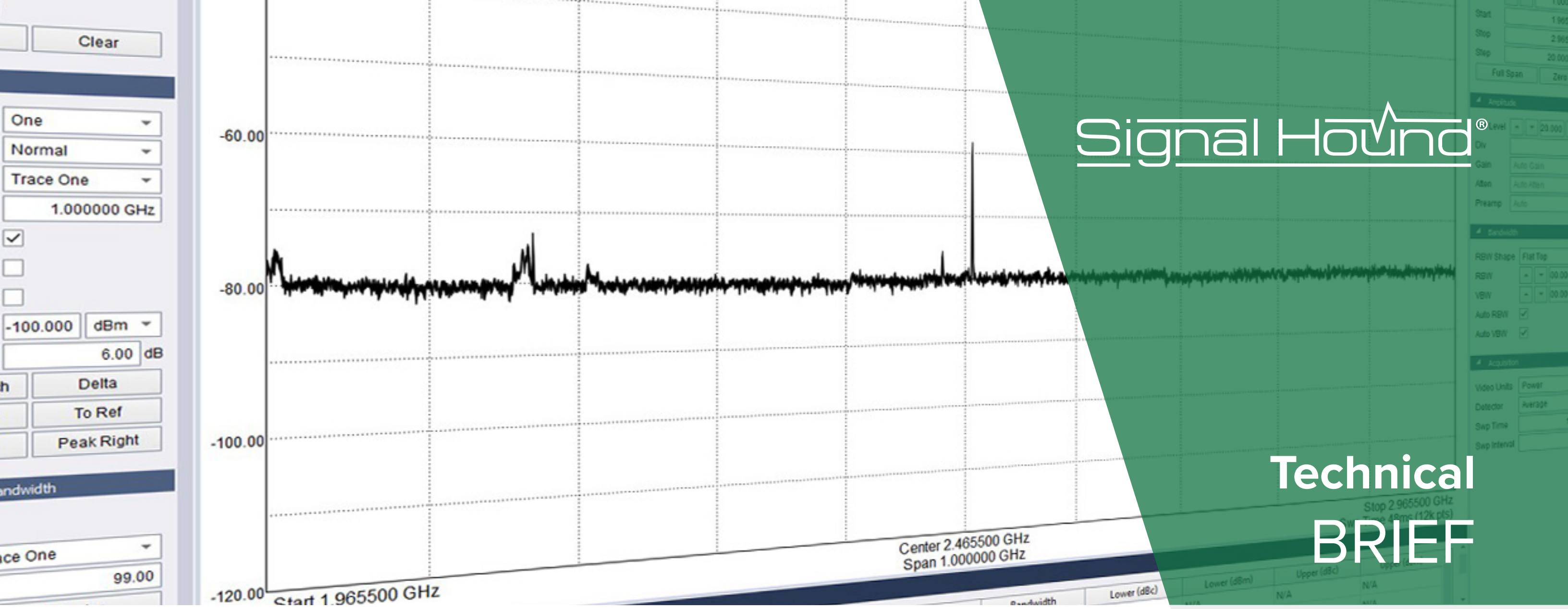

Technical BRIEF

Understanding the Noise Floor

on a Real-Time Spectrum Analyzer

Signal Hound is often asked about the performance of its real-time spectrum analyzers versus a traditional swept spectrum analyzer architecture. Today, real-time spectrum analyzers are universally available from the smallest to the biggest test and measurement equipment companies, and as the use of real-time spectrum analyzers becomes more prevalent in the industry, some common questions have followed.

This paper provides an overview on these topics and explains how the real-time spectrum analyzer architecture provides a comparable result to the traditional spectrum analyzer architecture of the past. This paper also provides actual measurements highlighting Signal Hound's real-time spectrum analyzer performance.

An Example Application for Reference

To aid in illustrating the concept of a noise floor, it is helpful to discuss this concept within the scope of an actual application. The application of electromagnetic interference (EMI) precompliance testing is one area producing some common architecture-related questions, with regard to spectrum analyzer types.

EMC regulations call out specific spectrum analyzer settings like resolution/video bandwidths and detector types (peak/average/quasi peak). For example, some Signal Hound customers are running MIL-STD-461 test method CE102 and conducted emissions in DO-160. These require peak detector measurements at relatively low signal levels, which drive relatively low noise floor specifications for the receivers used.

In the EMI world, the HP8566 spectrum analyzer was the industry standard. Engineers could simply set the instrument to "max hold" and come back to find the worst-case results. Today, Signal Hound's relatively low-cost and low-form factor BB60C provides comparable measurements.

About VBW and RBW

When looking for signals that may be close to the noise floor, it is important to set up the spectrum analyzer to minimize noise. Traditional swept frequency analyzers used their video bandwidth (VBW) filter for this. VBW basically acts as a low pass filter, reducing the noise floor, but not impacting the level of signals present.

With Signal Hound's real-time spectrum analyzer, there are no hardware VBW filters – this capability is performed in software. Signal Hound's software algorithms create a filtering effect on the IQ stream that essentially provides a similar result to traditional spectrum analyzers.

While the signals that are being tested will yield the same result, the noise level itself will be similar but not the same – after all, it's noise! (Note—the reason for this is a complicated answer, diving into the Gaussian noise probability curve − and the various filtering effects, both digital and analog − that smooth this curve.)

Both analog and digital resolution bandwidth (RBW) filters should behave similarly regarding noise. Digital RBWs are based on the window function used, so the shape is a little different than that of their analog counterparts; however, if the noise bandwidth matches, the response to noise is comparable.

In some cases, with the traditional swept frequency analyzer RBW filters, the 3 dB resolution bandwidth may be substantially different than the noise bandwidth, thus requiring a correction factor. Real-time analyzers with FFT-based RBWs do not have this issue as the two are very close together.

Generally, when concerned with peak readings, removing or minimizing the effect of VBW filters should come first. In Signal Hound's Spike™ software, if VBW > RBW is set, the video bandwidth filter is bypassed.

Figure 1a shows an example measurement when VBW is greater than RBW.

When VBW is set to be less than or equal to RBW, the effect of that VBW filter is digitally approximated by averaging. Figure 1b shows an example of this measurement.

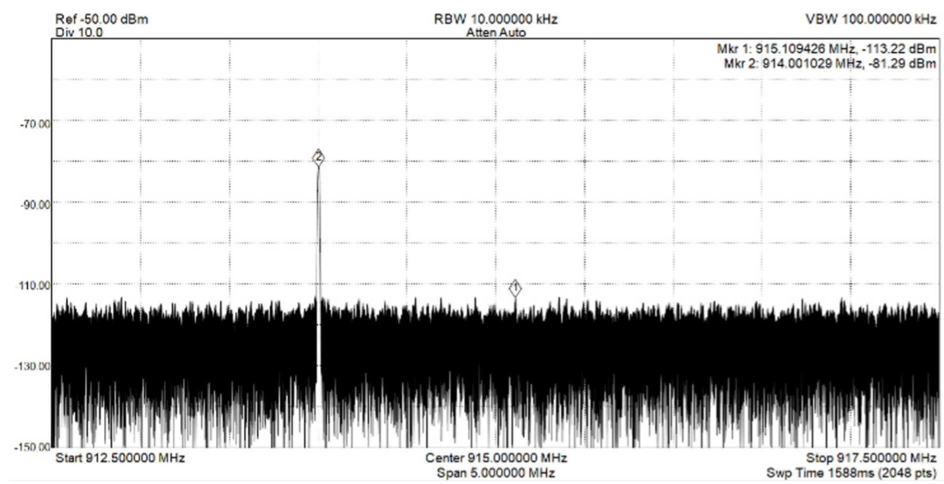

Figure 1a—VBW > RBW; RBW = 10 kHz, VBW = 100 kHz

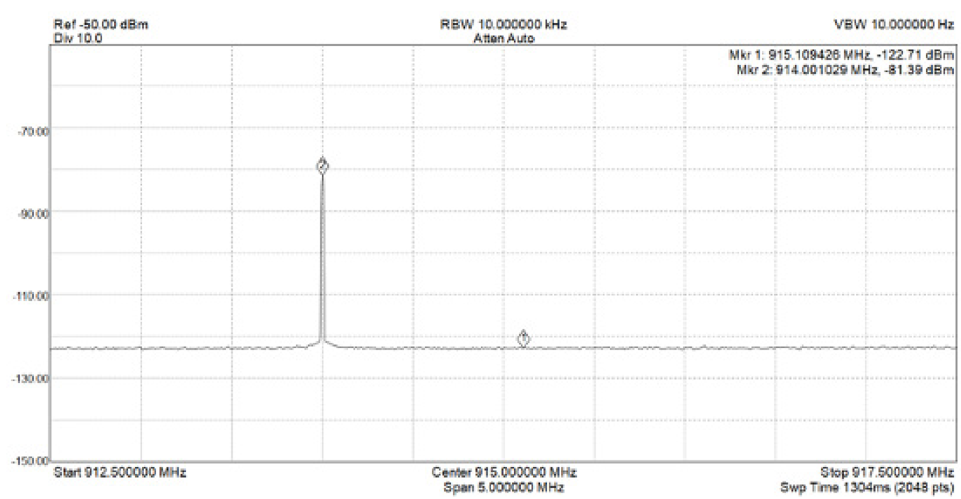

Figure 1b—VBW ≤ RBW; RBW = 10 kHz, VBW = 10 Hz

Figure 1—By adjusting the ratio of the RBW and VBW, one can drive the noise floor level without impacting the stationary signals that may be present. Real-time spectrum analyzers use software filtering that results in a comparable result to traditional swept frequency spectrum analyzers.

Detection Methods: Peak, average, and quasi-peak

For EMI pre-compliance testing, it is important to use the detector method required by the regulatory standards.

Commercial devices in the U.S. follow FCC Part 15, while military, automotive, and medical devices have industry specific standards. These standards specify how to measure the noise floor.

Most standards follow the CISPR 16-1 detection methods of peak, quasi-peak, and average. For traditional swept frequency spectrum analyzers, these were implemented with actual hardware. For Signal Hound's real-time spectrum analyzers, all three are implemented using the Spike™ software filtering algorithms.

- Peak detection captures the peak value received by the analyzer. In the old HP8566 days, this was achieved by setting the analyzer to "max hold" and letting it run for a while.
- Average detection provides the average value of the signal over its period.
- Quasi-peak detection weighs each component based on the repetition frequency of the spectral components making up the signal.

For general pre-compliance measurements, it is common to use peak detection as it offers a worst-case reference point for debugging the DUT.

As a rule of thumb, traditional spectrum analyzers typically had about a 10 dB difference when measuring the noise floor with either a peak or average detector. When comparing peak and average (Gaussian) noise, it is difficult to define an exact number because it depends on how far out on the Gaussian probability curve one may go, which is random to a point. The longer the dwell time, the higher the probability of a single, slightly higher measurement.

With the real-time spectrum analyzer, a range of 7-11 dB is typical, depending on settings. There will occasionally be outliers (as expected with a Gaussian distribution). Any smoothing or averaging will bring this number down quickly.

Setting the spectrum analyzer to peak detection for pre-compliance measurement is common as it provides a worst-case result. If the DUT passes using peak detection, there is about 8 dB of headroom for what may be seen during compliance measurements. If problems are found using peak detection, zoom into the problem areas and study them further using average or quasi-peak detection methods.

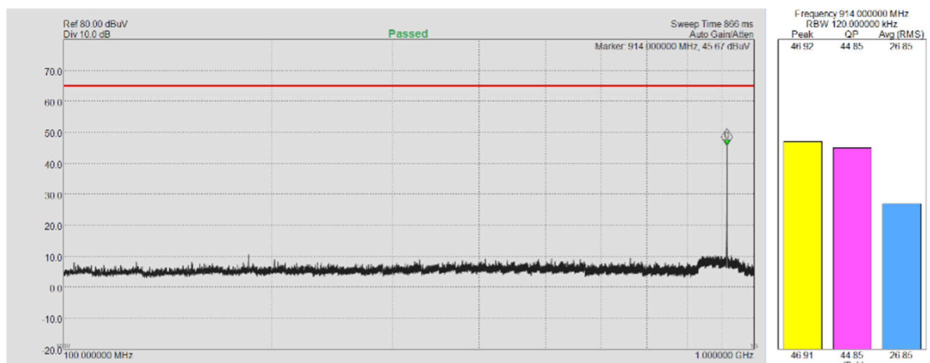

Figure 2a—Detector readings for primary signal level

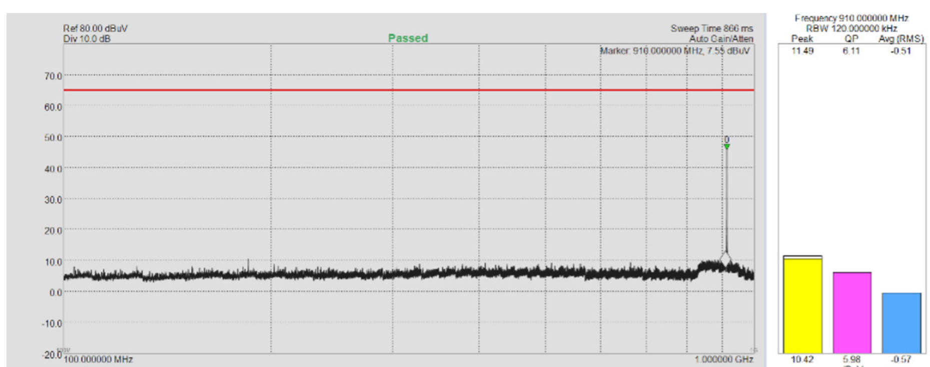

Figure 2b—Detector readings for noise floor

Figure 2—the BB60C highlights both the signal and noise levels for each of the detector types.

Determining Test System Noise Floor

Finally, this paper will discuss the general noise floor of the test setup based on measurement settings.

For this, factor in the BB60C's displayed average noise level (DANL), the regulatory standard's required RBW, any transducer factors (LISN, antenna), and a peak correction factor.

System Noise Floor = RTSA DANL + 10 log(RBW) + Transducer Factor + Correction Factor

For example, the BB60C specifies its DANL in dBm/Hz at a 1 Hz RBW. Therefore, for a conducted measurement from 500 kHz to 10 MHz, the BB60C DANL is -154 dBm/Hz. Factoring a 10 kHz RBW will add 40dB, resulting in a noise floor of:

- ➔ System Noise Floor = -154 + 40 + Transducer Factor + Correction Factor

  Or:

- ➔ System Noise Floor = -114 dBm + Transducer Factor + Correction Factor

Based on the equations above, the noise floor can be improved further with either the transducer or correction factors. Adding a pre-amplifier will boost signal levels above the noise floor, but across all frequencies. In cases where there are noisy signals due to the environment or test setup, one can add filters for out-of-band signal reductions. Where possible, adding a higher gain antenna can also improve the noise floor.

For more information about Signal Hound's real-time spectrum analyzers and Spike™ software, visit www.signalhound.com.

Further Reading

Learn more about Signal Hound's robust, real-time USB-powered spectrum analyzers at signalhound.com/learn.

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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