.0.1.1.

Performance Tests conducted in my home RF lab, December 15-25, 2014.

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 500 ms. Sampling rate 125 kS/s.

Table 1: MDS in dBm.

PGA	Dither	MDS dBm
0	0	-118
1	0	-120
0	1	-113
1	1	-122
f_0 =14100 kHz. CW, B = 500Hz.		

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.

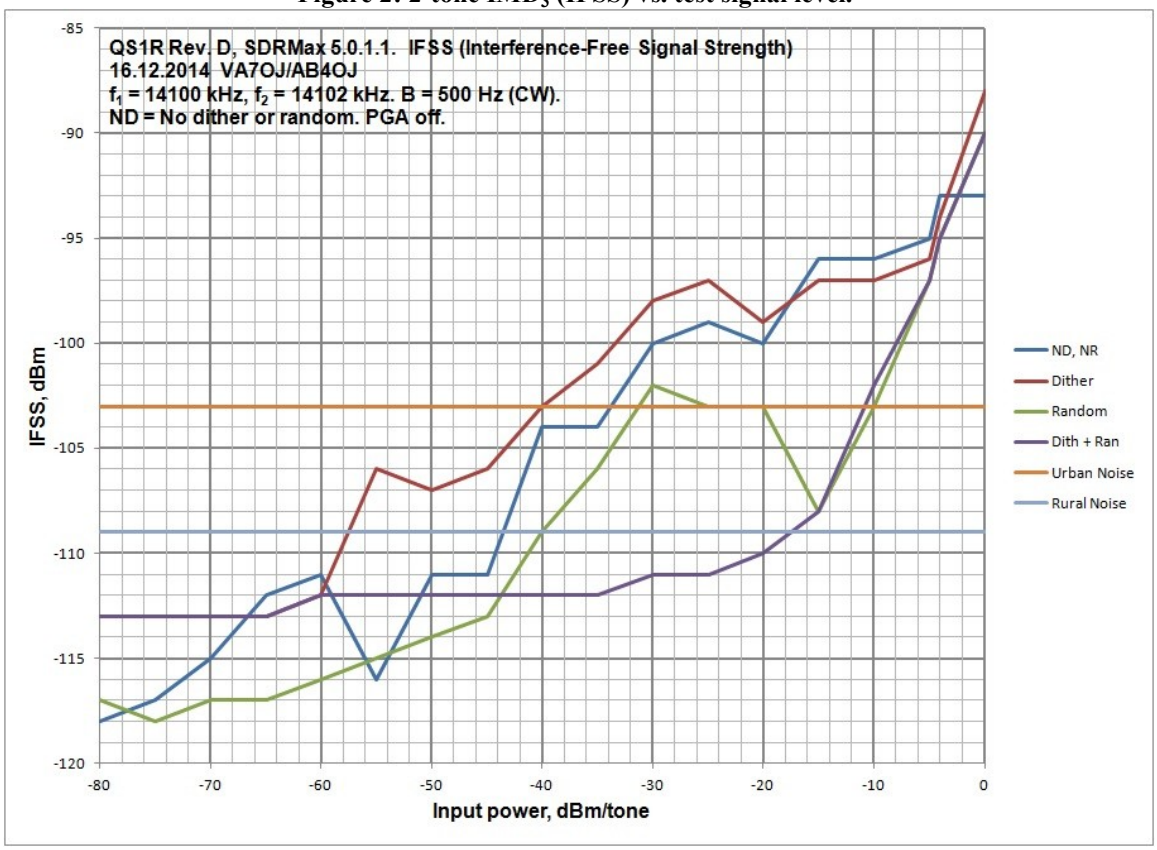
Test Conditions: 9.830 MHz, 500 Hz CW, B= 500 Hz, ATT off, NR off, NB off, ANF off, PGA off, negative offset. RMDR *in dB* = input power (P_i) – MDS *(both in dBm)*. Here, MDS = -118 dBm at 9.830 MHz.

Table 2: RMDR in dB.

Offset kHz	P_i dBm	RMDR dB
1	-9	109
2	-4	114
3	-1	117
5	+1	119
10	+6	125
f_0=9830.3kHz. B=500Hz. MDS=-118dBm.		

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$_3$ (IFSS) vs. test signal level.



4. 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 utilized.

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, Dither off, Random off, ATT off, NR off, NB off, ANF off, AGC slow.

Table 4: NPR Test Results.

DUT	Det BW kHz	Mode	BSF kHz	BLF kHz	PGA	P_{TOT} dBm	NPR dB[2]	Theor. NPR dB[1]
QS1R REV D	2.5	USB	1248	60…1296	0	-1	62	82.4
					1	-4	66	
		LSB	1940	60…2044	0	-2	67	80
					1	-5	71	
		LSB	3886	60…4100	0	-2	70	77
					1	-4	72	
		USB	5340	60…5600	0	-1	71	76
					1	-5	72	
		LSB	7600	316…8160	0	-2	69	74.3
					1	-5	72	

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. Activating Dither and/or Random does not affect NPR.

5. References:

1. QS1R website: http://www.srl-llc.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

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