

NVNA Users' Forum International: IMS 2007, Honolulu, Hawai'i June 7, 2007

Approximately 30 participants from industry, government and academia attended the meeting. The agenda is contained in the slides "UsersForum_June2007." These notes and the slides will be available shortly at www.arftg.org.

Discussion Topic 1:

Measurements of cascaded devices in non-50-ohm environments - *How do engineers approach modeling and measurement of multiple nonlinear devices?*

The topic was introduced by Jan Verspecht who described the issues of connection of devices, which in a non-50 Ohm system can yield reflected waves that are not insignificant, and that can affect the overall measurement and model of the cascade. The PHD model accounts for incident and reflected waves at both ports and can therefore accommodate non-50 Ohm environments. (Note: the PHD model is not the only published model that can describe large-signal behavior in a non-50 Ohm environment). David Root, who also worked on development of this model, stated that the PHD model is an extension of the concept of S-parameters, with all of the description of mismatch, to the large-signal regime.

- The moderator asked the forum members whether anyone has used the PHD model. At present no-one is using the model as it is perceived that an LSNA is required to perform the measurements. Jan pointed out that a single-tone PHD model can be extracted using a VNA, and David said that the model can be extracted from simulation using a small-signal mixer simulation.
- A group member stated that a multi-harmonic flowgraph technique can also be used, and it straightforward to analyze, but requires knowledge of the harmonic impedances.
- Another member commented that to describe the nonlinear transmission line devices that he uses, 30-100 harmonics would be required; the PHD model is a frequency-domain model.
- Jan described how the PHD model can be extended to include a description of memory effects, by evaluating the model as if there was a slow variation of phase, in other words, a slow frequency modulation. The memory effect is a slow modulation, but the state variable description is unknown, requiring a specific method for identification, such as noise signals, pulse measurements, etc. David stated that the memory effect is part of the envelope formalism.

Returning to the topic of cascaded measurement and modeling, one member made the comment that currently, the main area of interest seemed to be power amplifier design, which is a single-stage network design. The discussion closed at this point.

PhD Research Overview: C. Roff of Cardiff University - *Applications of Non-linear Measurements with Multi-harmonic Active Load-Pull.*"

Chris discussed his PhD work research topic "Applications of non-linear measurements with multi-harmonic active load-pull." This work involves developing measurement system based on an MTA and a four-channel sampling scope that uses active harmonic source and load pull to emulate the class F environment. He also discussed how the system can be used to improve amplifier design by rapidly optimizing waveforms. He showed I/V measurements of the "knee walk-out" problem for GaN HFETs that can limit power densities in these devices. He then demonstrated use of the measurement system to experimentally engineer the best case waveforms for a given transistor in real time. A short discussion of the work followed. See the slides "Roff PhD Research" for more information.

Discussion Topic 2:

What am I losing when I perform multi-tone measurements? - *Do periodic signals composed of sinusoids really capture device behavior?*

The discussion was initiated by Paul Tasker of Cardiff University who stated that the use of multitone signals to emulate digital modulation can give lots of useful information. However, he wondered whether the quality of the measurement decreases with the number of tones used and whether one would need to measure a prohibitively large number of tones at the fundamental and harmonics to accurately represent a wideband digitally modulated signal.

- One participant said that he uses specially tailored time-domain multisines for his measurement-based models and notes that they are fine for his application, which is the prediction of BER. He has used them for years.
- Someone else pointed out that to make distortion measurements of real signals, it is necessary to window, which means you are effectively using a multisine anyway. You may have different magnitudes and phases for each time sample, but still it is a multisine. Others agreed: multisines are simply Fourier coefficients of a sampled signal.
- One participant asked: What if you have a fixed number of tones but keep increasing the bandwidth? How wide of a bandwidth could you simulate?
- Someone suggested looking at the autocorrelation of the input to make sure it has the right statistics. If the time sequence is too short, you may not get the right power spectral density.
- Others agreed: to measure memory effects you need a long sequence of symbols. One participant stated that using 1024-2048 tones would be necessary to emulate 128 symbols.
- One member pointed out that the LSNA measure up to 1000 symbols of 1 microsecond. Or you can do several measurements and then average them.

In conclusion: Use of multisines can be challenging because many tones may have to be measured. But if the statistics of the real signal are known, the multisine can be designed to emulate them (at least the power spectral density).

Research updates:

(1) Jean-Pierre Teyssier of the University of Limoges presented "Comparison of methods to measure pulsed RF signals." He discussed three different techniques: (1) IF

narrowband detection, (2) IF wideband detection, and (3) stroboscopy. The first two are frequency-domain techniques. The stroboscopic technique will increase the measurement time, but it has the advantage of retaining the dynamic range. See the slides “Limoges Research Update” for more information.

(2) Steve Cripps from Hywave Associates discussed "An LSNA based non-intrusive voltage probe." He discussed using voltage probes as an alternative to directional couplers with much lower insertion loss. The challenge is finding a voltage probe that has reasonably flat broadband performance, no magnetic field response, and appropriate spatial discrimination. He has developed such a probe and a companion load-pull system, although the probe could be incorporated into any passive load-pull system. The probe can be used for real-time waveform monitoring of high power devices. See the slides “Hywave Research Update” for more information.

Announcements:

Next Users’ Forums:

- October 2007 in Munich, Germany at EuMC. Monday October 8th from 10:50-12:30
- December 2007 in Tempe, AZ at the 70th ARFTG Microwave Measurement Conference.

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

Organizers:

Dr. Kate Remley (remley@boulder.nist.gov)

Dr. John Wood (john.wood@freescale.com)

Dr. Dominique Schreurs (Dominique.Schreurs@esat.kuleuven.ac.be)