GaAs and GaN related service

24/12/2014

Measurement capability

Brochure of the daily services

Services	Nb Frequency	Nb Biasing	Nb Transistor	Various Informations
Active load pull measurement 1-40GHz (CW)	1	1	11	without contours
	1	4	3	
	2	1	4	
	2	4	1	
	1	1	6	with contours
	1	3	2	
	2	1	3	
	2	2	1	
Active load pull measurement 1-40GHz (Pulsed)	1	1	8	without contours
	1	4	2	
	2	1	3	
	2	3	1	
	1	1	4	with contours
	1	2	2	
	2	1	2	
	2	2	1	
Static + Sij (<40GHz) study	-	-	7	complete[1] characterisation
DC pulsed measurements	-	1	10	150 to 300 points / quiescent bias point
	-	2	6	
	-	4	4	
DC + Sij (<40GHz) pulsed measurements	-	1	4	150 to 300 points / quiescent bias point
	-	2	2	
	-	4	1	
Design (transistors, amplifier)	contact us			
Non linear modelling	contact us			
Report and reverse engineering	1 day for 4 days of measurements			

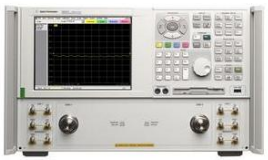
[1] Measurements of diodes in forward and reverse, transconductance, ID(VDS, VGS), ID(VGS, VDS), IG(VDS, VGS), IG(VGS, VDS) characteristics, access resistance extraction, injection (low total gate width transistors), Sij parameter measurements (6 bias points).

Table is for reference, not updated, if not meets requirement, please contact us

DC~67GHz On wafer small signal system

Agilent B1500/B1505
CV IVmeasurement
0.1 fA / 0.5 μV

GPIB



Agilent E8363B-EU NWA（10MHz~67 GHz）

GPIB

Agilent N8975A
Noise Figure analyzer
10MHz to 40GHz

Test Signal

Test Signal

GPIB

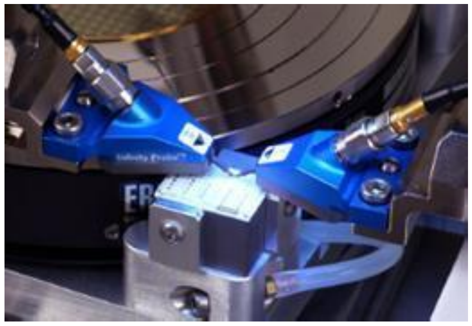
1/f noise

GPIB

Test Signal

GPIB

EDAtest /modeling/design tool

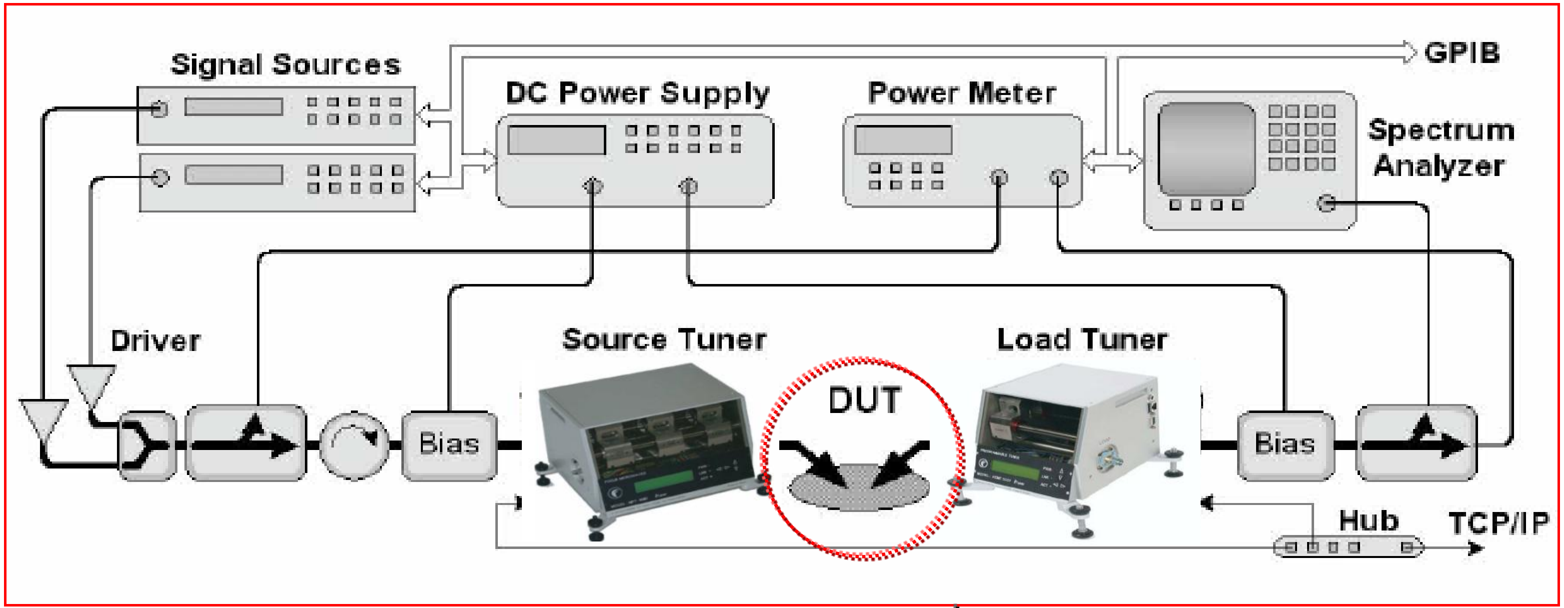


Cascade 11101B
microwave probe-station
Infitity i67 probe card

Function：

1. IV curve；
2. S parameter（10MHz~67GHz）
3. 1/f and HF thermal noise （~40GHz）
4. Phase noise and freq. spectrum（3Hz~75GHz）

0.8-50GHz Power load-pull system



Function：

1. Power device load-pull test
2. Harmonic noise matching
3. 0.8-18GHz, on-wafer test system in LAB1 (China)；
4. 0.8-40GHz, on-wafer test system in LAB2 (France)；
5. 0.8-50GHz for packaged power device；
6. low-high temperature： -60~+200℃

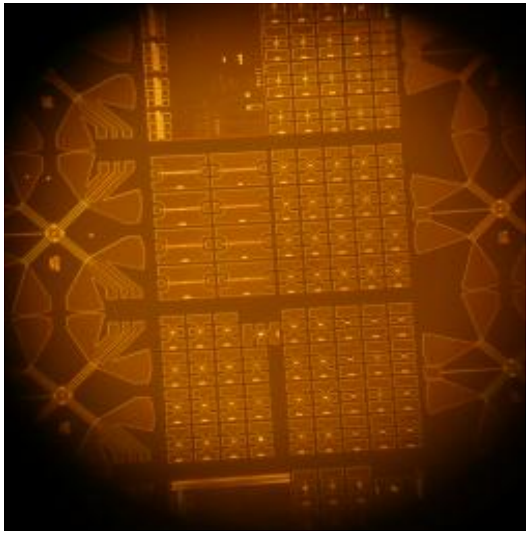
III-V Compact Model Development

☐ GaAs/GaN HEMT modeling

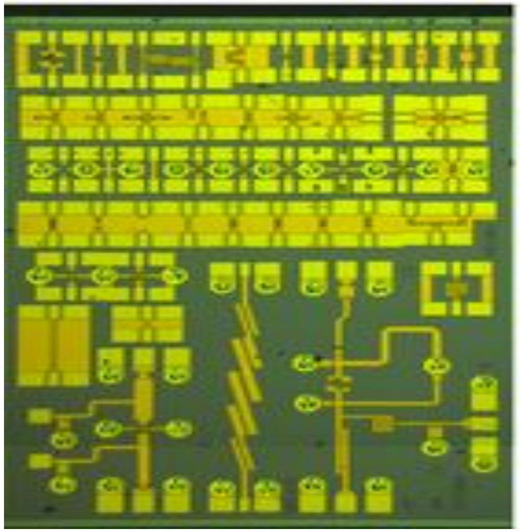
- ➢ Agilent EEHEMT, Angelov, Angelov-GaN, Curtice
- ➢ Verilog-a based large-signal model

☐ GaAs/InP HBT

- ➢ Agilent HBT, HiCUM, VBIC, GP..



In housed InP HBT



OMMIC 70nm mHEMT

WIN PP1551 GaAs HEMT

XMOD SP based GaAs\GaN HEMT large-signal model

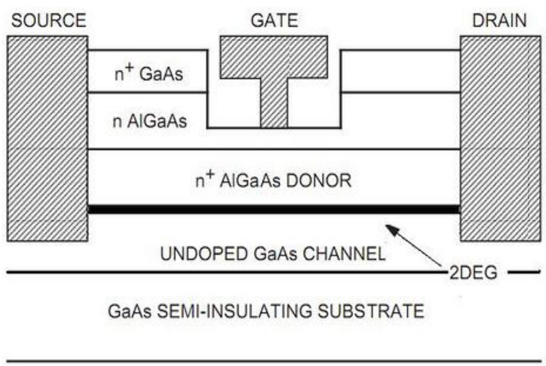


Fig: GaAs HEMT cross section

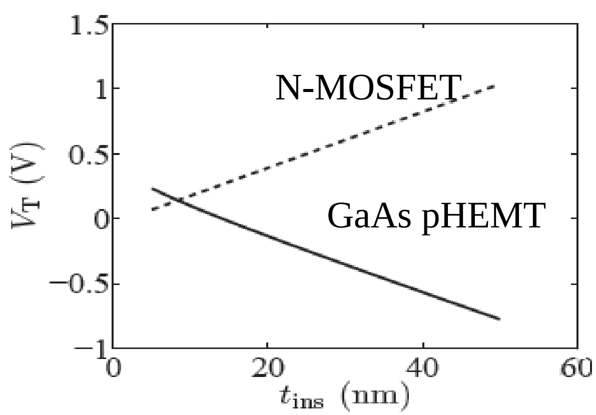


Fig: Inversion and accumulation Vth performance and insulator thickness

- **GaAs\GaN HEMT introduce surface potential**
  - Suppose AlGaAs fully depleted
  - 2-DEG as ultra-thin charge sheet
  - bottom layer as insulator
  - neglect impact of hole
  - unconfirmed fact or through flatband voltage correction
- **Model equation development method**
  - Introduce mathematic function to modify flatband voltage to get correct Vth variation trend
  - Introduce function fine tune bias dependent charge relationship
  - Make use of Si PSP advantage
- **Solve future GaN E/D HEMT for digital circuits application during simulation**
- **Past WIN foundry test in 2013**

XMOD SP based GaAs\GaN HEMT large-signal model

- **Accurate physical mechanism based model**
  - Charge based, SP → I/Q - V ， suitable for non-linear simulation
  - Model is process parameter based , which makes yield targeted model doable
  - For mixed signal application, solve GaN digital circuits design related issue
- **Better than EEHEMT and OMMIC self built model**
  - DC、S parameter, wide bias fitting is better than EEHEMT and with HF noise and power simulation result

Table Comparison of capabilities between Agilent EEHEMT and XMOD LSP Model.

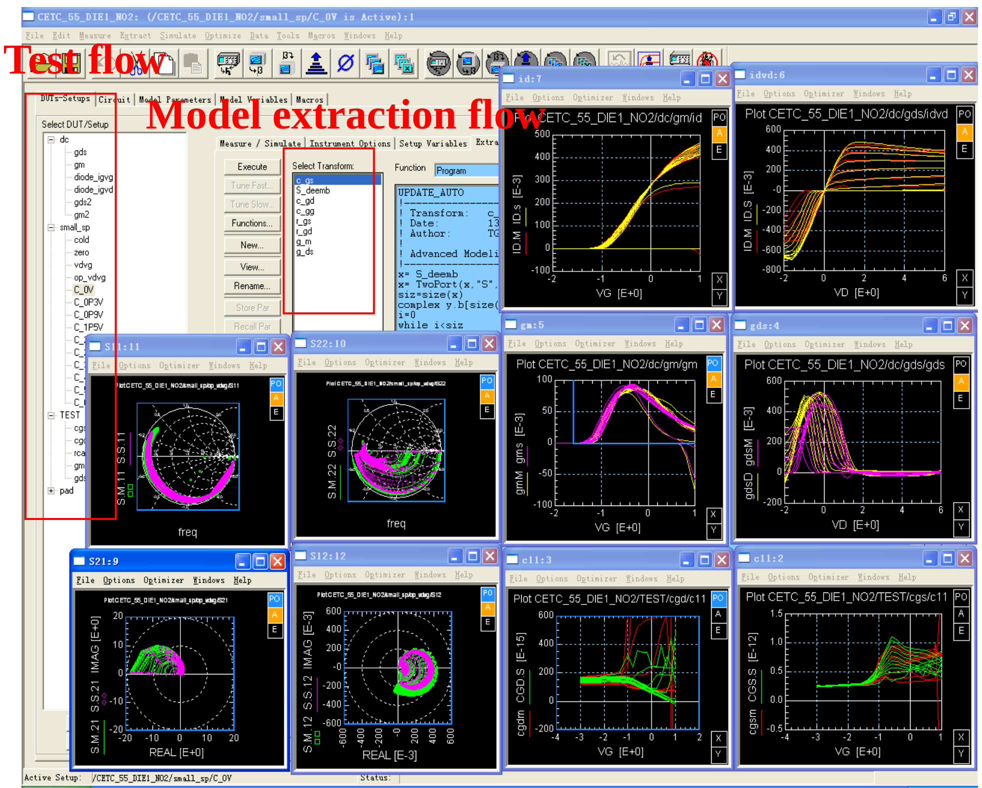
	Physics Based	Digital Application	Nonlinear Application	I\Q-V High Order Derivable	Charge Conservation	Self Heating	Yield Analysis
EEHEMT1/3	×	?	√	1	×	×	×
LSP	√	√	√	> 3	√	√	√

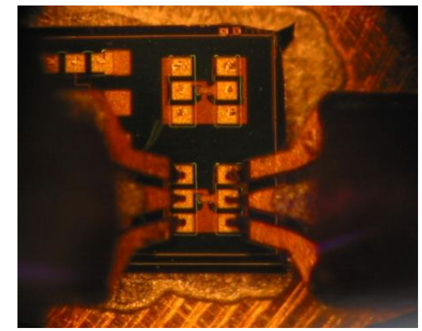
xmod Technologies

SOFTWARE AND SERVICES FOR THE MICROELECTRONICS INDUSTRY

Model Extraction Tool Kit Development

- Pass GaAs HEMT model evaluation through several partners
- Agilent IC-CAP based





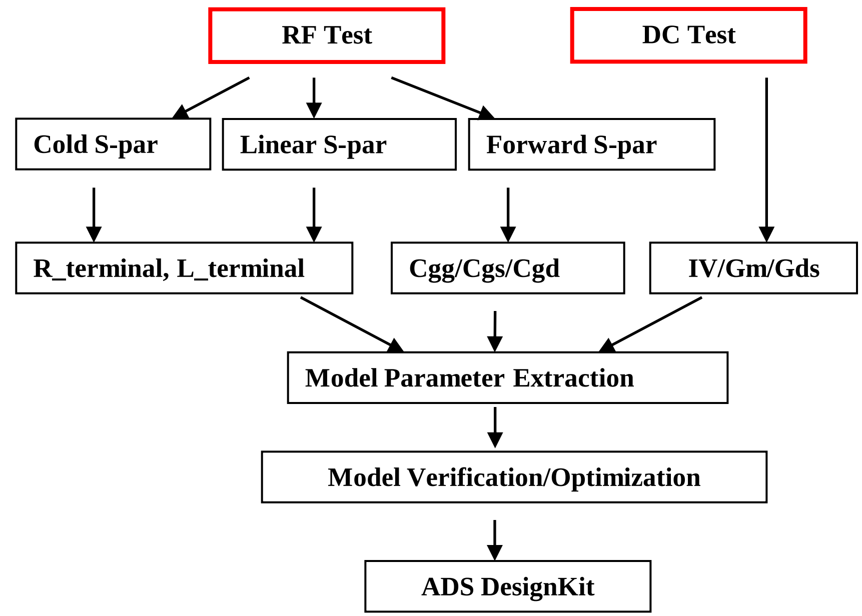


Fig. model extraction flow

Case Show: WIN GaAs HEMT Sample Measurement

1. DC/S-parameter test

Devices	Device 1		Device 2		Device 3	Device 4
Number of samples	X5		X5		X5	X5
Temperature °C	-55		25		85	
Vds0 (V)	Between 0 and 16 V (16V is BV, careful)					
Vgs0 (V)	Between Vp and 0.6 V (Vp is offstate)					
Measurement	DC+Sij CW					

2 . Pulsed I-V test

Devices	Device 1
Number of samples	X5
Temperature °C	25
Vds0 (V) / Vgs0 (V)	Vds pulsed 0-16V Vgs step 0.1V
Measurement	Pulsed IV

3. Power Load-pull test

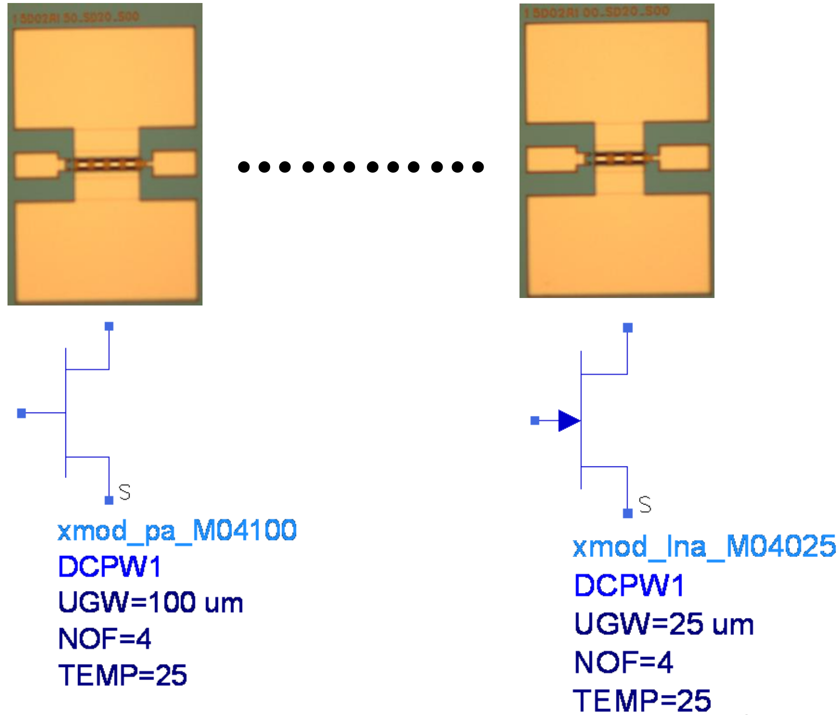
Devices	Device 1
Number of samples	X1&X5
Temperature °C	25
Frequencies	3 (32,35,38GHz)
Vds0 (V) / Vgs0 (V)	Vds=6V, Vgs at IDS close to static 70mA (dynamic up to 120mA limitation) and determined dynamically at the best Pout
Measurement	Loadpull 1 tone (H1 only)

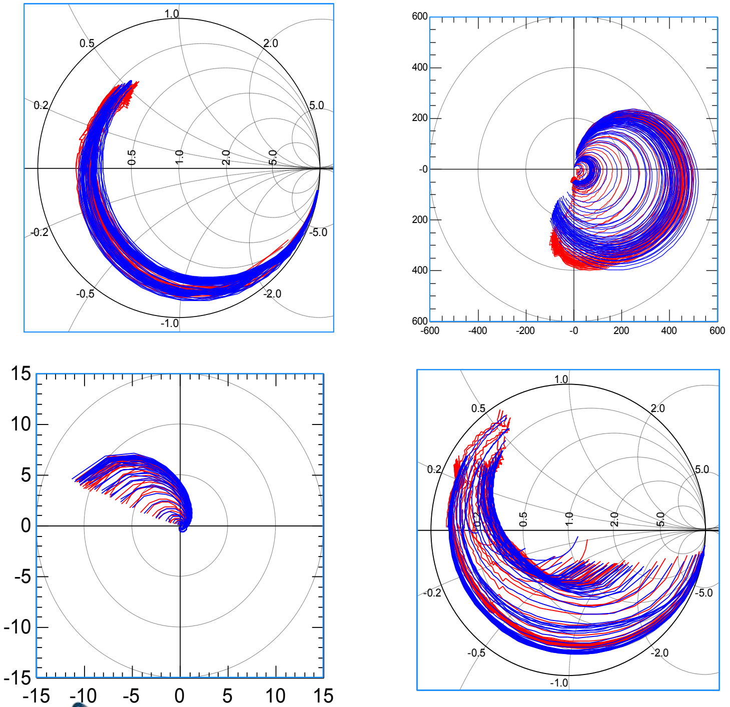
4. Noise figure test

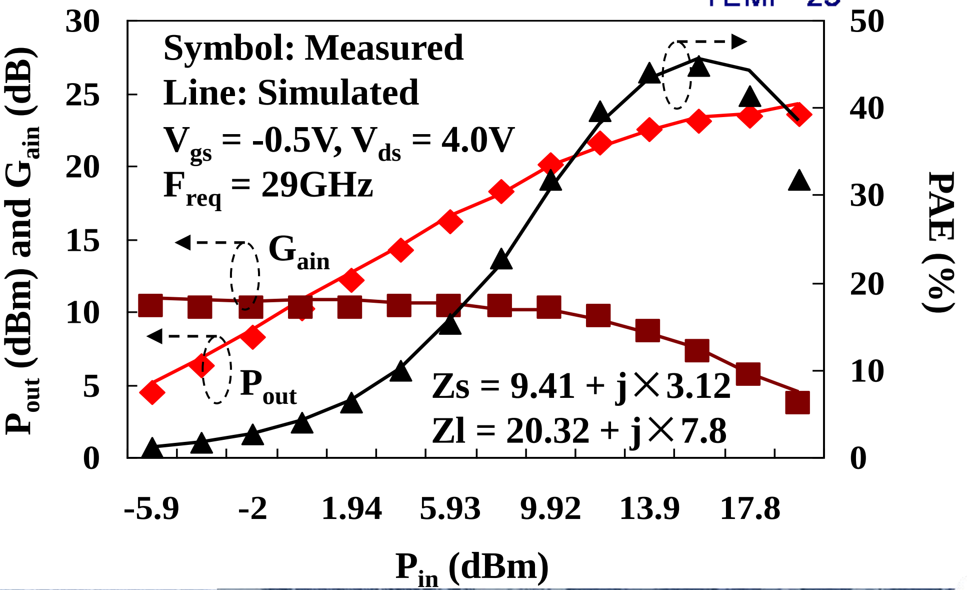
Devices	Device 2	Device 3	Device 4
Number of samples	X1	X1	X1
Temperature °C	25		
Vds (V)	1		
Vgs (V)	Between -1.2V and -0.5 (3 bias point)		
Measurement	Noise figure		

5. Power Model Lib Development

- PP1551 Power GaAs HEMT precess
- For mmw T/R chip design
- LSP model for LNA application
- EEHEMT for PA application







Potential entry points of XMOD & Customer

- ☐ **Golden device to debug test equipment set up**
- ☐ **Testkey layout design or audit**
- ☐ **Measurement outsourcing**
- ☐ **Modeling outsourcing (including reliability model in Wafer or Package level)**
- ☐ **Design house or foundry consulting**
- ☐ **On-site training or training course for customers**

Next page

Dr. Franz Sischka studied communication engineering at the University of Stuttgart, Germany, where he received his Diplom-Ingenieur and Ph.D. degrees in 1979 and 1984. He joined Hewlett-Packard in Boeblingen/Germany, working in R&D in the fiber optics group. Since 1989, he became a consultant for Hewlett-Packard's, later Agilent-EEsof's device modeling software IC-CAP. During that time, he has focused on developing strategies for verified, reliable device measurements and also worked on modeling strategies for diodes, bipolar and GaAs transistors, as well as for passive components like spiral inductors, varactors etc.

HP EEsof Design Technology

IC-CAP Modeling Reference

Measurement, Modeling and Simulation of
Electronic Components and Circuits

May 1999
HP Part No. 85190-90088

HEWLETT® PACKARD

Book author: Dr. Franz Sischka is consultant of XMOD and will come to shanghai in June 2015 to hold 2 days training course and deliver on-site training or consulting for company

Course Topics

Main detailed topics:

1. **Measurements**
2. **Measurement Data Quality Verification**
3. **Selecting a Model (Simulation)**
4. **Performing the Modeling**

_____MEASUREMENT RELATED_____________

- Standardized Data Formats For Electronic Device Measurements
- Chapters about DC, CV, S-Parameter, Nonlinear-RF and 1/f Noise

_____DATA QUALITY VERIFICATION RELATED__________

- Chapters about DC, CV and S-Parameter verifications
- Nonlinear Network Analyzer Data Verification

Keywords:
Nonlinear Vector Network Analyzer (NVNA), DC Biasing Verification, NVNA Calibration Verification

_____SIMULATION RELATED___________

- How to Simulate Pulsed DC Curves

Keywords:

Pulsed DC Measurements, Device Self-Heating, Simulating Pulsed DC curves, Thermal Node of Transistor Models

- How to Simulate CV Curves

Keywords:

CV Measurement Principle, Simulating CV Curves, Interpretation of the Simulated Impedance, CV Simulations for Devices with >2 Pins

- How to Simulate S-Parameters

Keywords:

S-Parameter Measurement Principle, S-Parameters from AC Simulations, DC Biasing, Influence of Bias-TEEs, Noisy or Discontinuous S-Parameter Simulation

- How to Simulate 1/f Noise

Keywords:

FET and Bipolar Noise Sources and Models, Measurement-Related 1/f Noise Simulations, Bipolar Noise Affected by DC Bias Resistance

____MODELING RELATED_____

- Modeling Methods: Line Fitting

Keywords:
Fitting a Line to Measurement Data, Regression Analysis, Linear Fit, Capacitance CV Fit, S-Parameter Fit, Diode Example

- Modeling Methods: Visual Parameter Extraction

Keywords:
Converting measurements into model parameter plots, verification of model equation validity

- Modeling Methods: Subcircuit Modeling

Keywords:
Fitting device measurements by using subcircuits composed of standard models

- Modeling Methods: Transistor PI Schematic Modeling

Keywords:
Description of how to convert S-Parameters of FET or HEMT Transistors to Inner PI Schematic Modeling and Parameter Extraction

- Equations for MultiPort Matrix Conversions

Keywords:
Z-Parameter, Y-Parameter, S-Parameter, Matrix Conversion, N-Port, Matrix Signal Flows