

Minutes of the 5th ARFTG NVNA Users' Forum

The 5th NVNA Users' Forum was held on Oct. 12th as a Focused Session of the European Microwave Conference in Amsterdam, the Netherlands. It was co-sponsored by ARFTG and by the European Network of Excellence TARGET. There were over 40 participants, representing academia and industry from around the world, but mostly Europe.

Papers

As this 5th meeting was part of the official conference program, a section in the proceedings was dedicated to this Forum. Groups having presented research updates at previous Forums or who were planning to do so at this Forum were given the opportunity to publish a paper. In the end, the following three papers were included:

- “NVNA Users Forums: Mission and Overview”, by D. Schreurs, K.A. Remley, and W. Van Moer
- “Real-time and optimal PA characterization speeds up PA design”, by F. Verbeyst and M. Vanden Bossche
- “An automated multiple-stimulus measurement system for characterising multiple-device amplifiers”, by J. Lees, A. Haczewski, J. Benedikt, and P.J. Tasker

Agenda

- 4:00 p.m.–4:05 p.m.: Welcome
- 4:05 p.m.–4:45 p.m.: Discussion topics 1 & 2
- 4:45 p.m.–5:25 p.m.: PhD research 1 & 2
- 5:25 p.m.–5:55 p.m.: Research updates
- 5:55 p.m.–6:00 p.m.: Announcements
- 6:00 p.m.–6:30 p.m.: Informal interactions

Discussion Topics

- *“Classes of ‘non-linear’ behaviour” What is the definition of ‘weakly nonlinear’? Is there a definition beyond the link with Volterra series analysis? (moderator: Wendy Van Moer)*

Jan Verspecht initiates this discussion topic and introduces it. He does not agree with the fact that ‘weakly’ nonlinear behavior is always associated with Volterra series analysis. The usual statement is: “it is weakly nonlinear if it can be modeled by Volterra series”, and also, “if it can be modeled by Volterra series, it is weakly nonlinear”. José Carlos Pedro confirms that he indeed uses this definition in his book.

The participants first try to pinpoint the origin of the term ‘weakly nonlinear’. According to James Hwang, Steve Cripps was the first person. José Carlos Pedro points out that the history is much older. First there was Wiener-Volterra before the 1950’s, followed by Martin Schetzen (“Nonlinear System Modeling Based on the Weiner Theory,” Proc. IEEE, Vol. 69, No. 12., Dec., 1981), Wiener & Spinner, and more recently S. Maas.

From the measurement point of view, 'mildly non-linear' (or like someone said: 'largely linear') is usually connected to figures of merit, like IP3, P1dB, etc.

Concerning classes of NL-systems, José Carlos Pedro mentions that the work on the non-linear Integral modeling (started in the 1990's) is a good example. At first, memoryless strong nonlinearities were considered. Next linear dynamical effects, and finally also non-linear dynamical effects.

- **“Are periodic, discrete-tone signals sufficient to emulate digital signals in device-, circuit- and system-level applications?” (moderator: Dominique Schreurs)**

Ludwig De Locht makes the following statements:

- One-tone or two-tone signals are not sufficient to simulate the behavior of a lot of systems, e.g., a power amplifier with adaptive biasing.
- Sweet spots are not worth very much because they change with biasing and two-tone spacing.
- Multitone signals are the best choice to simulate digital systems on all levels.

Jean-Pierre Teyssier agrees with these statements and points out that they have already for a long time a nonlinear measurement system that uses multisines. However, an RF Arbitrary Waveform Generator is needed and this instrument is still very expensive. Another way to realize such a setup is by using IQ modulators, but these will introduce some phase uncertainties.

José Carlos Pedro agrees that multisines are very useful in testing but that they are only an approximation of the signals used in real-life... Multisines are periodic signals and hence contain no information. They provide however a lot of information about the system.

Sweet spot testing with 2-tones is dangerous but gives information about the device.

Dominique Schreurs points out that the bandwidth of OFDM signals is much larger than the 8 MHz acquisition bandwidth of the Large Signal Network Analyzer. What will be the evolution on solving this problem? The group of Paul Tasker uses subsampling to measure modulated signals. Alain Barel mentions about a work package within TARGET that focuses on this particular item.

Discussion of Ph.D. research

- **Johan Paduart** (VUB, Belgium) first presented a short overview of his PhD research on “Blackbox identification of nonlinear MIMO systems” (see file: PhD_Research_Paduart.pdf), after which he solicited inputs from the participants on two questions:

“Is it a good idea to use state space? Are there better alternatives?”

Dominique Schreurs is also working on state-space modeling, but uses a different formulation. Whereas Johan treats it as a linear system to which non-linear terms are added, others consider it as a nonlinear system on its whole.

The discussion then gets distracted to representation formats. José Carlos Pedro addresses the dis/advantages of polynomials, artificial neural networks and radial basis functions. Dominique Schreurs concurs by saying that radial basis functions turned out to be inadequate to model the typical nonlinear behaviors of microwave transistors.

*“How can one prove stability for the model described (state space + static nonlinearities)?”*No decisive answer.

- **Giovanni Loglio** (University of Firenze, Italy) first presented us a short overview of his PhD research on “Extraction of the conversion matrix with a variable IF” (see file: PhD_Research_Loglio.pdf), after which he solicited inputs from the participants on three questions:

“Do you see a possible method to measure quantities that I can relate to the conversion matrix parameters, so that I can validate my method with results obtained in a completely different way?”

No decisive answer.

“Are there some verification procedures you can use to assess the goodness of a NVNA calibration? How do they work?”

Jan Verspecht answers that this is still a hard problem to solve and that a lot of work is still needed in this open field. He suggests measuring a robust non-linear device with an expected response after each calibration. This would be the equivalent of measuring a SHORT after an LRM calibration (LINE - OPEN REFLECT - MATCH). In that sense, NIST has developed some procedures which allow one to verify the correctness of a linear calibration. For the phase calibration, however, there is not yet a primary standard, but they try to characterize the errors of the nose-to-nose procedure.

Nevertheless you have to believe in your calibration and you will not be able to see small errors (which is similar as in case of S-parameter measurements).

“Where does the pulse generation happen in the downconverter module? Is it part of the FracN synthesizer or is there a different pulse generator on each MTA card?”

The participants reply that there is only one pulse generator.

Research updates

- **Jonathan Lees**, A. Haczewski, J. Benedikt, and P.J. Tasker (Univ. Cardiff, U.K.):
“An automated multiple-stimulus measurement system for characterizing multiple-device amplifiers”

Presented slides: see file: Research_Update_Lees.pdf

- **Alessandro Cidronali** (Univ. Firenze, Italy):
“Behavioural model of mixer in linear operation”

Presented slides: see file: Research_Update_Cidronali.pdf

- **Frans Verbeyst** (NMDG Engineering, Belgium):*“Real-time PA characterization and behavioural modeling”*

Presented slides: see file: Research_Update_Verbeyst.pps

Announcements and open discussion

The NVNA Users’ Forum was founded by ARFTG. It was first organized at the Fall ARFTG conference in Dec. 2002, and was held bi-annually at the Spring ARFTG conference (always in

conjunction with IMS) and at the Fall ARFTG conference since. Due to the high research efforts on nonlinear measurement techniques and use of nonlinear measurements in Europe, it was approved by ARFTG that the 5th NVNA Users' Forum could be held in Europe. Thanks to the co-sponsorship by TARGET, this event now took place at the EuMW. At the end of the meeting, a vote was held asking the participants whether they would like to see the next Fall meeting in conjunction with the Fall ARFTG meeting or in conjunction with the EuMW again. The attendees had an unanimous preference for the EuMW.

Next Forums!

The 6th NVNA Users' Forum will be held in conjunction with the 2005 IMS in Long Beach, California, USA. Date and location will be announced on the ARFTG website and through the NVNA Users' Forum e-mail distribution list.

The format of the NVNA Users' Forum held at the Fall conference is still under discussion.

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