TARGET
TOP AMPLIFIER RESEARCH GROUPS IN A EUROPEAN TEAM

Course description: **RF Device Characterisation**

Modules:

1. Introduction to RF Device Semiconductor Devices
2. Calibration Issues, Static DC and S-Parameter Characterisation
3. Pulsed DC and S-Parameter Characterisation
4. Extrinsic Characterisation and De-Embedding
5. Nonlinear Vector Network Analysis
6. Source and Load Pulling Techniques
7. Power Amplifier Measurements
8. Noise Characterisation
1. Thermal Characterisation

Audience:

This course is designed for engineers working in RF device characterisation, modelling and PA design.

Preliminary Knowledge:

- If module 1 is not booked basic RF device semiconductor knowledge is advisable.

Our presenters:

Frank Schwierz (Technical University Ilmenau, Germany)
Gottfried Magerl (Technical University Wien, Austria)
Markus Mayer (Technical University Wien, Austria)
Jean-Pierre Teyssier (Universitè de Limoges, France)
Teresa Martin-Guerrero (Universidad de Malaga, Spain)
Jan Verspecht (Jan Verspecht bvba, Belgium)
Holger Arthaber (Technical University Wien, Austria)
Angel Mediavilla (Universidad de Cantabria, Spain)
Thierry Parra (CNRS - Centre National de la Recherche Scientifique, LAAS, France)
Jan Kuzmik (Technical University Wien, Austria)
Dionyz Pogany (Technical University Wien, Austria)

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Module 1 - Introduction to RF Device Semiconductor Devices

For accurate characterisation of RF devices it is important to understand the operational principles of these devices. This module provides the important basics. The most important RF transistor figures of merit are introduced and basic RF transistor concepts and issues related to the suitability of different semiconductors for RF devices are discussed. Further on the module provides an overview of all advanced RF transistor concepts currently in use or under development. The basic device structures, operation principles and state-of-the-art performance of transistors are discussed and design rules for RF high-power transistors are explained.

Presenter: Frank Schwierz
Duration: 2 hours
Please note: It is advisable to book this module to recall operation principles of RF devices.

Module 2 – Calibration Issues, Static DC and S-Parameter Characterisation

Calibration is a most important issue in every RF measurement setup. To obtain accurate measurement results the magnitude and phase relations at the DUTs (device under test) ports have to be known for each frequency point which is measured. This module explains the most important calibration techniques SOLT and TRL in detail. Measurement techniques for linear characterisation of RF devices are presented to obtain DC and small signal S-parameter data at static quiescent points.

Presenter: Gottfried Magerl
Option:
Markus Mayer
Duration: 2 hours
Please note: It is always advisable to book this fundamental module.

Module 3 - Pulsed DC and S-Parameter Characterisation

The high frequency behaviour of RF devices is strongly dependent on the device's temperature. DC and S-parameter measurements with a static quiescent point will show altered results when operated at a different bias point. To exclude the thermal effect pulsed measurements are performed with pulse lengths shorter than the thermal time constants. Pulsed measurements can further exclude the so called trapping effect where carriers are trapped in structure defects on the device's surface. This module illustrates the techniques of pulsed characterisation in detail.

Presenter: Jean-Pierre Teyssier
Duration: 2 hours

Module 4 – Extrinsic Characterisation and De-Embedding

For RF device modelling it is of great importance to extract the nonlinear kernel of the device which is embedded in a circuitry of various parasitic passive elements such as bond wires, pad capacitances and via interconnects. In this module measurement techniques and algorithms are presented to de-embed the parasitic circuitry to obtain the measurement data of the intrinsic kernel of the device under test.

Presenter: Teresa Martin-Guerrero
Duration: 2 hours

Module 5 – Nonlinear Vector Network Analysis

Characterising the nonlinear behaviour of a RF device sufficiently for modelling by linear measurement needs a lot of effort. A far more convenient method is the nonlinear vector network analysis where the device is characterised under large-signal excitation and the resulting input and output voltages and currents are measured. With this measurement method not only the fundamental frequency behaviour of the device is known but also the generated harmonics are known in magnitude and phase. This module gives you a comprehensive introduction to nonlinear vector network analysis, its calibration and measurement setups.

Presenter: Jan Verspecht
Duration: 2 hours

Module 6 – Source and Load Pulling Techniques

Characterisation of RF devices is usually done under 50Ω input and output termination. High power devices can thus only operate at very low output power levels. Presenting various source and load impedance conditions to the transistor's input and output will enable characterising a device delivering up to maximum output power. Further on the devices nonlinear behaviour varies with different source and load impedance where source and load pulling allows for characterisation of this behaviour. To improve efficiency of a power amplifier often the generated harmonics are terminated differently to the fundamental frequency to shape output current and voltage waveform. Harmonic load pull systems allow independent control of the fundamental and harmonic terminations and the DUT's voltage and current waveforms can be measured and optimized. Thus, harmonic controlled power amplifiers can be prototyped by measurement without the need of a model.

Source and load pulling is a powerful tool to characterise a device's behaviour under different load conditions, to verify device models based on 50Ω termination and to prototype power amplifiers in a short time. This module will present the fundamentals of load pulling as well as sophisticated harmonic load pull setups.

Presenter: Holger Arthaber
Option:
Markus Mayer
Duration: 2 hours
Please note: It is advisable to book this module together with module 5.

Module 7 – Power Amplifier Measurements

Due to high crest factors of modern modulation formats linearity is a key issue of power amplifiers used for wireless communication systems. The varying envelope level is operating at baseband frequency and due to dispersion effects the transistor's behaviour for the envelope signal will be different to RF. Further on the baseband signal will be terminated differently the will also cause change in temperature in the intrinsic device influencing the RF behaviour. Therefore, linearity tests such as two tone test are not appropriate anymore as a substitute for other modulation formats since the device's behaviour is dependent on the history of the envelope signal – the device is showing a memory effect. This module will address theory and measurement methods of characterising a power amplifier's behaviour with a focus on linearity measurements.

Presenter: Angel Mediavilla
Duration: 2 hours

Module 8 – Noise Characterisation

Noise performance of radio receivers is a crucial issue. Semiconductor material and device improvements result in higher frequencies and smaller noise figures. This module will introduce measurement techniques to characterise the noise behaviour of RF devices with very low noise figures and will present measurement systems for noise characterisation at very high frequencies.

Presenter: Thierry Parra
Duration: 2 hours

Module 9 – Thermal Characterisation

In this module experimental methods on temperature and thermal power mapping in the DC and transient state will be explained. Examples of self-heating effect investigations on GaN HEMTs will be presented.

Presenter: Dionyz Pogany and Jan Kuzmik
Duration: 2 hours