What are Impedance Errors in Multitone (Intermod) Measurements?

Normally a load pull system is calibrated at one frequency. When two-tone signals are used it has to be decided what the impedance is seen by the DUT at the second tone. In general it is assumed that this impedance is close to or the same as the first tone impedance. This may be wrong ! The two measurement parameters which determine the size of the error are: The Frequency Offset between the two tones and the physical distance between the DUT and the tuning element (probe, slug) of the tuner. A third source of error is the nature of the tuner used: A narrow band tuner or one with complex electronic components inside which cause discontinuous frequency behaviour may be prone to phase and amplitude jumps at small frequency offsets. Where the behaviour of mechanical tuners at small frequency is well understood and can be predicted accurately, the behaviour of electronic tuners is unpredictable and has to be measured explicitely for each tuner state. For slide screw mechanical tuners the two tone impedance error generated by the setup is as follows:

Delta Gamma=0;

Delta Phase(º) = 0.024 · Lel (cm) · Delta.F (MHz),

where Lel=electrical length between DUT and tuning element of tuner and Delta.F= Frequency Difference between the two tones. Example: 1cm test fixture with Al2O3 substrate (E=10) plus adapter to GPC7 @ Delta.F=1 MHz would cause

Delta.Phase = 0.024* (3cm [fixture] + 2.5cm [adapter] + 4cm [inside the tuner up to the probe]) *1 MHz = 0.23°.

On a wafer setup however, if cables with teflon core (E=2.4) are used, as some tuner manufactures do, the test fixture length may exceed 10 cm and the phase error becomes ~ 0.5°. If a higher frequency offset is used, such as 5 MHz, the same setup would cause errors of several degrees.

This problematic remains the same for noise measurements with double sideband receivers or for setups with long cables or sections between DUT and tuners, such as all harmonic tuning setups using multiplexers; this means IMD measurements in setups using Triplexers bear a systemic error, as do all active load pull systems (see active load pull, pros and cons).

To reduce this error Focus has developed successfully through continuous RF and mechanical development, ultra low loss and very short bendlines and tuner positioners, which allow phase errors of a maximum of a few degrees even on wafer.