
WLAN and WiMAX Integrated Solutions

Turnkey Solutions for WLAN and WiMAX Load Pull Measurements

Abstract – Focus Microwaves offers load pull measurement solutions for WLAN and WiMAX device characterization. On-wafer and packaged source and load pull measurement for fundamental and harmonic frequencies include Pout, Gain, PAE and EVM. WLAN and WiMAX solutions can be supplied as turnkey systems or integrated into existing setups¹.

Introduction – As customer requirements become more demanding and difficult to attain, using models or standard load pull benches are insufficient to design products that stand out in today's marketplace. WLAN and WiMAX transistors and power amplifiers in particular have strict requirements for output power (Pout), gain, power-added efficiency (PAE) and error-vector magnitude (EVM) that surpass existing product specifications. In order to design the next generation of PA's special care must be given to performing device characterization using the appropriate hardware and software. Focus Microwaves offers several alternative solutions to this task, as outlined below.

Hardware Requirements - Because **harmonic tuning** is as necessary as fundamental tuning [1] any load pull setup requires both fundamental and harmonic tuners. Focus Microwaves offers four such solutions, three of which are best for on-wafer load pull. A comparison of harmonic techniques with supporting data can be found in [5].

Available Focus Test Solutions:

- Add harmonic tuning to existing load pull setups using Focus harmonic tuners (PHT, Fig.1)
- Focus Combination Tuner iCCMT 1220-2H, specifically designed for WiMAX (Fig.2)
- Multi-Purpose Multi-Harmonic Tuner (iMPT 1818-TC) for Fo, 2Fo and 3Fo tuning (Fig.3)
- Triplexer setup for packaged devices and limited VSWR requirements

Solution 1: Using a Fundamental and a Harmonic Rejection Tuner (Figure 1)

WiMAX measurements can be performed using Computer-Controlled Microwave Tuners (CCMT) and Programmable Harmonic Rejection Tuners (PHT). This method is modular and allows current owners of Focus or Maury fundamental tuners to upgrade their capabilities with harmonic tuning through the simple addition of a PHT. The PHT is inserted between the DUT and the load tuner, as shown in Figure 1 and allows phase control of the second and third harmonics while maximizing the magnitude of the reflection (frequency dependent between $\Gamma=0.85$ and $\Gamma=0.95$). Harmonic reflection is generated with exchangeable individual harmonic resonators, customized for each particular 5% frequency band. It is therefore necessary to obtain resonators for each frequency band of interest [2]. The PHT is very low-loss at the fundamental frequency, thereby maximizing the tuning range at fo and has low-pass behavior, thus avoiding spurious, out-of-band oscillations; because of the reduced size of the setup, this solution is good for on-wafer measurements.

¹for Focus CCMT and Maury Microwave ATS® tuner systems

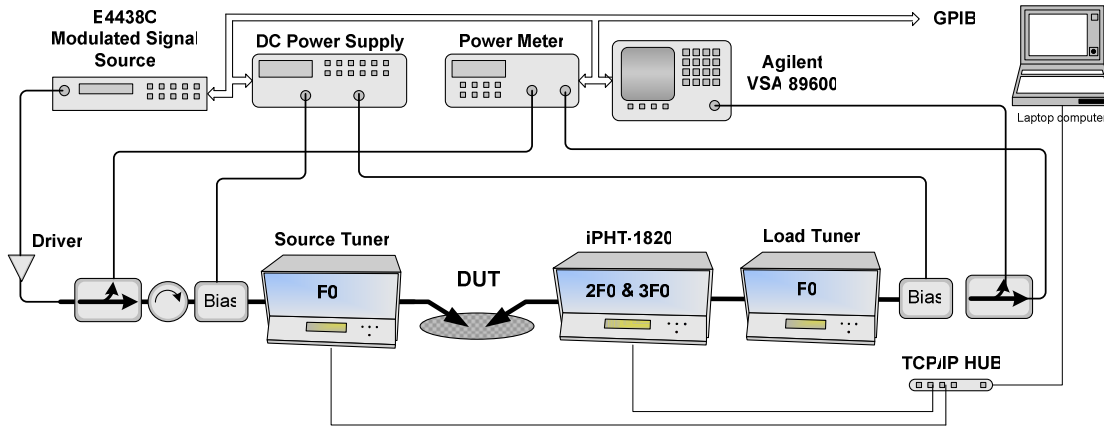


Figure 1: WiMAX Setup using Fundamental (CCMT) and Harmonic (PHT) Tuners

Solution 2: Using a Combination WiMAX Tuner for fo and 2fo tuning (Figure 2)

Alternatively, WiMAX measurements can be performed using a Combo Tuner, specifically designed for this application, the **iCCMT 1220-2H-WiMAX**, which combines both fundamental and second harmonic tuning. The **iCCMT 1220-2H-WiMAX** covers 2 to 12 GHz for fo and 2fo tuning and replaces the need for two separate tuners, while maintaining full functionality of both the CCMT and PHT [3]. This tuner allows full tuning at the fundamental frequency and full phase control of the second harmonic. Because there are no external connections involved, since both tuning sections use the same airline, the **iCCMT 1220-2H-WiMAX** is extremely low-loss thereby maximizing the tuning range at fo. Because of the further reduced size of the setup, this solution is well suited for on-wafer measurements.

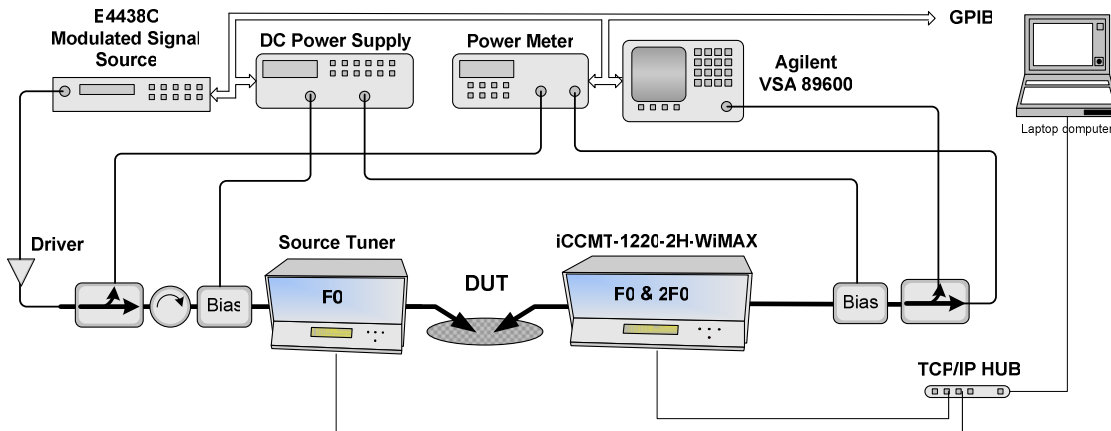


Figure 2: WiMAX Setup using a Combination Tuner (integrated Fo & 2Fo)

Solution 3: Using a Multi-Purpose, Multi-Harmonic Tuner iMPT-1818-TC (Figure 3)

Finally, WiMAX measurements can be performed using a Multi-Purpose Multi-Harmonic Tuner (iMPT 1818-TC) which can tune f_0 , $2f_0$ and $3f_0$ independently [4]. The iMPT 1818-TC allows for three-frequency tuning while replacing two separate tuners, as shown in Figure 3. The MPT makes use of three wideband, integrated and independently calibrated tuning sections, which can be automatically positioned for full f_0 , $2f_0$ and $3f_0$ control in both magnitude and phase. There is no need for resonator change or other hardware manipulations to cover the whole frequency range. Because all tuning is accomplished within one structure, without external components or adapters, the MPT offers the lowest loss solution and maximum tuning range at f_0 . Because of the further reduction in size this solution is the best available to date for on-wafer load pull.

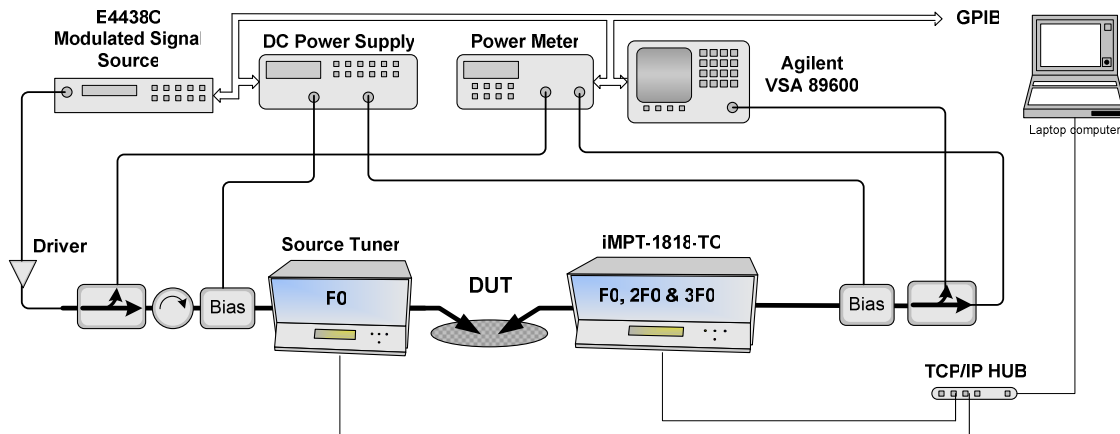


Figure 3: WiMAX Setup Using a MPT Multi-Purpose Multi-Harmonic Tuner (integrated f_0 , $2f_0$ & $3f_0$)

Solution 4: Focus setup using a Diplexer or Triplexer [5]

In case of budgetary constraints and in order to re-use existing tuners in the lab, an alternative configuration may be used. It consists of a wideband source tuner (as before) and two or three output tuners in a star configuration combined using frequency discriminator (Diplexer for f_0 & $2f_0$, or Triplexer for f_0 , $2f_0$ and $3f_0$ tuning). It is a classical harmonic load pull test setup, which has been sometimes used before the introduction of harmonic tuners (PHT) by Focus Microwaves in 1997. Some laboratories still use this technique. It is easily understandable and can be used if the devices are unconditionally stable at low frequencies and the VSWR requirements are low: the Di-Tri-plexers introduce VSWR-reducing losses and out-of band reflections.

In no case, however, a single wideband tuner should be used at the output, since harmonic tuning is crucial for EVM optimization. Because of the size and cumbersomeness of this setup, the Triplexer solution is not recommended for on-wafer measurements.

Software Capability – Full test software compatibility with existing and future instrumentation being released by Agilent, Anritsu, R&S, Keithley and others is necessary. Focus Microwave's WinPower suite includes, among dozens of measurement parameters **the most important ones for WiMAX: Pout, PAE, EVM and device currents and voltages.** WinPower is compatible with Agilent's E4438C

modulated signal source and VSA 89600-series vector signal analyzer and associated firmware, as well as R&S SMU and FSQ vector-series analyzers. Corrected values of EVM are instantly imported into WinPower and displayed as ISO-contours.

Constant-Pout harmonic load pull is the most essential measurement routine and builds the basis of our WiMAX solution.

With only a few mouse clicks you are able to minimize source mismatch and optimize the load for output power and EVM and determine optimum load at the harmonic frequencies for EVM, while maintaining a constant output power.

Our entire solution can be mounted and calibrated within a couple of hours, with the possibility of fully automating the load pull procedure through the use of MACRO commands.



Figure 4: iMPT-1818, 1.8-18GHz for WiMax and WLAN harmonic load pull testing

Figure 5: In-house integrated WiMax harmonic load pull setup using MPT multi-harmonic tuner, as per Fig. 3



Conclusion

For any modern application it is not enough to simply have a good tuner, an overall good solution is needed. Focus' solutions have been evaluated in-house and at various customer's sites and have proven suitable for this type of testing, each one of course with its advantages and shortcomings.

Only a fully integrated load pull solution for fundamental and harmonic tuning with the appropriate software routines and instrument compatibility delivers the required accurate data for realizing "EVM-optimized" amplifier designs. Focus Microwaves offers a tailored solution for WLAN and WiMAX measurements within any budget and any degree of existing equipment. Focus provides more than tuners; it delivers a working WLAN/WiMAX measurement test bench.

References

- [1] Application Note 59, “The Effects of Harmonic Tuning on EVM”, Focus Microwaves, Sept. 2006
- [2] Product Note 44, “PHT - Programmable Harmonic Tuner”, Focus Microwaves, Nov. 1997
- [3] Product Note 46, “Programmable “Combo” Load Pull Tuners”, Focus Microwaves, May 1998
- [4] Product Note 79, “MPT, A Universal Multi-Purpose Tuner”, Focus Microwaves, Oct. 2004
- [5] Application Note 58, “An Operational Comparison of Harmonic Load Pull Methods With Regards to PAE”, Focus Microwaves, In Print.
- [6] Application Note 5989-3144EN, “8 Hints for Making and Interpreting EVM Measurements”, Agilent Technologies
- [7] Product Note 89400-14, “Using Error Vector Magnitude Measurements to Analyze and Troubleshoot Vector-Modulated Signals”, Agilent Technologies