System Design Oriented RF Block Modeling : When Top-Down Reaches Bottom-Up

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Outlines

- Introduction
  - RF design needs vs RF models
  - Block models vs behavioral models
- LNA model
  - LNA architecture
  - Existing LNA model
- Unified model implementation
  - Features
  - Implementation
- Simulation results
  - Bluetooth transceiver

Introduction

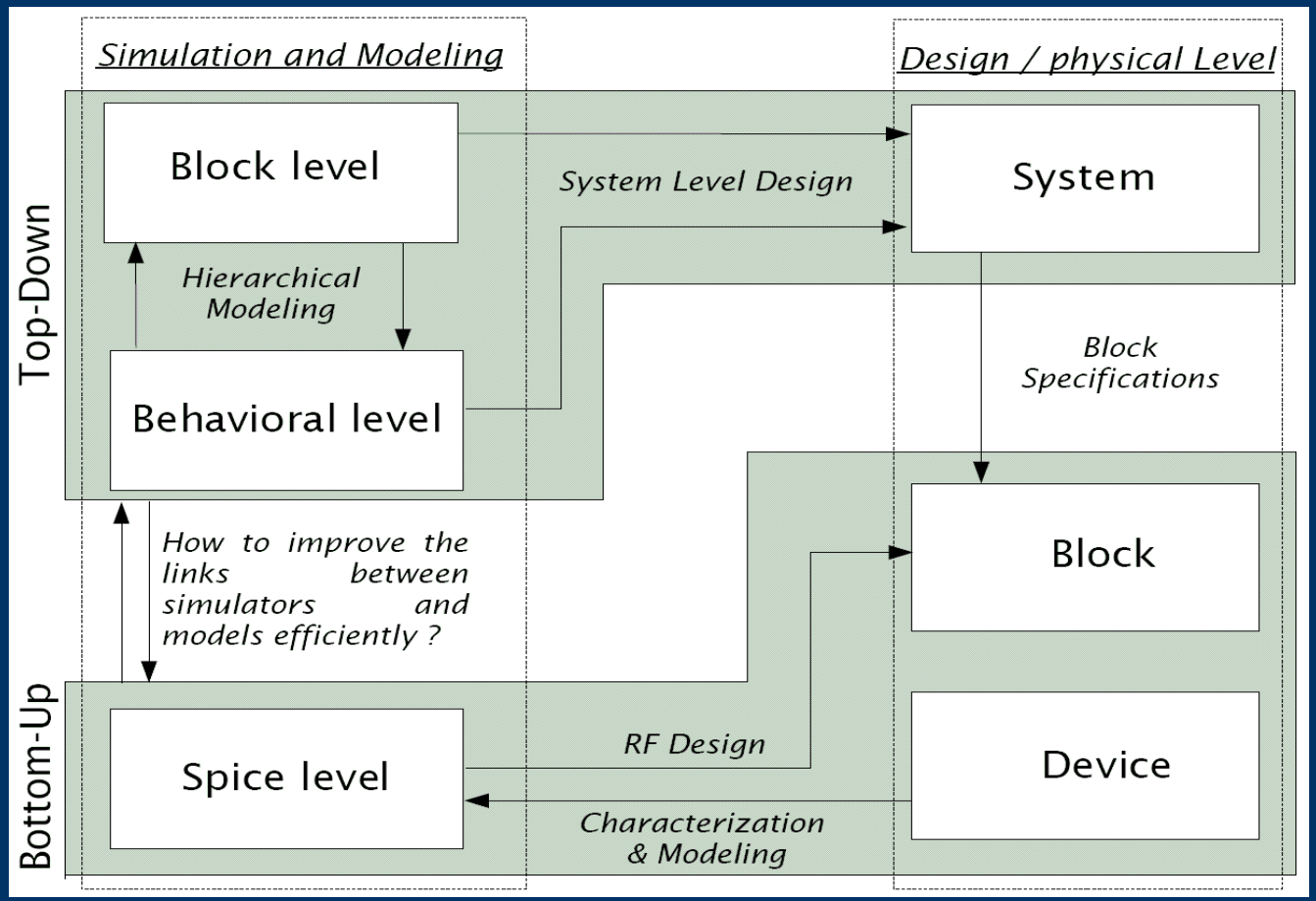
- System design requirements
  - IP reuse
    - Well known performances
    - Low development time
  - Simple and accurate models
    - Low simulation time
  - Hierarchical modeling
    - Account for block and system complexity
  - Unique design platform
    - Simulator interoperability

Introduction

- Characterization and modeling performances
  - Block diagram modeling
    - high simulation time
    - Low development time
  - Behavioral modeling
    - Low simulation time
    - Fully compatible with SPICE simulations
  - Physical modeling
    - All of the above model come from SPICE simulations or measurements
    - High development time
  - Interoperability between block and behavioral models

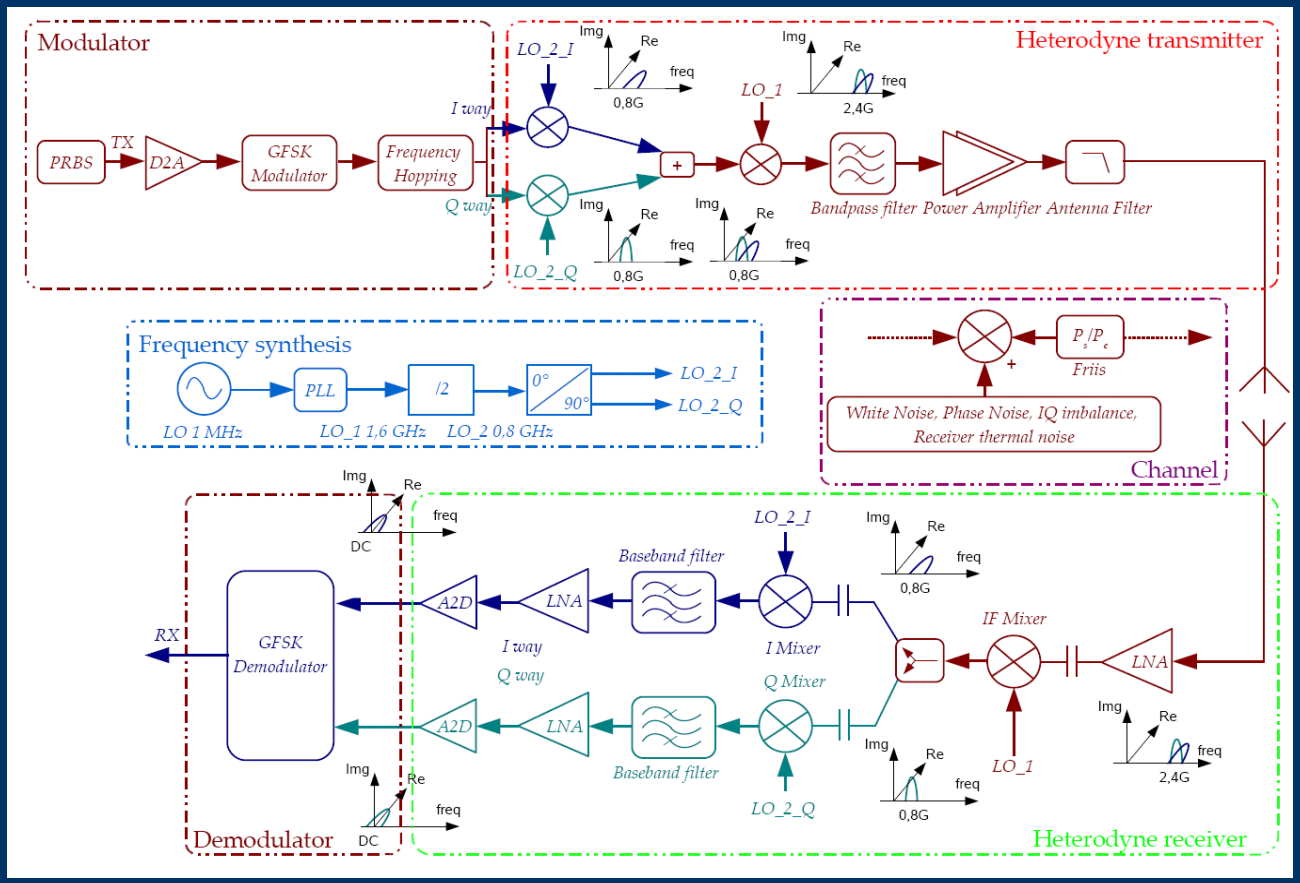
Introduction

- RF Design methodology



Introduction

- Bluetooth transceiver



The optimal complete simulation requires several hierarchical models.

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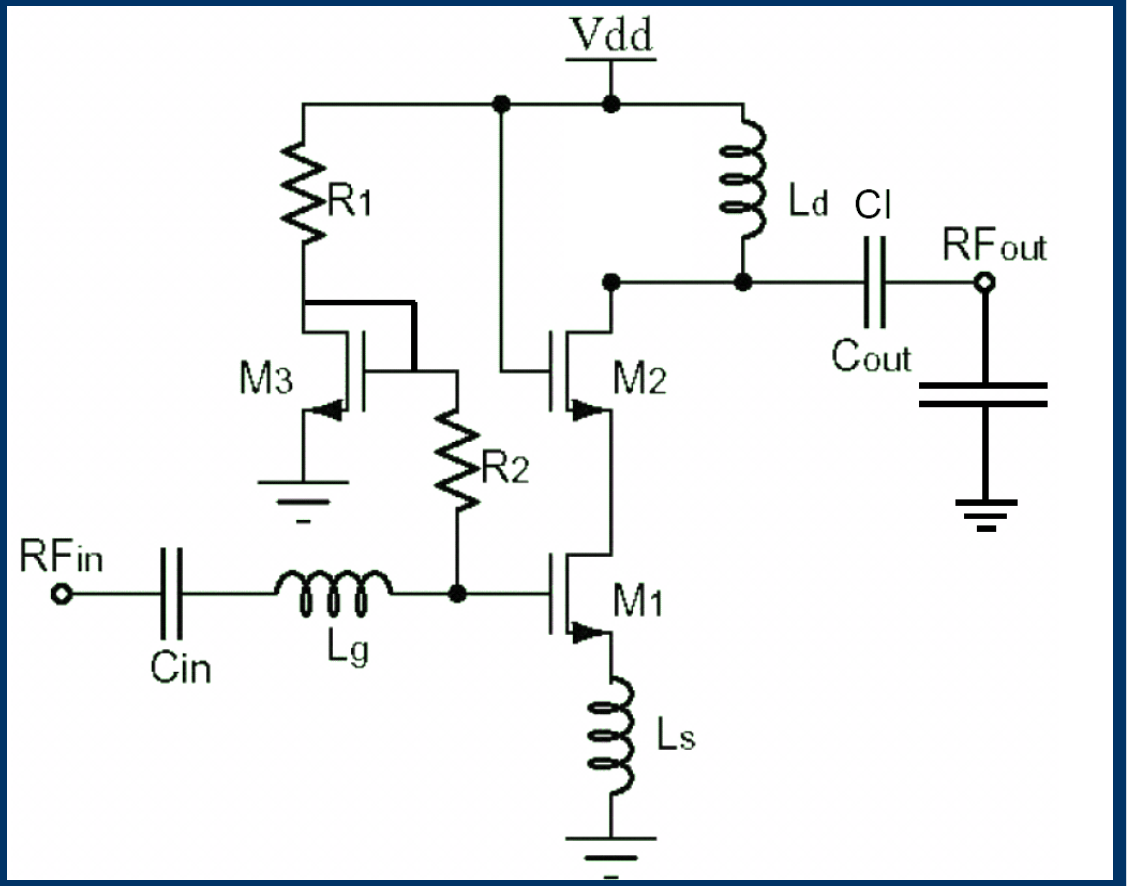
LNA model

- LNA Characteristics
  - Physical parameters
    - W/L,
    - Ls, Ld, Lg,
    - ...
  - Electrical parameters
    - Gain,
    - NF,
    - IP3,
    - ...

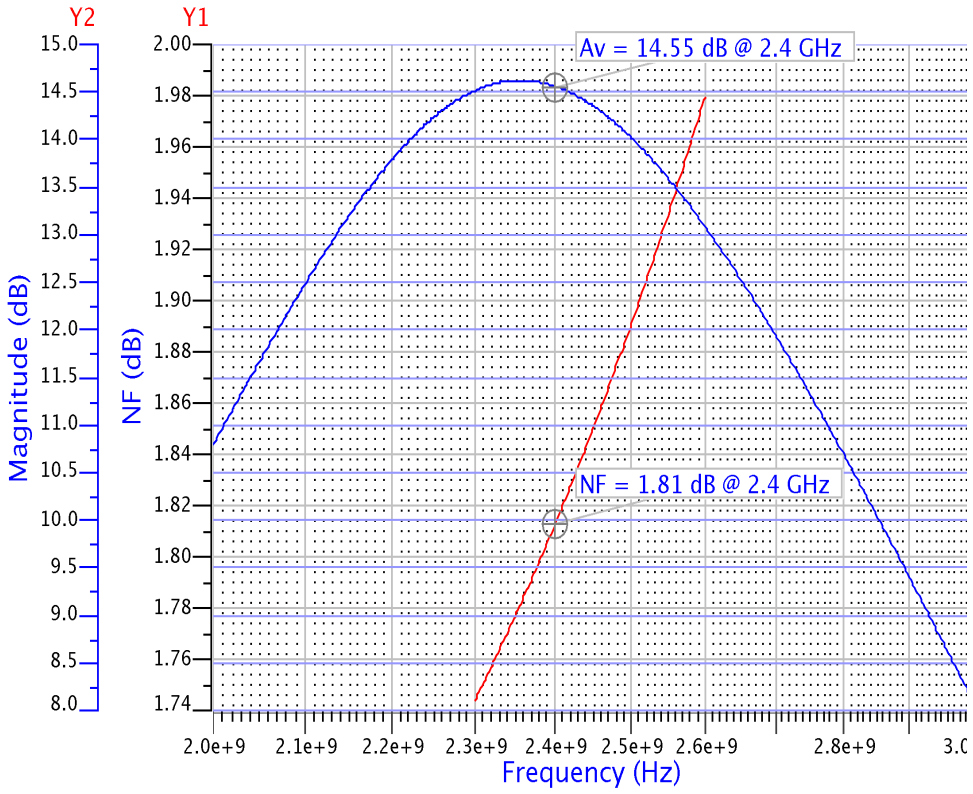


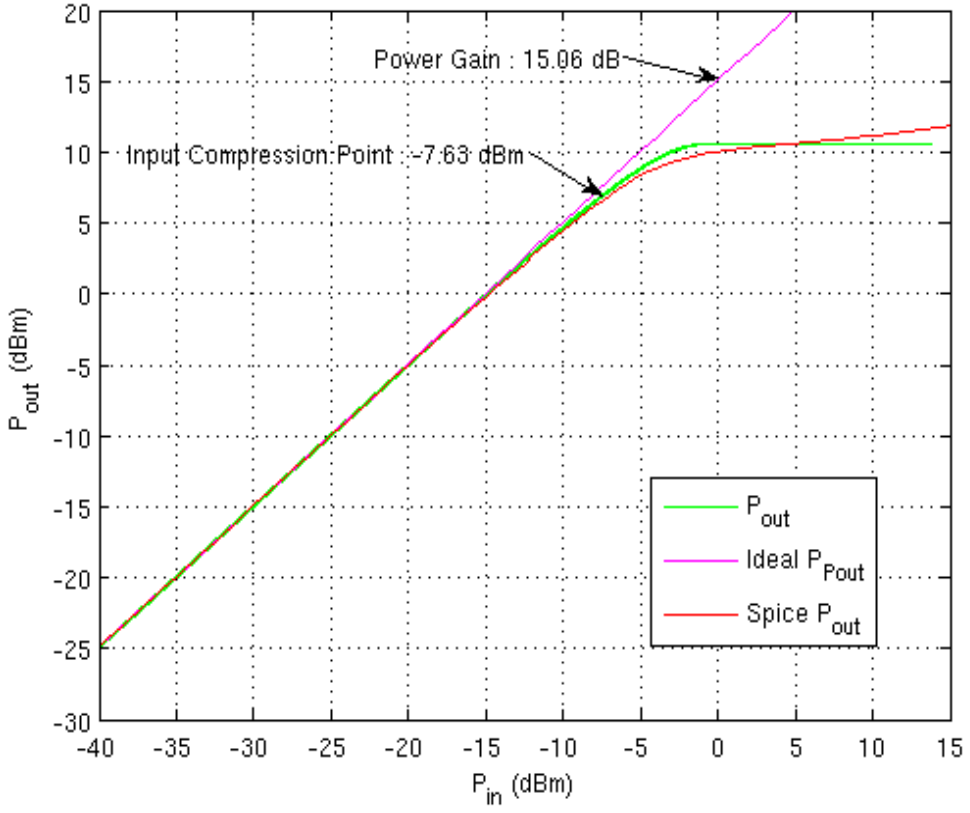
LNA model

- LNA core model
  - Model architecture : any of existing model including
    - Gain,
    - Noise,
    - Non linearities
  - Modeling language
    - Mathematical treatment allowed
    - Electrical parameters as input
  - Model accuracy
    - Comparable to SPICE simulation

LNA model

- LNA core model features





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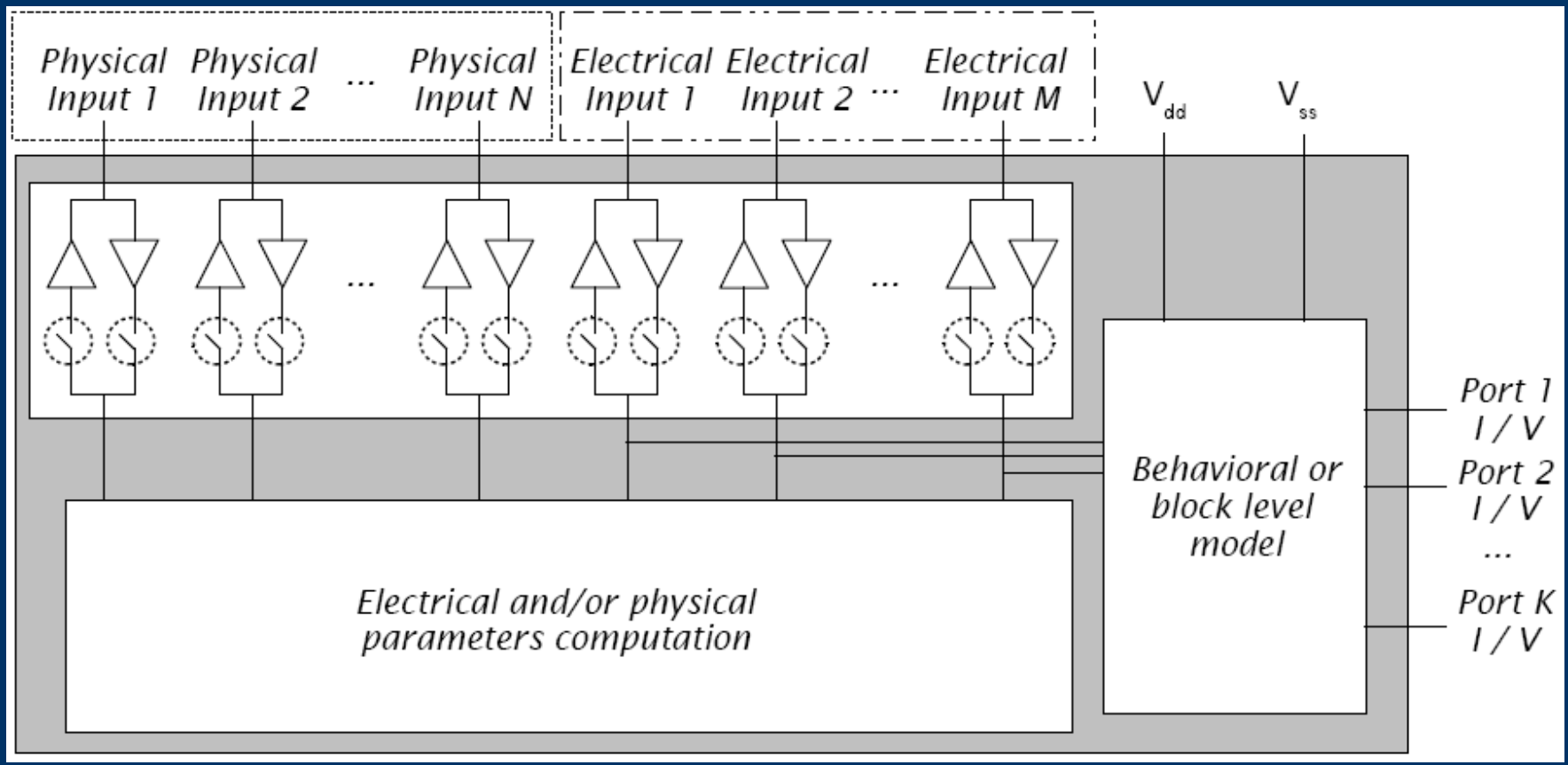
Unified model implementation

- Model architecture

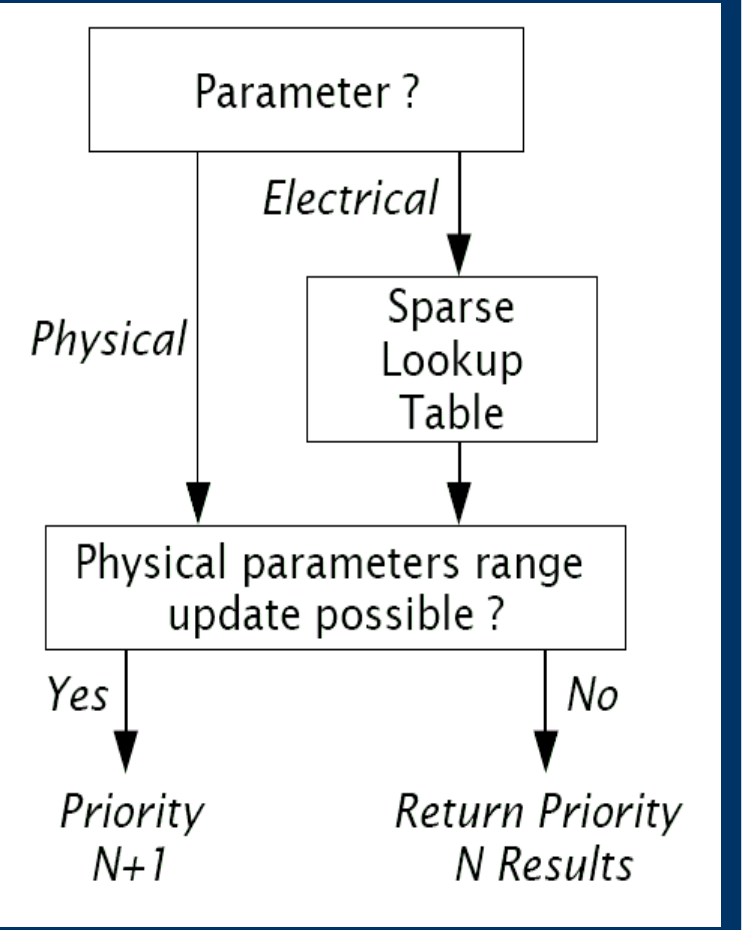


Unified model implementation

- Model implementation
  - SPICE simulations for the look-up table
    - Golden device : existing IP and corresponding SPICE simulations
    - Exhaustive sweep on the physical parameters (transistor sizes, passive component calues, ...)
    - Extraction of the corresponding electrical parameters
    - Storage efficiency : sweeps which do not ensure input and output matching can be removed from the look up table
    - High simulation time => need to automate the extraction and simulation results checking

Unified model implementation

- Model implementation
  - Electrical and physical parameters accessed independantly
  - Look up table representing electrical parameters as a function of physical parameters
  - Loop until the user-defined priorities can not be respected



Unified model implementation

- Unified model features
  - SPICE simulations accuracies
  - Behavioral model performances in terms of simulation time
  - Good representation of actual RF block performances at system level
- Limitations
  - Development time limited by the amount of preliminary SPICE simulations
  - Model valid for a given LNA architecture

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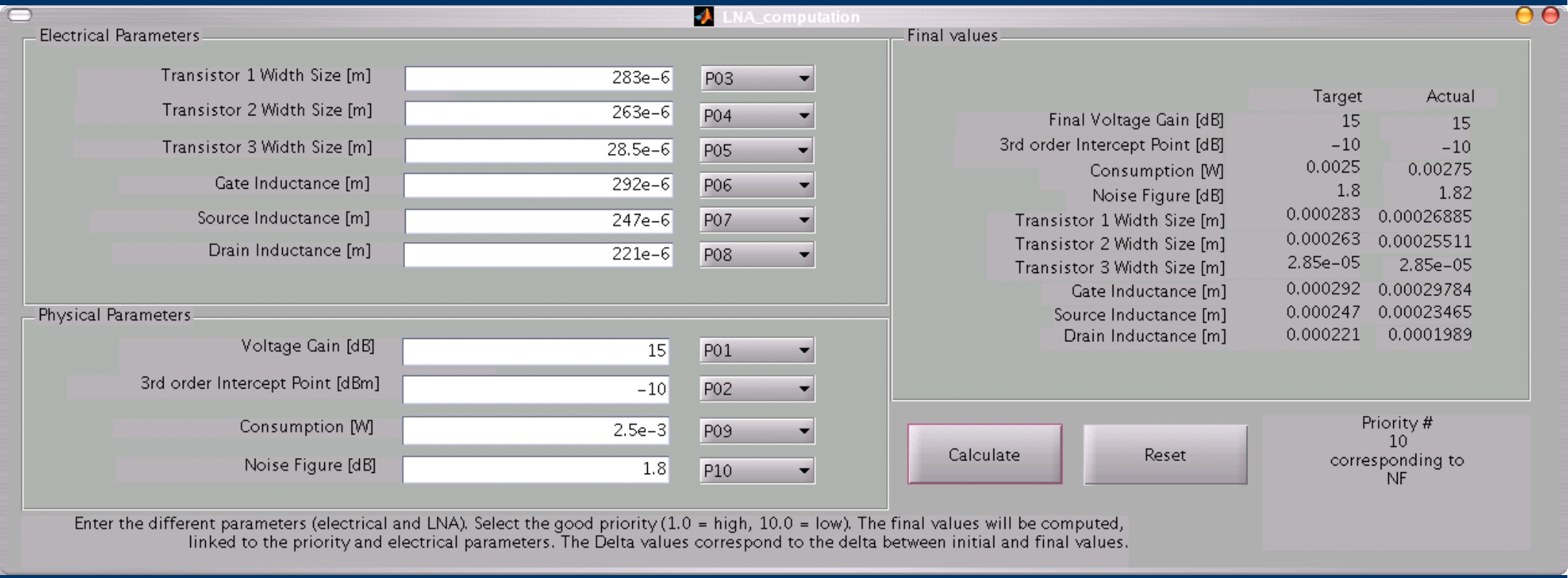
Simulation results

- Optimisation results



Simulation results

- Transceiver simulations
  - Simulink simulations,
  - Linux station, 2GHz procesor, 8Mo RAM

LNA model	Simulation sampling time	Time / bit
Ideal	0.1ns	4,7s
Non-linearities + noise	0.01ns	68s

Conclusion

- New solution for system design
  - Realistic RF block models accessible at system level
  - SPICE accuracy and block / behavioral models efficiency
  - Based on existing RF blocks models
  - Graphical user interface available
- Further work
  - Generalization to all RF blocks
  - Check that the look-up table sizes do not limit the simulations

Questions ?