Holzworth Real Time Phase Noise Analyzers

Measuring the TRUE NOISE FLOOR of a Cross Correlation Analyzer

INTRODUCTION

A key attribute that sets Holzworth HA7000 Series Real Time Phase Noise Analyzers apart from the competition is the capability for measuring the absolute phase noise floor of each instrument. This is very valuable information because like spectrum analyzers, no two phase noise analyzers are identical even if they are of the same make and model number. The absolute noise floor measurement capability is available with Holzworth phase noise analyzers due to a unique reconfigurable front end that allows users to access several internal modules. The ability to measure the actual noise floor of the instrument provides users with a known level of confidence in their data by demonstrating the instrument's true noise floor relative to the measured data.

Most cross correlation phase noise analyzers provide a noise floor *approximation* that is calculated during data acquisition using the real and imaginary information from the phase vectors. This approximation is better defined as a *confidence factor* or *gain indicator* and is often mistaken as being noise floor of the instrument, which it is not. The Holzworth HA7000 Series application GUI also offers this calculated confidence factor, referred to as the *xCorr SNR (Cross Correlation Signal to Noise Ratio)*. The *xCorr SNR* is a calculated trace displayed as a shaded area beneath the measured data trace and is a useful indicator of the data accuracy based on the margins shown. As with other phase noise analyzers, this *xCorr SNR* information is not to be mistaken for the noise floor of the instrument.

HA7062C REAL TIME PHASE NOISE ANALYZER OVERVIEW

The HA7062C *Real Time* Phase Noise Analyzer is an industry leader with respect to proven accuracy, high reliability, automation and flexibility; offering extremely fast measurement speeds to reduce product development time and/or optimize ATE manufacturing throughput.

The HA7062C has a proprietary high speed digital signal processor for real-time measurements, but the proven accuracy and speed starts with the analog front end (Figure 1) providing unparalleled performance. A key component of the analog front end is a pair of Holzworth HSX Series RF Synthesizers as the test system's internal LOs (Local Oscillators). These ultra low noise RF synthesized sources combined with the FFT engine to provide one of the most advanced phase noise analyzers available.

The unique, reconfigurable front end provides direct access to the internal LOs as well as to both the RF and LO input ports at each channel's phase detector (mixer). Making these sub-system access points available to the user are what enables measuring the absolute phase noise floor of the analyzer.

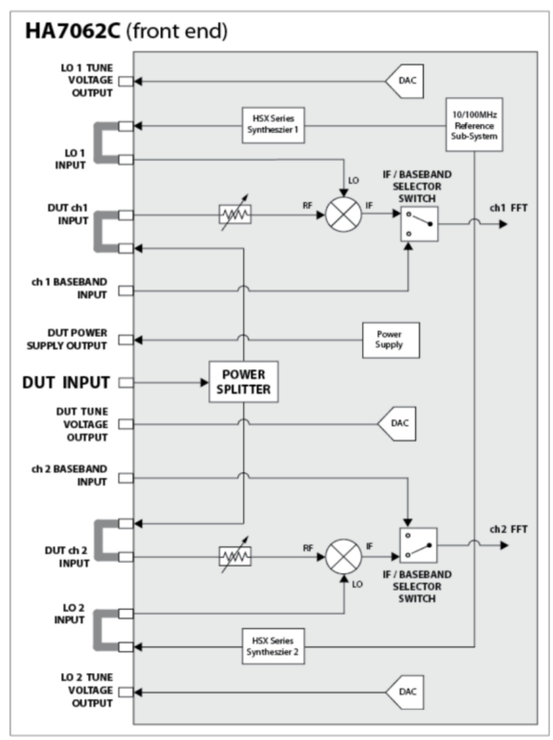

Figure 1: HA7062C Block Diagram

 Holzworth Instrumentation Inc. January 2019

HA7062C NOISE FLOOR MEASUREMENT OVERVIEW

The key to measuring the absolute phase noise floor of the HA7000 Series analyzers is the ability to directly access each of the internal phase detectors (mixers) via the DUT ch1 Input port and the DUT ch2 Input port.

Access to each phase detector allows users to connect two separate, non-coherent RF signal sources. Simply defined, any non-isolated common mode noise between the DUT ch1 Input and the DUT ch2 Input will limit the noise floor, relative to the number of cross correlations.

As shown in Figure 2, the external RF signal sources are referred to as DUT1 and DUT2. The analyzer's internal LO (Local Oscillator - "HSX Series Synthesizer") sources are referred to here as LO1 and LO2. The internal LOs are the limiting factors for the analyzer's phase noise floor when operating in *Internal LO Mode*. In order to accurately reflect the noise floor limit of the instrument, the DUT1 and DUT2 signal sources should have the same or better phase noise performance as LO1 and LO2. Therefore, Holzworth recommends a set of fixed frequency OCXOs (Oven Controlled Crystal Oscillators) as DUT1 and DUT2 to help ensure better phase noise than the internal LO1 and LO2 synthesizers.

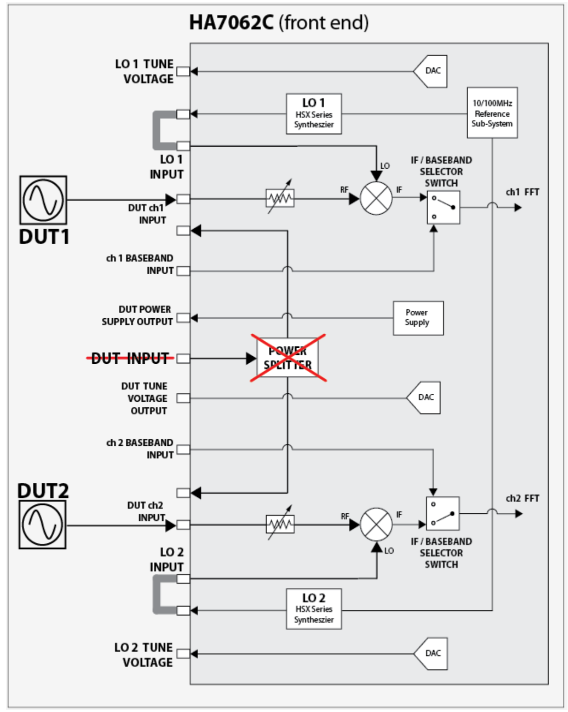

Figure 2: Noise Floor Measurement Setup

NOISE FLOOR MEASUREMENT EXAMPLE

As noted, in order to measure the absolute noise floor of the HA7062C Real Time Phase Noise Analyzer, the DUT1 and DUT2 sources should have the same or better phase noise than the internal LO1 and LO2 HSX Series RF Synthesizers. For this example, two 100MHz OCXOs from Wenzel Associates have been selected as DUT1 and DUT1 (see Figure 3).

Figure 3: 100MHz OCXOs as DUT1 and DUT2

Note that both the measurement offset frequency range and the number of cross correlations selected will directly affect the absolute phase noise floor of a cross correlation phase noise analyzer. With DUT1 and DUT2 connected to their respective input ports, the user must then specifically make the desired adjustments to the measurement offset frequency range and the number of cross correlations. Once the these settings are entered into the application GUI, the user simply selects *Acquire* and the real time cross correlation engine will quickly measure the 100MHz noise floor of the instrument.

Figure 4 demonstrates the different levels of measured noise floor performance of the instrument for 1x, 10x and 100x cross correlations for a 100MHz DUT. Keep in mind that this noise floor data is not dependent on the actual performance of the signal sources that are used as DUT1 and DUT2, as long as their phase noise performance is at least as good as that of the internal synthesized LOs. The phase noise performance of the internal LOs is available in the product User Manual.

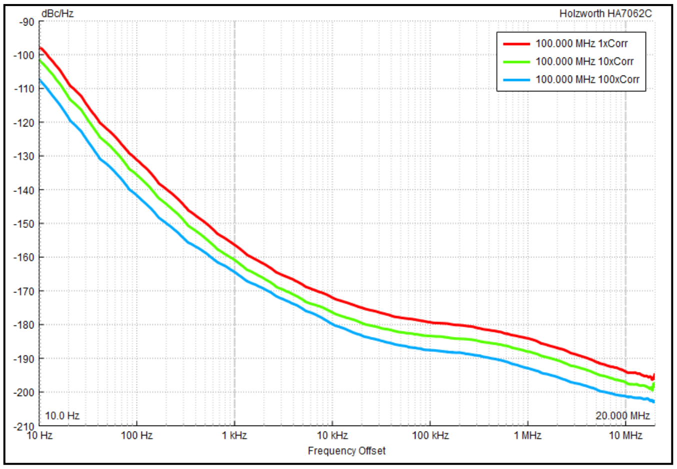

Figure 4: 100MHz Phase Noise Floor Comparison

REAL NOISE FLOOR DATA PROVIDES PIECE OF MIND

Phase noise analysis is a very powerful tool for quantifying signal stability and it has become highly implemented throughout the electronics and communication industries. With the advent of cross correlation in phase noise analysis, measurement floors that were previously considered impossible are now commonplace. However, even cross correlation systems also have limitations making it very important to understand the specific noise floor limits of the phase noise test system being used, for better or for worse.

Without the knowledge of the actual noise floor limitation of the system, it is difficult for a user to fully demonstrate the validity of their data. Figure 5 is a snapshot of the Holzworth GUI showing the difference between the actual measured noise floor (green trace) and the calculated *xCorr SNR* (shaded area located below the red data trace).

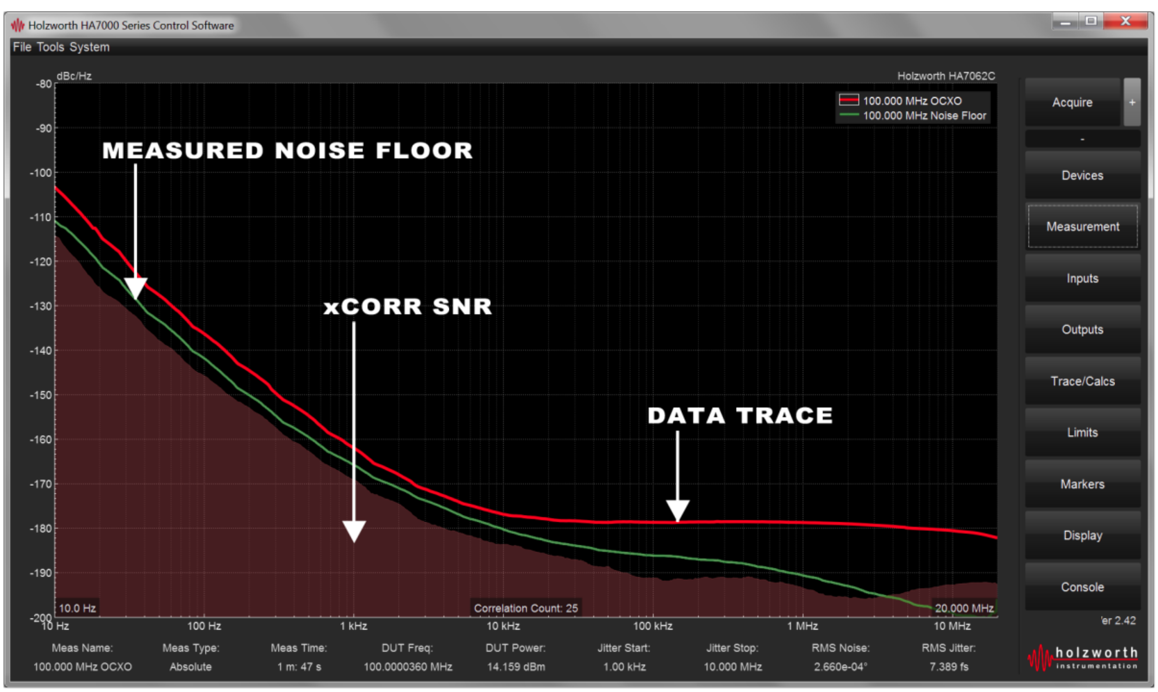

Figure 5: Measured Noise Floor vs. *xCorr SNR*

The *xCorr SNR* indicates that there is ample margin for the 100MHz OCXO being tested at 25x cross correlations. However, the *xCorr SNR* provides no information of where the relative noise floor actually lies. In this example, the measured noise floor at 25x cross correlations reveals the true measurement margins of the instrument. Therefore, the data is known to be accurate because it resides above the actual measured noise floor. If the data trace were to have actually converged with the measured noise floor trace then the user has a concrete indication that the test system has reached its limit under the set measurement conditions. A greater number of cross correlations could then be employed to further reduce the noise floor (as shown in Figure 4) and ensure data accuracy.

The mathematical nature of a *confidence interval, xCorr SNR, gain indicator, etc*. of any cross correlation phase noise analyzer must be understood in order to better interpret its story. Otherwise, if a user can simply measure the noise floor, there is no interpretation required.