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Application Note 33

Harmonic Tuning Isolation in Load Pull Setups using PHT

Programmable Harmonic Tuners (PHT) allow the highest reflection factors both at the fundamental and harmonic frequencies. Other alternatives, like electronic multistate tuners or electromechanical tuners using triplexers reach less Γ_{max} at DUT reference plane (VSWR≈10:1 or less), whereas PHT allow VSWR≈20:1 (at f_0) and ≈100:1 at $2f_0$, $3f_0$.

There is a side-effect of PHT on the impedances at the fundamental frequency. Under certain tuning conditions this "limited isolation" effect may be non-negligible.
<u>The harmonic tuning routines of the Load Pull Software "WinPower" take this limited isolation into consideration and correct for it when tuning at the fundamental frequency.</u>
This phenomenon originates from the fact that the reflection factor at f_0 is the vector sum of the reflection factors at f_0, $2f_0$ and $3f_0$ and the residual reflection of the slabline.
By properly adjusting the distance between the 2 resonators $2f_0$ and $3f_0$, it is possible to increase the isolation to values between -40 and -25dB. This isolation is not constant, it is dependent of the positions of the resonators $2f_0$ and $3f_0$.
Three experiments carried out at f_0=1.9 GHz demonstrate the effectiveness of the correction routines in WinPower and prove that the result is sufficient for accurate harmonic load pull measurements.

Test 1: A 360° harmonic phase sweep is generated and the reflection factor at f_0 is measured with a calibrated VNA. The <u>harmonic correction</u> is <u>desactivated:</u> there are no corrections from the fundamental tuner to keep the f_0 impedance constant.
The maximum measured deviation in magnitude is **0.03** and in phase **3.5°.**

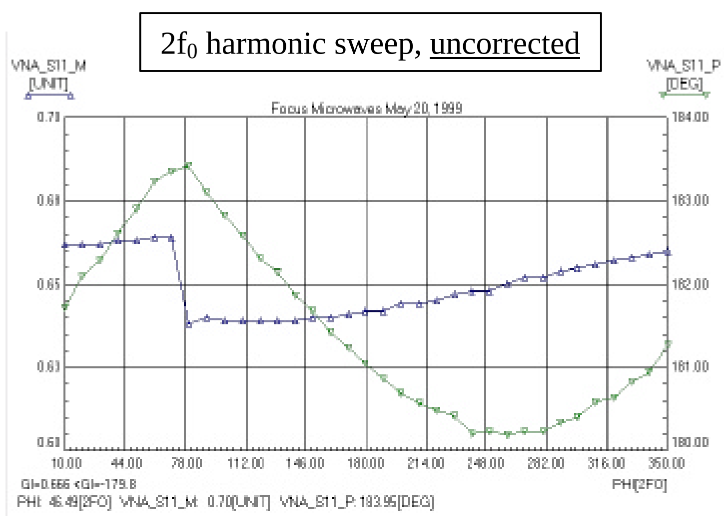

Figure 1: Effect of second harmonic tuning on $\Gamma(f_0)$, uncorrected.

Test 2: A 360° harmonic phase sweep is generated using **WinPower** and the reflection factor at f_0 is measured. The harmonic correction is activated: the harmonic tuning correction routine takes automatically account of the actual reflection factor at the fundamental frequency before moving the harmonic tuners and tunes back with the fundamental tuner to re-instate the previous situation. The maximum deviation of the fundamental tuned reflection factor is now between **0.003** and **0.006** in magnitude and **0.7°** in phase.

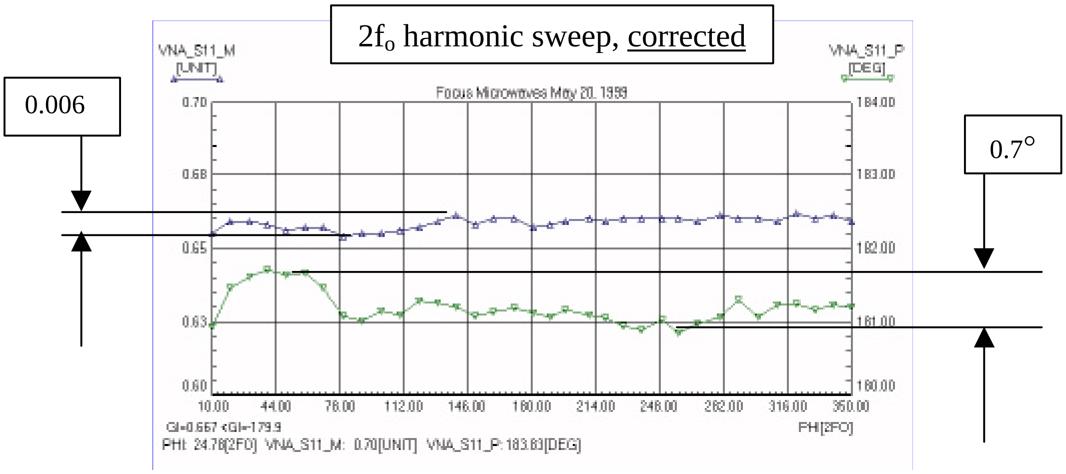

Figure 2: Effect of second harmonic tuning on $\Gamma(f_0)$, automatically corrected.

Test 3: A 360° harmonic phase sweep is generated, the reflection factor measured at f_0. The harmonic correction is activated. This test is done at a high fundamental reflection factor $\Gamma(f_0)$=0.895. Even in this extreme case the automatic correction successfully compensates for the variations due to the $2f_0$ harmonic phase sweep. The variation of the fundamental reflection factor remains within the order of magnitude of the tuner and VNA measurement accuracy. The effect of 3rd harmonic tuning on $Z(f_0)$ is always smaller.

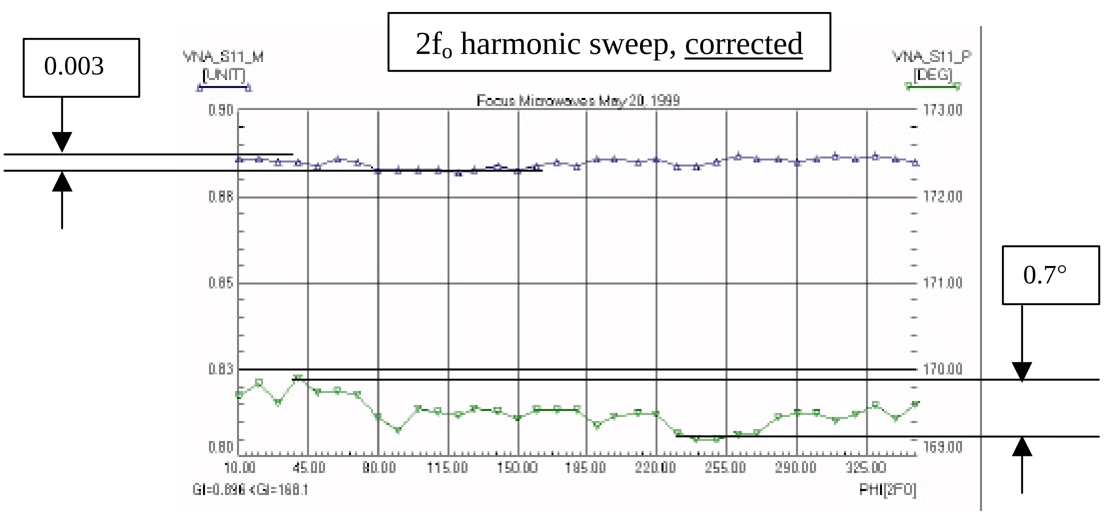

Figure 3: ffect of second harmonic tuning on $\Gamma(f_0)$ at high VSWR, automatically corrected.