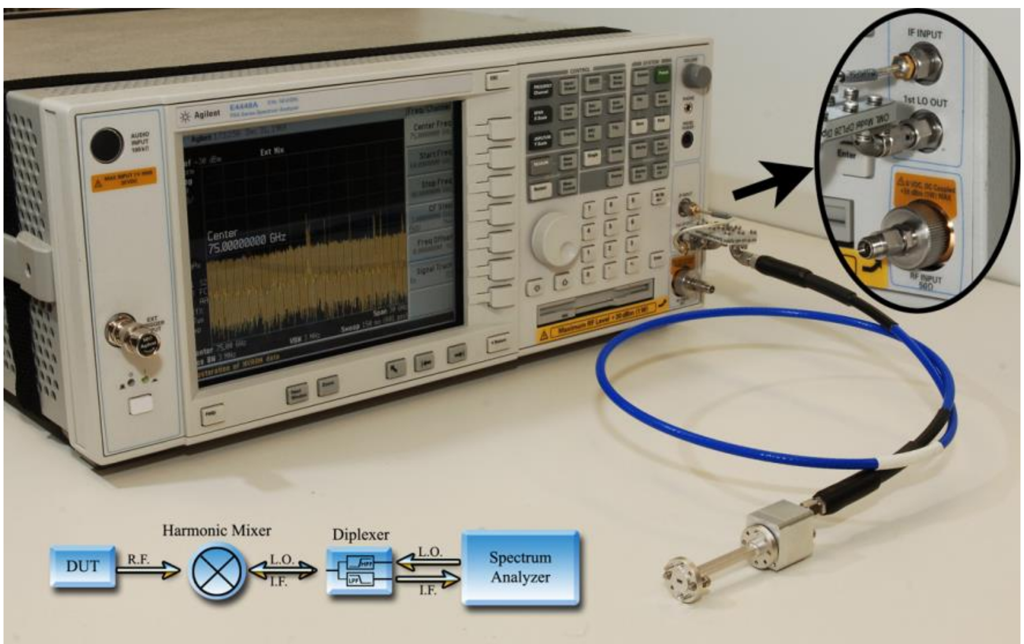
Method for Determining Correction Factors

Introduction

As shown in the following application scenario, OML offers harmonic mixers (reference the MxxHWD series) to extend microwave signal analysis to the millimeter wave spectrum. Engineers can use conversion loss as a method for determining correction factors that compensates for the harmonic mixer in modern spectrum analyzers. An engineer can also utilize an RF source module as a reference to generate more optimized correction factors for their given spectrum analyzer and setup. In both cases, the accuracy of this conversion loss method is traceable to power meter measurements.

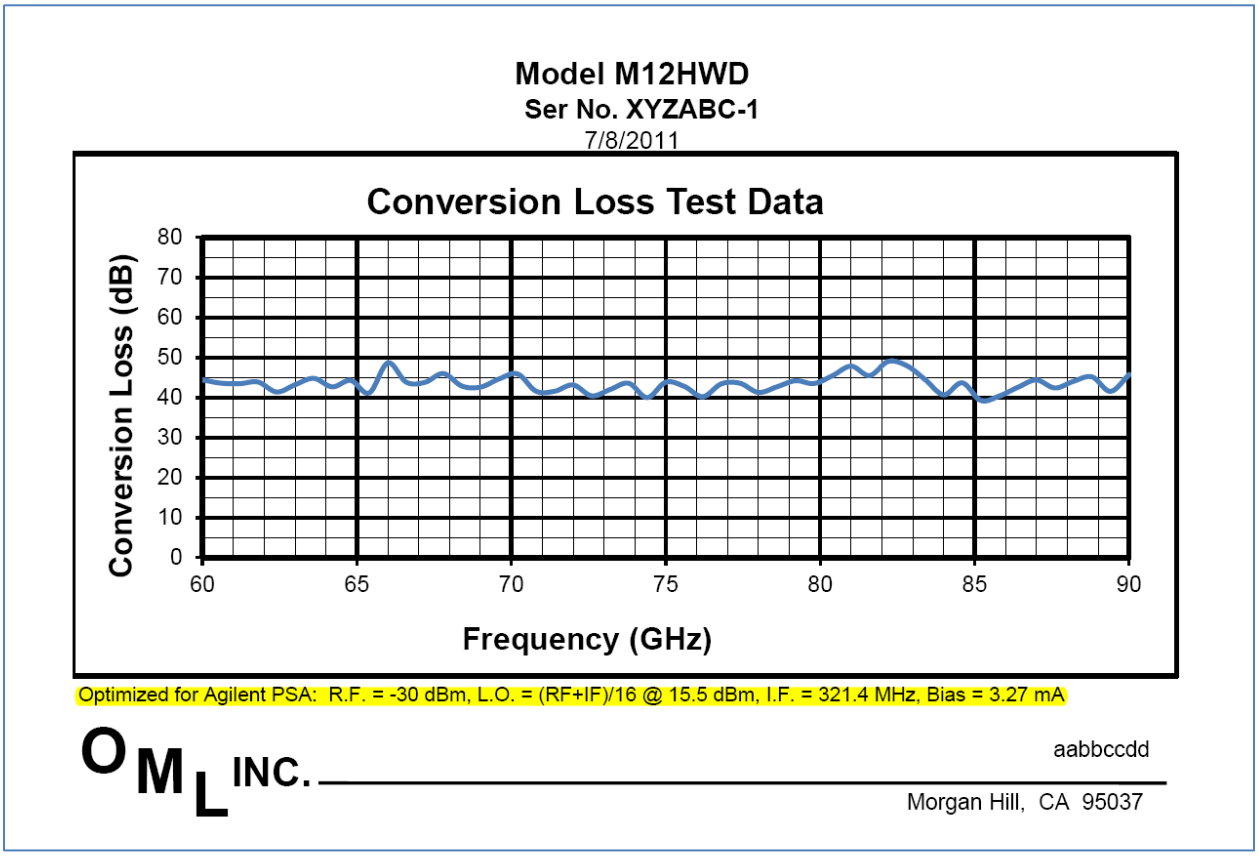


Given this introduction, this application note will describe a process based on power meter measurements for characterizing the harmonic mixer's conversion loss. By understanding this process, engineers can gain more insight into the harmonic mixer operation as an external mixer for modern spectrum analyzers. Furthermore, the applied principles based on traceable power measurements offer practical tools for optimizing or trouble-shooting mm-wave signal analysis.

OML Inc. 300 Digital Drive Morgan Hill, CA USA 95037 Tel: 408-779-2698 Fax: 408-778-0491 www.omlinc.com

Conversion Loss Setup Considerations

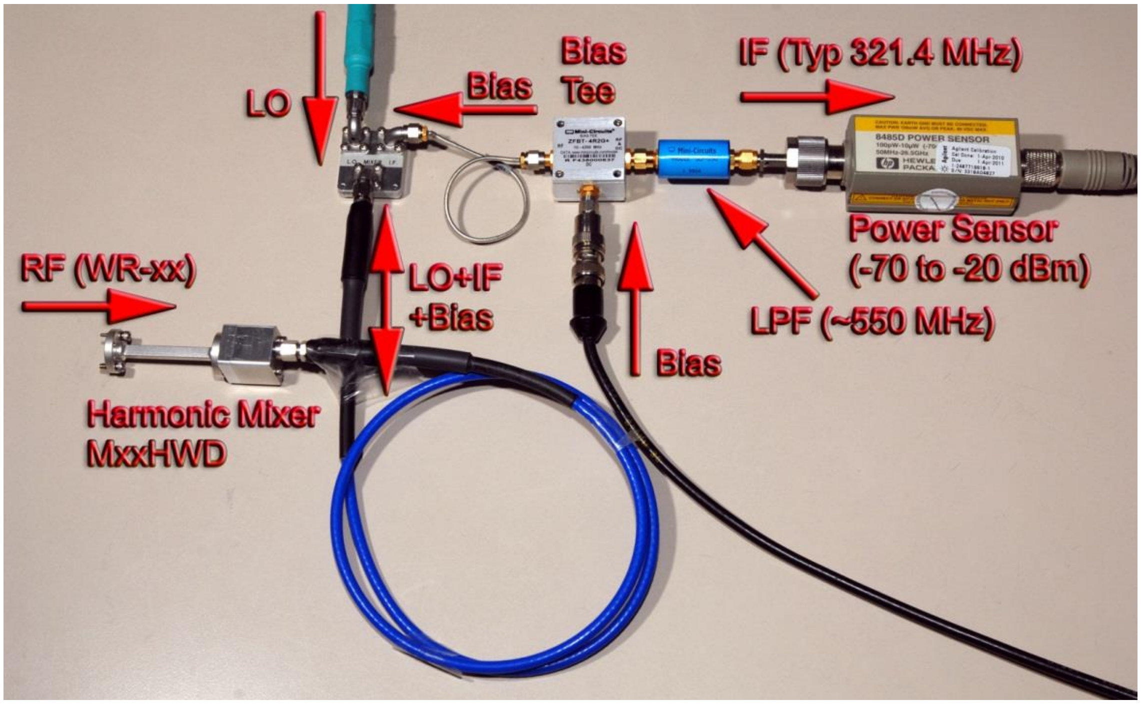
In general, the harmonic mixer's IF contains a harmonic mixture of the RF and LO inputs that satisfies the equation of m(RF) + n(LO). In preparation for a conversion loss measurement, the predetermined LO, IF, and multiplier settings are necessary. Fortunately, these setup conditions are summarized on the provided test data as highlighted in the following figure.



The highlighted text informs the engineer that the conversion loss data emulates the Keysight PSA external mixing conditions. The predetermined settings for the PSA consists of LO power of 15.5 dBm, IF of 321.4 MHz, and multiplier (n) of 16. The harmonic mixer also accepts bias to further optimize the swept frequency response, which is 3.27 mA. Using these conditions as guidance, an engineer can setup synthesizers, a power meter, a power supply and some accessories to conduct conversion loss measurements.

Test Station Layout

To emulate the conditions of the PSA, the harmonic mixer assembly requires RF, LO, IF, and Bias connections. These prerequisites determine the test station layout as shown in the following photo that highlights signal flow and connection points.

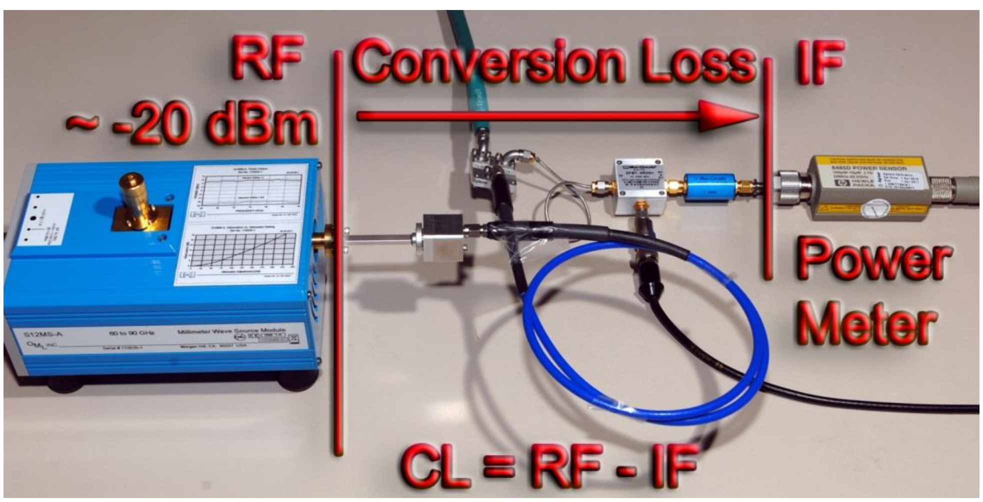


Connection	Considerations
RF	Use a microwave synthesizer and mm-wave source module (reference SxxMS). Attenuation is required to satisfy the -30 dBm conditions stated on the test report. As a practical tip, output power of -20 dBm can substitute for -30 dBm to simplify RF power meter measurements with minor degradation in linearity.
LO	Use a microwave synthesizer. The output power level necessary to duplicate the setup conditions is +15.5 dBm.
IF	Assuming conversion loss of 40 dB, the IF level is in the vicinity of -60 dBm when using an RF input of – 20 dBm. For this reason, a power sensor with -70 dBm sensitivity is recommended (e.g., 8485D). A low pass filter (e.g., Mini-Circuits SLP-550) is recommended to measure only the desired IF.
Bias	A bias tee (e.g., Mini-Circuits ZFBT-4R2G+) and external voltage power supply are necessary to supply bias. Without LO applied, the voltage is increased until an in-line current meter reaches the designated bias condition. Care is required to not exceed damage and capacity limits.

Conversion Loss Measurements

Using the conversion loss equation of CL = RF – IF, the process continues with a measurement of the RF input power. It might be helpful to refer to this measurement as a calibration step since the purpose is to designate a reference plane for the subsequent conversion loss measurement. As shown in the following step, the RF from signal generator, source module, and attenuator is measured using a waveguide power sensor (e.g., V8486A). Record the measured RF values for later calculations.

Next, connect the test station components to the RF. As shown in the following photo, the output IF is measured using the power meter.

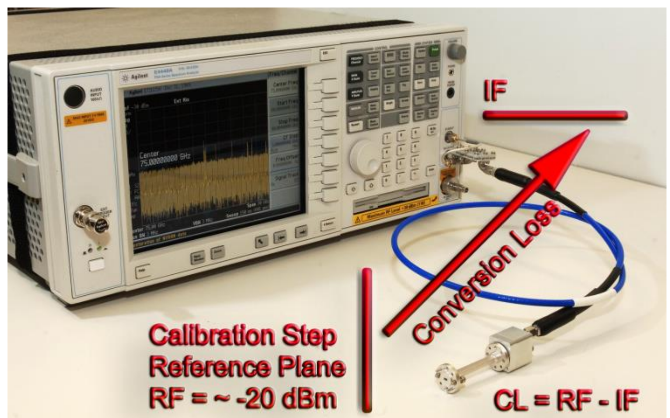


The last step is to calculate conversion loss (CL) as the difference between RF and IF. This measurement approach is based on power measurements, which is similar to how OML characterizes conversion loss of their harmonic mixers.

Correction Factors

The conversion loss method generates correction values that effectively calibrate the spectrum analyzer readouts for the RF-to-IF path through the harmonic mixer. Simply transfer these conversion loss values into correction factor entries (i.e., frequency, amplitude) to conduct millimeter wave measurements. This conversion loss calibration method will provide accurate and repeatable results as long as physical setup, LO and bias conditions are identical.

As an alternative, an engineer can also conduct a user-friendly calibration that compensates for the overall combined effects of both harmonic mixer and spectrum analyzer. In many cases, this alternative calibration technique yields more optimized results than using the OML conversion loss values because instrument-to-instrument variations are taken into account. In this alternative approach, the engineer disables the conversion loss correction factors, essentially preset the instrument, and instead uses readouts from the spectrum analyzer to calculate optimized conversion loss values as correction factors.



The alternative calibration step uses a similar setup. As shown in the above photos with overlays, the measured RF power standard of -20 dBm establishes the reference plane for the conversion loss measurement. Next, connect the source module output to the harmonic mixer waveguide input and then connect the harmonic mixer coaxial output to the spectrum analyzer (the IF/LO connectivity of the external mixer option may require an external diplexer). This completes the physical setup step for a more optimized calibration. The noticeable difference in this optimized setup is the substitution of the spectrum analyzer for the power meter in this conversion loss measurement.

Using this alternative setup, an engineer can calculate the more optimized correction factor as the difference between raw uncorrected amplitude readouts and the traceable power standard (CL = RF – IF).   By using the spectrum analyzer instead of the power meter, this alternative method yields more optimized calibration for the given setup and spectrum analyzer. In addition, this approach offers a mechanism for periodically checking the performance of the overall measurement system.

Summary

Engineers can use conversion loss as a method for determining correction factors that compensates for the harmonic mixer in modern spectrum analyzers. An engineer can also utilize an RF source module as a reference to generate more optimized correction factors for their given spectrum analyzer and setup. In both cases, the accuracy of this conversion loss method is traceable to power meter measurements.