Signal Hound®

Noise Power Ratio Testing on a Budget

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Application NOTE

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Introduction

Measuring intermodulation distortion is critical for the telecommunications industry. Two-tone IP3 testing is fine for many applications, but does not do a very good job of simulating actual channel conditions on a multi-carrier system, which more closely resembles bandwidth-limited white noise.

Noise power ratio (NPR) testing traditionally consists of a broadband Additive White Gaussian Noise (AWGN) source covering the entire bandwidth to be tested, and a deep, narrow notch filter somewhere within this bandwidth, typically 10% or less of the total bandwidth. The noise power ratio is the ratio of the signal power density to the power density of the notch, which is a combination of thermal noise and intermodulation products. While a band pass filtered noise source and notch filter may work in some cases, there is an easier way which is both inexpensive and far more flexible.

By averaging together several successive measurements using 1000-tone sets that have random-phase relationships, the CCDF curves nearly converge. That means that this synthetic noise technique closely approximates the AWGN/notch filter technique. Synthetic noise also lends itself to automated testing because it exists completely in the digital domain. There is no bandpass filter that requires manual tuning.

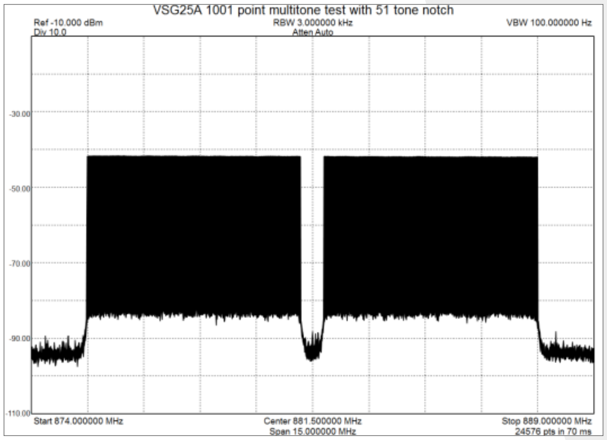

Figure 1—VSG25A test signal for NPR testing

A modern vector signal generator with 100 MHz of bandwidth, and capable of producing either digitally filtered AWGN, or 1000+ tones with a random phase relationship, is the foundation of modern NPR testing. Until now, these generators would cost you thousands, or even tens of thousands of dollars.

With the release of the new Signal Hound VSG25A, the cost of generating a 1001-tone notched test signal with up to 100 MHz of bandwidth is less than $600.

NPR measurement requires that you analyze the RF spectrum before and after the device under test (DUT) is inserted. The signal and notch are both converted to power density, and then a ratio is calculated, typically expressed in dB. Software to automate this process may be cost prohibitive. However, something as simple as adjacent channel power ratio (ACPR), a built-in measurement available for all Signal Hound spectrum analyzers, is all you need.

Since the output of the VSG25A already has flatness corrections applied, making it reasonably flat across its entire bandwidth, the power density anywhere outside of the notch will be fairly constant. As long as you set up your noise channel bandwidth to an integer multiple of your tone spacing, and center your channel within the noise, the channel power measurement should correlate very closely with the noise power ratio.

For a 1001 tone test, the BB60C and VSG25A together typically have a noise level of about 40 dB below the signal level without a device under test. This is sufficient for accurate NPR measurements to about 42 dB, after correcting for system noise. Using an Agilent PSA Series spectrum analyzer (instead of the BB60C) with the VSG25A, changes these numbers to 53 and 55 dB, respectively.

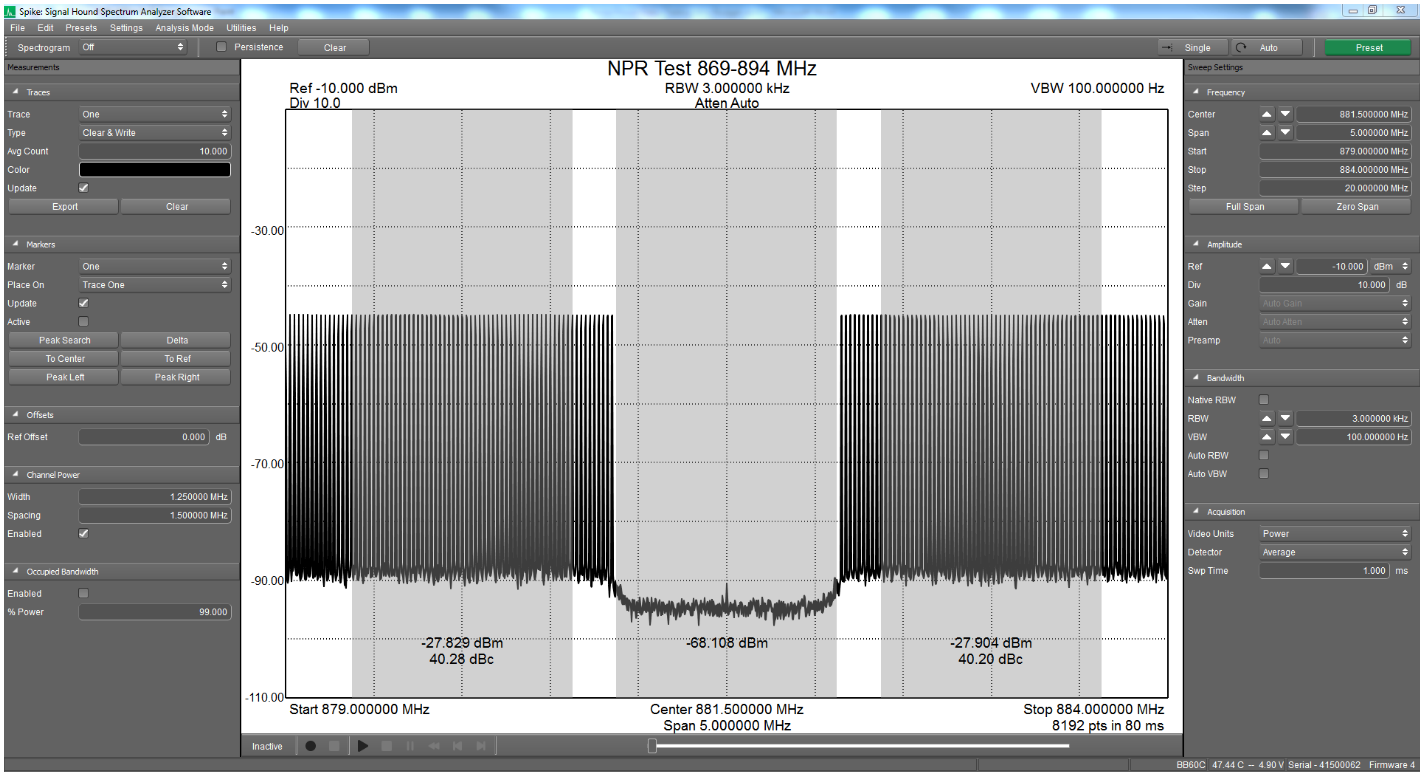

Figure 2—VSG25A 1001-tone, 25 MHz span NPR test noise floor with BB60C. Center 5 MHz shown.

There are a few corrections to apply, typically amounting to a fraction of a dB. If the DUT noise rises less than 15 dB from the system noise floor, subtract out the system noise. Additionally, if the notch bandwidth is more than 10% of the total bandwidth, compensating for the energy notched out may be desirable.

Procedure for Testing NPR with the VSG25A and BB60C

1. Generate The VSG25A output signal.

- **1.1.** Set the center frequency and amplitude.
- **1.2.** Select Multi-tone.
- **1.3.** Set tone spacing to 1/1000 desired noise bandwidth (1.00 kHz to 100 kHz).
- **1.4.** Select 1001 tones.
- **1.5.** Enter desired notch frequency and width, and then click APPLY.
- **1.6.** Null out the LO feed-through.
  - **1.6.1.** Using the BB60C and Spike™ software, observe the VSG25A signal.
  - **1.6.2.** Set center and span so you are measuring only the notch.
  - **1.6.3.** Peak search. This is the frequency of your LO feed-through.
  - **1.6.4.** Tweak I and Q offsets iteratively until the LO feed- through is at a minimum.

2. Measure your system noise for reference.
    - **1.1.** Using the channel power controls, enter a channel bandwidth approximately equal to your notch bandwidth, and channel spacing of approximately 25% more than your notch bandwidth.
    - **1.2.** Set your span to about 5 times your notch bandwidth so you can see adjacent channel power.
    - **1.3.** Look for the ACPR reading (in dBc). Average left and right ACPR for your system NPR noise floor.
    - **1.4.** Set the BB60C reference level for best NPR (typically +/- 5 dB from input signal level).
3. Insert your DUT. If it is an amplifier, add fixed attenuation after the amplifier to approximately cancel the gain.
4. Measure NPR by averaging left and right ACPR. Record value.
5. On the VSG controls, click the APPLY button again. After about a second, a new set of random tone phases will be ready for your next reading.
6. Repeat steps 4 and 5 until around 10 measurements have been made. Average these for your NPR measurement at this input amplitude.
7. Increase or decrease signal level on the VSG. For best accuracy, increase or decrease attenuation after the amplifier as well. Otherwise, increase or decrease the BB60C's reference level.
8. Repeat steps 4-7 until all amplitudes are measured.
9. Plot results as NPR (dB) vs. input power (see Figure 3 on the next page).

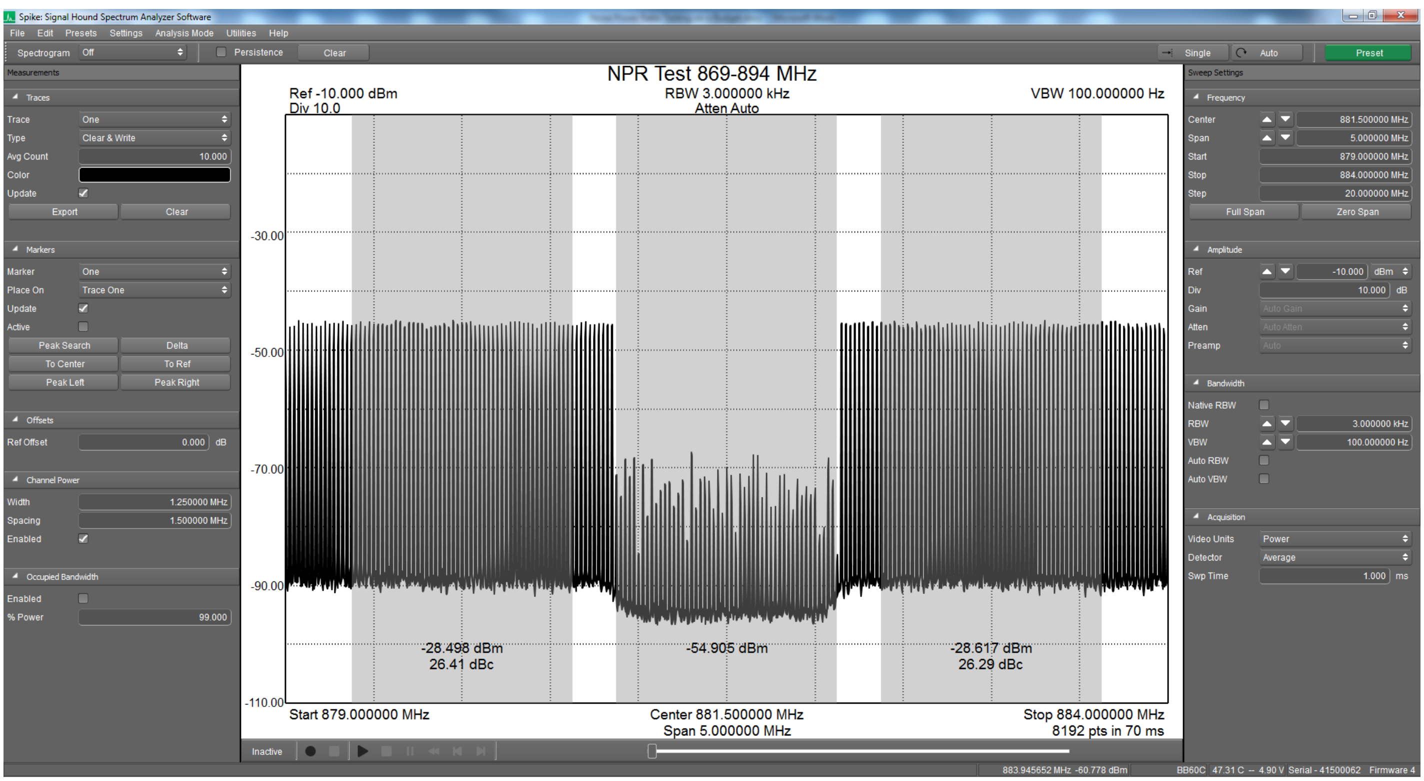

Figure 3—VSG25A 1001-tone, 25 MHz span NPR test of an amplifier. Center 5 MHz shown.

Further Reading

Download the VSG25A and BB60C manuals from SignalHound.com.

About Signal Hound

Signal Hound designs and builds powerful, affordable spectrum analyzers and signal generators for engineers and RF professionals around the globe. Whether you're needing EMC precompliance capabilities in a small two-person shop or spectrum monitoring on a national scale, our test equipment is designed with you in mind. Accurate and powerful enough for mission-critical RF analysis, priced at a point accessible to most, and supported by a talented group of engineers committed to what they do – we truly believe that our devices offer unrivaled value in the test equipment industry.

In business since 1996 and selling our own line of Signal Hound test equipment since 2010, we've built the foundation of our company on years of test equipment repair, service, hardware and software development, and manufacturing experience. Signal Hound is a small company with big goals – and an even bigger commitment to providing our customers with an outstanding experience when purchasing and using our products.

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