Configuring the Spectrum Analyzer to Measure Low-Level Signals

Bird Systems/Applications Engineering

Introduction

Measuring low-level signals with a spectrum analyzer is a common challenge. The fundamental reason for this is the noise generated within the spectrum analyzer limits the lowest signal level detectable. Even if a user knows the specified noise level of the spectrum analyzer when terminated with a 50Ohm load ("Displayed Average Noise Level" or "Noise Floor"), he or she may not be fully aware of how to properly configure the analyzer to achieve that specification. Also, the settings required to achieve the terminated DANL specification may not be suitable for every application.

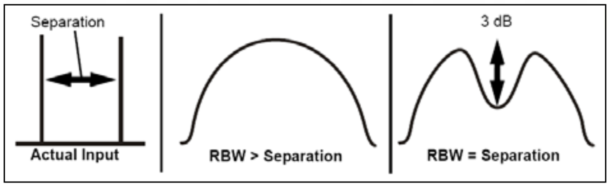
The Noise Floor, or Displayed Average Noise Level (DANL), of a spectrum analyzer determines the lowest possible signal level that can be measured by the unit. For example, if one is attempting to measure a signal that is -130dBm, the spectrum analyzer must have a DANL that is lower than -130dBm. Ideally, the measured signal should be a few dB above the DANL in order to be clearly discernable. If the input signal's noise level is greater than the spectrum analyzer's DANL, then the noise level of the input signal will dominate. In this case, nothing can be done to further lower the noise displayed on the unit.

Many factors affect the DANL of a spectrum analyzer. A spectrum analyzer may allow for a very low minimum DANL, but without optimizing the settings of the internal signal processing chain, the DANL displayed may be much higher. In order to optimize the spectrum analyzer, one must first understand the contributing factors behind DANL. For example, the minimum DANL specification of Bird's SignalHawk is -135dBm and is achieved with the following settings:

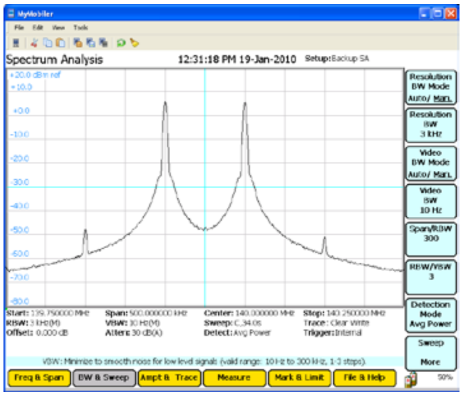
- Resolution Bandwidth (RBW) of 100Hz
- Video Bandwidth (VBW) of 10Hz
- Preamp Gain of 24dB
- Average Detection Mode

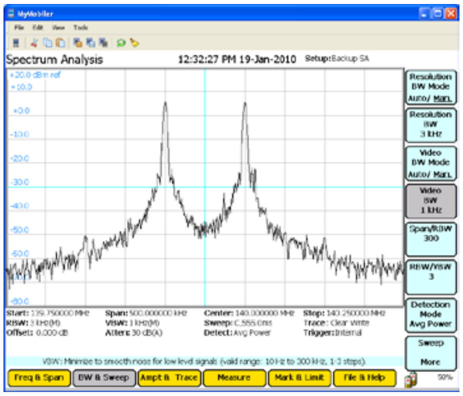
This minimum DANL will only be achieved when the input of the analyzer is terminated with 50Ohms or is excited by a signal source having a significantly lower noise level than the DANL.

The Resolution Bandwidth (RBW) of a spectrum analyzer determines the smallest resolvable frequency separation. The easiest way to understand how RBW affects the trace shown on a spectrum analyzer is to think of RBW as the width of spectrum that is analyzed in one step. In this analogy, using a wider RBW analyzes a larger portion of spectrum at once and completes the entire sweep in less time, but will reduce trace detail. If the RBW is wider than the frequency separation of two signals, then both signals will be analyzed within the bandwidth and the spectrum analyzer will display only one apparent signal on the screen. If the RBW is equal to the frequency separation of the two signals, a 3dB dip between the two signals will appear.



As the RBW decreases, more and more resolution between the two signals will be seen, and consequently, one full sweep over the set span will take longer to complete. It is important to note, however, that RBW can be too narrow in some instances. For example, if the RBW is not wide enough to include the sidebands of a modulated signal, the spectrum analyzer will display an inaccurate measurement. As RBW width decreases, the amount of uncorrelated noise power decreases, and this reduces the DANL seen on the spectrum analyzer.

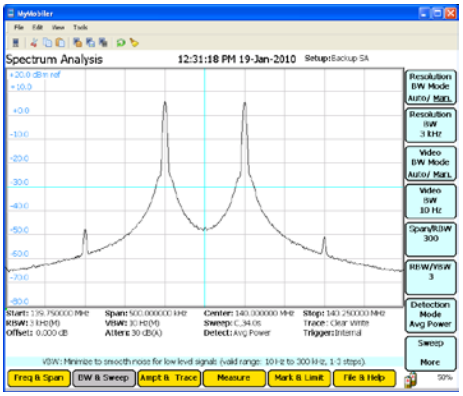


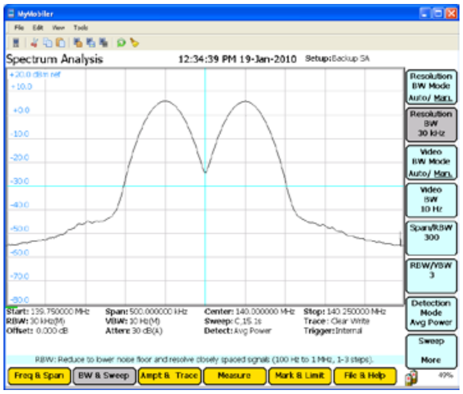


Ex. Actual Signal Input

Ex. Wider RBW

Video Bandwidth (VBW) determines how much smoothing is performed by the spectrum analyzer's video filter after the collected RF signal is converted to a video signal for display. Since VBW follows RBW in the processing chain, no smoothing takes place if VBW is wider than or equal to RBW. Reducing VBW decreases the magnitude of the displayed noise, thus signals near the noise floor can be perceived. However, reducing VBW also increases the sweep time.





Ex. Actual Signal Input

Ex. Wider VBW

The Preamp Gain setting controls the built-in low-noise amplifier on the signal input. Because the spectrum analyzer's internal noise is a constant and is generated by the circuitry following this preamp, the DANL of the unit can be lowered by amplifying the incoming signal, then compensating for the applied internal preamp gain. For example, a -30dBm signal is passed through the internal preamp having a 24dB gain. The resulting signal would display at a level of -6dBm without compensation. However, since the preamp is internal to the spectrum analyzer, this displayed signal is automatically corrected to the original -30dBm value. Consequently, if the internal noise of the spectrum analyzer following the preamp is -110dBm, it displays at a level of -134dBm once the

24dB correction is applied. If there is no signal injected into the spectrum analyzer, then the effective DANL is lowered by approximately the amount of internal preamp gain applied. One must be careful about using a spectrum analyzer's internal preamp since applying too much power to the following internal circuitry of the unit could cause internal damage. For example, the preamp on Bird's SignalHawk should not be used with input signals greater than -30dBm.

Setting the Detection Mode to Average displays the average of the raw data collected for each display pixel. This is recommended for noise-reduction, since averaging the multiple raw data samples collected for each data point makes the resulting measurement less sensitive to noise. The number of raw data samples collected by Bird's SignalHawk is controlled by a combination of the RBW, VBW, and chosen frequency span settings.

A spectrum analyzer may be capable of measuring low-level signals, however, it should be understood that the sweep time will be very long based on the settings used to obtain the DANL specification. Changing any of the settings above in order to decrease the sweep time will also increase the DANL. In general, if the span is kept constant, sweep time will be increased by using more data points, decreasing RBW, or decreasing VBW. Yet, once these conditions are understood, measuring hard-to-detect low-level signals is no longer a challenge.