Application Note

Using Anritsu's Spectrum Master™ and Economy Bench Spectrum Analyzers to Measure SSB Noise and Jitter

MS271xB

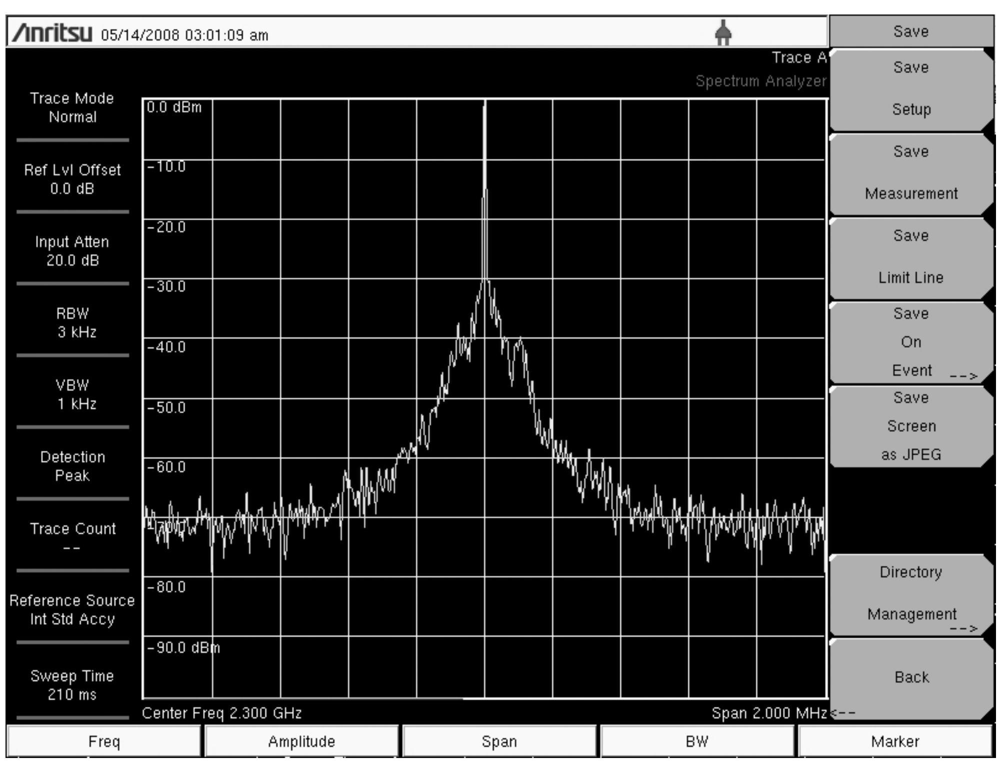
Economy Spectrum Analyzer

MS272xB

Spectrum Master™

SSB noise can easily be seen on a spectrum analyzer by looking at the signal "skirts" when viewing a sine wave signal (see the figure below). If the resolution bandwidth is narrow relative to the measurement span, (<1/1000) and you see noise on the skirt away from the CW signal frequency you are seeing SSB noise. Quantifying the amount of SSB noise for a test oscillator must be done carefully as it is not possible to distinguish SSB noise from the test oscillator from the SSB noise of the local oscillators in the spectrum analyzer itself. The best way to guarantee good DUT measurements is to use a spectrum analyzer that has far better phase noise performance than the DUT.

Spectrum analyzer SSB noise measurements do not distinguish between phase noise (PM) and amplitude (AM) noise. However, AM noise on CW signals is typically minimal and good correlation is found between spectrum analyzer SSB values and phase noise values measured with dedicated phase noise measurement equipment.

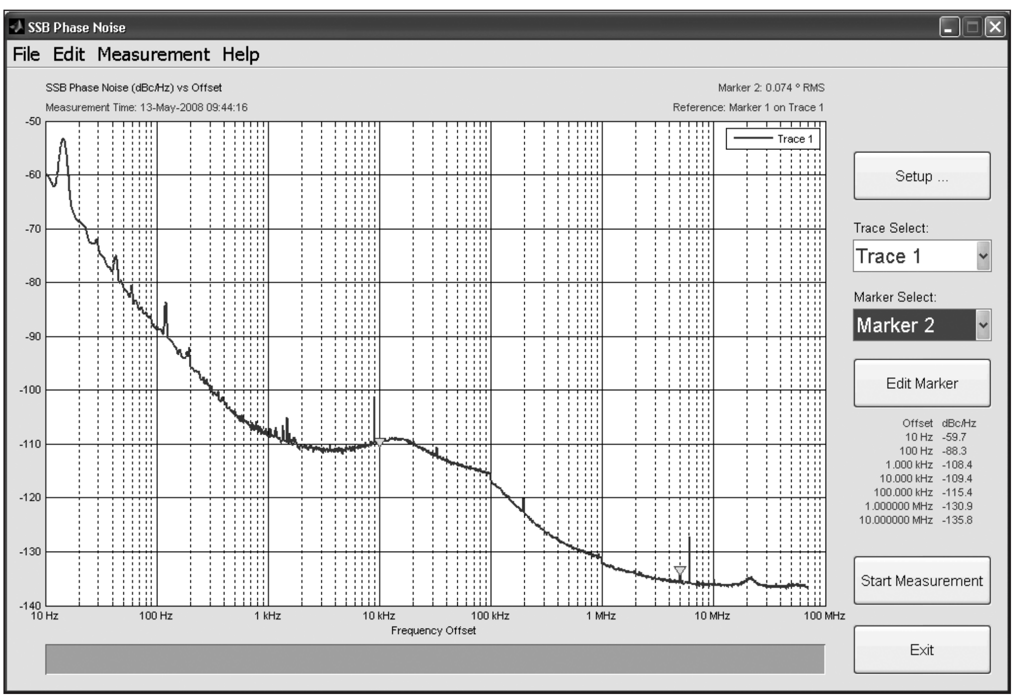


The Anritsu Spectrum Master and Economy Bench Spectrum Analyzers, have exceptional phase noise performance allowing them to be used measure the synthesized local oscillators in wireless communications equipment.

Spectrum analyzers are not appropriate, however, for measuring very high quality synthesizers, such as laboratory grade synthesized Signal Generators or atomic clocks. In this case, the measurement would be of the residual phase noise floor of the spectrum analyzer, rather than of the device under test. A spectrum analyzer is also of limited use when measuring drifting sources such as VCOs, because the VCO frequency drift can affect the measurement. At large offsets, such as >1 MHz, this is usually not a problem, but at small offsets such as 1 kHz, the VCO output will often drift out of the measurement span, invalidating the results.

Phase noise is quantified in dBc/Hz at various offsets from the carrier. c is the test signal carrier power and the noise is the RMS power in a 1 Hz bandwidth. Spectrum analyzers directly display power in the RBW used along the horizontal axis. The CW power does not change with RBW. The measured noise power does change by 10 dB for each decade change in BW used. Generally measurements are taken over 5 or more decades of offset frequency starting at just 10 Hz and going out beyond 10 MHz from the carrier frequency. Multiple RBWs are generally used to collect this data as it would take 20 million seconds(K*span/(BW*BW), where k~2), to sweep a 1 Hz filter over a 10 MHz span. A software program is generally used to combine the many separate measurements together to provide a continuous plot over many decades of frequency offset.

Below is a plot of phase noise relative to the carrier vs frequency offset which was made using Phase Noise Measurement Software PN 2300-517 for Anritsu's Spectrum Master and Economy Bench analyzers.



Example of Phase Noise Plot with Jitter Measurement from 10 kHz to 5 MHz Offset; Markers Delimit the Frequency Offset Range for the Jitter Measurement.

LO noise requirements are often specified as a single RMS jitter value. This jitter value can be determined by integrating the phase noise results over many decades of offset, and conversion to the correct units – degrees, radians, or seconds

The range of offsets to arrive at the jitter value is typically from the symbol rate of the communications system out to the system bandwidth . For OFDM communications systems such as WiMAX, the limit at the symbol rate is because the Common Phase Error (CPE) is removed by the receiver, and CPE is primarily at offsets less than the symbol rate. Offsets larger than the system bandwidth are filtered by the receive filter, and again will have little influence.

For WiMAX, the exact offsets will depend on the specific profile being used, but one example might use offsets from 10 kHz to 5 MHz. For LTE, the principle is the same, but the offsets would be slightly different, and again depend on the mode that the radio will use. An example for LTE might be 15 kHz to 20 MHz.

The phase noise graph provides more than just a way to get the jitter over a specific frequency offset range; it's also a tool for better understanding the PLL operation. If we examine the phase noise plot in the above figure we see several distinct regions. For the range of offsets from 10 Hz to about 1 kHz and from about 100 kHz to 1 MHz, there is a roughly constant slope of 20 dB per decade. These are the regions where the resonant elements in the frequency reference and the VCO are dominant. From about 1 kHz to 10 kHz, we see a flat region, transitioning to the 20 dB/decade slope on either end. This is the broadband noise floor of the reference, when multiplied up to the RF frequency. The PLL loop bandwidth is also in this region, probably near the high end of the range. Depending on the loop filter, there may be a large peak in this region, which indicates an underdamped condition, and can cause instability problems. Above about 1 MHz or so offset, we see the broadband noise of the VCO.

Conclusion

Phase noise and jitter are key performance metrics for local oscillators for wireless broadband transmitters and receivers.

An excellent way to verify the jitter performance of these local oscillators is to use the Anritsu Spectrum Master and Economy Bench analyzers with 2300-517 Phase Noise Measurement Software. This combination is low cost, has plenty of performance, and easily shows the jitter over commonly used ranges of frequency offsets.

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