Comparing Active versus Passive Load Pull: Strengths & Weaknesses

NOTICE: This document reflects the **stand of technology in 2004**.

Meanwhile new harmonic tuner solutions (MPT) by Focus Microwaves and active systems DLP by Mesuro have been introduced, which dilute some of the differences of active versus passive harmonic tuning.

JULY 2010: Additional Comparison - Active - Passive

Introduction

Active load pull systems use a 'virtual' load: part of the outgoing signal is modified in amplitude and phase by an amplifier/phase-shifter network and re-injected into the output port of the DUT. The DUT 'sees' a load reflection factor, which can be equal to, or even larger than 1 (the dream of every test engineer), because of the amplification involved.

Having developed and marketed an active load pull system a few years ago ourselves (Cover story Microwaves & RF Magazine, November 1995) we feel compelled to outline its strengths and weaknesses for the non-expert reader, based on our experience.

Strengths

A well-designed active load pull system (i.e. one made cautiously to avoid spurious oscillations of the active load) has the following inherent strengths:

. It can synthesize load reflection factors larger than 1, thus compensating for the loss of cables and test fixtures. This is particularly interesting for 'on-wafer' testing.

. It can synthesize loads very fast (milliseconds) since it uses only electronic components.

. It can measure very fast (if used with single tone signals and a synchronized Network Analyzer as a receiver).

. It allows to measure the DUT large signal input impedance and absorbed power , and thus the Power added Efficiency (PAE).

. The parameters that can be measured this way are essentially: Single tone (unmodulated) Power, Gain and PAE. info@focus-microwaves.com +1 514 684 4554 www.focus-microwaves.com

Weaknesses

The weaknesses of active load pull systems are mostly related to typical applications and budget constraints

. Two-tone (Intermod) or modulated signal (CDMA, ACPR etc..) suffer from systematic phase error

. Significant loss of test speed, when using modulated signals

. Power limitations and prohibitive cost of available linear RF amplifiers3

. Incompatibility with Network Analyzers having a carrier signal phase drift

. Incompatibility with Source tuning

. Parasitic oscillations even at absolutely stable active load, since the (unknown) DUT is part of the active loop.

Alternatives

The alternative to active load pull is passive load pull using electromechanical tuners. The question is: can passive load pull respond to test situations where active load pull seems to be the only solution? The answer is: In practically all cases: 'yes'.5 The key advantage of passive load pull over active load pull is its affordable component and system cost, combined with robustness of operation and hardware; not to neglect is the fact that passive load pull is one step up from manual load pull, which most test engineers are familiar with, understand, interpret and feel comfortable with its results and their derivation and can handle after short training.

Comments:

(1) The electrical length of the signal path through the active load is very long. This creates an error in the load impedance between lowest and highest frequency in the signal envelope. This may not be negligible at all. The only way we know to minimize this fundamental problem is to minimize the electrical length between DUT and origin of the reflection factor (RF probe in passive tuners). We do not have any information, nor any feeling, of how wrong the measured contours will be, due to this systematic measurement error. For more details, please see Impedance Error in two tone L/P tests.

(2) If single tone tests are performed, the VNA can be used as very fast receivers, using the frequency list routine to measure RF power at different impedances using external triggering. This requires, however, a phase-lock operation. If two tones or a modulated signal are used, then the phase-lock information is lost: Impedance measurement is not possible. So, the L/P system has to be switched back and forth between modulated and unmodulated signal to perform both tests. This causes an important loss of test speed. If a CDMA (or similar) test signal is used aiming to measure ACPR, then we need a spectrum analyzer.info@focus-microwaves.com +1 514 684 4554 www.focus-microwaves.com In this case the test speed is dictated by the measurement speed of the spectrum analyzer, which may be several seconds for a single sweep, depending on resolution and video bandwidth used.

(3) Our tests have shown that linearity of the amplifiers in the active load is 'critical', especially when measuring modulated signals. A power reserve of roughly 10dB shall be available, after correcting for the network and cable losses. So, for load pull testing 30 Watt transistors for ACPR using an active load pull system, one should be prepared to come up with a 300 Watt amplifier, at least. Further considerations, regarding the difficulty to inject tens of Watts of RF power into a 1 Ohm transistor using 50 Ohm amplifiers, and the power requirements of those amplifiers, being left out of this discussion, it is obvious that this test method is bound to face serious limitations in power tests.

(4) During our work with ALPS, we found that it was not possible to synchronize our system with any of the new Wiltron (Anritsu) 37000 network analyzers. The phase reading was inconsistent. We had more luck with the Wiltron 360 and the HP analyzers, including the 8510 and 8753. This was the stand of 1997/98.

(5) The availability of Harmonic and Prematching Tuners (PHT, PMT by Focus) fills the gap for high SWR and harmonic testing to a large extent. It remains to find a practical solution for testing chips on wafer below approximately 1 Ohm load (source) impedance.