Microsemi
Power Matters.™

Dual Channel Cross-correlation Phase Noise Measurement

Application Notes

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Introduction

Microsemi designs and manufactures microwave amplifiers with low residual phase and amplitude noise. A Dual Channel Cross-correlation PM/AM Noise Measurement System is used to develop low phase noise amplifier solutions covering frequencies from 1 GHz to 18 GHz with phase noise performance as low as –180dBc/Hz. The Figure 1 shows the residual phase noise performance of an X-Band amplifier at 11GHz displaying –167 dBc/Hz at 1 KHz offset from the carrier.

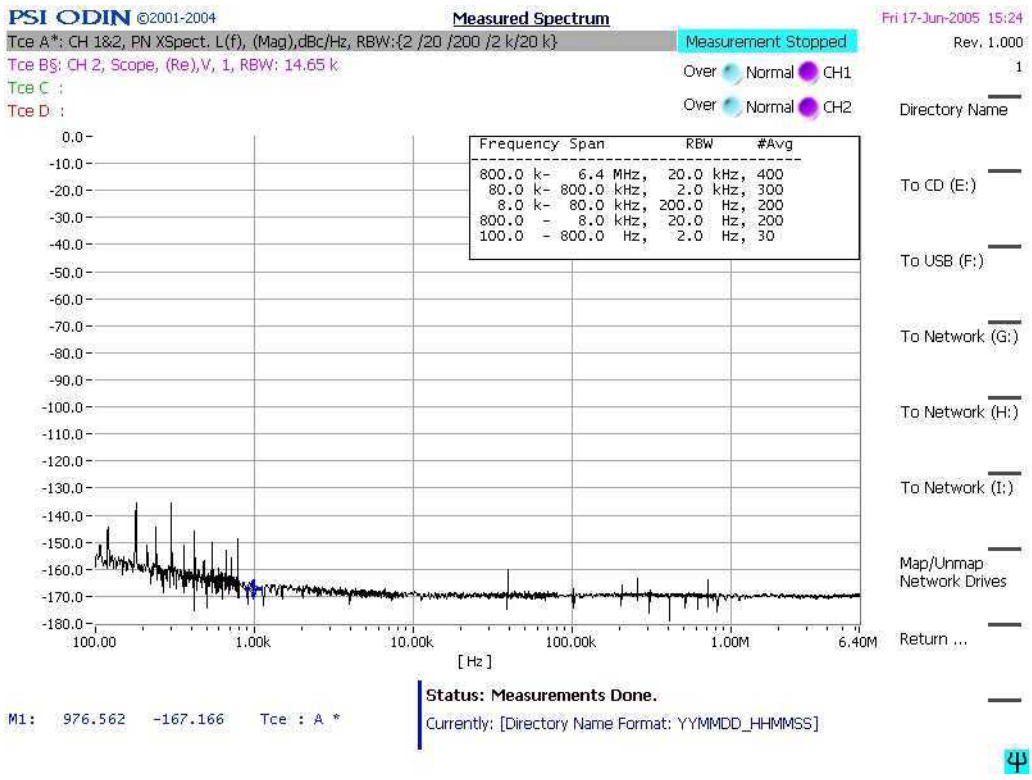

***Figure 1* • Residual Phase Noise Performance**

X-Band Low Phase Noise Amplifier
Gain = 16 dB
P1dB = 18 dBm
-167 dBc/Hz at 1 KHz offset from carrier

Residual Phase Noise Measurement

For residual phase noise measurements, the measurement set up as seen in Figure 2, consists of a reference source, splitter, phase shifter, and double balanced mixer. The phase shifter is used to bring the signals at the RF and LO ports of the mixer into quadrature. The mixer acts as a phase detector and outputs a DC voltage at the IF port proportional to the phase difference between the RF and LO. The FFT analyzer processes this signal and the residual phase noise is determined. Single channel measurements lump the phase noise from the DUT, mixer and baseband amplifiers together and calls the result, the residual phase noise of the DUT. There is an inherent inaccuracy in this approach when measuring extremely low phase noise amplifiers.

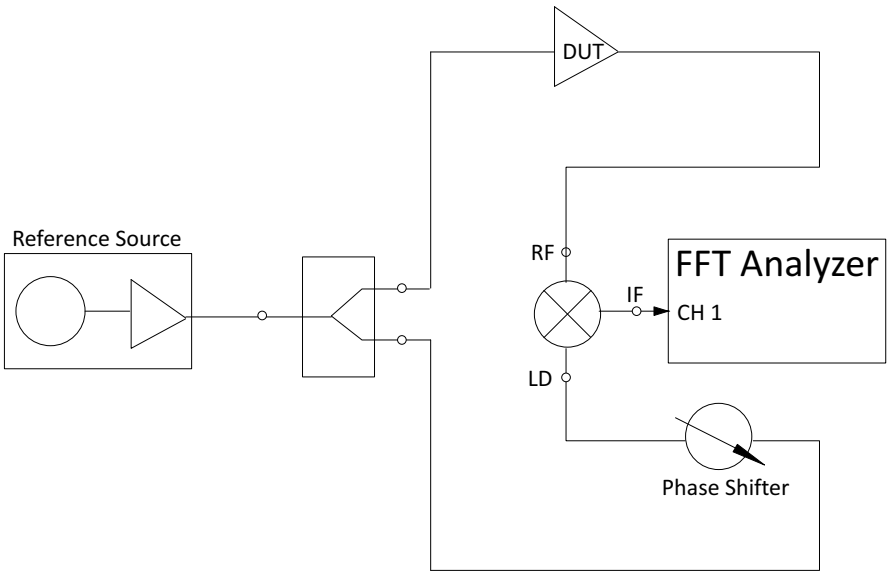

***Figure 2* • Block Diagram of Residual Phase Noise Measurement Set Up**

Dual Channel Cross Correlation Measurement

Cross correlation removes the mixer and baseband LNA noise from the measurement results. Referring to the block diagram of the Dual Channel Cross Correlation Set Up shown in Figure 3, the FFT analyzer analyzes the data from two measurement channels for correlation. The phase noise from the device under test is coherent or correlated in both channels and averages to a finite value. The flicker noise from the mixer diodes and white noise from the baseband LNAs are non-coherent (they are independent sources of phase noise) and this noise averages downward to zero.

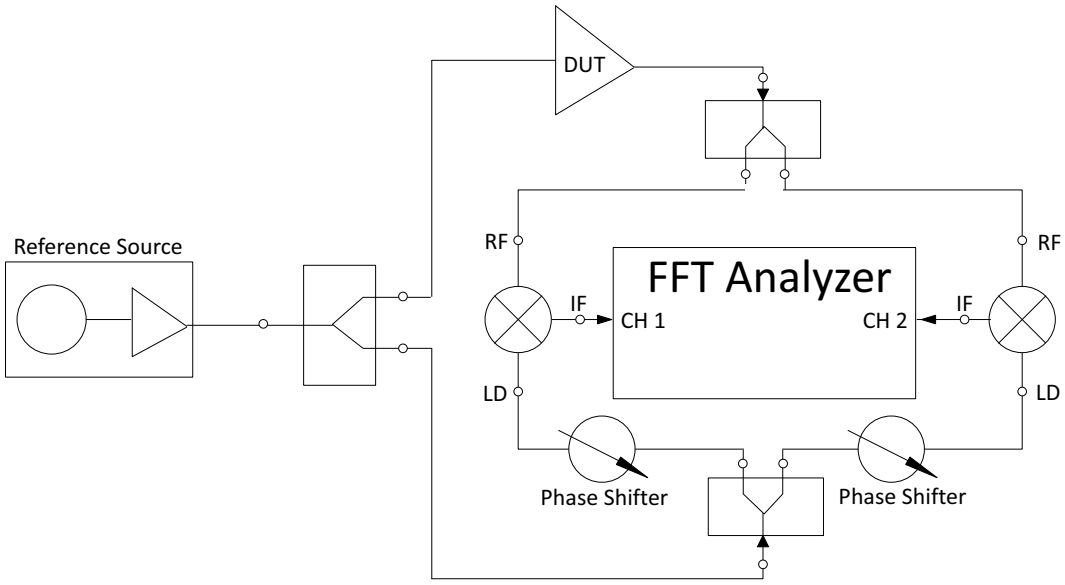

***Figure 3* • Block Diagram of Dual Channel Cross Correlation Measurement Set Up**

The Figure 4 illustrates the effectiveness of cross correlation when measuring an amplifier with extremely low phase noise. Traces 1 and 2 (black and red) show the phase noise performance of the amplifier when measured with two separate single channels. Trace 3, with Cross correlation, has removed 4 dB to 5 dB of additive noise from the measurement system. This trace represents the true performance of this amplifier, -165 dBc/Hz at 1 KHz offset.

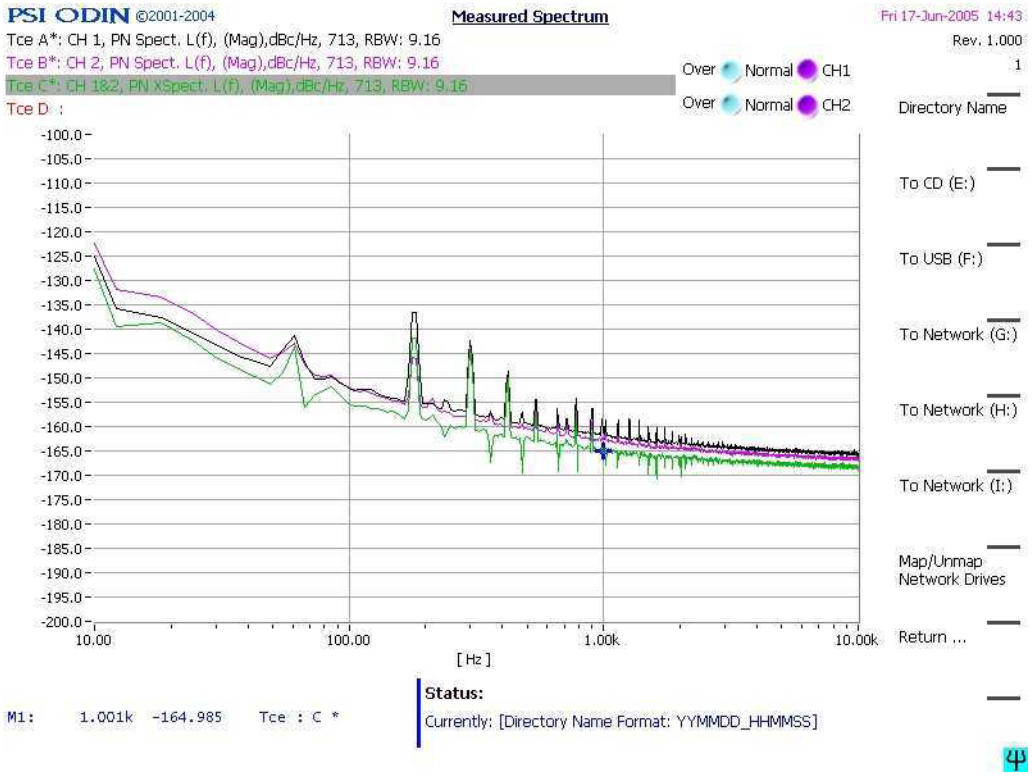

***Figure 4* • Effectiveness of Cross Correlation when Measuring an Amplifier with Extremely Low Phase Noise**

- Trace A - Amplifier Performance through Channel 1
- Trace B – Amplifier Performance through Channel 2
- Trace C – Amplifier Performance with Cross Correlation between channels 1 and 2

Measurement System Noise Floor

The noise floor of the measurement system is critical. A high noise floor can mask the true performance of a device. Ideally, the noise floor is at least 10 dB below the noise of the device. The Microsemi noise floor is measured regularly to guarantee the validity of the results. In Figure 5, Cross correlation has reduced the measurement noise floor by 10 dB to 15 dB.

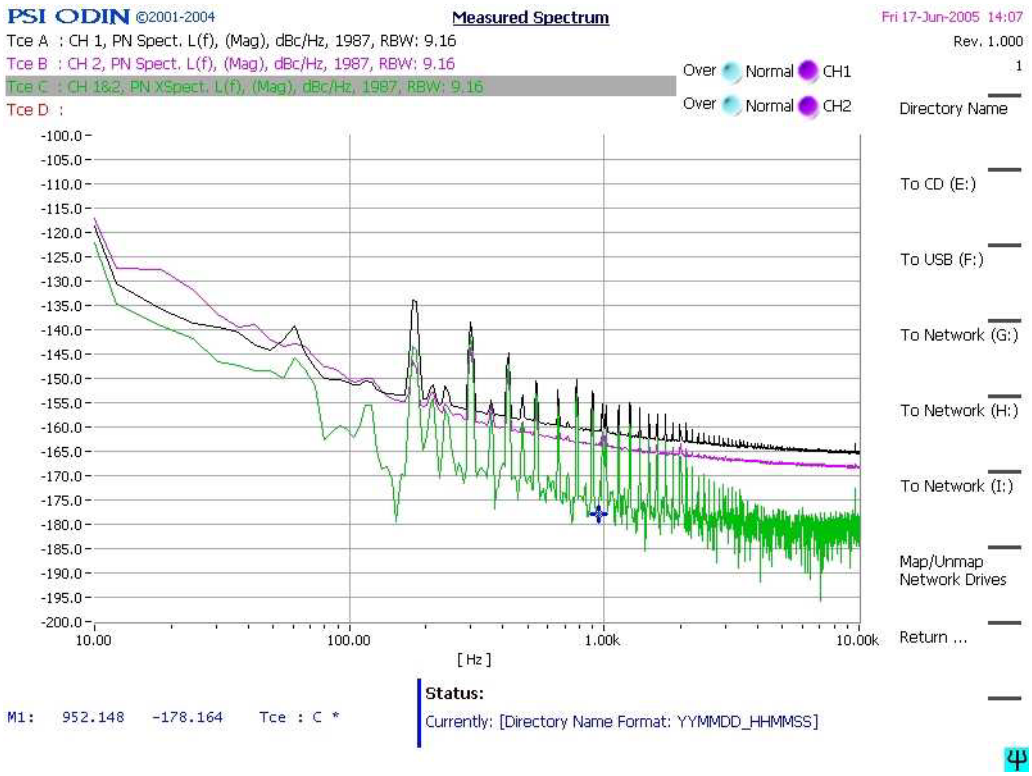

***Figure 5* • Measurement System Noise Floor at X-Band**

After approximately 2,000 averages the noise floor has reduced by over 12 dB

Reference Source

The Reference Source provides RF drive to the DUT and its AM and PM noise contributes to the phase noise floor of the measurement system. Referring to the single channel diagram, source PM noise is present at both the RF and LO ports of the mixer. Phase noise from the source is cancelled assuming the RF and LO paths are at quadrature and have equal electrical delays. Microsemi's reference source consists of a low phase noise signal generator and a low AM noise driver amplifier. Note, AM noise from the reference source is coherent in both channels and therefore is not removed during cross correlation measurements.

List of Changes

The following table shows important changes made in this document for each revision.

Date	Changes	Page
Revision 1 (December 2015)	Updated to Microsemi format.	NA
Revision 0	Initial Release	NA

*Note: *The revision number is located in the part number after the hyphen. The part number is displayed at the bottom of the last page of the document. The digits following the slash indicate the month and year of publication.*

Microsemi Corporate Headquarters
One Enterprise, Aliso Viejo,
CA 92656 USA

Within the USA: +1 (800) 713-4113
Outside the USA: +1 (949) 380-6100
Sales: +1 (949) 380-6136
Fax: +1 (949) 215-4996

E-mail: sales.support@microsemi.com

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