

Keysight Technologies

Five Hints for Successful Measurements in Noise

Improving Analyzer Sensitivity and Sweep Rate

Application Brief

Noise is a characteristic of electronic circuits which causes random disturbances of useful information between a transmitter and a receiver. Therefore, it is a fundamental parameter to be tested in all transmitter and receiver components as it typically limits the overall performance of any wireless system. As signal and spectrum analyzers are high-performance broadband receivers, internal noise impacts the analyzer's ability to measure very low amplitude signals while maintaining high accuracy and fast sweep speed. This note discusses the top hints to improve measurement sensitivity and accuracy for small signals, especially those near the noise.



Unlocking Measurement Insights

Hint 1: Reduce the resolution bandwidth

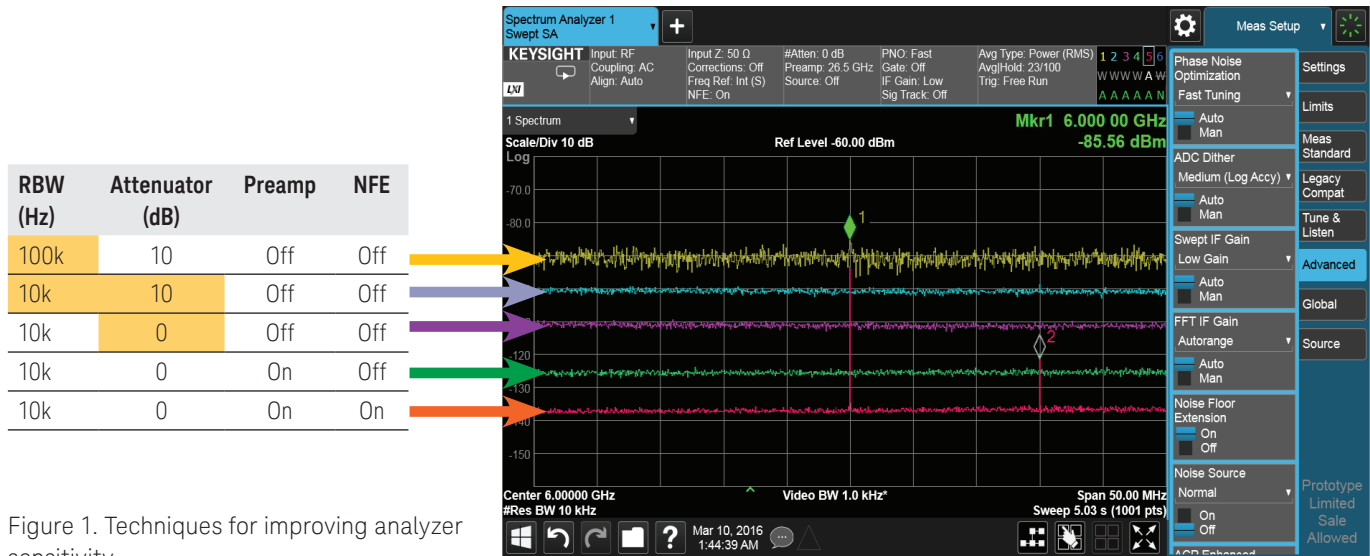
Figure 1 shows several measurements of the same low-amplitude signal as the analyzer settings are adjusted to improve the noise floor of the instrument. To begin, the upper trace (yellow) shows a typical measurement using a signal analyzer configured with 100 kHz resolution bandwidth (RBW) filter and 10 dB front-end attenuation. Here the signal amplitude is very close to the displayed noise floor of the instrument. A marker (marker 1) placed at the peak of the signal reports an amplitude of -85.56 dBm. When comparing the peak to the displayed noise floor, there is about a 5 dB Signal-to-Noise Ratio (SNR) for this baseline measurement. This low SNR will impact the accuracy of the amplitude measurement. The blue trace in Figure 1 has a 10 dB lower noise floor when the RBW is reduced from 100 kHz to 10 kHz. The noise floor can be further reduced using this technique but at the expense of increased sweep time. On traditional analog resolution filters, it can be shown that analyzer sweep rate is inversely proportional to the square of the RBW.

Hint 2: Reduce signal analyzer attenuation

There are other techniques that will improve analyzer sensitivity without increasing sweep time, such as reducing the front-end attenuation of the analyzer. This attenuation technique allows the operator to manually adjust the analyzer's input attenuator down to 0 dB. The magenta trace in Figure 1 shows the improved noise floor with a 0 dB attenuation setting. Caution must be observed when removing front-end attenuation, as it is possible to overdrive the analyzer if another high-power signal is present along with the desired low-power signal to be measured.

Hint 3: Use a preamplifier

The preamplifier technique requires an analyzer configured with a broadband internal or external preamplifier. The preamplifier improves the system's noise figure and lowers the displayed noise floor, as shown in the green trace of Figure 1. The analyzer's internal preamplifier reduces the noise floor by an additional 15 dB. It is now possible to observe a spurious tone highlighted at marker 2 that was not seen before.



Hint 4: Remove the signal analyzer's noise from the measured signal

Another technique that improves analyzer sensitivity is Noise Floor Extension (NFE) which is available on Keysight's X-Series signal analyzers. The NFE process identifies the instrument noise contribution to the signal for the current instrument state and automatically subtracts it from the measurement in real time from spectrum results. The red trace in Figure 1 shows the measurement with NFE applied resulting in an additional 8 dB reduction in the displayed noise floor.

The effectiveness of NFE can be expressed in several ways. Average noise power in the display (DANL) is usually reduced by 10 to 12 dB in the analyzer's low band (below 3.6 GHz) and about 8 dB in its high band (above 3.6 GHz). While the apparent noise level will be reduced, only the analyzer's noise power is being subtracted. Therefore, the apparent power of signals in the display will be reduced if the analyzer's noise power is a significant part of their power, and not otherwise. In Figure 2, a signal with multiple tones of decreasing amplitudes measured near the analyzer's uncompensated noise floor is shown by the yellow trace. Using NFE yields the more accurate trace in blue. Note that the error due to analyzer noise contribution is negligible for the first/highest tone, but is approximately 3 dB for the 6th tone, where the tone amplitude is approximately the same as the analyzer's noise floor.

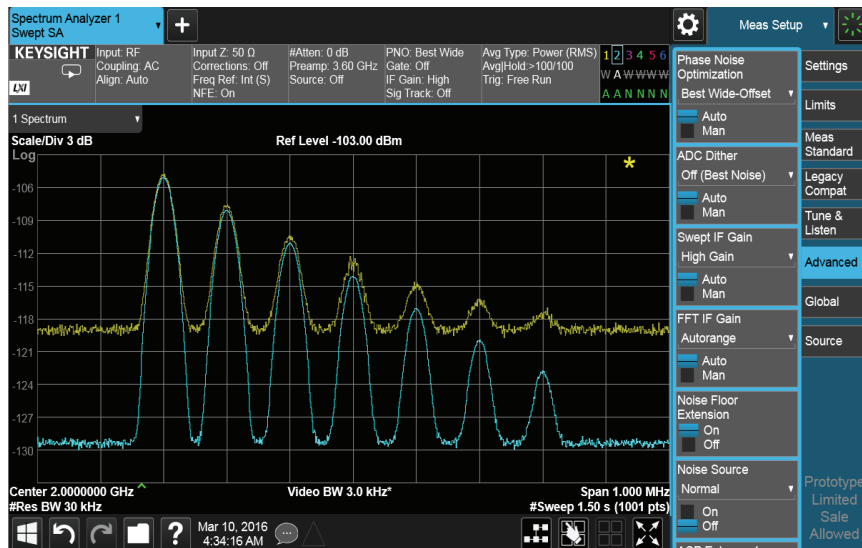


Figure 2. NFE improves effective noise floor by 10+ dB and requires no user action beyond keystroke activation.

Hint 5: Use oversweep to speed up sweep time

Traditionally, a signal analyzer will automatically couple the sweep time to the frequency span and selected resolution bandwidth (RBW) in order to maintain a calibrated display. When the sweep time is reduced below an acceptable point, amplitude and frequency errors occur. The grey trace in Figure 3 shows a measurement with the proper sweep time setting. The red trace shows a measurement having a sweep time that is too low, resulting in amplitude and frequency errors. When using a fully-digital IF, the “oversweep” technique characterizes the digital RBW response and corrects these errors, resulting in faster sweep rates than would be possible with traditional analog RBW filtering. Keysight refers to this technique as fast sweep¹ and provides sweep rates up to 50 times faster than traditional methods without compromising measurement accuracy.

The X-Series signal analyzers with Option FS1 are programmed to correct for the effect of sweeping too fast for resolution bandwidths between about 3 kHz and 300 kHz. As a result, sweep times that would otherwise be many seconds may be reduced to milliseconds, depending upon the particular settings. Table 1 shows a comparison of the sweep times for an analyzer measuring across a 26.5 GHz span using traditional RBW filtering and then configured with fast sweep.

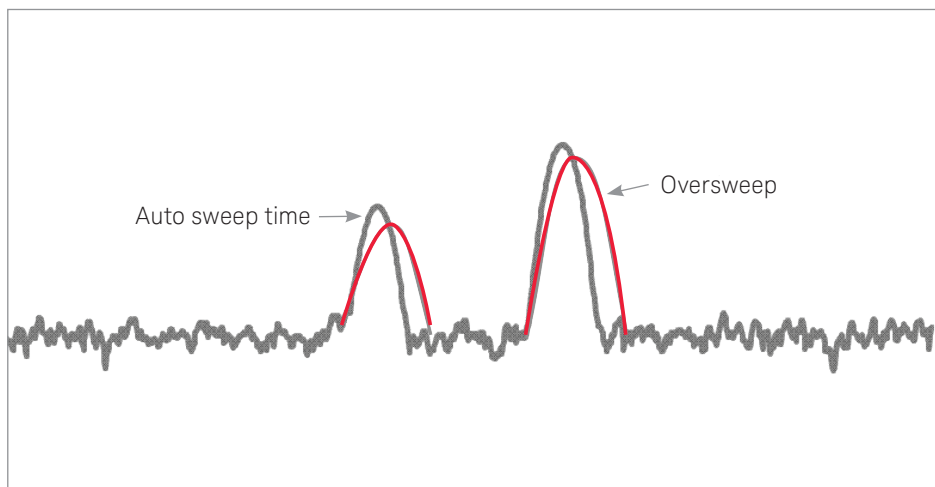


Figure 3. Effects of oversweeping the RBW filter.

RBW	Traditional methods (secs)	Fast sweep option FS1 (secs)
1 kHz	> 4000	540
3 kHz	2710	60
10 kHz	244	5.8
30 kHz	27.1	0.9

Table 1. 26.5 GHz sweep time comparisons: traditional methods versus the X-series fast sweep option.

1. If further information on fast sweep and spur search methodology is desired, refer to application note 5991-3739EN.

Keysight EXA X-Series signal analyzers offer the highest sensitivity and fastest sweep rates available in mid-range analyzers

It is possible to apply one or any combination of these techniques in order to improve the noise floor to acceptable levels. With Keysight Technologies' EXA N9010B signal analyzer, you can more easily find and analyze your signal, as well as spurs and anomalies that you would not have seen before because they were hidden in the noise. The EXA gives you more measurement insight with sensitivities between -165 dBm/Hz and -153 dBm/Hz, providing you the flexibility for a wide range of challenging noise and spurious measurements. When the N9010B is configured with an internal preamplifier option (several choices available) and the industry's only smart USB preamplifier (U7227A/C/F), the sensitivity of the instrument improves. Preconfigured with fast sweep, and with the added NFE option, the N9010B will provide the highest sensitivity and fastest sweep rates of any mid-range analyzer on the market today.

N9010B EXA signal analyzer configuration for best sensitivity and fast sweep	
Step 1. Select maximum frequency range (required option)	
Frequency options (select one)	Option Description
	503 10 Hz to 3.6 GHz
	507 10 Hz to 7.0 GHz
	513 10 Hz to 13.6 GHz
	526 10 Hz to 26.5 GHz
	532 10 Hz to 32 GHz
544 10 Hz to 44 GHz	
Step 2. Add a preamplifier	
Preamplifier options (select one)	P03 100 kHz to 3.6 GHz
	P07 100 kHz to 7.0 GHz
	P13 100 kHz to 13.6 GHz
	P26 100 kHz to 26.5 GHz
	P32 100 kHz to 32 GHz
	P44 100 kHz to 44 GHz



Figure 4. Configuring the EXA with industry's only smart USB preamplifier, the Keysight U7227A/C/F, improved the sensitivity of the instrument.

DOWNLOAD YOUR NEXT **↓INSIGHT**

Keysight software is downloadable expertise. From first simulation through first customer shipment, we deliver the tools your team needs to accelerate from data to information to actionable insight.

- Electronic design automation (EDA) software
- Application software
- Programming environments
- Productivity software

Learn more at

www.keysight.com/find/software

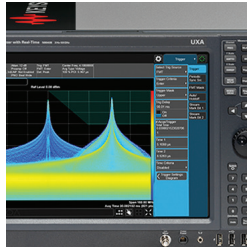
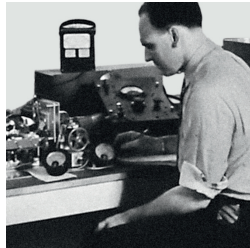
Start with a 30-day free trial.

www.keysight.com/find/free_trials

U7227 Series USB preamplifiers			
	U7227A	U7227C	U7227F
Frequency	10 MHz to 4 GHz	100 MHz to 26.5 GHz	2 to 50 GHz

From Hewlett-Packard through Agilent to Keysight

For more than 75 years, we've been helping you unlock measurement insights. Our unique combination of hardware, software and people can help you reach your next breakthrough. **Unlocking measurement insights since 1939.**



For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

Americas

Canada	(877) 894 4414
Brazil	55 11 3351 7010
Mexico	001 800 254 2440
United States	(800) 829 4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 11 2626
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 6375 8100

Europe & Middle East

Austria	0800 001122
Belgium	0800 58580
Finland	0800 523252
France	0805 980333
Germany	0800 6270999
Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	800 000154
Sweden	0200 882255
Switzerland	0800 805353
	Opt. 1 (DE)
	Opt. 2 (FR)
	Opt. 3 (IT)
United Kingdom	0800 0260637

For other unlisted countries: www.keysight.com/find/contactus (BP-02-10-16)



www.keysight.com/go/quality
Keysight Technologies, Inc.
DEKRA Certified ISO 9001:2015
Quality Management System

myKeysight
www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

Three-Year Warranty

www.keysight.com/find/ThreeYearWarranty
Keysight's committed to superior product quality and lower total cost of ownership. Keysight is the only test and measurement company with three-year warranty standard on all instruments, worldwide. And, we provide a one-year warranty on many accessories, calibration devices, systems and custom products.



Keysight Assurance Plans

www.keysight.com/find/AssurancePlans
Up to ten years of protection and no budgetary surprises to ensure your instruments are operating to specification, so you can rely on accurate measurements.



Keysight Infoline

Keysight Infoline
www.keysight.com/find/service
Keysight's insight to best in class information management. Free access to your Keysight equipment company reports and e-library.

Keysight Channel Partners

www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

www.keysight.com/find/switch2exa