NPR measuring method

The report outlines the conventional procedure with notch filter and describes an alternative procedure without notch filter.

NPR measurement via notch filter

The common procedure for NPR measurement (NPR=Noise Power Ratio) on RF receivers, includes a noise generator and a narrow-band steep notch filter, with a blocking attenuation of 100dB, so that in the bottom of the notch filter only the background noise (MDS) of the receiver is visible **(Fig. 1)**. If the applied, external noise signal is magnified until the SDR reaches its saturation, an additional noise appears in the base of the filter as well, indicating the resulting intermodulation. At the same time the noise at the AF output of the receiver increases by 3dB after (S+N)/N=2. This point then corresponds to the maximum dynamic range (P_{TOT}) of the SDR under test or its largest, distortion-free dynamic range.

As an example **Fig. 2** shows the NPR measurement on a broadband, 14Bit SDR without front-end filter (ColibriNANO, fe = 0-55MHz), measured with a noise bandwidth of 0 to 55MHz and a notch filter of 2.4MHz. At a noise level of P_{TOT} = -28dBm a maximal NPR of 50dB results. The NPR can be read on the screen, it corresponds to the difference between the injected noise power (P_{TOT}) and the limit sensitivity (MDS).

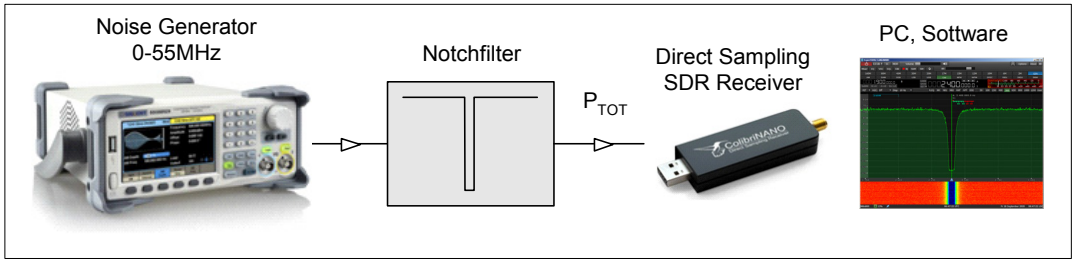

Fig.1: NPR measuring station

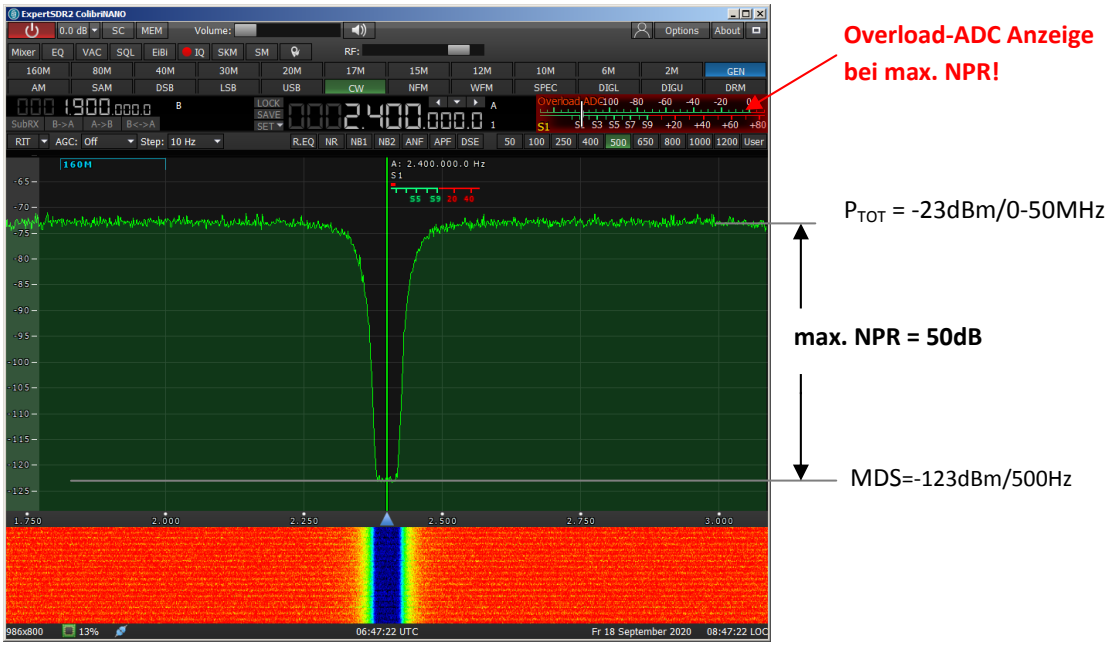

Fig. 2: NPR measurement via a notch filter

The NPR is calculated using the formula

NPR = P_{TOT} - 10log (noise bandwidth/resolution bandwidth) - sensitivity

NPR = -23dBm - 10lg (55MHz/500Hz) - 123dBm = -23dBm -50dB - (-123dBm) = 50dB

If the noise signal is further increased, the SDR very quickly reaches its limit (saturation, clipping) and produces strong intermodulation **(Fig. 3)**.

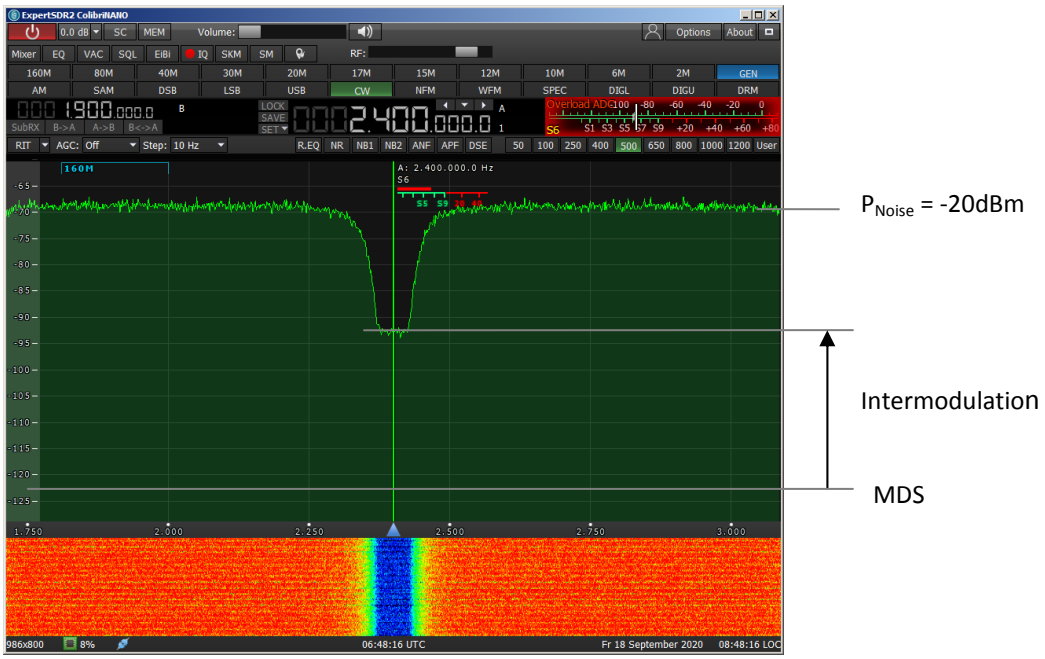

Fig. 3: SDR overload

Advantages and disadvantages

An advantage of the classic NPR measurement is the very precise NPR determination via the noise rise in the bottom of the notch filter or via the noise rise at the AF output. It's suitable for analog and digital receivers.

The following disadvantages apply: A suitable NPR measuring station is e.g. the noise level transmitter RS-50 from Wandel & Goltermann (1, 2), which is however difficult to obtain due to its age (year of manufacture 1970). The W&G RS-50 was also not originally developed for NPR measurements on SDR receivers, which means that it lacks some important functions. The NPR can only be measured on special frequencies, for example 1248kHz, 2438kHz or 3886kHz, but not directly on the valid amateur radio bands. The largest selectable noise bandwidth is only 316...17300kHz, so that an NPR cannot be measured on higher frequencies, such as in the 15 or 10m band. The do-it-yourself construction of an NPR measuring station, with suitable notch filters for all bands, which have a blocking attenuation of 100dB, is difficult and costly **(3)**.
An alternative to analog NPR test equipment would be a vector signal generator, but suitable instruments, such as the SMBV100A from R&S, are very expensive and do not have sufficient blocking depth.

NPR determination via Overload-ADC-Display

In the classic NPR measurement using a notch filter in **Fig. 2**, a red warning message "Overload ADC" appears on the screen at the same time at maximum NPR. This message indicates that the ADC is close to saturation. Since the Overload-ADC message and the maximal NPR are generated at the same noise level (P_{TOT}), the Overload display can therefore also be used to determine the NPR, whereby the Notchfilter is then no longer needed!

During the measurement in **Fig. 4** I left out the notch filter and determine the NPR only by the ADC overload display. This is of course no longer a "NPR measurement", but a NPR determination via the overflow display. The SDR is used here quasi as a measuring device. All you need now is a noise generator, which should cover the whole reception range of the SDR.

Measurement procedure: First, the sensitivity limit (background noise, MDS) of the receiver **(Fig. 5, left)** must be determined without an input signal. Then the noise generator is connected and the level is increased until the Overload-ADC indicator lights up in the display **(Fig. 5, right)**. This is done exactly as before with a level P_{TOT} = -23dBm. However, the warning message does not light up continuously, as it would do with a strong CW signal, but only appears as a flashing display. The maximum level of the ADC is reached at this moment and the difference between noise input (P_{TOT}) and sensitivity (MDS) corresponds to the maximum NPR. Also here I get an NPR of exactly 50dB. The NPR calculation is the same as before:

NPR = -23dBm - 10lg (55MHz/500Hz) - 123dBm = -23dBm -50dB - (-123dBm) = 50dB

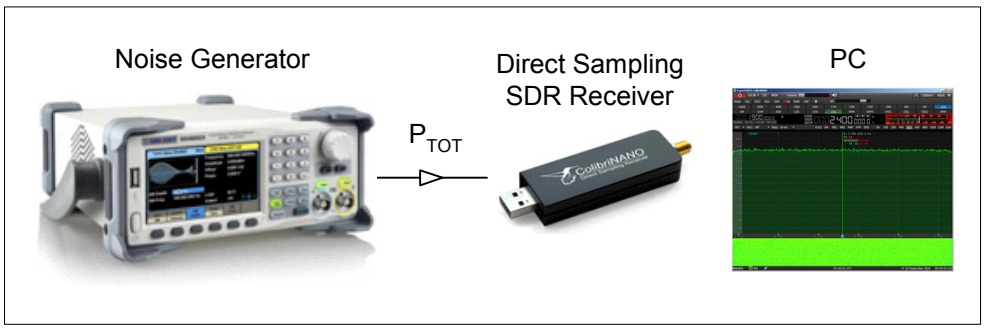

Figure 4: Simplified NPR measurement setup

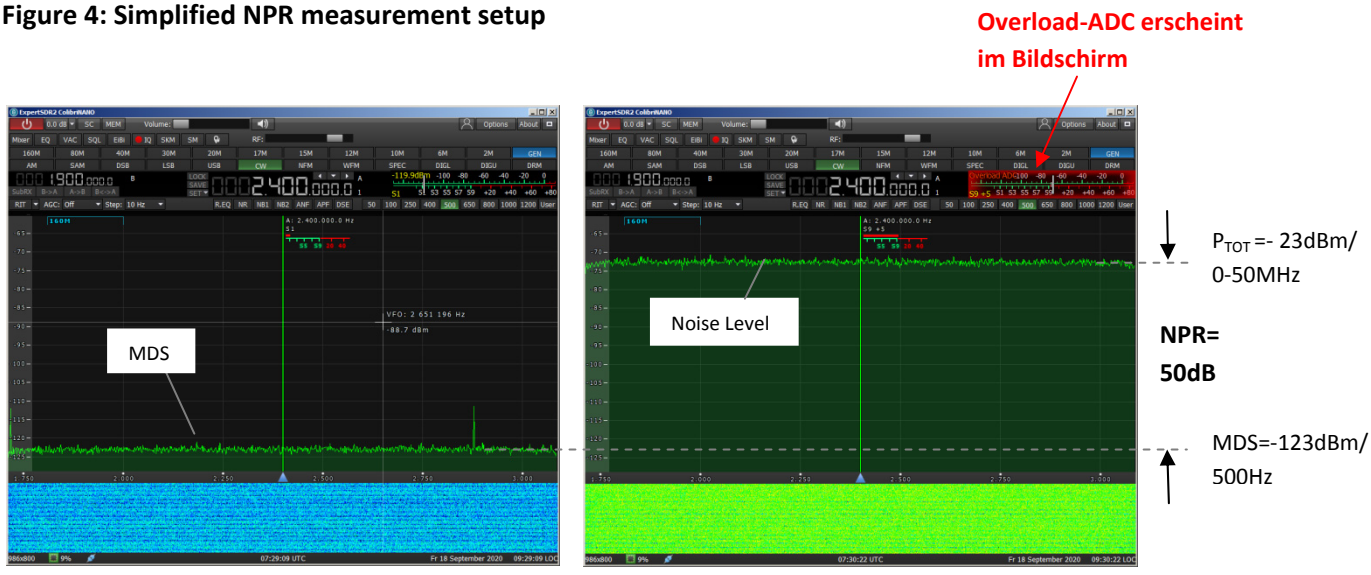

Figure 5: NPR measurement via Overload ADC and MDS

The advantages and disadvantages

Here are the advantages of NPR detection via overload ADC message:
- Simple and fast measurement.
- The NPR determination can be performed on any frequency of the SDR, e.g. 1.8MHz, 3.7MHz, 7.1MHz, 14.1MHz, 21.2MHz and 28.2MHz.
- works without notch filter

Complicated constructed notch filters with 100dB attenuation are no longer necessary.

The disadvantages: The NPR measurement can only work with direct scanning SDR's, which have an "ADC-Overload" display. With measurements on IC-7300 and ColibriNANO, I got the same NPR results as with Notchfilter. Whether the measurement works on other SDR's with OVL display as well, I cannot say!

Summary

The described NPR determination via the ADC-Overload display should not and cannot replace the classical NPR measurement via suitable notch filters. However, the effort for an NPR measuring station is quite high and the NPR detection via OVL should show an "affordable" alternative.

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Literature:

(1) Noise Power Ratio (NPR) Testing of RF Receivers, Adam Farson
https://www.ab4oj.com/test/docs/npr_test.pdf

(2) Noise Power Ration, DC4KU
http://www.dc4ku.darc.de/Noise-Power-Ratio.pdf

(3) HF-Measurements, OE3HKL, Kurt Hoffelner
http://www.oe3hkl.com/hf-measurements/npr-messplatz-rauschgenerator.html