# 2023 101st ARFTG Microwave **Measurement Conference** (ARFTG 2023)

San Diego, California, USA 16 June 2023



IEEE Catalog Number: CFP23ARF-POD **ISBN:** 

979-8-3503-2346-7

### **Copyright © 2023 by the Institute of Electrical and Electronics Engineers, Inc. All Rights Reserved**

*Copyright and Reprint Permissions*: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

### \*\*\* This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.

IEEE Catalog Number:	CFP23ARF-POD
ISBN (Print-On-Demand):	979-8-3503-2346-7
ISBN (Online):	979-8-3503-2345-0
ISSN:	2836-1407

### Additional Copies of This Publication Are Available From:

Curran Associates, Inc 57 Morehouse Lane Red Hook, NY 12571 USA Phone: (845) 758-0400 Fax: (845) 758-2633 E-mail: curran@proceedings.com Web: www.proceedings.com



## Session A: Over-the-air measurement topics

# Practical Verification of Over-the-Air Measurements and Correlation across Measurement Setups...1

Thomas Deckert, Okay Schierhorn, Harsh Nitharwal, Jan Fromme NI

### **Robot-Based Multi-Purpose Measurement Platform for 6G Communications...5**

Woohyun Chung, Chihyun Cho, Jae-Yong Kwon Korea Research Institute of Standards and Science

### Dynamic Range by Design in OTA EVM measurements...9

Paritosh Manurkar<sup>1,2</sup>, Daniel G. Kuester<sup>2</sup>, Joshua M. Kast<sup>2,3</sup>, Robert D. Horansky<sup>2</sup> <sup>1</sup>University of Colorado, Boulder, <sup>2</sup>National Institute of Standards and Technology, <sup>3</sup>Colorado School of Mines

## Session B: Modulated and spectral analysis

# A Measurement-Referenced Error Vector Magnitude for Counterfeit Cellular Device Detection...13

Ameya Ramadurgakar<sup>1,2</sup>, Kate Remley<sup>2</sup>, Dylan Williams<sup>2</sup>, Jacob Rezac<sup>2</sup>, Melinda Piket-May<sup>1</sup>, Robert Horansky<sup>2</sup> <sup>1</sup>University of Colorado, Boulder, <sup>2</sup>National Institute of Standards and Technology

### Spectral Purity Evaluation of VNA Frequency Extenders to Enable Electronic Software-Based Power Control...17

C. De Martino<sup>1,2</sup>, J. Bueno Lopez<sup>2</sup>, M. Spirito<sup>2</sup> <sup>1</sup>Vertigo Technologies B.V., <sup>2</sup>Delft University of Technology

### Pulsed Sub-THz Wideband Vector Component Analysis...21

Jean-Pierre Teyssier, Joel Dunsmore, Johan Ericsson, Sam Kusano, Nizar Messaoudi Keysight Technologies

# Accurately Applying Wideband Modulated Signals to a DUT Using an Extended VSG-VSA Setup...25

Frans Verbeyst, Paweł Barmuta, Marc Vanden Bossche, Markus Rullmann NI

## Session C: Doug Rytting Memorial session: Advanced Linear Network Analysis

### D-Band Characterization of a Commercial High-Resistivity Silicon Calibration Substrate...29

Gia Ngoc Phung<sup>1</sup>, Hyunji Koo<sup>2</sup>, Chihyun Cho<sup>2</sup>, Jae-Yong Kwon<sup>2</sup>, Uwe Arz<sup>1</sup> <sup>1</sup>Physikalisch-Technische Bundesanstalt, <sup>2</sup>Korea Research Institute of Standards and Science

### Dielectric Spectroscopy of Liquids by De-embedding Two-Port Measurements...33

Maede Chavoshi<sup>1</sup>, Matko Martinic<sup>1</sup>, Hélène Ponsaerts<sup>1</sup>, Maya Van Dijck<sup>1</sup>, Bart Nauwelaers<sup>1</sup>, Tomislav Markovic<sup>1,2</sup>, Dominique Schreurs<sup>1</sup>

<sup>1</sup>KU Leuven, <sup>2</sup>University of Zagreb

### Verification of Reference Impedance from Common On-Wafer Calibrations on Commercial Calibration Substrates...37

L. Nyssens, M. Rack, R. Tuyaerts, D. Lederer, J.-P. Raskin Université catholique de Louvain,

## Session D: Non-Linear, Large-Signal VNA Techniques

# VNA-Based Characterization of Frequency Multipliers Phase-Distortions Under Continuous-Wave and Modulated Signal Excitation...41

Mahitab Eladwy, Ahmed Ben Ayed, Slim Boumaiza University of Waterloo

### Modulated-Input Control and Linearization of a Multi-Port Millimeter-Wave PA by VNA-based Calibrated Wideband Measurements...45

<sup>1</sup>Mattia Mengozzi, <sup>1</sup>Gian Piero Gibiino, <sup>1</sup>Alberto Maria Angelotti, <sup>1</sup>Corrado Florian, <sup>1</sup>Alberto Santarelli, <sup>2</sup>Christoph Schulze, <sup>2</sup>Olof Bengtsson <sup>1</sup>University of Bologna, <sup>2</sup>Ferdinand-Braun-Institut

# A Rigorous Analysis of the Random Noise in Reflection Coefficients Synthesized via Mixed-Signal Active Tuners...49

Faisal Mubarak<sup>1,2</sup>, Fabio Munoz<sup>1</sup>, Marco Spirito<sup>2</sup> <sup>1</sup>IVan Swinden Laboratorium, <sup>2</sup>Delft University of Technology

### First Comparison of Active and Passive Load Pull at W-Band...53

Christopher Clymore, Emre Akso, Matthew Guidry, Henry Collins, Wenjian Liu, Christian Wurm, Nirupam Hatui, Umesh Mishra University of California Santa Barbara

## **Interactive Forum**

### A 3D FW-EM Simulation-Based PSOD Method for Characterizing On-Wafer Devices Compensating for Short Pattern Error...57

Yunsang Shin, Sangwook Nam Seoul National University

# Design of Optimal Length for Waveguide Offset Shorts in D-band based on Uncertainty Analysis...61

Chihyun Cho<sup>1</sup>, Jae-Yong Kwon<sup>1,2</sup> <sup>1</sup>Korea Research Institute of Standards and Science, <sup>2</sup>University of Science and Technology

# Implementing Direct RF Sampling at Sub-Nyquist Rate for Error Vector Magnitude Measurements...65

Xifeng Lu<sup>1,2</sup>, Paritosh Manurkar<sup>1,2</sup>, Dazhen Gu<sup>1</sup>, Daniel Kuester<sup>1</sup>, Robert Horansky<sup>1</sup> <sup>1</sup>National Institute of Standards and Technology, <sup>2</sup>National Institute of Standards and Technology

### **Evaluating Correlation Between Measurement Samples in Reverberation Chambers Using Clustering...68**

Carnot Nogueira<sup>1,2</sup>, Kate Remley<sup>1</sup>, Robert D. Jones<sup>1,3</sup>, Robert D. Horansky<sup>1</sup> <sup>1</sup>National Institute of Standards and Technology, <sup>2</sup>University of Colorado, <sup>3</sup>Colorado School of Mines

### VNA-Based Large-Signal Drain-Modulated Power Amplifier Measurement Setup With Digital Pre-Distortion...73

Rob Vissers, Christian Fager, Gregor Lasser Chalmers University of Technology

### **Over-the-Air Characterization of mmW Near-Field Channels...77**

Yagmur Ozturk, Niru K. Nahar, Kubilay Sertel The Ohio State University

### NPR assessment without multi-tone phase randomization...81

Ricardo Figueiredo<sup>1,2</sup>, Nuno Borges Carvalho<sup>1,2</sup> <sup>1</sup>Universidade de Aveiro, <sup>2</sup>Instituto de Telecomunicacoes

# Validity of Room-temperature Calibration for On-wafer Measurements up to 220 GHz, 125 °C, and 48 h...85

Tianze Li, Lei Li, James C. M. Hwang Cornell University

# Characterization of a Compact Wideband Microwave Metasurface Lens for Cryogenic Applications...89

Ali Al-Moathin<sup>1</sup>, Mingyan Zhong<sup>1</sup>, Qusay Al-Taai<sup>1</sup>, Yunan Jiang<sup>1</sup>, Michael Farage<sup>1</sup>, Jalil ur Rehman Kazim<sup>1</sup>, Muhammad Zulfiqar Ali<sup>2</sup>, Fatemeh Nikbakhtnasrabadi<sup>1</sup>, Megan Powell<sup>3</sup>, Prince Khatri<sup>3</sup>, Manoj Stanley<sup>4</sup>, Alessandro Rossi<sup>3,4</sup>, Hadi Heidari<sup>1</sup>, Muhammad Ali Imran<sup>1</sup>, Qammer H. Abbasi<sup>1</sup>, Nick Ridler<sup>4</sup>, Martin Weides<sup>1</sup>, Chong Li<sup>1</sup>

<sup>1</sup>University of Glasgow, <sup>2</sup>Oxford Instruments NanoScience, <sup>3</sup>University of Strathclyde, <sup>4</sup>National Physical Laboratory

#### In-Situ Measurement of Transmitter Antenna Input Current Using a Software-Defined Radio...93

Austin Egbert<sup>1</sup>, Adam Goad<sup>1</sup>, Samuel Haug<sup>1</sup>, Charles Baylis<sup>1</sup>, Benjamin Kirk<sup>2</sup>, Anthony Martone<sup>2</sup>, Robert J. Marks II<sup>1</sup> <sup>1</sup>Baylor University, <sup>2</sup>Army Research Laboratory