FutureCom – RF Measurements for future communications applications

## 15th February 2023 13:00 – 16:30 CET

# FutureCom training Workshop on non-50 Ohm and Multiphysics measurements

**Training workshop description**

Characterizing devices for future communications systems brings many challenges. When moving to calibrated non-50 Ohm measurements special care must be taken. Moreover, it is essential to understand the limitations of these non-50 Ohm measurements. In this training workshop all these aspects will be illuminated, after an initial introduction on large signal measurements, error and uncertainty will be discussed. Followed by a discussion on power calibration using transfer standards, which is of particular importance for on-wafer measurements. All will be placed in a circuits/system context with modulated signals in the final presentation, including combining non-50 Ohm measurements with multi-physics thermal and RF electric field measurements.

This training course will provide basics as well as finer details of the topics mentioned. Please review the abstracts and speaker's biographies below.

**Agenda, 15th February 2023 13:00 – 16:30 CET:**

13:00 – 13:35 Haider, VSL - Overview of source- and load-pull systems for large signal measurements

13:40 – 14:15 Shokrolahzade, TU Delft - Reduced Calibration Error Employing Parametrized EM models and DC Load Extraction

14:20 – 14:55 Singh, NPL - Characterising active devices using real-time uncertainty tools

Break

15:10 – 15:45 Poduval, VSL - VNA as a High Dynamic Range RF Power Transfer Standard

15:50 – 16:25 Buisman, University of Surrey - Emulation load pull from devices to circuits, combined with multi-physics thermal & electric field measurements

Labtour: visiting VSL's RF lab

The presentations are around 35-40 minutes each. The labtour is in person and will take place after the final presentation.

This workshop is both in person as well as online, please use the following link to access the training workshop. If the link is not present, please ask your contact person.

Talk 1

**Title**: Overview of source- and load-pull systems for large signal measurements

**Abstract**: This talk overviews the various source- and load-pull systems developed for large signal device characterisation. This includes detailing the advantages and disadvantages of the different approaches and developing a load-pull system at VSL.

**Speaker**: Karrar Haider, VSL, Delft, NL
**Biography**: Syed Karrar Haider was born in Pakistan, in 1995. He received his B.Sc. degree in avionics engineering from the National University of Sciences and Technology (NUST), Pakistan, in 2019. In 2019, He joined Pakistan Aeronautical Complex Kamra, Pakistan, to work as an avionics system engineer for the integration of onboard avionic systems. He is currently pursuing his M.Sc. degree in electrical engineering (RF&MW) from National University of Sciences and Technology, Pakistan. In 2022, He joined VSL, Dutch National Metrology Institute, as a master thesis intern to work on the development of load-pull system for active device characterization at VSL. During his tenure, he has worked on the design of impedance standard substrate for SOLR (up to 67 GHz) and TRL (up to 330 GHz) calibrations. His research interests include electromagnetic simulations of coplanar waveguide structures and small- and large-signal characterizations of electronic devices and circuits working in mm-wave frequency range.

Talk 2

Title: Reduced Calibration Error Employing Parametrized EM models and DC Load Extraction

**Abstract:** In this work, we present an approach to reduce the error arising from the variations of the lumped load, due to process spread, in probe level calibrations. First, full-wave electromagnetic (EM) simulations are employed to generate the nominal standard responses, then a parametric EM simulation of the load structure is used to generate a parametrized model of the standard. The approach is tested using a Short-Open-Load-Reciprocal calibration algorithm and an impedance standard calibration substrate developed on a 150 mm Quartz wafer (400 µm thick). In this process the high fidelity of the lateral dimension of the fabricated structures, realized using IC Photolithography, allows to confine the variations of the load response to only the thin-film resistor thickness spread. The DC response of the load, measured during the calibration step, is used to identify the specific RF response of the probed load from the parametric model. A complete analysis using full-wave EM simulations accounting for process variation is presented together with a set of experimental data up to 67GHz

**Speaker:** Ehsan Shokrolahzade, TU Delft, NL

**Biography:** Ehsan Shokrolahzade was born in Tehran, Iran in 1995. He received his Bachelor's degree in Electrical, Electronics and Communications Engineering from Iran University of Science and Technology in 2017. He then pursued his Master's degree in Electromagnetics (Field and Wave) at the same university, which he completed in 2020.In 2022, he joined the Electronic Research Laboratory Group, Delft University of Technology, as a PhD candidate.

His research interests include mm wave on wafer measurements, Cryogenic RF measurements, cryogenic power calibration, mm wave and cryogenic measurement uncertainty assessment, antenna characterization, Near field sensing systems, VNA Calibration algorithms and non-linear device characterization.

Talk 3

**Title**: Characterising active devices using real-time uncertainty tools

**Abstract**: All measurements have an associated uncertainty, and it is important to know the uncertainty in order to quantify the reliability of the measurement result. This training will run through common methods used for measurement uncertainty in S-parameters. The modern tools are used to determine uncertainty in real-time of devices with variable performance, such as amplifiers. Methods to evaluate the measurement uncertainty in return losses, input power, output power, power gain, 1 dB compression point, etc., based on the use of the VNA dynamic uncertainty option (VNA-DUO) software tool from Keysight Technologies, will be covered.

**Speaker**: Dilbagh Singh, NPL, Teddington, UK

**Biography**: Dilbagh is a Research Scientist for the National Physical Laboratory in Teddington, UK in the Department of Electromagnetic and Electrochemical Technologies. He has more than 25 years' experience working in industrial, academic and government scientific research establishments. His main area of interest is in the development of methods for making accurate electrical measurements of active devices at very high frequencies.

Talk 4

**Title**: VNA as a High Dynamic Range RF Power Transfer Standard

**Abstract**: VNA, as a high dynamic range RF power transfer standard is investigated with measurements up to 50 GHz. A method is presented to investigate and ensure the validity of VNA's one-port calibration error terms while modifying the test signal power. The widely used direct-comparison transfer and feed-through methods for power sensor calibrations are investigated using a VNA. The efficacy of the VNA is established through a detailed comparison comprising calibration of 2.4 mm power sensors up to 50 GHz using +10 dBm to -20 dBm test signal dynamic range.

**Speaker**: Devika Poduval, VSL, Delft, NL

**Biography**: Devika Poduval graduated from the Delft University of Technology with an M.Sc. degree in Electrical Power Engineering, Delft, Netherlands, in 2020. In 2021, she joined the VSL National Metrology Institute, Delft, where she works as a Scientist with the Department of Electricity. She is actively involved in calibration measurements and developing measurement systems for R & D activities, mainly within RF power and DCLF facilities.

Talk 5

**Title**: Emulation load pull from devices to circuits, combined with multi-physics thermal & electric field measurements

**Abstract**: Predictive characterisation techniques, such as emulation active load pull of circuits, add significant advantages during the design phase of such complex systems. Using such techniques, multiple cases will be illustrated: load modulated amplifiers, multi-stage differential amplifiers, phased arrays, as well as massive MIMO arrays. These load pull methods only give access to the in/output terminals of devices and circuits. Here we will discuss to combine these advanced load pull methods with multi-physics measurements, obtaining crucial information on temperature and RF electric fields under realistic device operation.

**Speaker**: Koen Buisman, University of Surrey, Guildford, UK and Chalmers University of Technology, Gothenburg, Sweden.

**Biography**: Koen Buisman received the M.Sc. and Ph.D. degrees in microelectronics from the Delft University of Technology, Delft, The Netherlands, in 2004 and 2011, respectively. From 2004 to 2014, he was with the Delft Institute of Microsystems and Nanoelectronics, Delft University of Technology. In 2014, he joined the Chalmers University of Technology, Gothenburg, Sweden, where he is currently an Affiliated Associate Professor with the Microwave Electronics Laboratory, Department of Microtechnology and Nanoscience. In addition, in 2020, he joined the University of Surrey, Guildford, U.K., where he is currently a Reader in microwave and mm-wave electronics. He is also the Director of the Nonlinear Microwave Measurement and Modeling Laboratories, a joint University of Surrey/National Physical Laboratory, Teddington, U.K. He has authored or co-authored more than 90 refereed journal articles and conference papers. He holds one patent. His current research interests include nonlinear device characterization, technology optimization, and design of linear transceivers for wireless systems.