NVNA Users' Forum U.S.: Tempe, AZ, November 28, 2007

Approximately 30 participants from industry, government and academia attended the meeting. The agenda is contained in the attached file "NVNA Agenda Fall 2007.doc" These notes will be available shortly at www.arftg.org.

Discussion Topic 1:
Envelope-Domain Measurements
As an introduction to this topic, two short presentations were made by research groups who are using and studying envelope-domain measurement systems.

The first presentation was by Paul Tasker of Cardiff University. In this envelope load-pull system, RF and baseband signals are measured separately and then combined. The b2 wave is absorbed by the load and is demodulated. Then an a2 wave is reinjected through the modulator to tune the impedance. The user changes the a2 characteristics to engineer the waveform.

Paul described a few of the design issues that went into this system:

- Uses of realistic input and output impedances (not restricted to 50Ω).
- Knowing the impedance across the modulation bandwidth is critical.
- Baseband tracking and alignment of modulated signals across signal paths is difficult.
- Uses multisine signals to emulate digital modulation.

The second presentation was by Don Kimball of the University of California at San Diego (UCSD). He described an envelope tracking system that his group uses to achieve higher efficiency since some waveforms have the same spectrum but may not provide the same efficiency. This system is used when the modulated signals have a long delay spread, for example, in military applications. A separate amplifier is used to track the envelope signal. The predistorted, reinjected envelope signal can increase efficiency of the design by tuning the drain at envelope frequencies (MHz range).

Don described some design issues for this system:

- Synchronization of the envelope and RF signals is critical. A VNA is used to characterize delays. Delays of up to one chip are acceptable.
- Two amplifiers are used to measure amplitude and phase separately.

A discussion on the synchronization issue followed. Some key points: Large asymmetries are seen when the envelope and RF are out of synch. Autocorrelation can be used for alignment.

PhD Research Overview: Chin Hsia of UCSD – *Envelope tracking.*
Chin discussed his PhD work on envelope tracking. He provided additional implementation details on the system described above. For example, the system requires use of broadband, high-power amplifiers. The system is used to study input and output

match, tracking ratio, and what signals give the best efficiency. The system is used to understand what is going on in a given PA design using envelope and drain pulsing.

Question: Chin's ADS simulations oscillate. What are the best parameters for the system? Ideas: The issue may be that the pulse duration is comparable to the bandwidth of the measurement system. Low-frequency feedforward techniques could be helpful. The DC impedance of the pulse measurement system is of concern as well.

Research updates:

(1) LSNA-related activities at The Ohio State University, presented by Patrick Roblin:
Ongoing projects include multi-harmonic real-time active load-pull: the equipment combines elements of the Maury LSNA instrument, XLIM pulsed IV capability, and Cardiff University-inspired bias and active load-pull set-ups, and can use modulated waveforms. The 'real-time' measurement aspect enables rapid and slow variation of the load to eliminate or stimulate memory effects.
Patrick presented some on-wafer measurements showing Class F loads: power, I-V time-domain waveforms were presented; a comment was made that these waveforms did not look like classical Class-F I-V waveforms; this may be due to the waveforms requiring to be de-embedded – the calibration being made to probe tip and not the intrinsic device. This aspect of the research was being pursued with the goal being to extract device models from time-domain waveforms.

(2) Technology Demonstration:
Loren Betts of Agilent demonstrated a pre-prototype instrument based on the PNA-X that uses a comb generator to provide a phase alignment of measured frequency components. Since it is VNA based, the system has a dynamic range of 130 dB. The frequency range is 10 MHz to 26.5 GHz. The frequency grid spacing could be on the order of kilohertz, but at the expense of frequency range.
Agilent is trying to gauge interest in this design from the microwave measurement community. The instrument could be used for extracting the coefficients of the polyharmonic distortion (PHD) model directly.

Announcements:

Next Users' Forums:

- Thursday June 19, 2008 at the MTT International Microwave Symposium
- October 2008 during European Microwave Week
- December 2008 during the 72nd ARFTG Microwave Measurement Conference

If you have ideas for discussion topics, PhD thesis presentations, or research updates, please contact the organizers.

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