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.

KEYSIGHT TECHNOLOGIES

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.

RBW (Hz)	Attenuator (dB)	Preamp	NFE
100k	10		
10k	10		
10k	0		
10k	0		
10k	0		

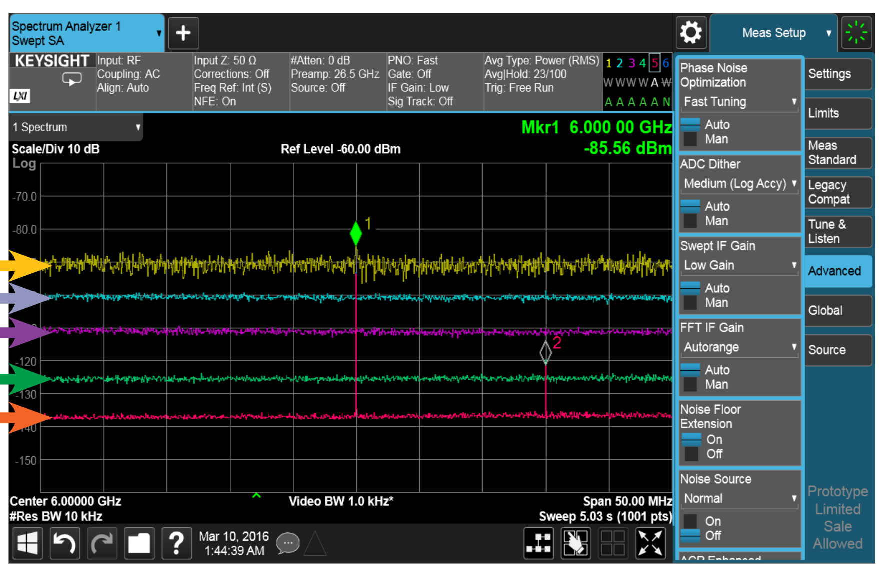

Figure 1. Techniques for improving analyzer sensitivity.

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.

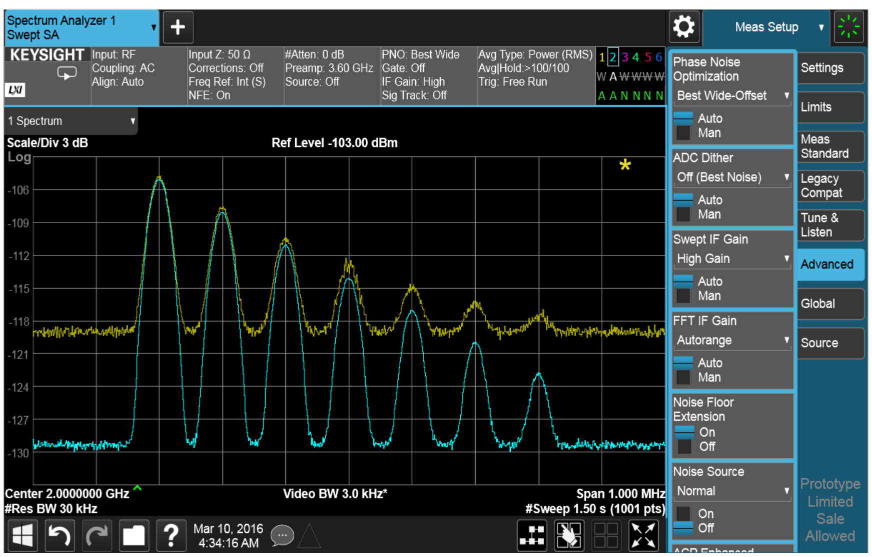

Figure 2. NFE improves effective noise floor by 10+ dB and requires no user action beyond keystroke activation.

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 sweep[1] 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.

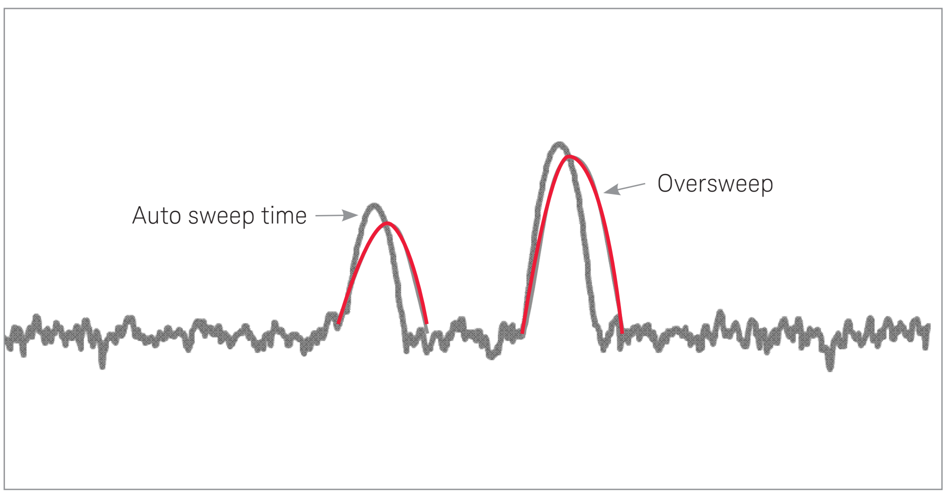

Figure 3. Effects of oversweeping the RBW filter.

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. 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

For the different techniques discussed, it is possible to apply one or any combination 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)		
	Option	Description
Frequency options (select one)	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.

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

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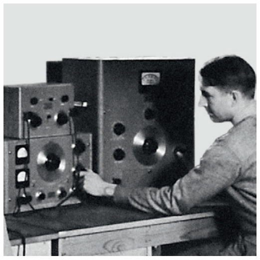
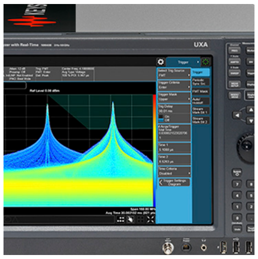


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