rakon

Application note

How to measure phase noise of ULN SAW Oscillators

Content

General

Rakon ULN SAW oscillators exhibit exceptional phase noise performance at frequency above 300 MHz.

The measurement of such phase noise is not obvious. The most common technique is to compare the phase noise of the oscillator under test to a reference oscillator with similar or superior noise performance using a PLL. A multiplied Crystal oscillator is not a suitable reference oscillator for measuring ULN SAW oscillator as its noise floor is generally larger than the noise floor of the SAW oscillator at the same frequency.

A SAW oscillator similar to the SAW oscillator under test is today the best reference oscillator. The measured phase noise is then the quadratic sum of the phase noise of both oscillators (oscillator under test and reference oscillator). If we may assume an equal noise contribution of each oscillator, the phase noise of the DUT is the measured phase noise minus 3 dB.

Residual phase noise of the test bench may also affect the measured phase noise mainly at noise floor level. It is why test bench makers propose multi channel measurements and/or cross correlation techniques in order to cancel the limitations due to the test bench.

Rakon has performed SAW oscillator phase noise measurements on the following test benches:

- DCNTS from NoiseXT
- PN9000 from NoiseXT (formerly Europtest, a subsidiary of Aeroflex company)
- E5052B from Agilent

Results are presented here after.

Synthesis

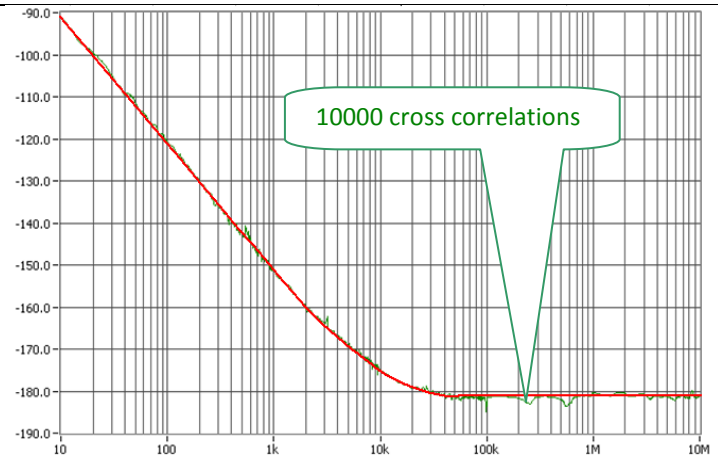
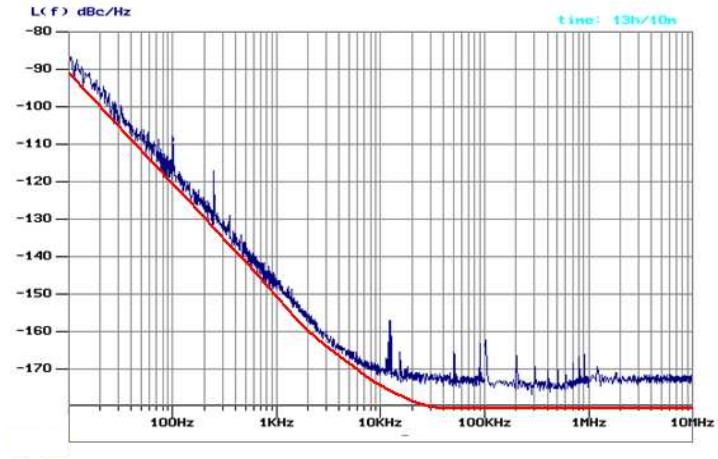
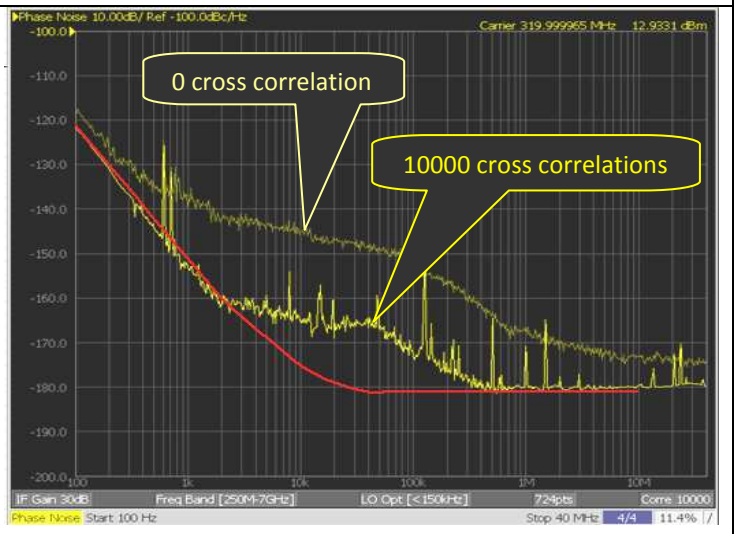
Main conclusion of comparative measurements is as follows:

- The best result is with DCNTS. Using 3 similar ULN SO for LO of each channel and common DUT (RF input), dual channel measurements and cross correlation techniques cancel completely the residual noise and limitation of the test bench (the residual noise floor is around -195 dBc/Hz). The measured PN is the true PN of the DUT. Leeson's model fits perfectly with the measurement.
- PN9000 may be described as one channel of the DCNTS. Using 2 similar ULN SO for Reference (LO) and DUT, the displayed PN is the quadratic sum of the PN of both oscillators + the residual PN of the test bench. The limitation on noise floor is around -175 dBc/Hz. The individual PN of each oscillator is not directly achievable. It is nevertheless equal or better than the displayed curve.
- E5052B is not suitable for measuring PN of ULN SO. Only 1 ULN SO is needed as DUT, but the internal reference of the test bench (which is derivated from a multiplied XO) limits the phase noise measurement for offset in the range [2 kHz – 300 kHz] even with 10,000 correlations ("overnight measurement"). The plotted phase noise is representative of the phase noise of the DUT only for close-in or far-out offsets. For offset in the range [2 kHz – 300 kHz] the displayed PN is the PN of the internal reference.

Glossary

- DCNTS: Dual Core Noise Test System
- DUT: Device Under Test
- LO: Local Oscillator
- OCSO: Oven Controlled SAW Oscillator
- PLL: Phase Lock Loop
- PN: Phase Noise
- RF: Radio Frequency
- SAW: Surface Acoustic Waves
- SO: SAW Oscillator
- ULN: Ultra Low Noise
- XO: Crystal Oscillator

Measurement plots

Test bench: DCNTS **DUT**: 3 similar SO as LO1, LO2 & common DUT (RF input) **Plot**: PN of the DUT (SO connected to RF input) + limitation **Test bench limitation**: none (noise floor is around -195 dBc/Hz when cross correlation is used to cancel internal noise and limitation) **Conclusion**: preferred test bench to measure true PN of SO. Leeson's model (in red) fits exactly with measurement (in green)	 **DCNTS**
Test bench: PN9000 **DUT**: 2 similar SO as LO & RF **Plot**: sum of PN of both SO (LO + RF) + limitation **Test bench limitation**: noise floor (around -175 dBc/Hz) **Conclusion**: suitable for quick PN measurements. Results are pessimistic. **Note**: Leeson's model (in red) for comparison purpose	 **PN9000**
Test bench: E5052B **DUT**: only 1 SO **Plot**: PN of DUT + limitation **Test bench limitation**: PN of internal references in the range [2 kHz – 300 kHz] even with 10000 cross correlations (overnight measurement) **Conclusion**: not suitable to measure PN of SO **Note**: Leeson's model (in red) for comparison purpose	 **E5052B**