NVNA Users' Forum: at IMS 2006, San Francisco, CA, June 15, 2006

The meeting started with each of the 40 participants giving a quick introduction. This was the first meeting for 14 of the participants. After the introductions, we went right in to discussion topic 1.

Discussion Topic 1:
What is the Importance of Modeling Memory Effects?

Questions:

- Which types of memory effects affect which model parameters and metrics?
- Commercial amplifiers do not typically display memory effects so why spend the time modeling them?

This led to the question: What are memory effects anyway?

To answer, several participants offered various descriptions of memory effects that can affect models at the device or system level. The answers reflect why modeling memory is important for various applications.

- They characterize the IF impedance, for example the terminating impedance of the bias lines will induce memory
- Any non-static nonlinearity is a memory effect. Can also be called dynamic distortion
- An IM3 slope that isn't three indicates a memory effect. Bias can contribute as can other effects. The goal is to separate the effects to be able to model them accurately
- Memory is often called "Current pull-up" in the device world, that is, trapping in the device. The output changes every time you apply a signal.
- Narrowband amplifiers can be linearized without dynamic pre-distortion since they don't display memory. The reason we need to model memory is to improve PA response through, for example, pre-distortion or improved design.
- The term memory effect is a renaming of old phenomena. Two identical inputs that produce different outputs are caused by memory effects. Variations with frequency (or delays) on different time scales are "short" or "long" term memory effects. Because information is contained in the envelope, long-term memory effects are more important that short-term memory effects.
- At the system level, we are worried about BER, so we need lots (millions) of simulations or measurements. That is why an efficient and accurate model of memory is important at the system level.
- Thermal memory is not seen much especially for stable devices. Electrical memory can be much more complicated.

Intermezzo Frans Verbeyst (NMDG) - Avoiding common pitfalls when going beyond S-Parameters
Frans gave a short presentation of some common problems that users can run into when making large-signal measurements. In particular, how one may incorrectly interprete the

"deterministic noise" in S-parameter measurements resulting from nonlinear behaviour as a S/N problem of the instrument and how to correctly relate small-signal measurements performed in LSNA mode to classical S-parameter measurements using forward/reverse measurements. See attached file “PitfallsGoingBeyondSpar_v2.pdf”.

PhD Research Overview: Arek Lewandowski - Covariance-based uncertainty representation for frequency and time-domain measurements

Arek discussed his PhD work on developing uncertainty analyses that can be used in both domains. See attached slides “Arkadiusz Lewandowski – NVNA Users' Forum – June 2006.pdf”. This overview led to discussion topic 2:

Discussion Topic 2: Uncertainties in Measurement-Based Models - Is it Possible??

One participant pointed out that the applicability of an uncertainty statement to a measurement-based model will depend on what the model is designed to do. That is, if a model is supposed to capture one condition very well, then it may be possible to think about applying an uncertainty analysis. But if it is supposed to cover a wide range of operating states (lots of single-measurement states), a repeatability analysis cannot be applied, and so an uncertainty statement would be difficult.

A participant suggested to first check the importance of the correlations before deciding to apply the full analysis. A reason for this is that it may be a problem to invert the covariance matrix.

There was also a confusion during the discussion that got clarified in the end. There is a fundamental difference between the approach applied to a system which is known/assumed not to change while performing repeated measurements and dealing with situations where one deals with variations between the observed quantities (typ. looking at a large number of physical samples which are not identical due to variations/uncertainties in the process generating these samples. In the former case, a WLS (weighted least squares) or MLE estimator can be used to detect model errors (and as such the violation of the assumption that the underlying system did not change while performing repeated measurements).

Other participant suggested that description of uncertainties in measurement-based models with the first-order statistics may not capture all of the statistical properties of these uncertainties and knew a reference that describes this effect: “J. Purviance, M. Meehan, D. Collins, "Properties of FET Parameter Statistical Data Bases," 1990 MTT-S Symposium Digest, pp. 567-570”.

Other participants thought that the measurement error in measurement-based models is typically much smaller than the modeling errors.

Research update:

The meeting concluded with a research update by Frans Verbeyst on some of the latest work being carried out at NMDG. See attached file “Metrology@NMDG.pdf”. Of special interest to the attendees was his comparison between the nose-to-nose approach and the

EOS-based approach to calibrate the HPR. Whereas the results were very similar up to 20 GHz, a difference of 25 deg. at 50 GHz was demonstrated. Today, it is impossible to “prove” that EOS provides the "correct" phase distortion of a sampling oscilloscope. However, given the fact that no discrepancy was found between the EOS-based amplitude distortion of a sampling oscilloscope and power-measurement based techniques, while there is discrepancy for the nose-to-nose-based amplitude distortion and the fact that the EOS-based calibration technique has the advantage of using a photodiode which is specified by NIST up to 110 GHz, it is "believed" that the phase distortion provided by EOS is more correct than the one provided by n2n. In conclusion, NMDG will adopt the EOS-based approach from now on.