VISION

Behavioral modeling & simulation solution

Overview

Helping our customers to design smart and safe communication systems !

www.amcad-engineering.com

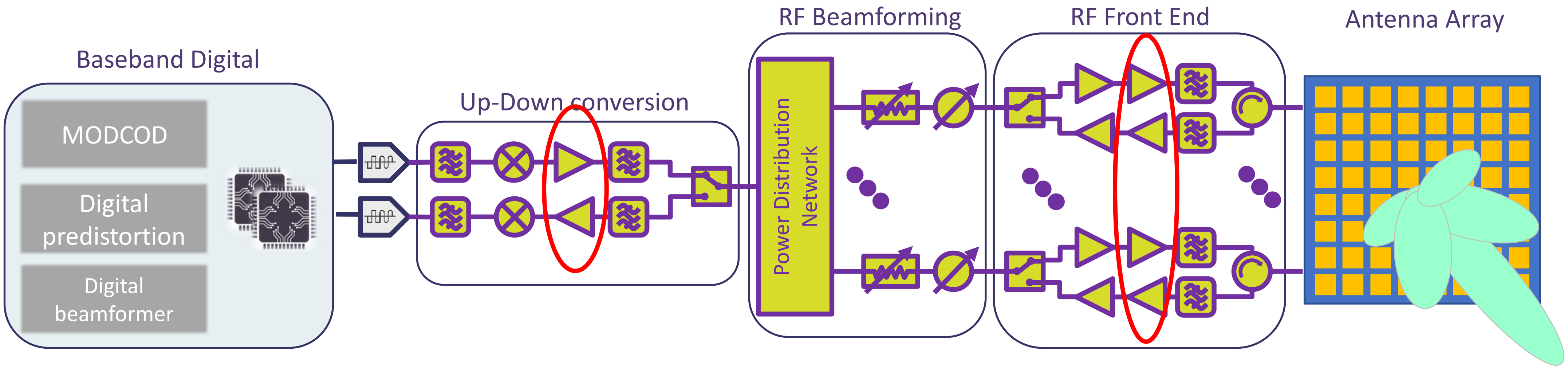
Outlines

Goal: presentation of main features of modeling and simulation available in the software

- Context
- VISION modeling flow
- Device Modeler
- System Architect
- Live Demo
- Q&A session

Circuit behavioral modeling for System design

Design challenges for next-generation communication systems



Meet the specifications !

Tools for effective specifications exploration
=> require accurate and robust system-level models of RF blocs
=> Focus on PA

Application examples:

- **Active antenna system simulation with PA behavioral models and Ansys HFSS antenna model**
- **Virtual DPD test bench in Mathworks Simulink with Amcad Vision models**

System Design

Bottom-Up Approach

(system design from COTS products)

fmi Functional Mock-Up Interface

MATLAB SIMULINK

System

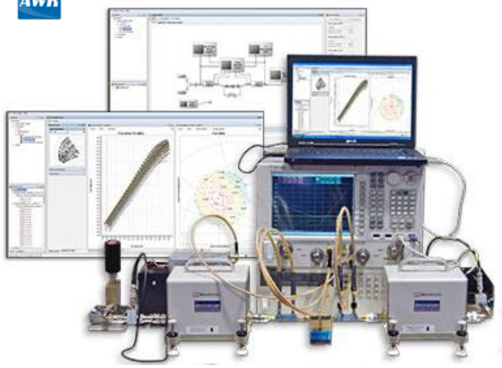
Sub-System

Circuit

Component

cadence | AWR

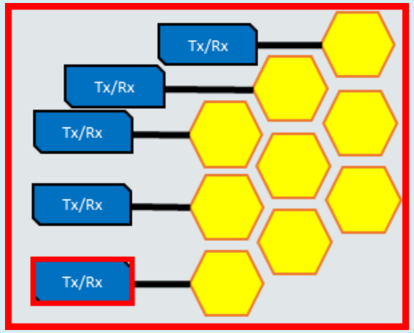
Advanced Design System



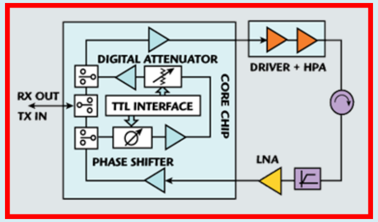
Ansys

SIMULIA

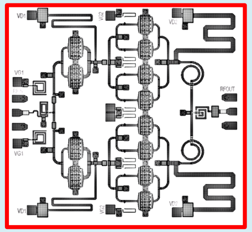
RF FrontEnd



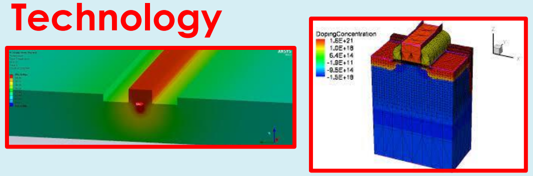
Tx/Rx Module



PA Module



Technology



Top-Down Approach

(design specific components for the project needs)

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Behavioral modeling

CIRCUIT DESIGN HOUSE A

Datasheet

Look-up table

Circuit design

SYSTEM DESIGN HOUSE

Behavioral model

Key competitive advantage for both

CIRCUIT DESIGN HOUSE B

Lack of information

Time consuming task

Convergence issue

Sensitive IP

Heavy co-simulation

Requirements

- Protected IP
- Wide domain of validity
- Data extraction from circuit simulation or measurement
- Fast simulation
- Integration in system simulator

=> Provide a comprehensive process is a challenge !

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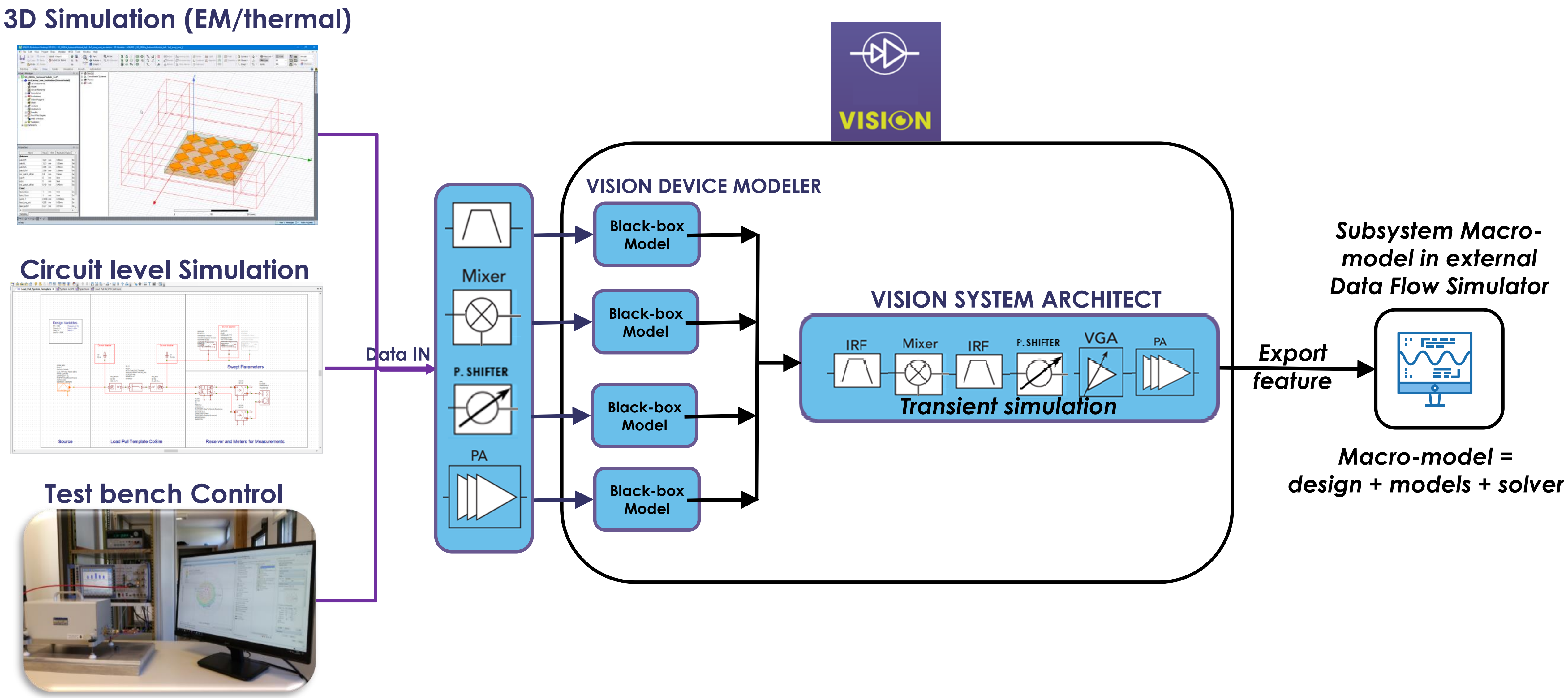
Behavioral modeling workflow



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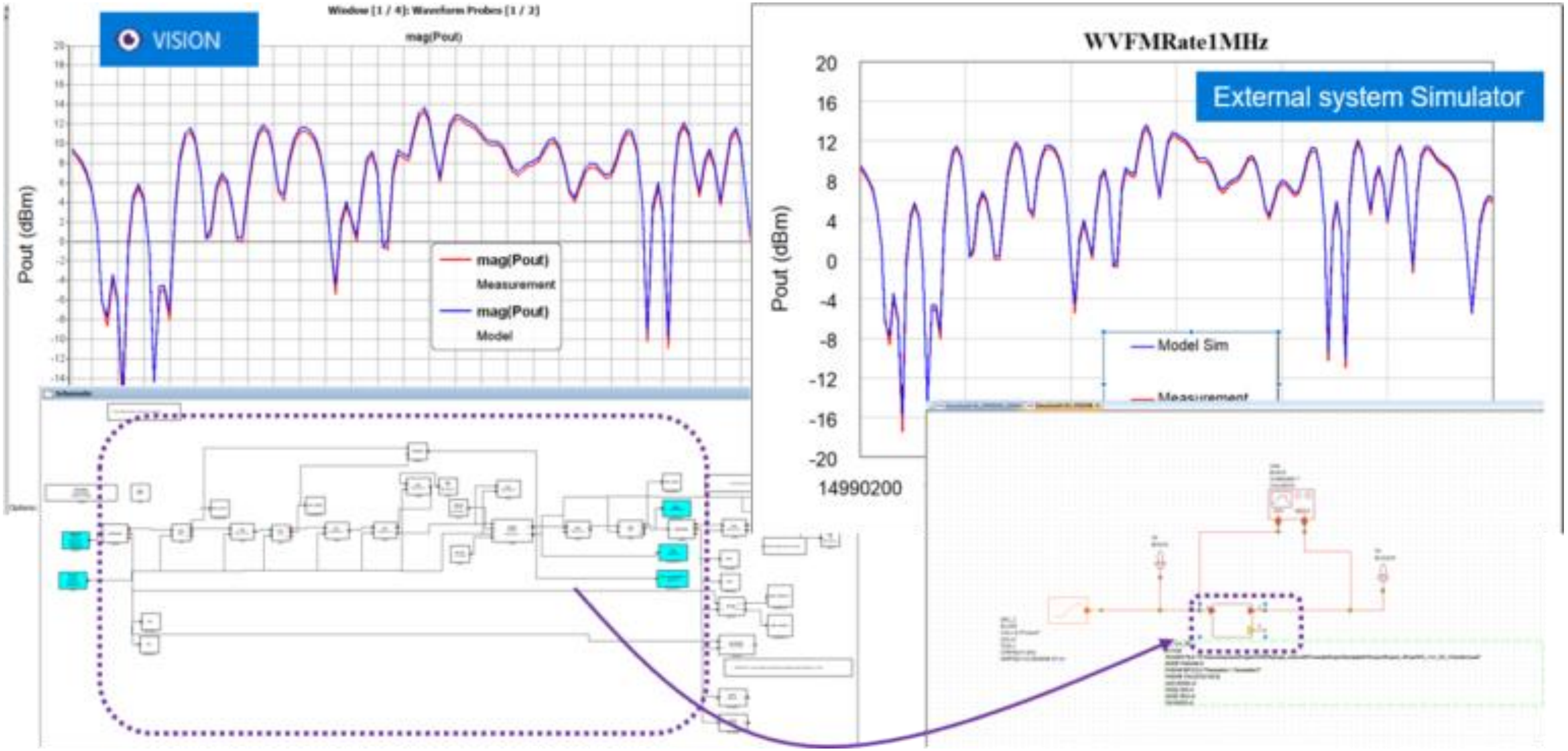
Circuit simulator template



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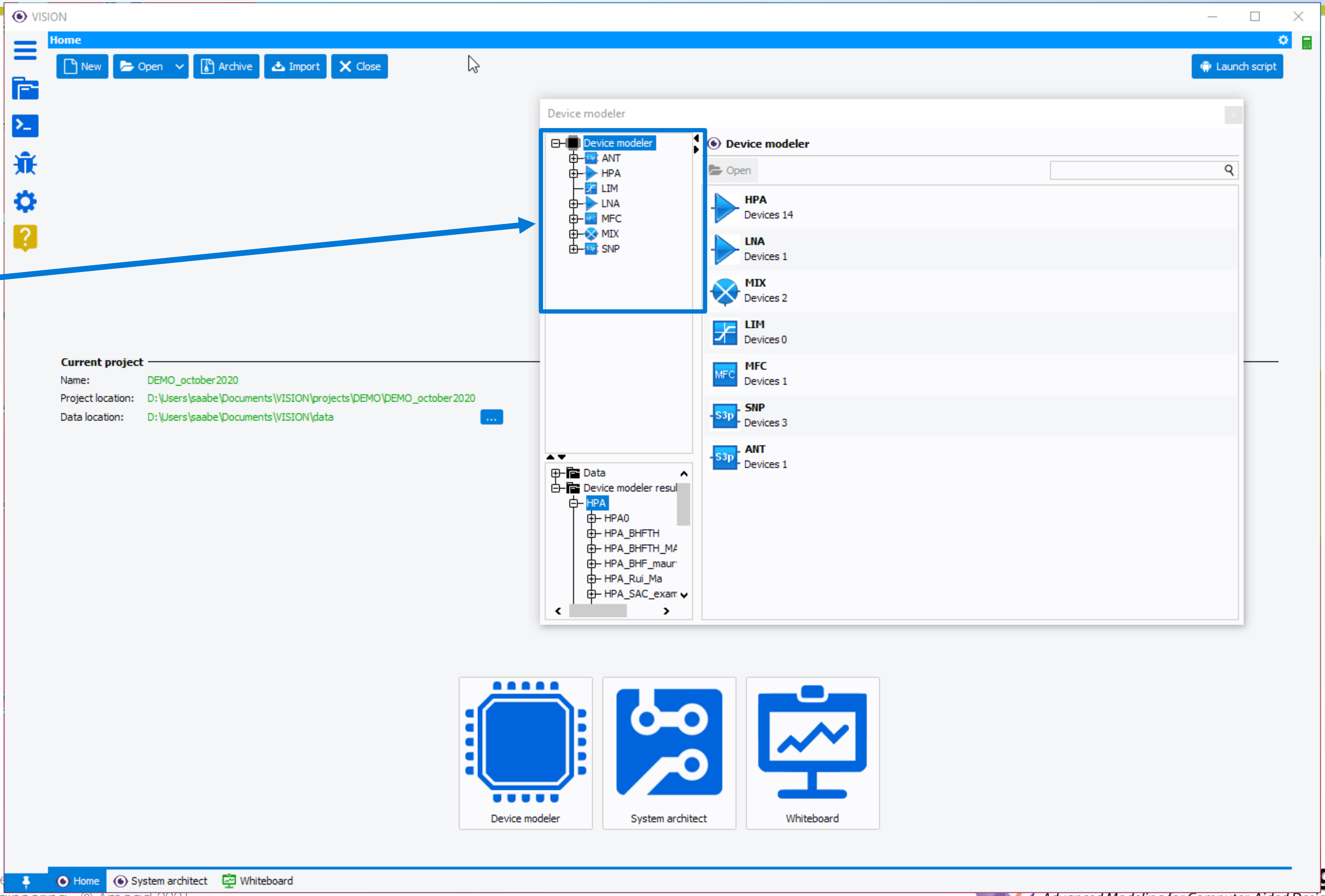
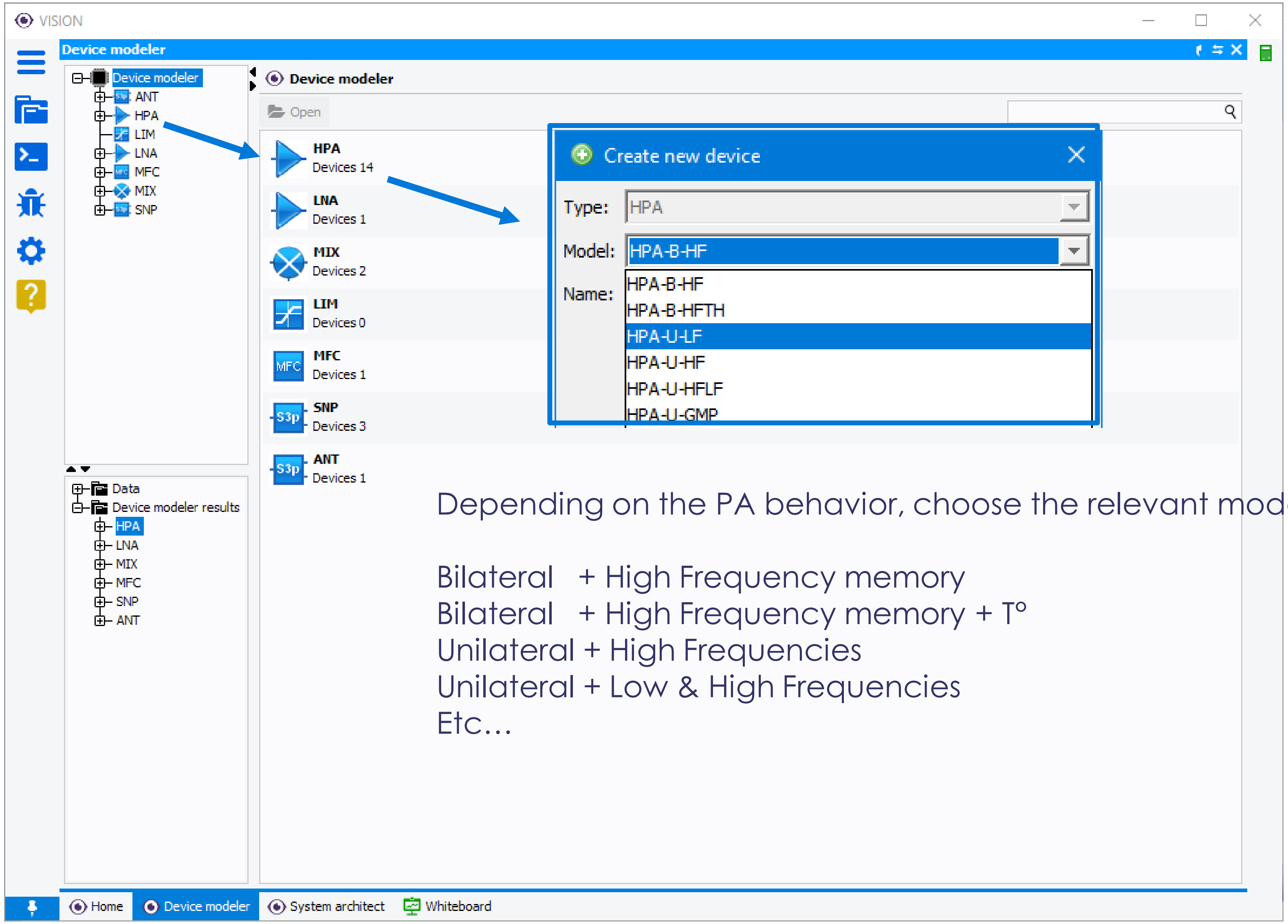
VISION device modeler

Circuit Modeling wizards

- High Power Amplifier
- Limiter
- Multi-function chip
- LNA
- Mixers
- Passive circuit (filters …)



VISION device modeler



Depending on the PA behavior, choose the relevant model:

Bilateral + High Frequency memory
Bilateral + High Frequency memory + T°
Unilateral + High Frequencies
Unilateral + Low & High Frequencies
Etc…

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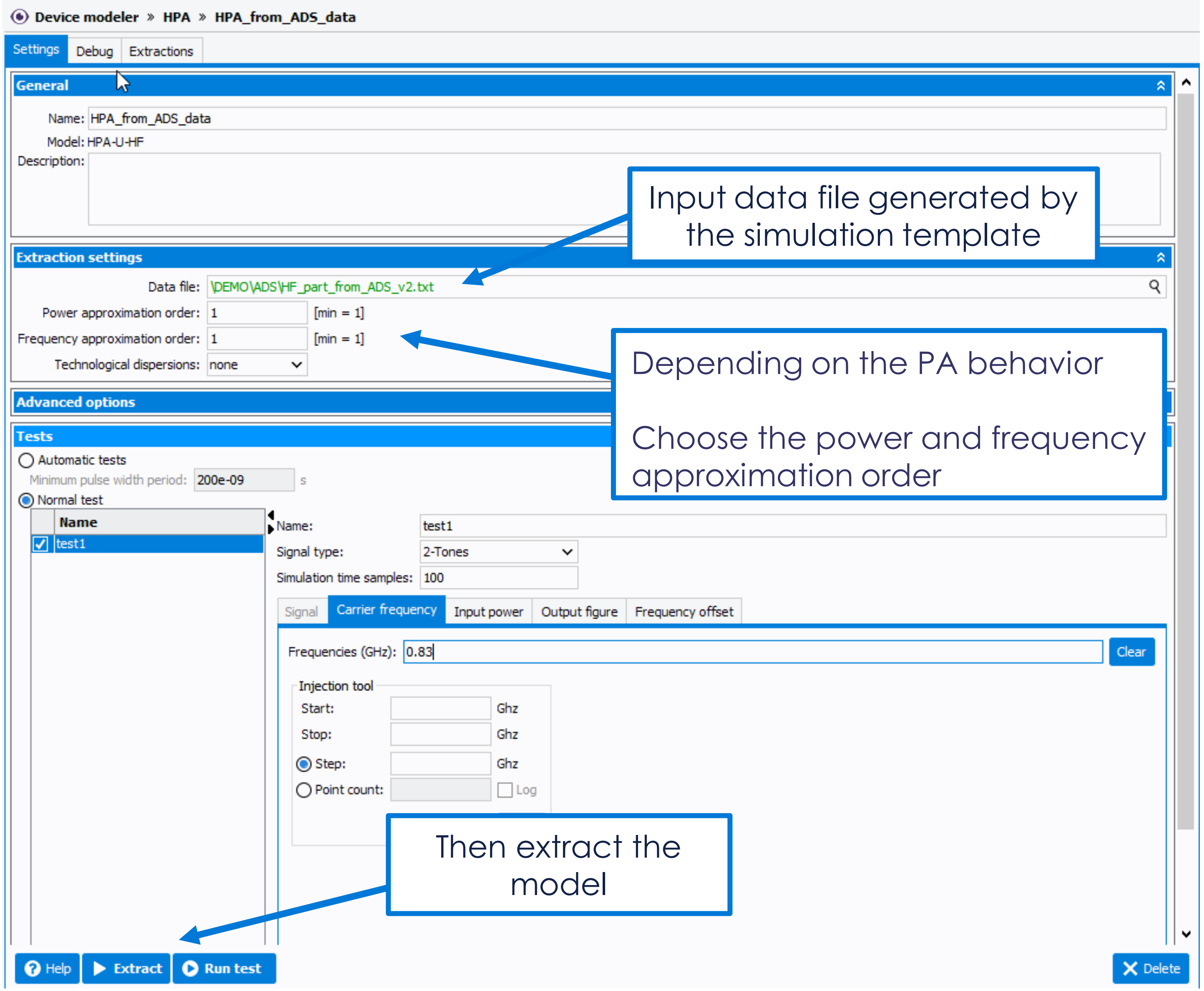
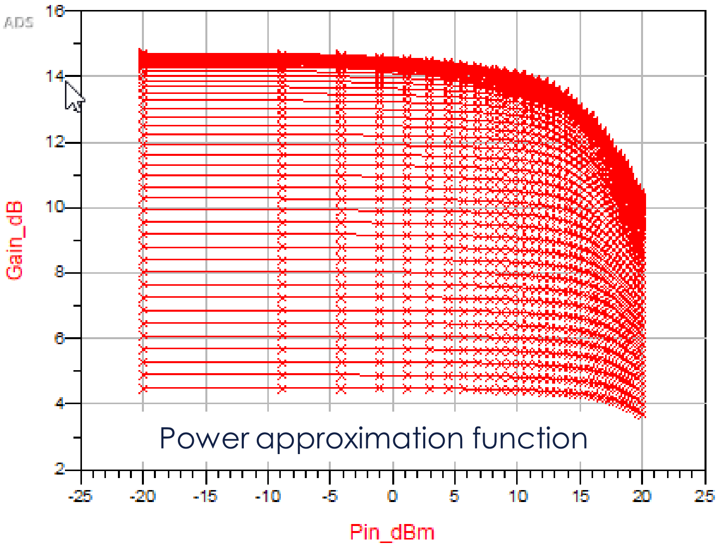
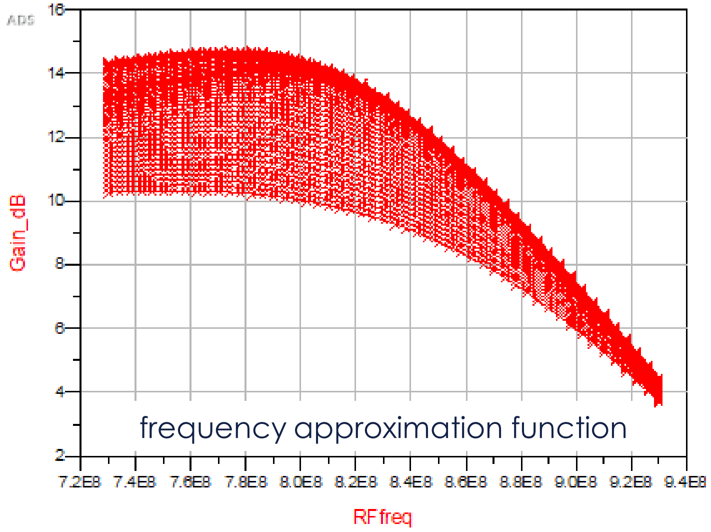
VISION device modeler







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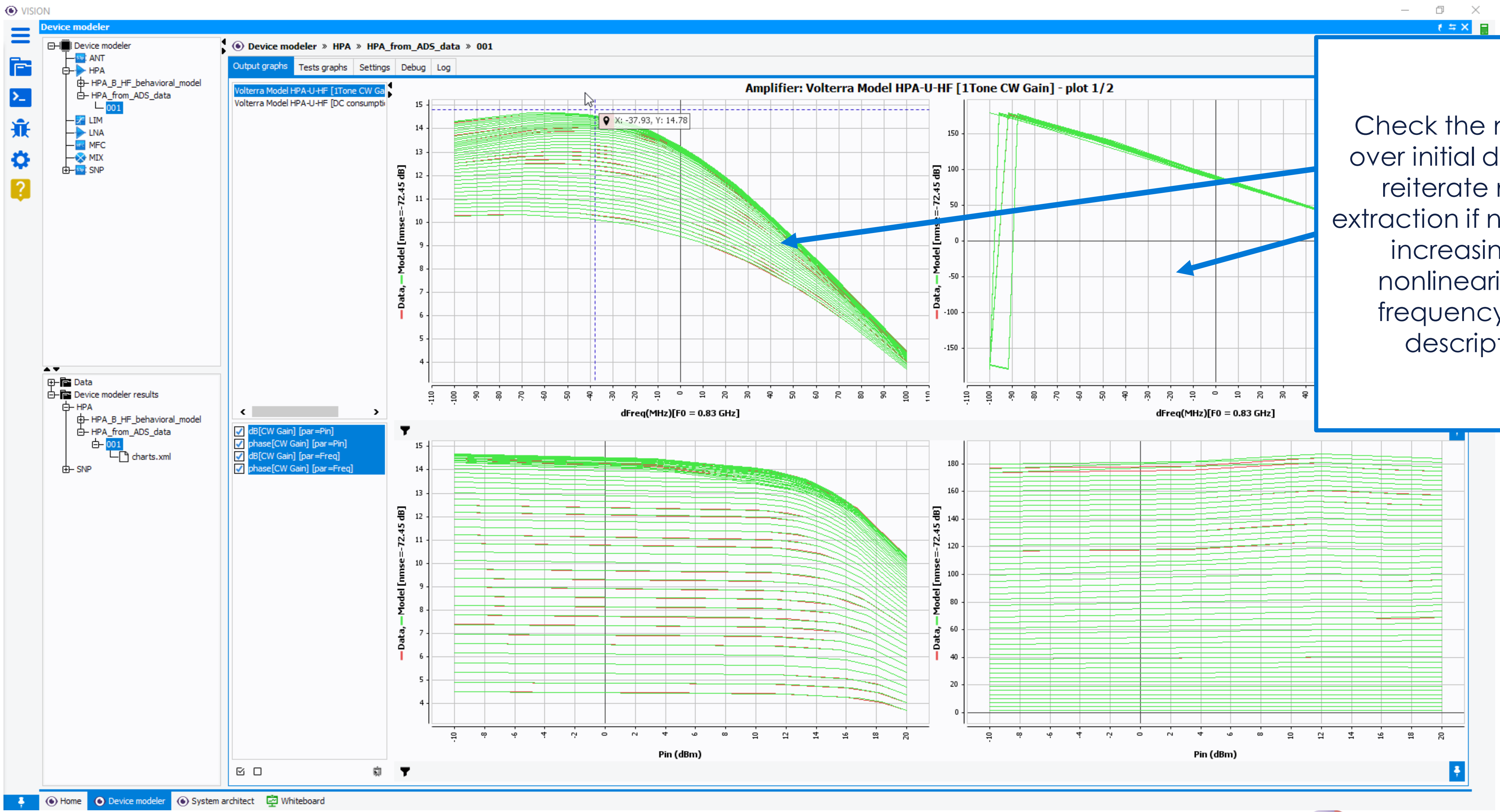
VISION device modeler – HPA-U-HF



Check the model fit over initial data, and reiterate model extraction if needed by increasing the nonlinearity and frequency order descriptions

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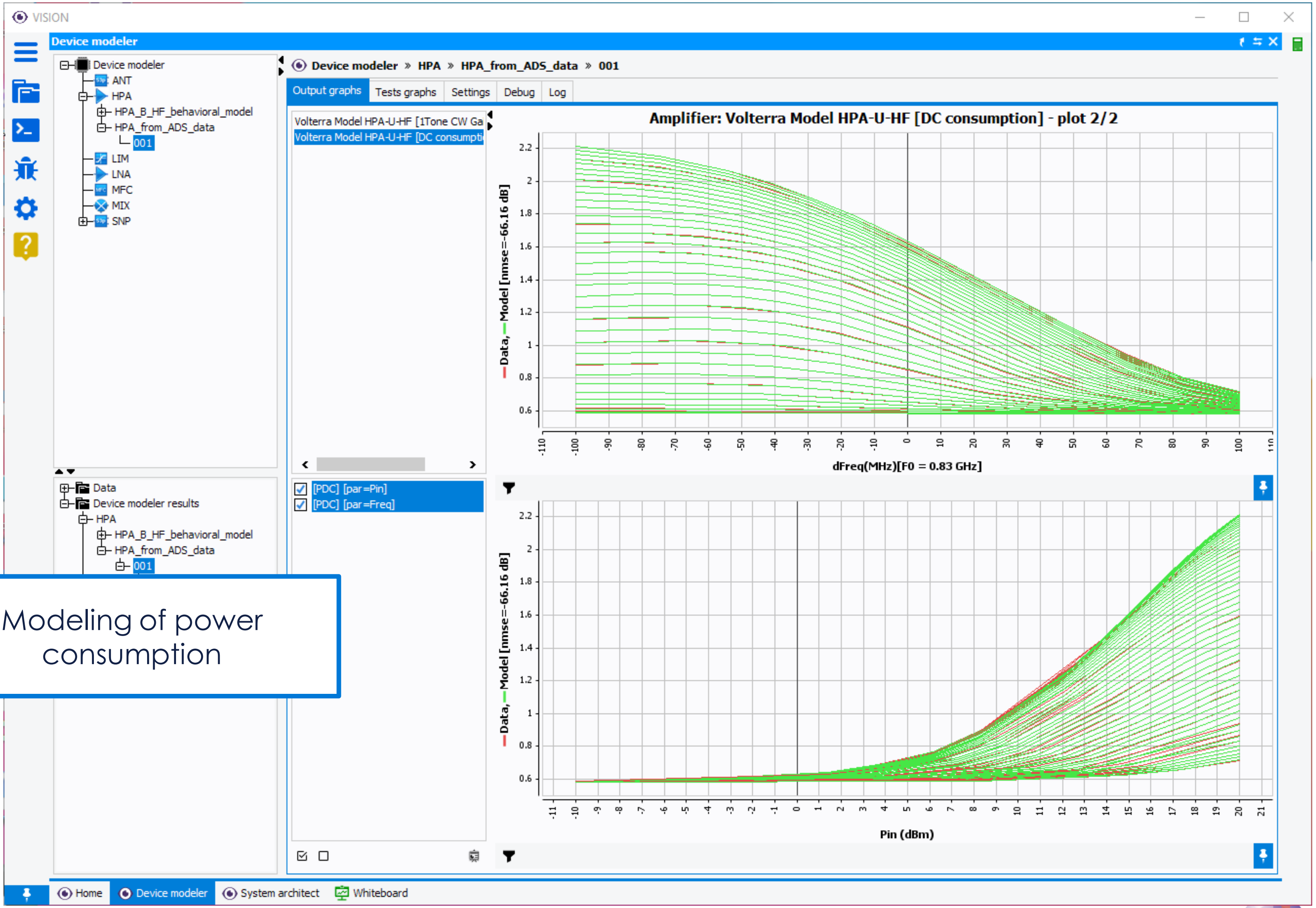
VISION device modeler – HPA-U-HF



Modeling of power consumption

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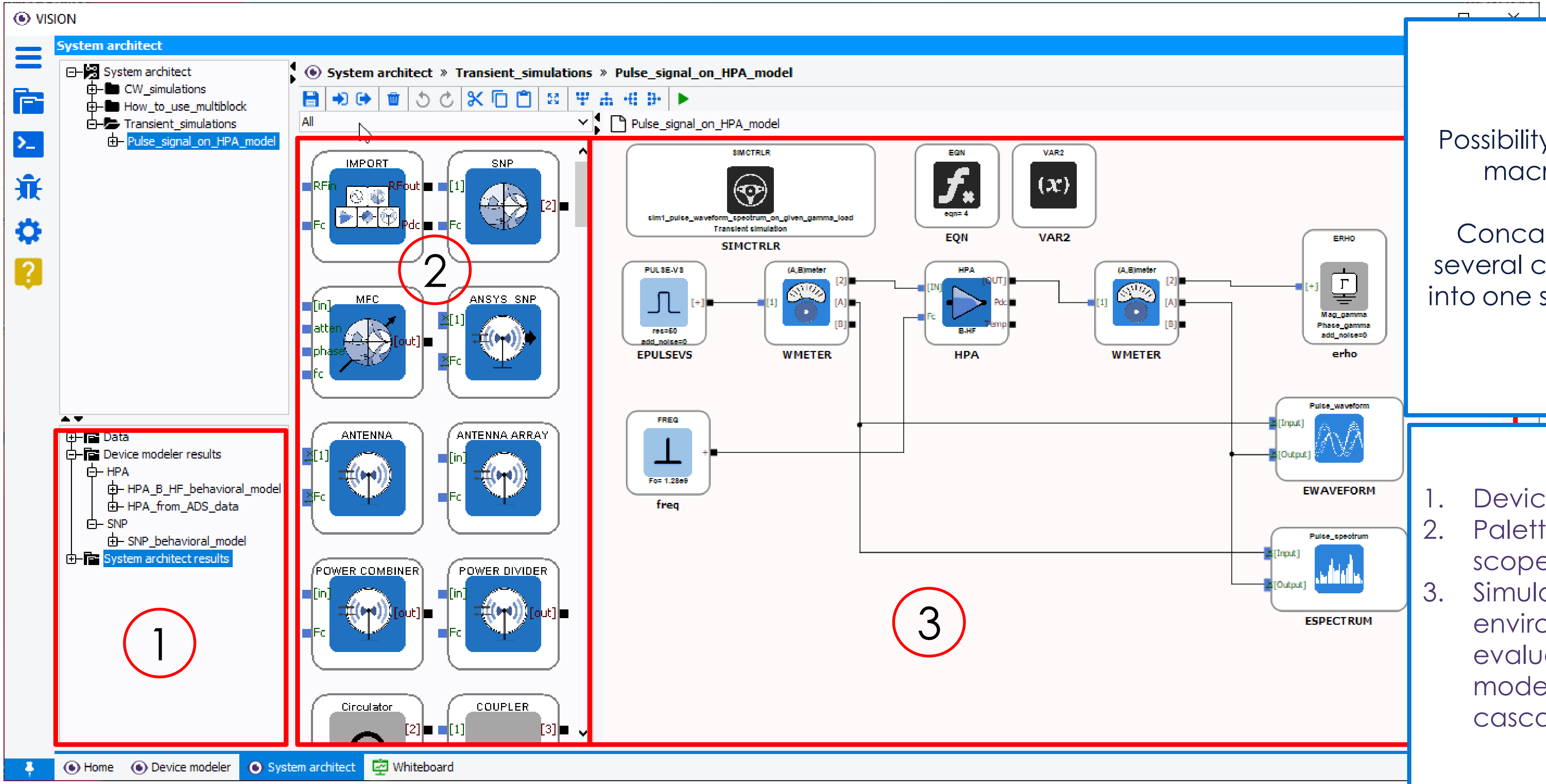
VISION System Architect



Possibility to create a macro-model
=
Concatenation of several circuit models into one system model

1. Device library
2. Palette of sources, scopes and probes
3. Simulation environment to evaluate one model or cascaded models

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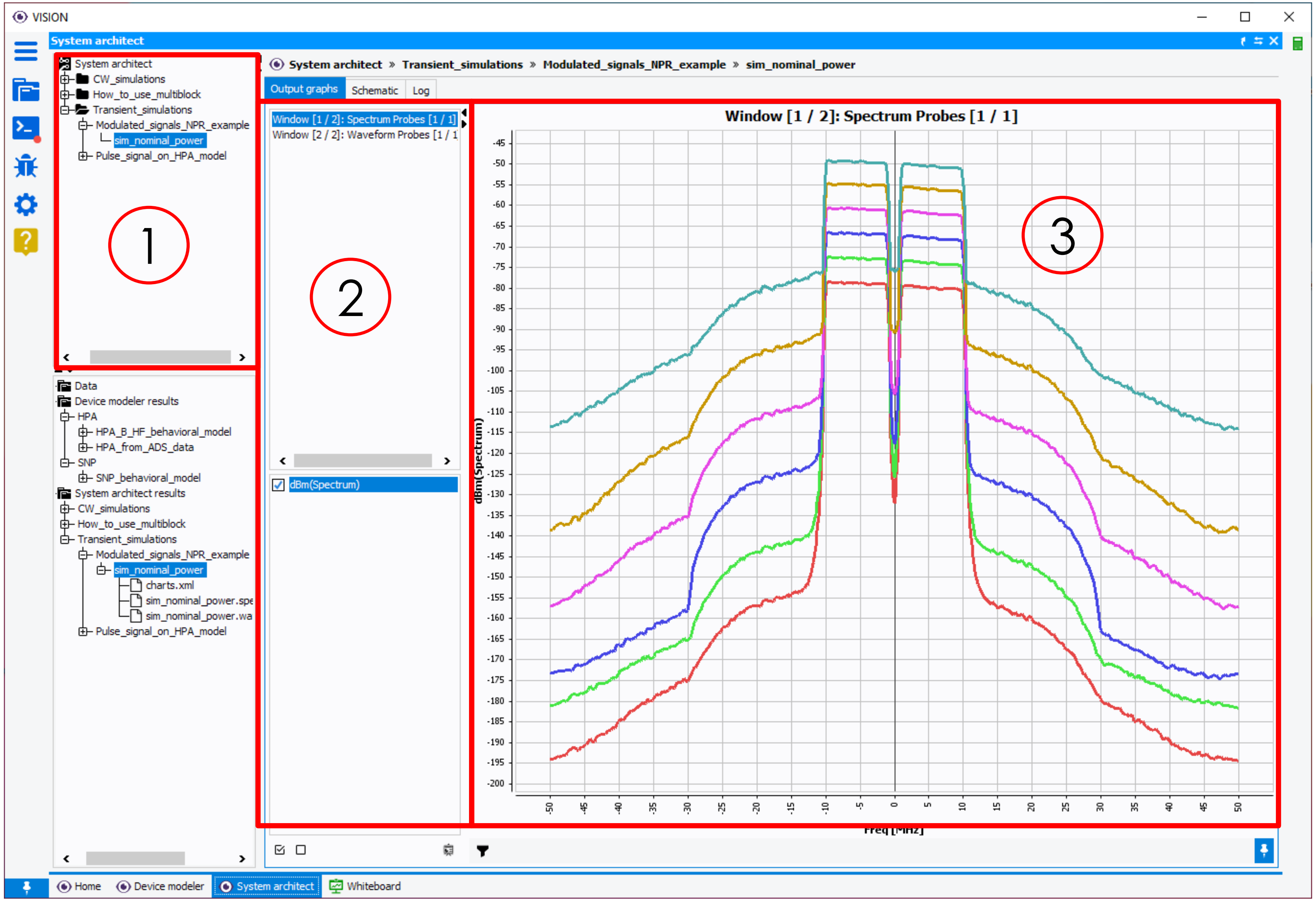
VISION System Architect



Checking the realistic behavior of the model with modulated signals

1. Schematic manager
2. Automatic display of results
3. Visualization and comparison between different simulations

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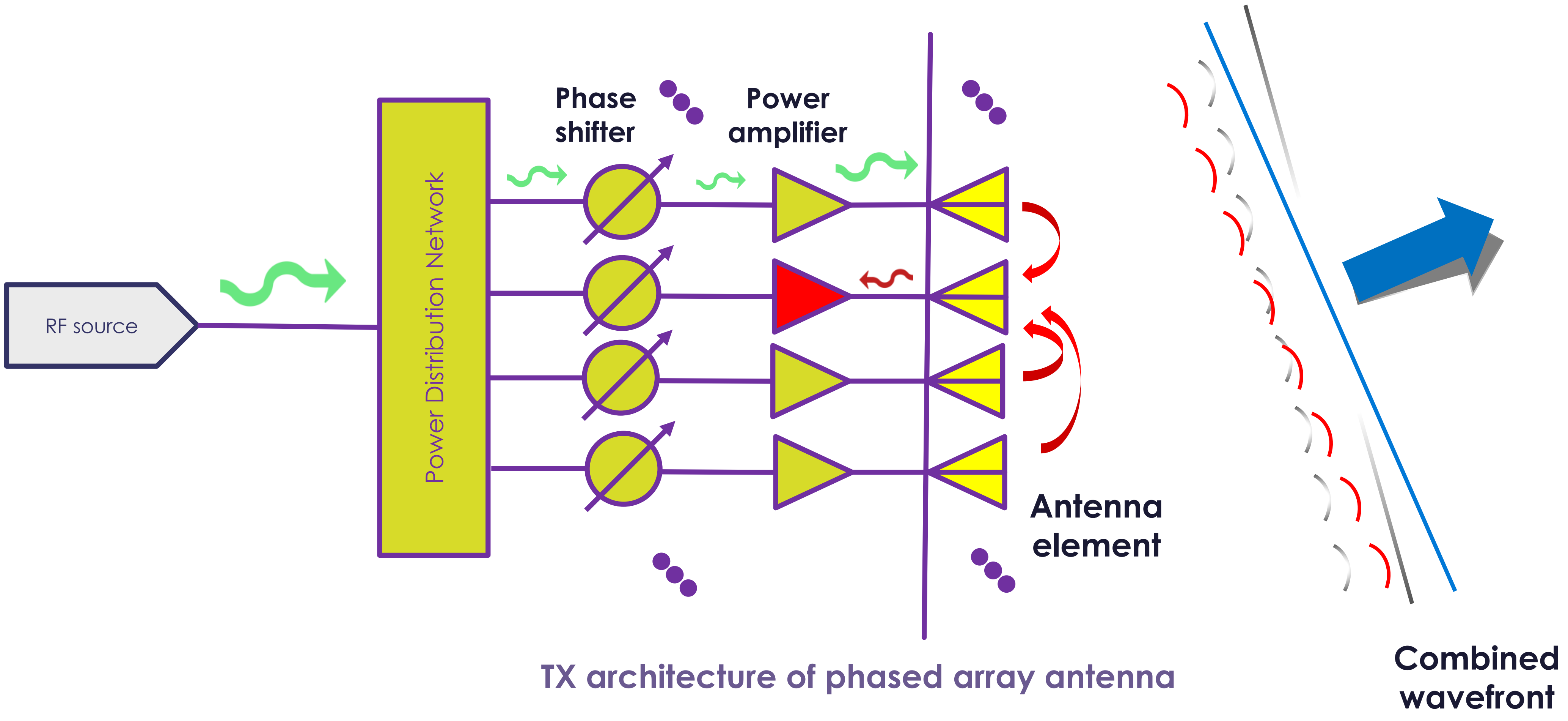
Advanced Antenna System example

Load pull effect in phased-array antenna systems



TX architecture of phased array antenna

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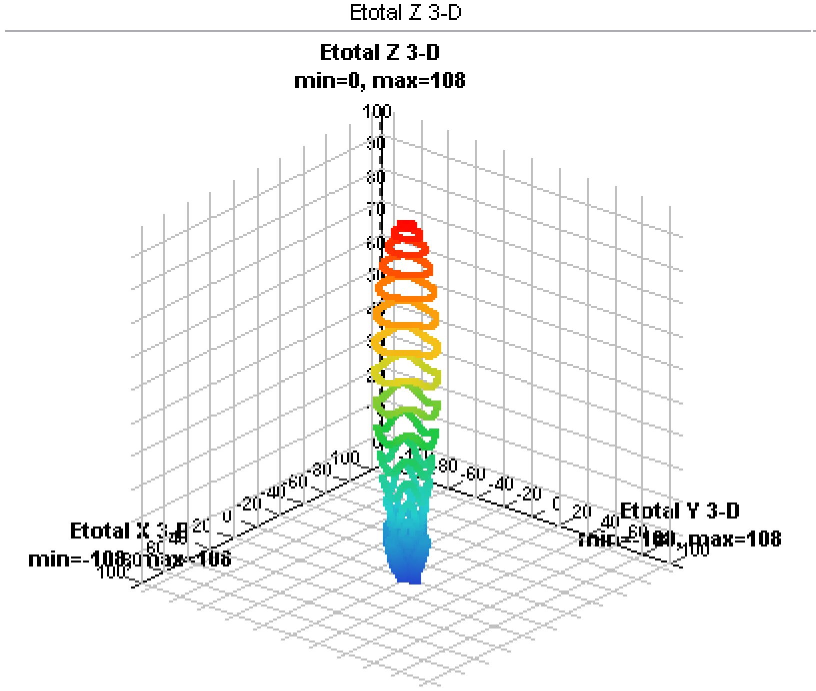
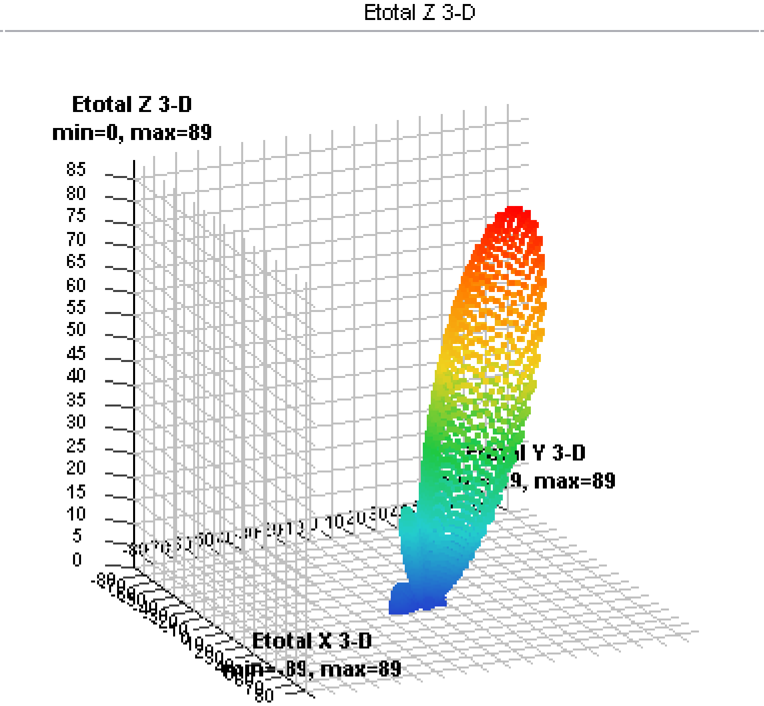
Advanced Antenna System example

Performance impacts on antenna radiation pattern

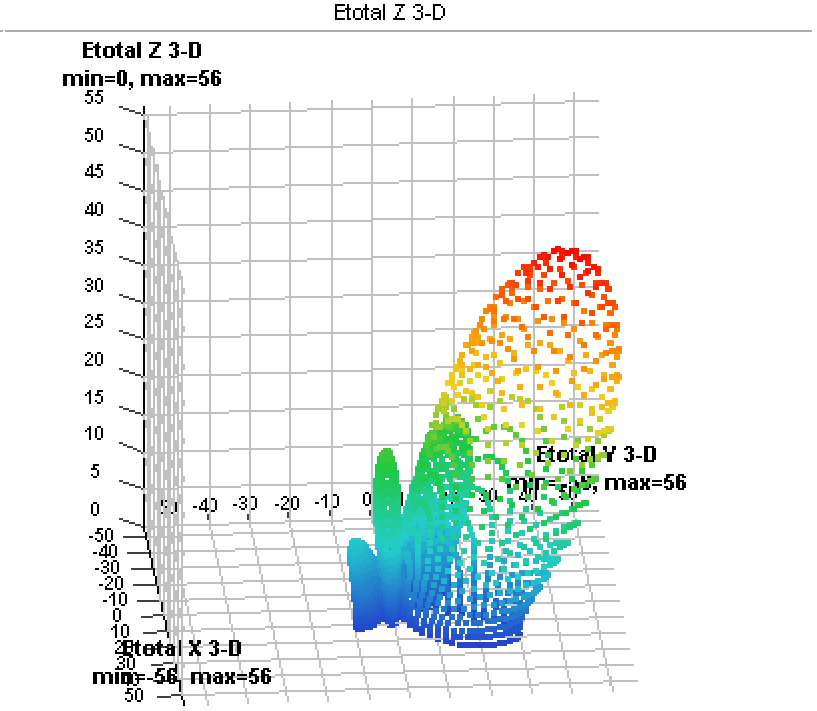
Radiation pattern can be plotted, while taking into account load-pull effect on the RF front-end



Phase shift X = 0°
Phase shift Y = 0°



Phase shift X = 60°
Phase shift Y = 60°



Phase shift X = 110°
Phase shift Y = 110°

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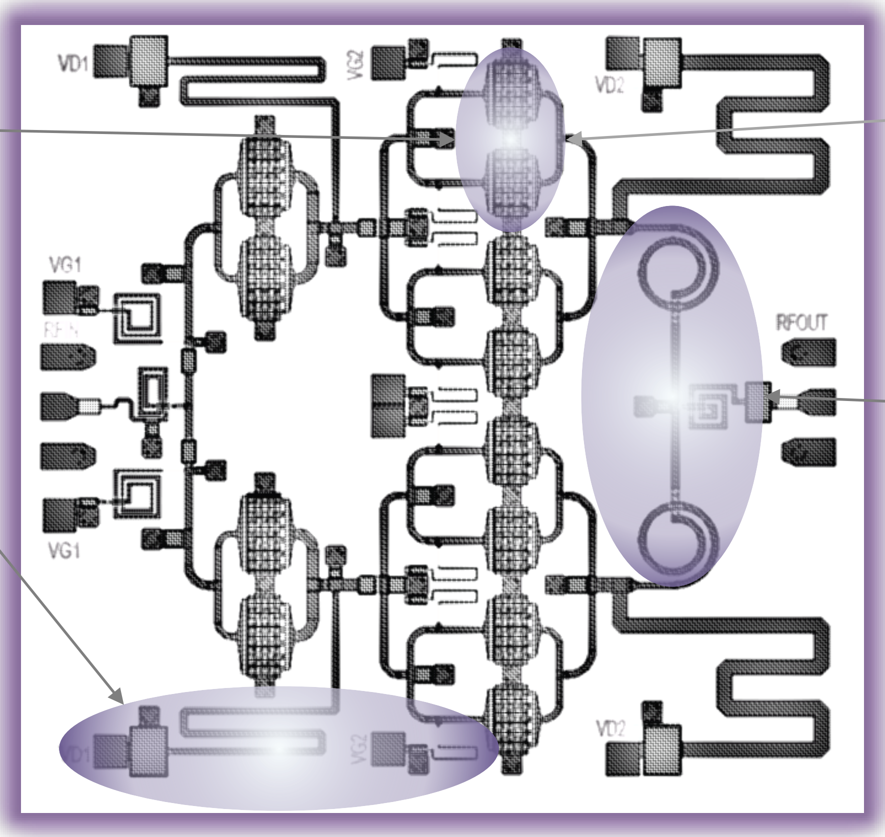
Digital Pre-distortion System example

PA = Non-linearity and memory effects

Self-Heating
Trapping effects
(Transistors)

Biasing Circuits
AGC Loops



Transit-time
(Transistors)

Band-pass, High-pass
Filters
(Matching networks)

Long term memory response (µs to secs)

Short term memory response (ns to µs)

Nonlinear coupling

Severely affects wideband modulation signal

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Digital Pre-distorsion System example

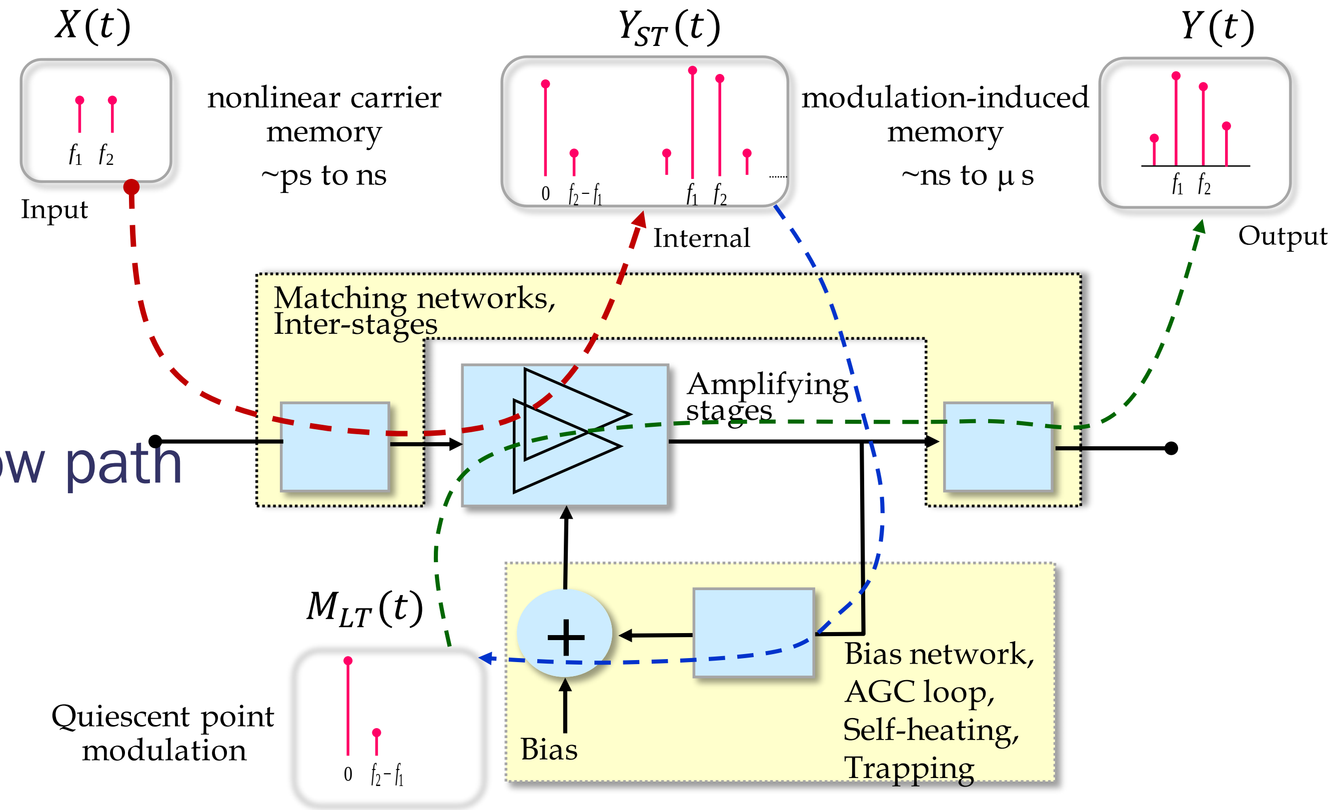
- ✓ Grey box analysis:
  - RF amplifier schematic summary
- ✓ Memory kinds separation:
  - Short term : red arrow path
  - Long term : blue arrow path
  - Feedback loop interaction : green arrow path
- ✓ Simplified feedback loop equation:

$$Y(t) = Y_{ST}(t)[1 + M_{LT}(t)]$$

- ✓ Separate Nonlinear integral equations

$$Y_{ST}(t) = \int_0^t h_{ST}(|X(t-\tau)|, \tau) X(t-\tau) d\,\tau$$

$$M_{ST}(t) = \int_0^t h_{LT1}(|X(t-\tau)|, \tau)|X(t-\tau)| d\tau + \int_0^t h_{LT2}(|X(t-\tau)|, \tau) \frac{d\angle X(t-\tau)}{dt} d\tau$$

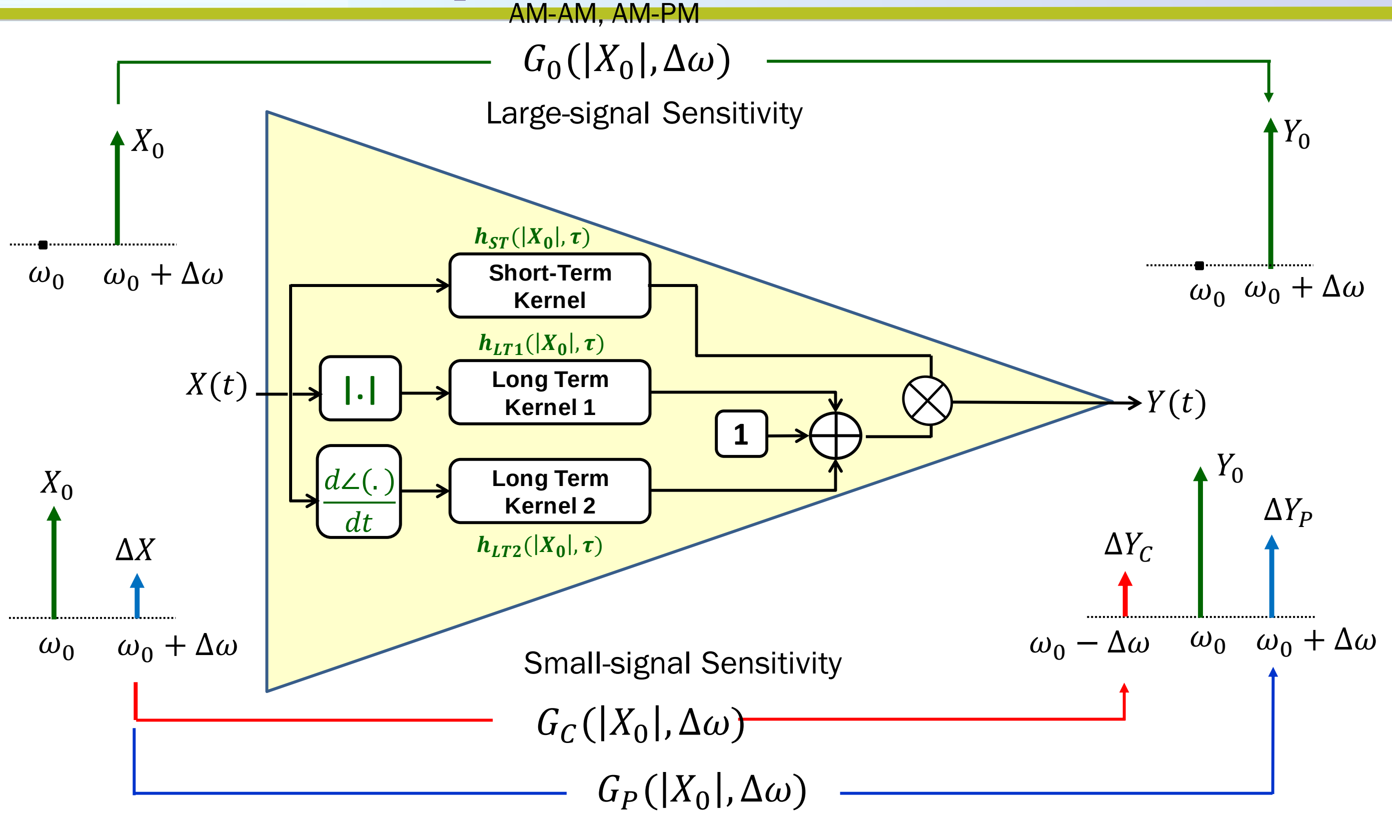


Digital Pre-distortion System example

Model characterization

✓ Elementary stimulus characterization

- Frequency swept, AM-AM, AM-PM characterization : $G_0(|X_0|, \Delta\omega)$
- Power swept, small-signal 1st and 2nd order sensitivity characterization: $G_P(|X_0|, \Delta\omega)$, $G_C(|X_0|, \Delta\omega)$



✓ Continuous-time kernel identification

$$\begin{bmatrix} G_0(|X_0|, \Delta\omega) \\ G_C(|X_0|, \Delta\omega) \\ G_P(|X_0|, \Delta\omega) \end{bmatrix}$$

Power integral : $|X_0|$
Laplace transform : $\Delta\omega$

$$\begin{bmatrix} h_{ST}(|X_0|, \tau) \\ h_{LT1}(|X_0|, \tau) \\ h_{LT2}(|X_0|, \tau) \end{bmatrix}$$

Continuous-time model kernels

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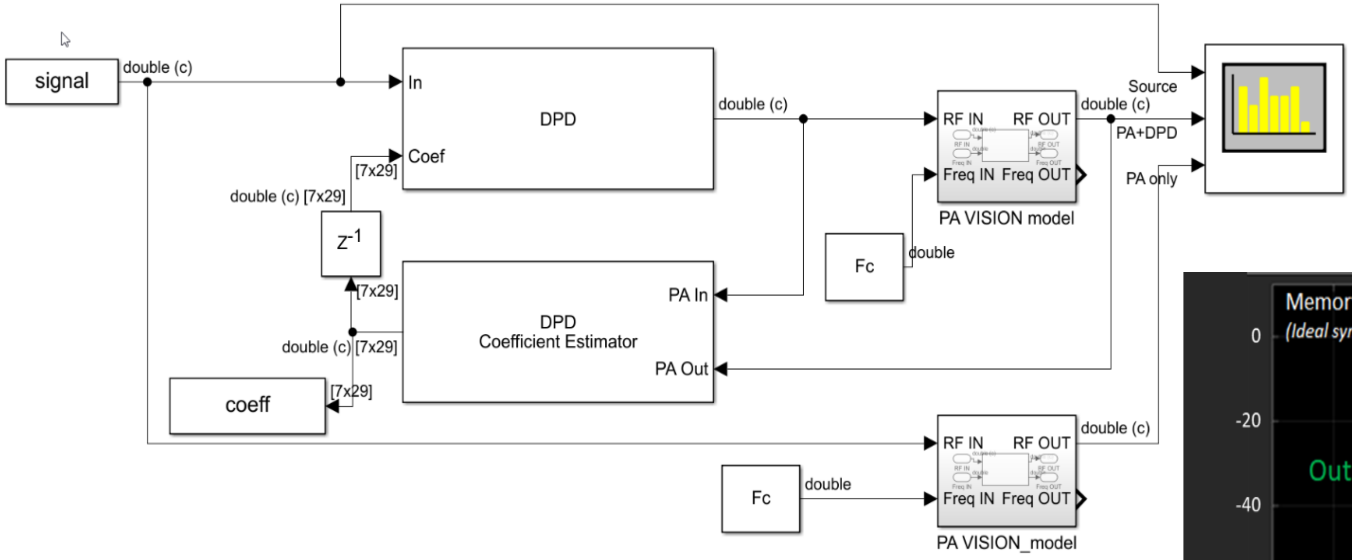
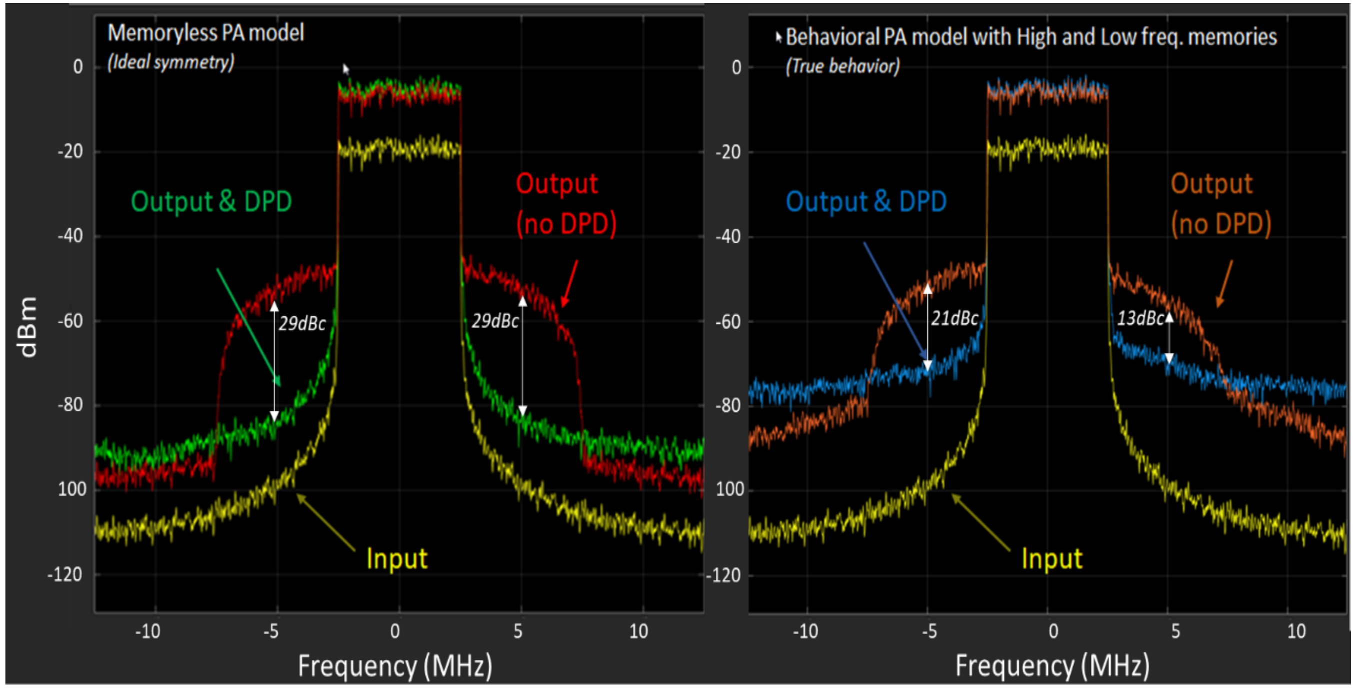
Digital Pre-distortion System example





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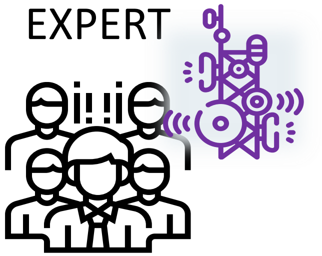
Circuit Behavioral Model for System Design

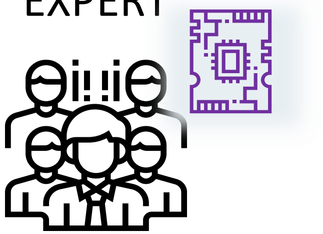
Behavioral models are useful because we can execute them in system simulation and learn faster than we can with product datasheet

SYSTEM EXPERT



- Analysis & Simulation
- Test & Verification
- Communication

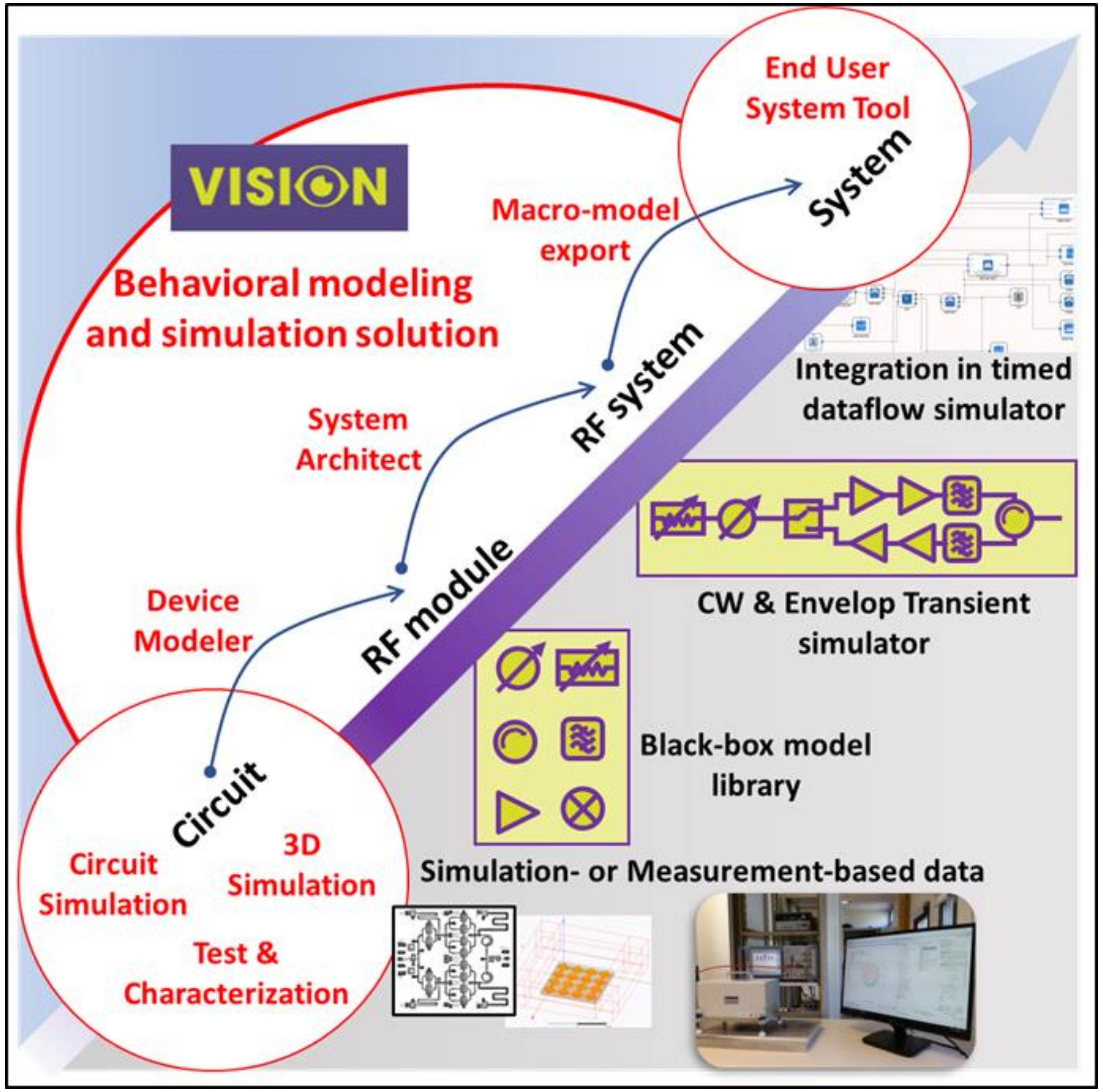
CIRCUIT EXPERT



Requirements

- Protected IP
- Wide domain of validity
- Model extraction from circuit simulation or measurement
- Fast simulation
- Integration in system simulator

Conclusion



- Design and optimization of RF and MW system
- Circuit/system level
- Behavioral Modeling workflow
- Bilateral behavioral model
- Behavioral model with memory effects

- Bilateral + memory effects (DPD in AAS)
- Thermal effects

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