Measuring Signal Source Phase Noise

Why You Can't Just Use a Spectrum Analyzer

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Industry has an increasing demand for spectrally pure signals in applications such as imaging radar, mobile communications, satellite communications, weather monitoring, etc. This requires fast, accurate and reproducible characterization of signal generation devices. Dedicated phase noise and amplitude noise measurement systems are needed with typically better than a -180 dBc/Hz measurement noise floor. What is needed are instruments to measure the Absolute Phase Noise of crystal oscillators (VCXO, OCXOs), SAW Oscillators, synthesizers, Phase Locked loops and VCOs (locked, or free-run high-Q), as well as the Additive Phase Noise of Amplifiers, Mixers, Frequency Dividers, and Multipliers.

Though a spectrum analyzer can be used to yield some characteristics, it is not very helpful for distinguishing amplitude and phase noise. Not only is separating amplitude and phase noise impossible, spectrum analyzers have inadequate dynamic range and noise-floor; the phase noise of the internal local oscillator in spectrum analyzers is too high, and they lack resolution bandwidth. For this reason, a dedicated system that demodulates and then analyzes amplitude and phase noise separately is required.

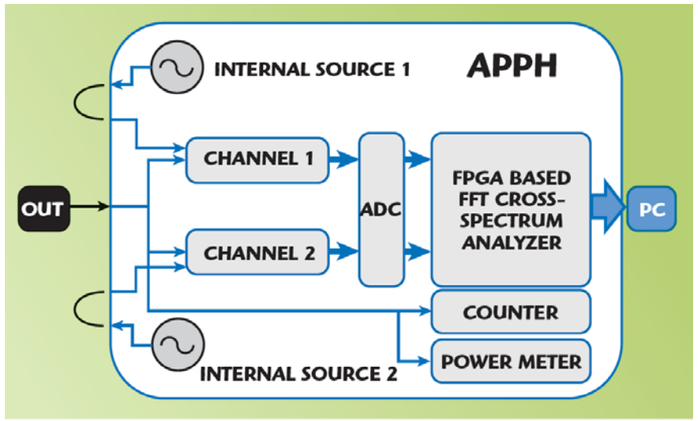

Fig. 1: APPH system block diagram.

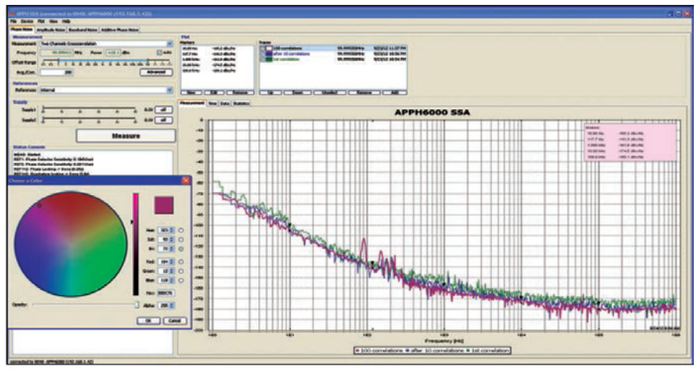

Fig. 2: APPH Graphical User Interface (GUI).

SOLUTION

Swiss-based Anapico has produced the APPH series of automated signal source analyzers which separate amplitude modulation and phase modulation measurements, measuring both independently to very low noise levels (below -180 dBc/Hz) with the capability of measuring additive noise of active and passive components. Offering a measurement capability up to 30GHz, with a fully integrated, cross correlation system that responds to the most common issues of phase, amplitude and base-band noise measurements, APPH analyzers provide high accuracy and reproducibility, fast measurement speed, high dynamic range with low system noise floors, while still remaining affordable for labs and production environments.

SYSTEM ARCHITECTURE

The core engine of the APPH series combines low-noise analog receiver channels with advanced digital signal processing technology to provide fast and repeatable noise measurements. The proprietary FPGA-based FFT cross-analyzer handles 125MSa/s in real-time, allowing thousands of correlations and sub −170dBc/Hz measurements within seconds. The LAN- or USB-controlled APPH series can use a PC, laptop or tablet as the controller, so there is no need for a display to be incorporated, which minimizes product costs while increasing reliability.

ACCURATE CALIBRATION

Enclosing the system in a compact, fanless chassis further eliminates spurious signals and ground and power line loops. Another very important consideration is precise calibration. Before shipment, each instrument is calibrated against a traceable noise standard to guarantee high precision, consistent and repeatable results. Optionally, a calibration standard can be supplied with the instrument to enable a user's on-site performance verification at any time.

MEASUREMENT CAPABILITY

Measurements supported for Anapico's APPH instruments include: additive or absolute phase noise measurement using internal or external references, amplitude noise measurements and other automated measurements for evaluating RF signal sources. SSB phase noise, amplitude noise, AM noise measurement, additive or residual noise characterization, and baseband noise measurements up to 30GHz can easily be made for sources such as crystal oscillators, PLL synthesizers, clocks, phase-locked VCOs, DROs, and many others.

The phase noise data shown in Figure 2 is data gathered from a low noise 100 MHz OCXO reference. The three traces shown are after first correlation (green, after 12 s measurement time), 10 correlations (blue, after 120 s) and 100 correlations (red, after 20 min), respectively. The noise floor of the DUT at −180 dBc/Hz is reached just after 10 correlations or two minutes. For this ultra-low noise measurement, even faster results can be obtained with external reference sources. The sensitivity of the system operated with the internal references is dependent on both the carrier frequency of the DUT and the frequency offset range.

Figure 3 shows the APPH's typical sensitivity when using the internal source to make a measurement, assuming an approximate 24 second measurement with an offset from 1Hz to 10MHz. However, the APPH signal source analyzers can also measure additive phase noise of amplifiers under different drive conditions, and the phase noise of frequency translating devices like prescalers or mixers. Additionally, amplitude noise measurements are also supported.

Figure 4 shows the amplitude noise obtained from one of Anapico's signal generators at 4 GHz, showing a trace with user defined markers and spurious list. The APPH also offers direct access to the FFT analyzer, which enables noise analysis of supply and control voltages. The APPH6040 with extended offset range as well as the APPH20G provide bandwidth beyond 40 MHz and transient measurement capability.

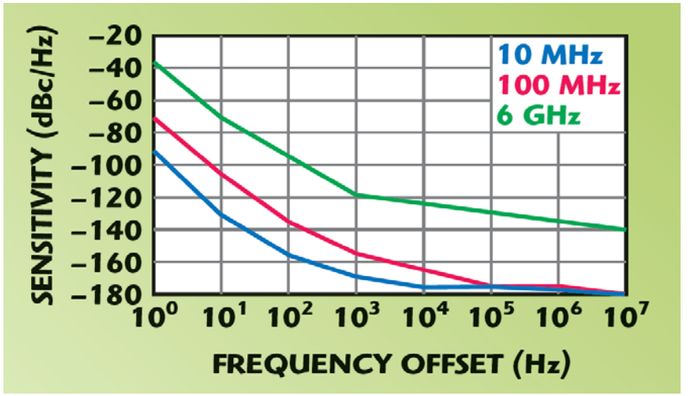

Fig. 3: Sensitivity of APPH with internal reference sources (after 24s).

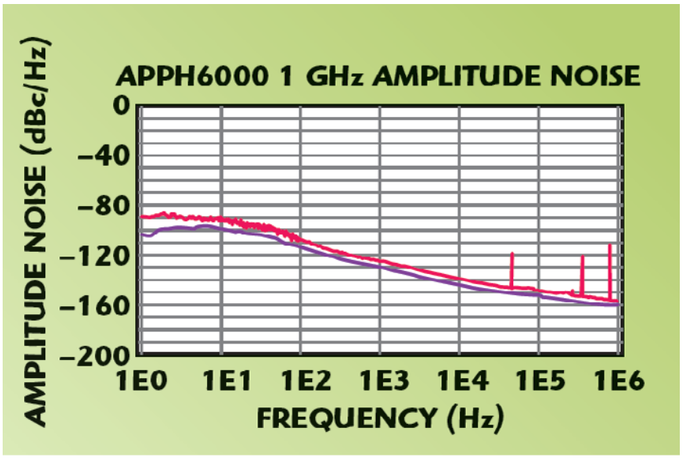

Fig. 4: Amplitude noise measurement with noise and spurious marker lists.

CONCLUSION

The APPH series of phase noise testers offers complete measurement functions for evaluating a wide range RF signal sources. They provide comprehensive measurements such as phase and amplitude noise measurement, residual noise characterization with direct access to the FFT analyzer for baseband signal and LF noise analysis. Using proven cross-correlation measurement procedures and self-calibration routines, reproducible and accurate measurements are obtained even under changing environmental conditions. Fully automated frequency acquisition and self-calibration greatly simplify use and applicability of the instrument, resulting in fast measurements and ease of operation. ■