PEDASOFT

EM Supreme®

Fully Integrated
EM Simulator for
RF Components and Modules

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ASK for our RF design and Modeling Services!

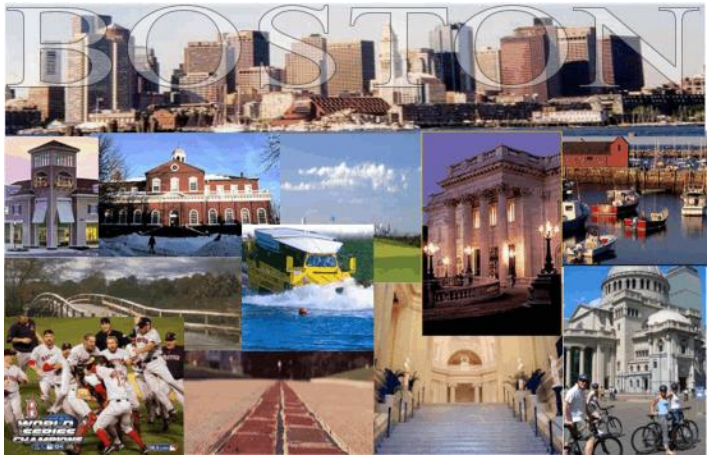
CONTENTS

CONTENTS

INTRODUCTION

PedaSoft

- Pedasoft LLC was founded in 2006 to create a higher accuracy EM simulation tool in order to reduce the time required to develop RF circuits.
- The EM-Core© time domain field solver and the EM-Supreme© simultaneous active and passive simulator were unveiled at the 2009 IMS.



INTRODUCTION

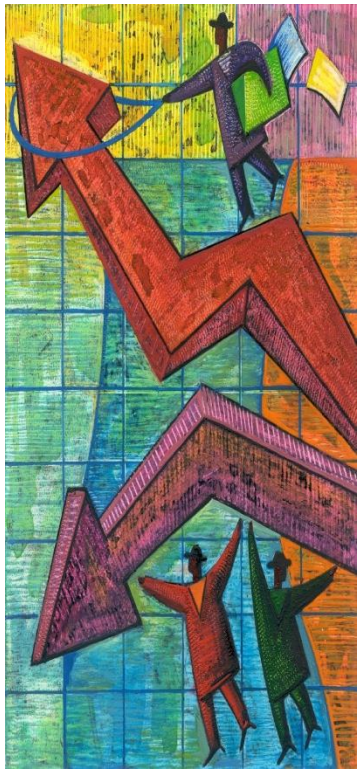
TRENDS

RF DESIGN CHALLENGES

- Multiband
  - › Number of different radios / wireless devices is growing.
- Design Cycles
  - › Time allowed for design is shrinking.
- Size
  - › Amount of area for any given function is shrinking.
- Clock Speed
  - › IC operating speed is increasing.
- Application / Standards Frequency
  - › New applications are increasing operating frequency.

MARKET

- Product Lifecycles
  - › Lifetime of any given product is shrinking.
- Internet of Things
  - › Number, standards and types of devices is growing rapidly.



INTRODUCTION

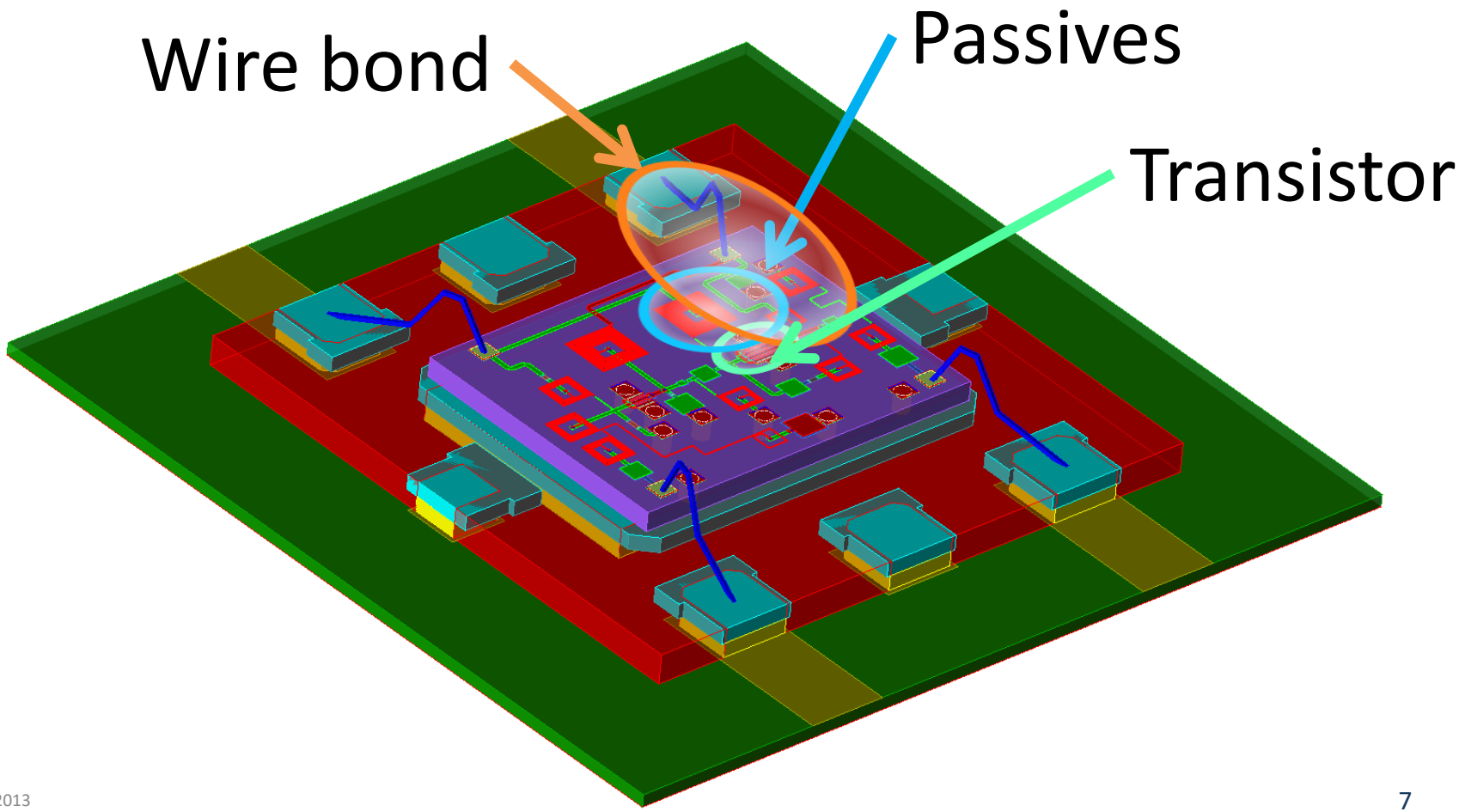
RF DESIGN CHALLENGES

- Iterations
  - Generally the longest time, not to mention cost, for a single iteration is the prototype fabrication time.
  - Reduced number of design iterations is necessary to meet time-to-market expectations.
  - Improved simulation accuracy is required in order to reduce the number of iterations, yet the number of design passes to meet the specification has not changed substantially over the last 20 years.
- Tools

  - Electronic Design Automation (EDA) has roots in two basic approaches:
    - Circuit Simulators
    - EM Field solvers
  - To overcome the limitations of both, EDA tools have incorporated the ability to paste in blocks of simulation results to permit “co-simulation” of circuit and EM results.
  - This approach is limited in its ability to accurately simulate circuit response and hence has not reduced the number of design cycles.

INTRODUCTION

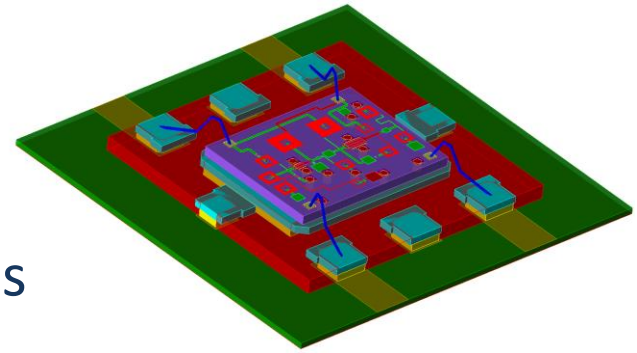
RF DESIGN CHALLENGES



CONTENTS

EM-SUPREME® OVERVIEW

EM-SUPREME®



- Finite Difference Time Domain (FDTD) model that uses no approximations.
- The tool models electromagnetic fields as they pass through the active and passive components to predict real circuit performance as it physically happens.
- Allows incorporation of the IC, passives, substrate and package in the model.
- Compatible with existing design tools to minimize learning curve.
- Two modes of operation:
  - Stand Alone – Provides all necessary tools to completely model a given component or module.
  - Optimization – Adds functionality to existing tools to improve prediction of the actual circuit performance.

What Exactly Can go Wrong

Transistor Models?

- Circuit-Based
- Measurements-Based with/without Quantum Mechanics correction-terms (through *curve fitting* or *NN*) .
- Models that take the EM distributed effects into account (possibly mm-wave frequencies) and PDK's
- You need to have a smart engine to choose between any of these models.
- Models have to be general.

EM Sample Problems

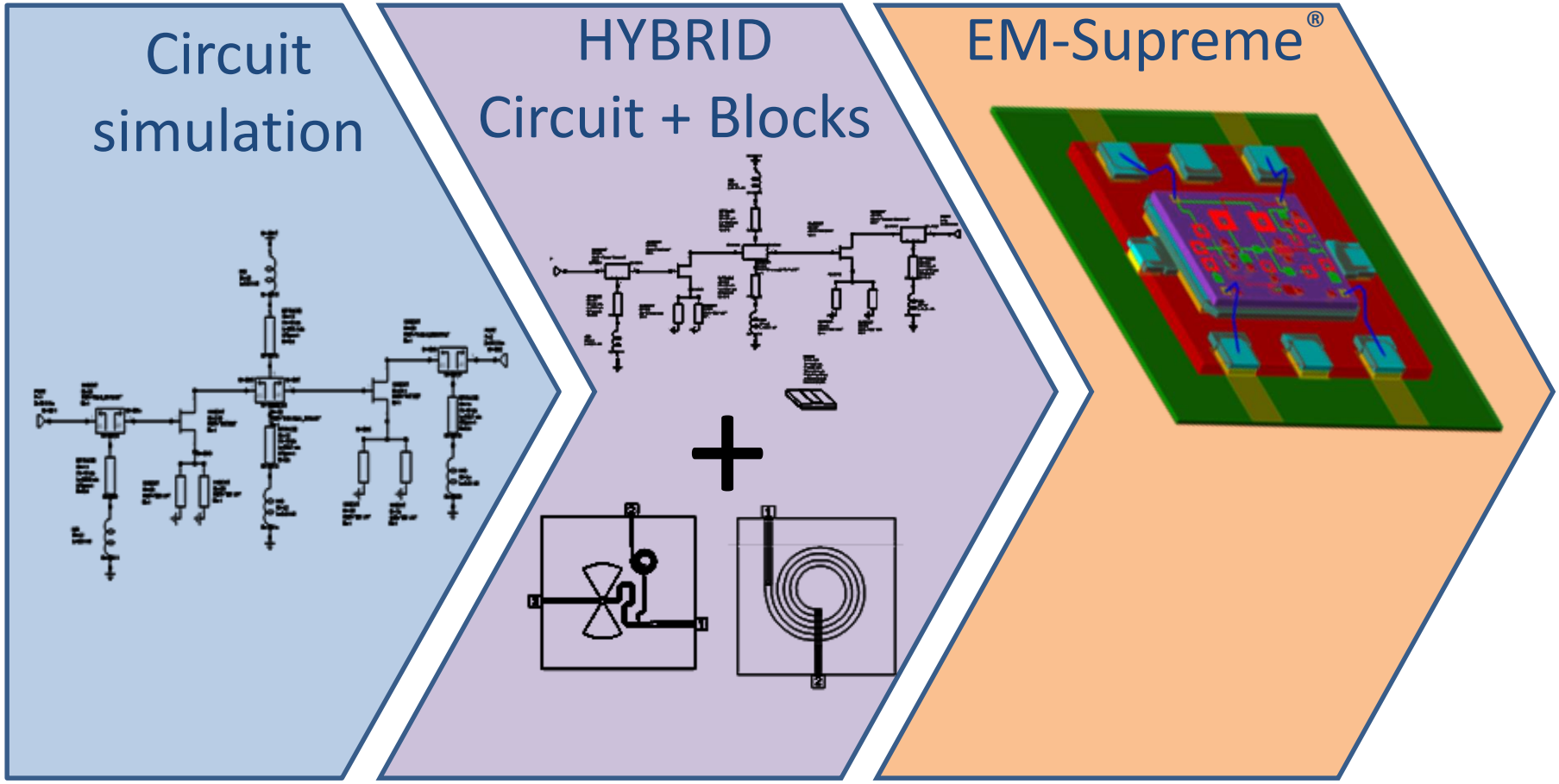
- *Coupling of EM and transistor* (through radiation for example) if you have distributed effects. The transistor is nonlinear so this effect is more pronounced specially for transient response and high-power high-frequency devices (GaN, LDMOS, etc).
- Possibility of coupling is everywhere (e.g. wire-bond, laminate multilayer, on chip spirals, you name it.

EM Sample Problems

- Mold simulation and coupling of EM-reflecting back from *laminate mold* into the IC. It's very important to look at the *transient response* of this. The only way to see the effect of model is to have a full simulation of the entire chip.
- *Magnetic coupling loops* (for example before and after a PA). The length of loops is changed as you add a transistor and may result to an unintended magnetic coupling.
- Coupling with noise in switching power supplies.

EM-SUPREME® OVERVIEW

EVOLUTION / ACCURACY



EM-CORE® OVERVIEW

EM SIMULATOR COMPARISON

Company	PedaSoft	Sonnet	CST	Ansys	Zeland	IMST
Product	EM-Core®	Sonnet	CST-Ems	HFSS	IE3D	Xccel
Geometry	2.5 & 3D	2.5D	3D	3D	3D	3D
Method	FDTD	MoM	FIM	FEM	MoM	FDTD
Time Domain	√	X	√	X	X	√
Freq Domain	X	√	√	√	√	X
Accuracy	High	Medium	High	High	High	High
Memory	Medium	Medium	High	High	Medium	High
Speed	Medium	Fast	Medium	Medium	Medium	Fast
Shielded	√	√	√	√	√	√
Radiated	√	X	X	√	X	X
DXF	√	√	√	√	√	√
Customizable	√	X	X	X	X	X
Cost	Low	Medium	High	High	Medium	Medium

EM-SUPREME® OVERVIEW

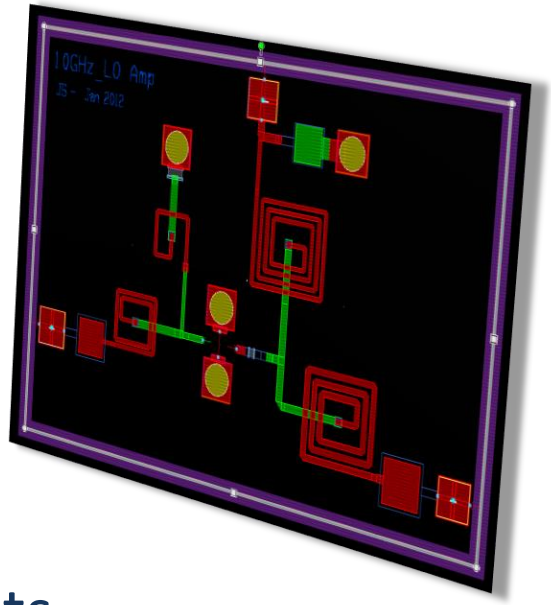
SYSTEM SIMULATOR COMPARISON

Company	PedaSoft	KeySight	AWR	Ansys
Product	EM-Supreme®	ADS + Momentum	MWO + AXIEM	Nexxim + HFSS
Geometry	2.5 & 3D	2D	2.5D	3D
Method	FDTD	FEM	MoM	FEM
Time Domain	√	X	X	X
Freq Domain	X	√	√	√
Circuit EM Hybrid	√	√	√	√
Active EM Hybrid	√	X	X	X
Circuit + Active EM	√	Co-simulation	Co-simulation	Co-simulation
Active Models	Unlimited	Limited	Limited	Limited
Accuracy	High	Medium	Medium	High
Memory	Medium	Low	Medium	High
Speed	Medium	Fast	Fast	Medium
Shielded	√	√	√	√
Radiated	√	X	X	HFSS Only
DXF	√	√	√	√
Customizable	√	X	X	X
Cost	Medium	High	High	High

EM-SUPREME® OVERVIEW

EM-SUPREME® ADDITIONAL FEATURES

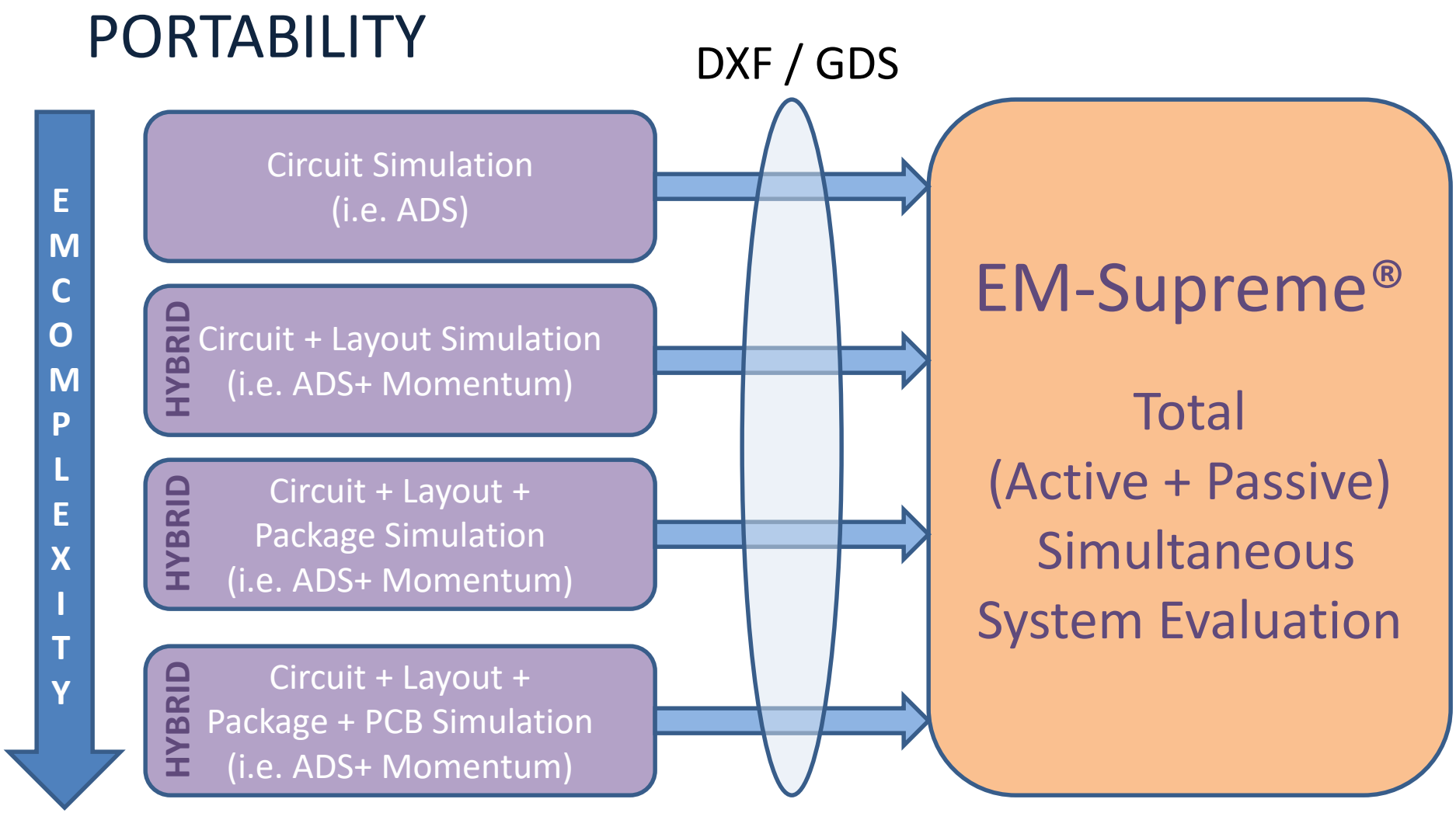
- Layout can be dissected to look at:
  - › Coupling
  - › Isolation
  - › Interference
- Transient Analysis of Sub-circuits
- Tx / Rx Path Multi-tone Analysis
- Load Pull / Source Pull
- Gain & Harmonics
- Radiation
- Software can be customized to meet specific customer requirements.



CONTENTS

- ✓ Introduction
- ✓ EM-Supreme® Overview
- ➢ Design Flow
  - PA Example
  - RF Power Transistor Application
  - Summary

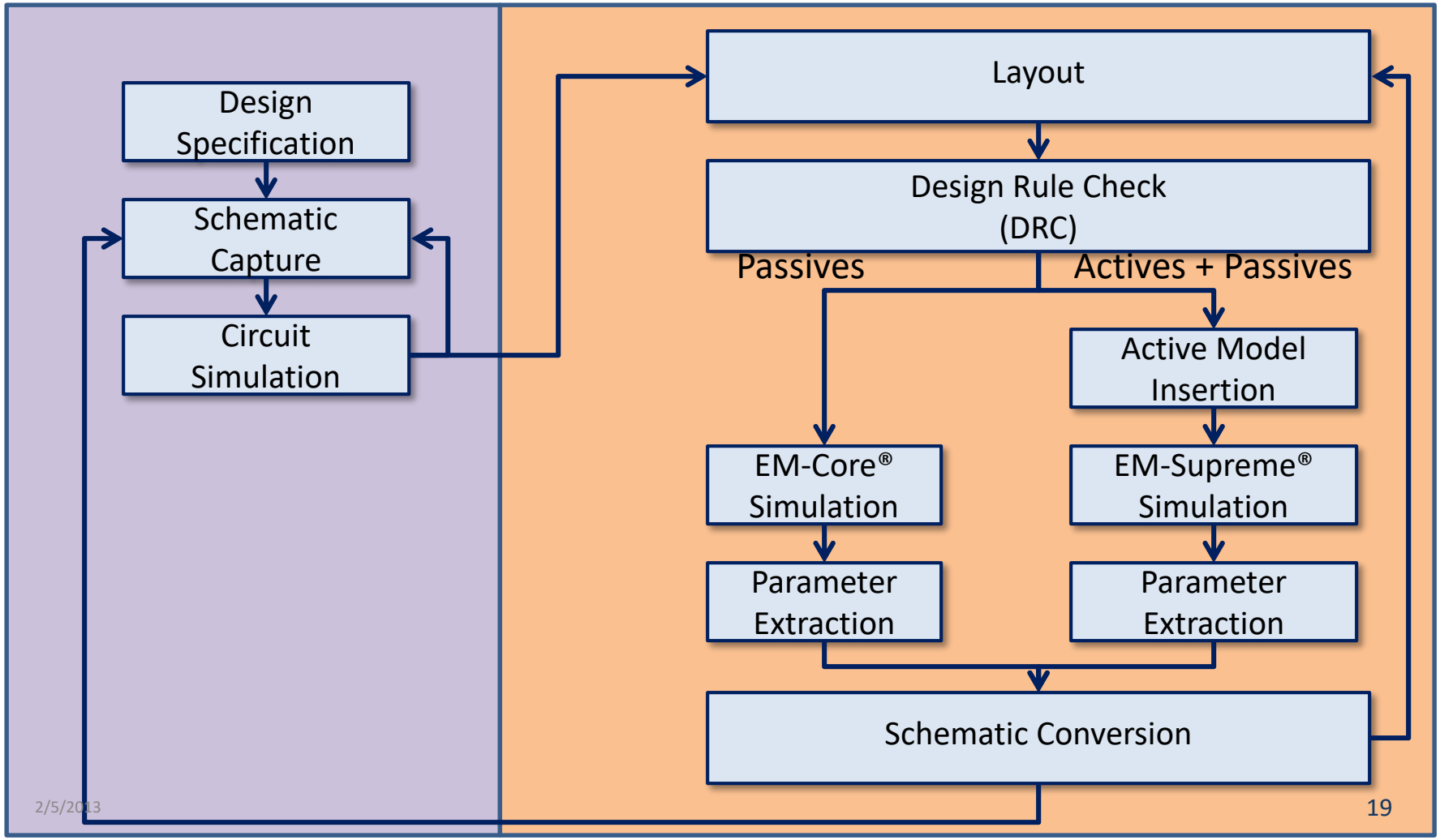
DESIGN FLOW


PORTABILITY
DXF / GDS
EMCOMPLEXITY
Circuit Simulation
(i.e. ADS)
HYBRID
Circuit + Layout Simulation
(i.e. ADS+ Momentum)
HYBRID
Circuit + Layout +
Package Simulation
(i.e. ADS+ Momentum)
HYBRID
Circuit + Layout +
Package + PCB Simulation
(i.e. ADS+ Momentum)
EM-Supreme®
Total
(Active + Passive)
Simultaneous
System Evaluation

DESIGN FLOW

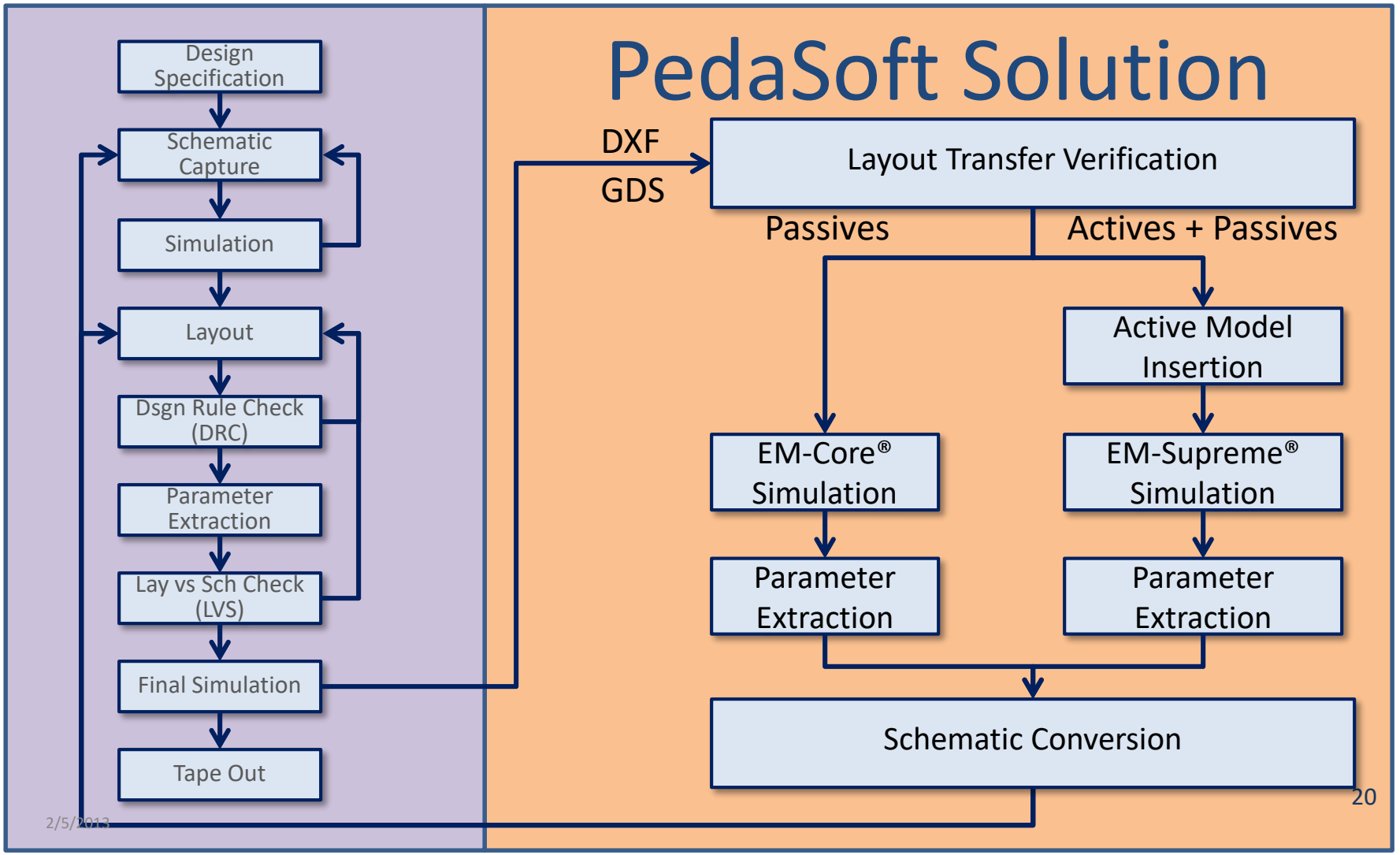
STAND ALONE MODE

PedaSoft Solution



DESIGN FLOW

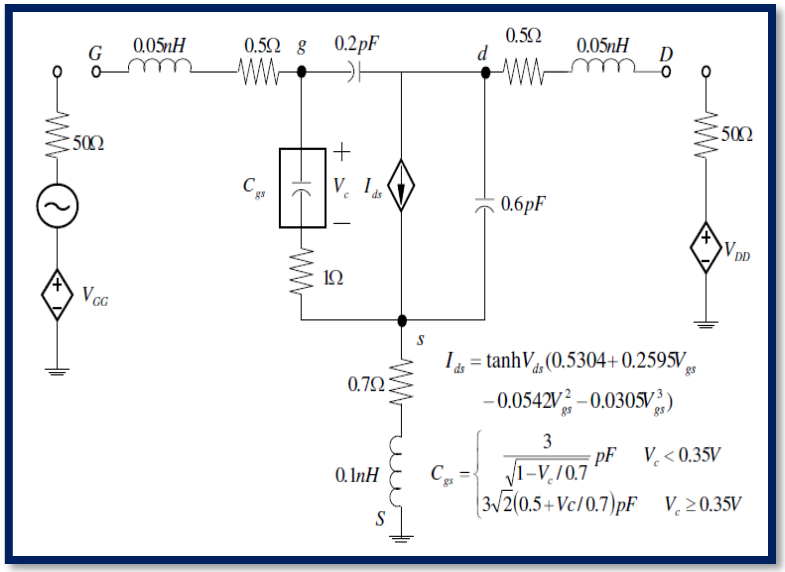
OPTIMIZATION MODE



DESIGN FLOW

ACTIVE MODELS

- EM-Supreme® can accept any model:
  - › Spice, Curtice, Angelov, Stats-Pucel, …
  - › Foundry PDK, TOM, Customer proprietary, …
  - › Measurement-based / Temperature dependent / …
- PedaSoft customized
  - › PedaSoft will take any of the above models and work with the manufacturer / foundry to optimize the model for best results in EM-Supreme®.



CONTENTS

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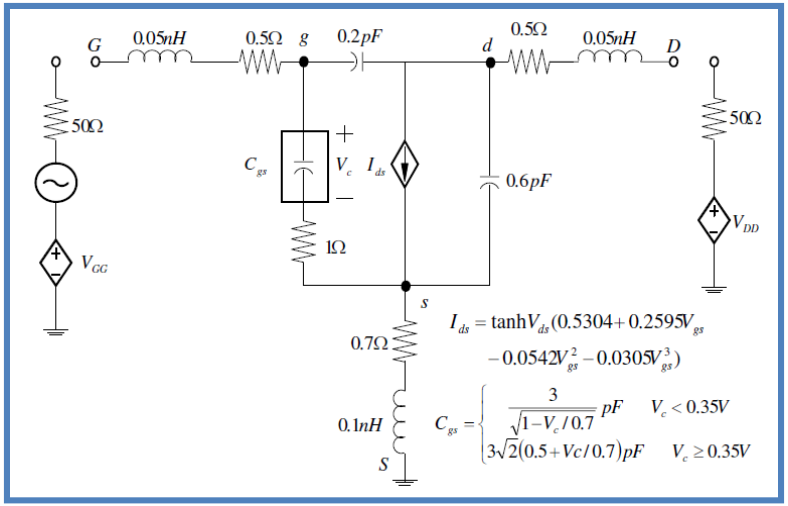
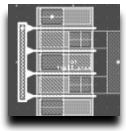
EXAMPLES

PA DESIGN

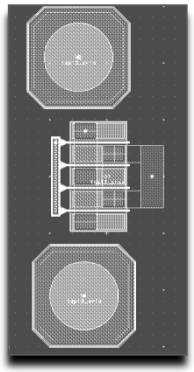
2 – 5 GHz flat gain target



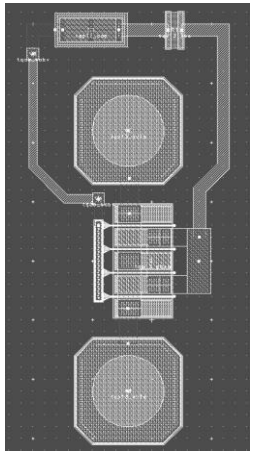
Transistor

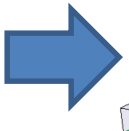


+ VIAs

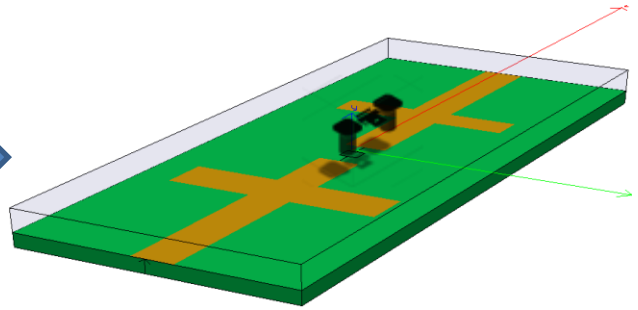


+
Feedback
Network



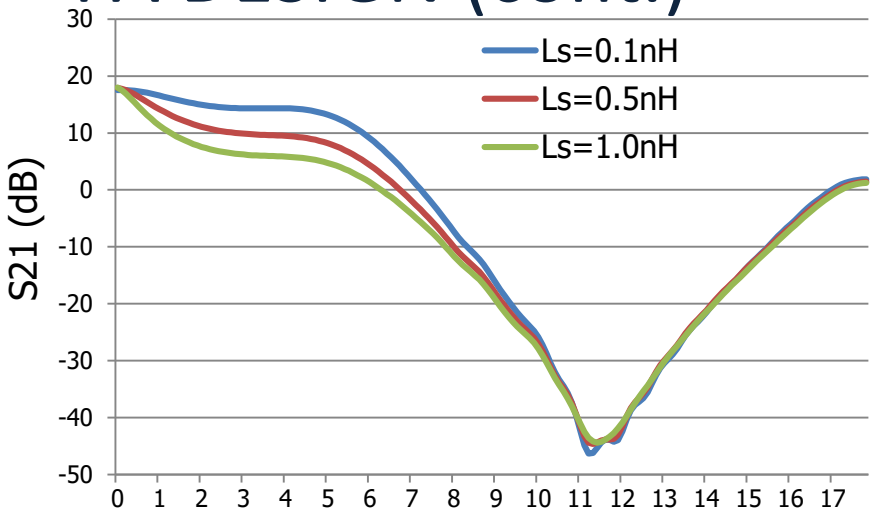


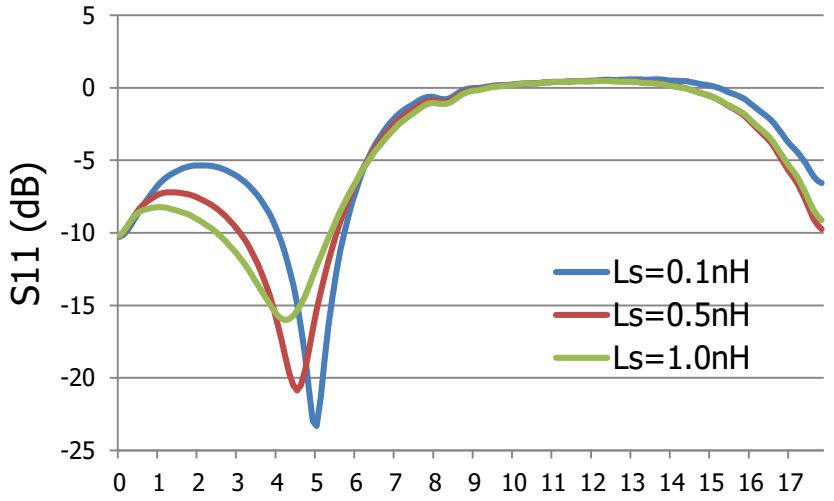
+ PCB

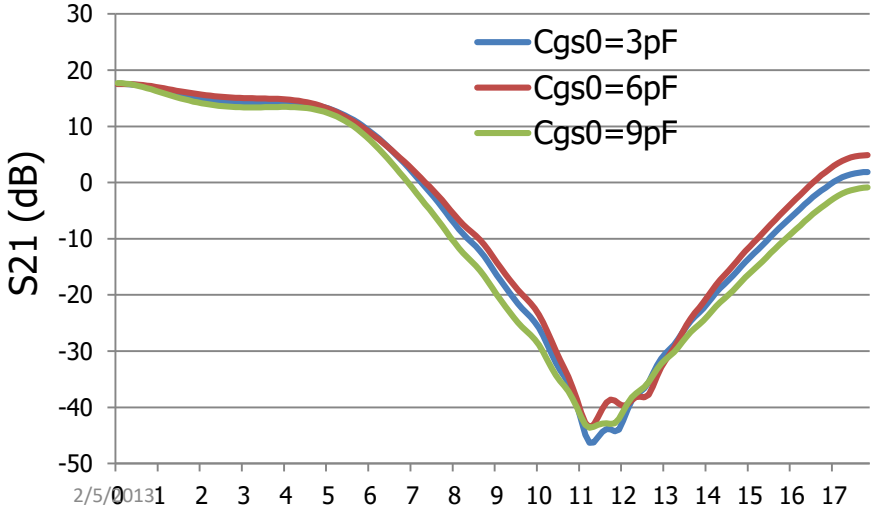


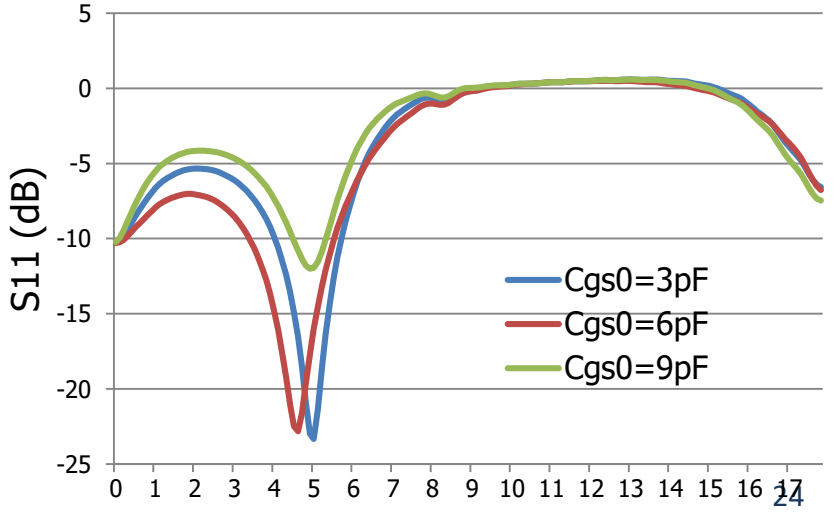
EXAMPLES

PA DESIGN (cont.)



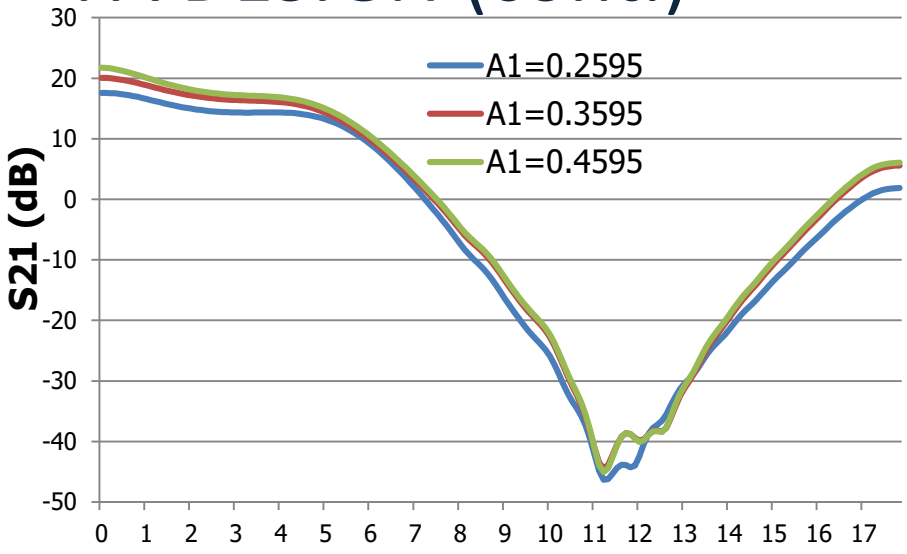


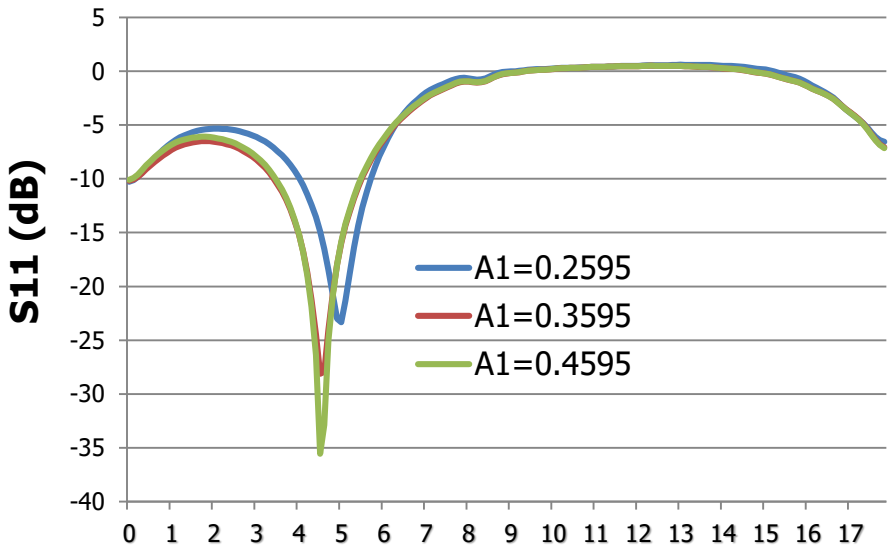




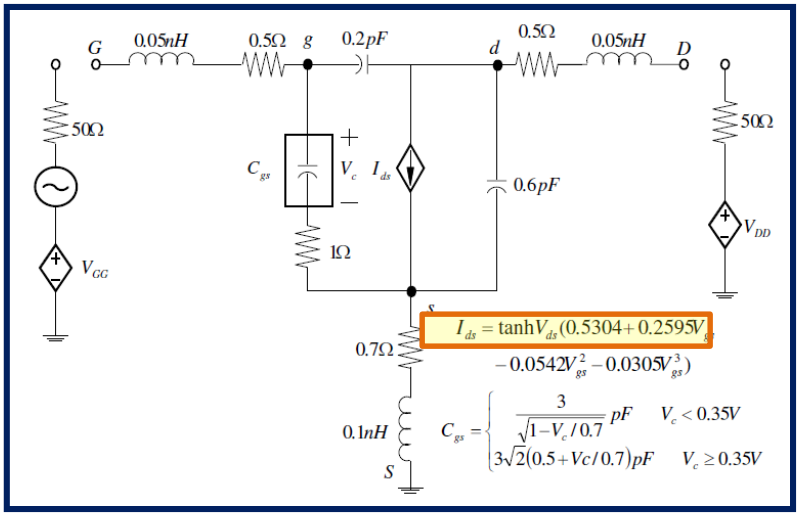
EXAMPLES

PA DESIGN (cont.)





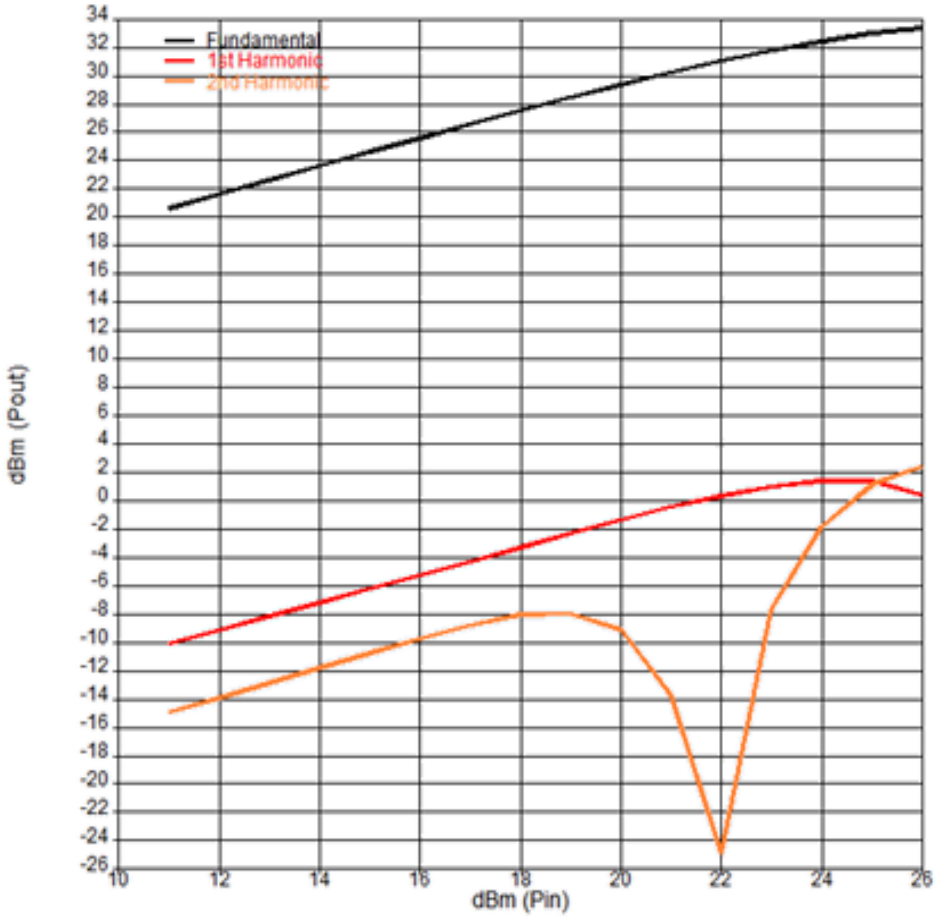
Endz	510.000
From Metal	Square5
To Metal	Square6
Source Impedance	50.000
Load Impedance	50.000
Cgs0	3.000
Cgd	0.200
cds	0.600
Ls	0.100
Lg	0.050
Ld	0.050
A0	0.5304
A1	0.2595
A2	-0.0542

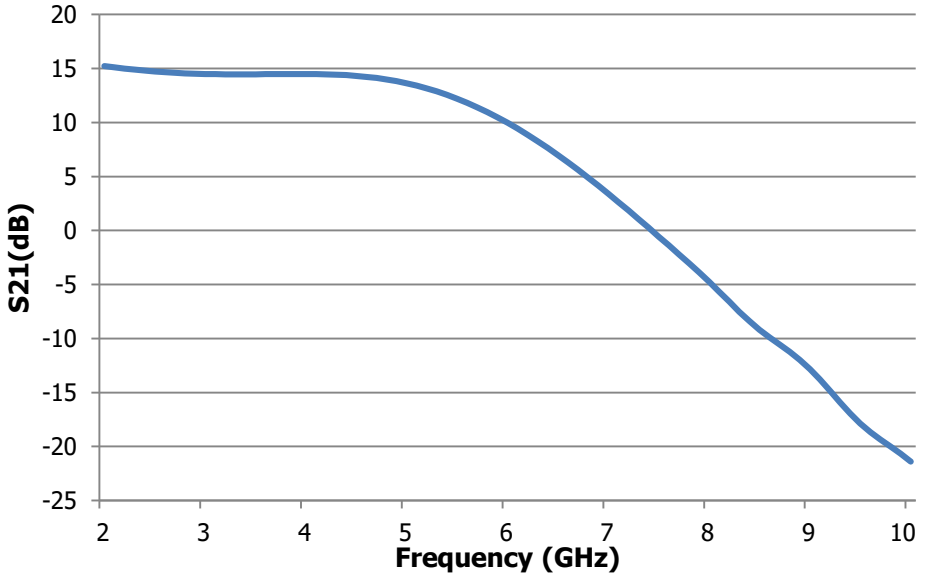


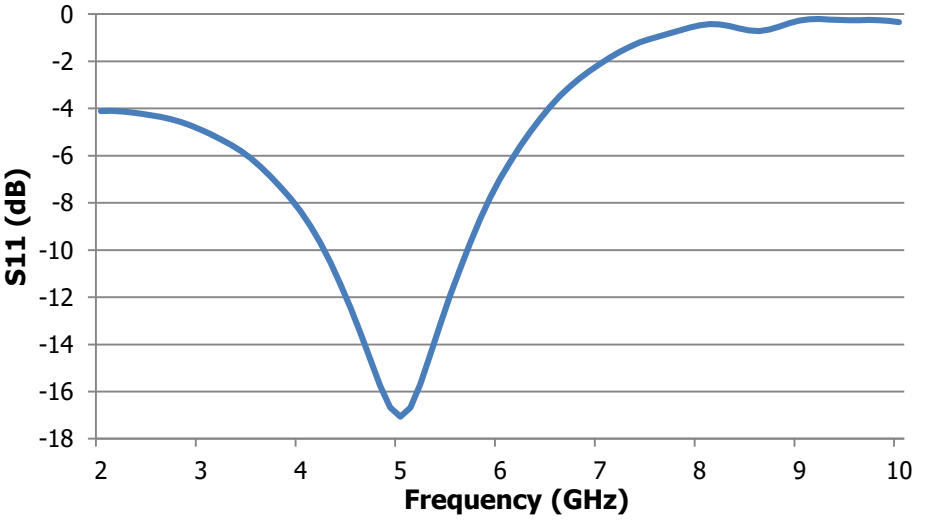
A3	-0.0305
Alpha	1.000
Ri	1.000
Rs	0.700
Rg	0.500
Rd	0.500
VGG	-0.810
VDD	18.960
Signal Simulations	Large
Temperature	300.000
Power Sweep (dbm)	10.000
Power Sweep Min (dbm)	0.000
Power Sweep Max (dbm)	30.000
Input Frequency (GHz)	6.000

EXAMPLES

PA DESIGN (cont.)



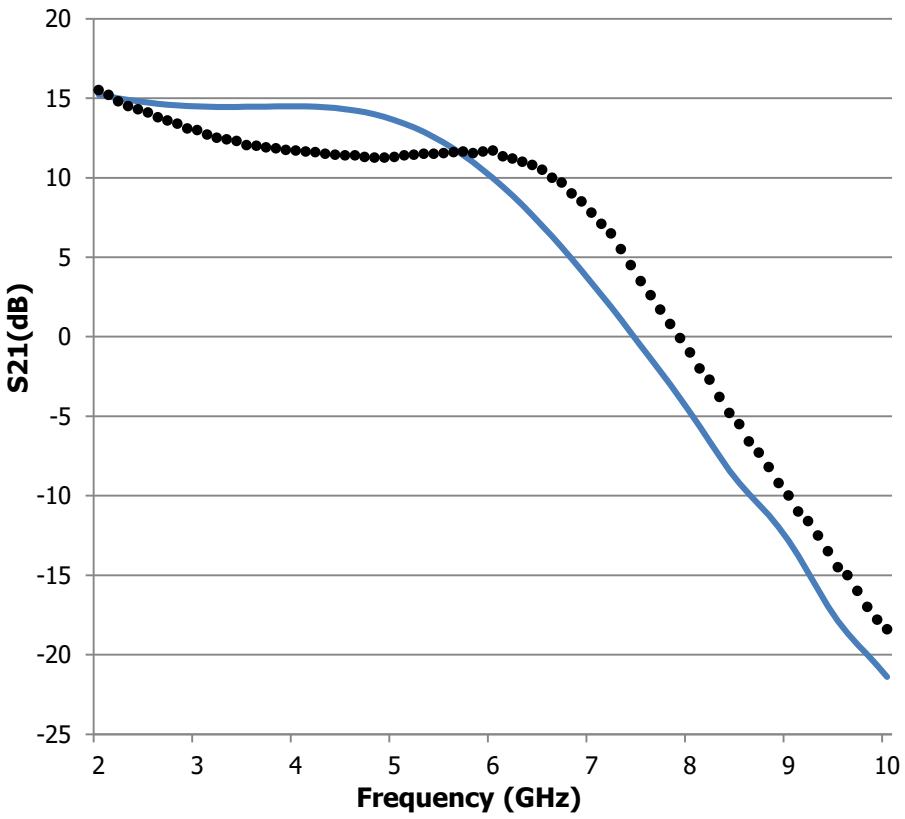


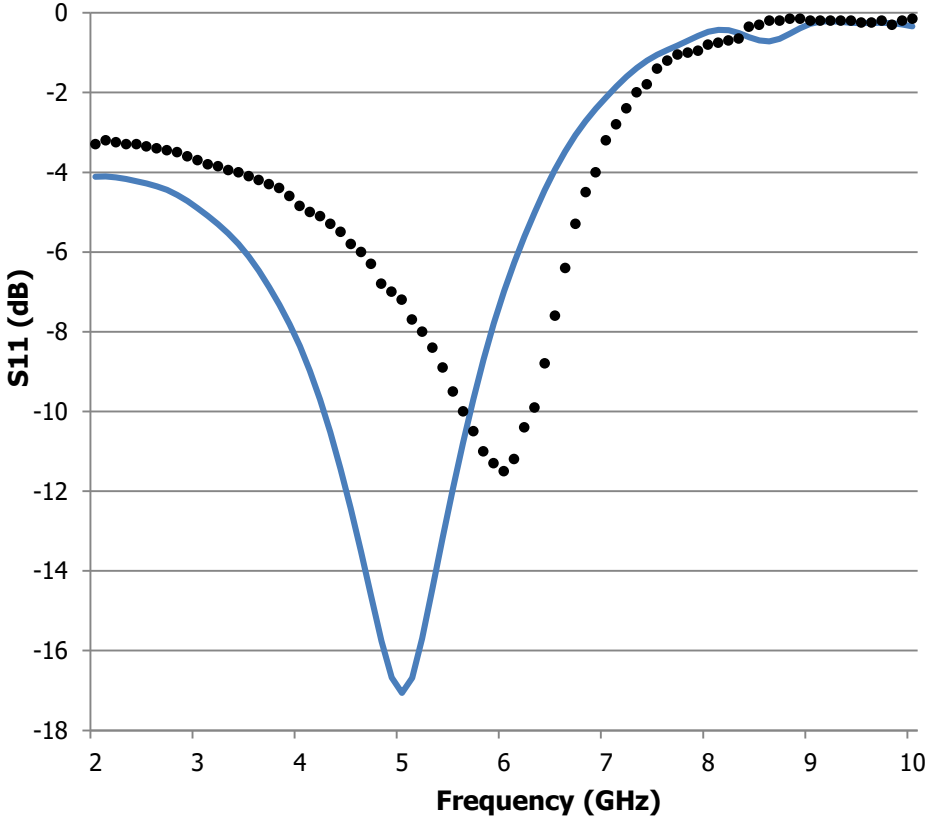


EXAMPLES

PA DESIGN (cont.)

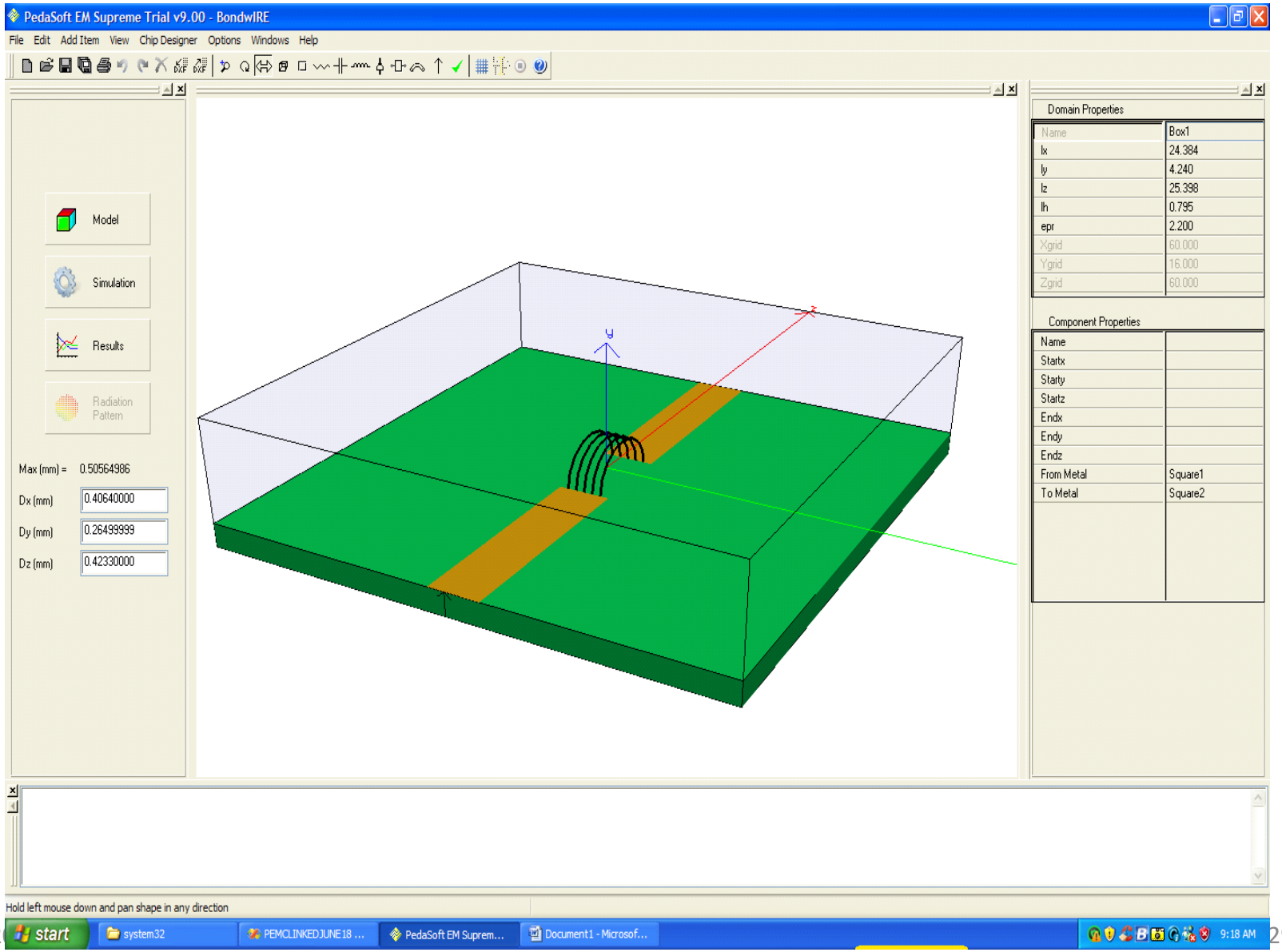
- Comparison of same circuit using co-simulation



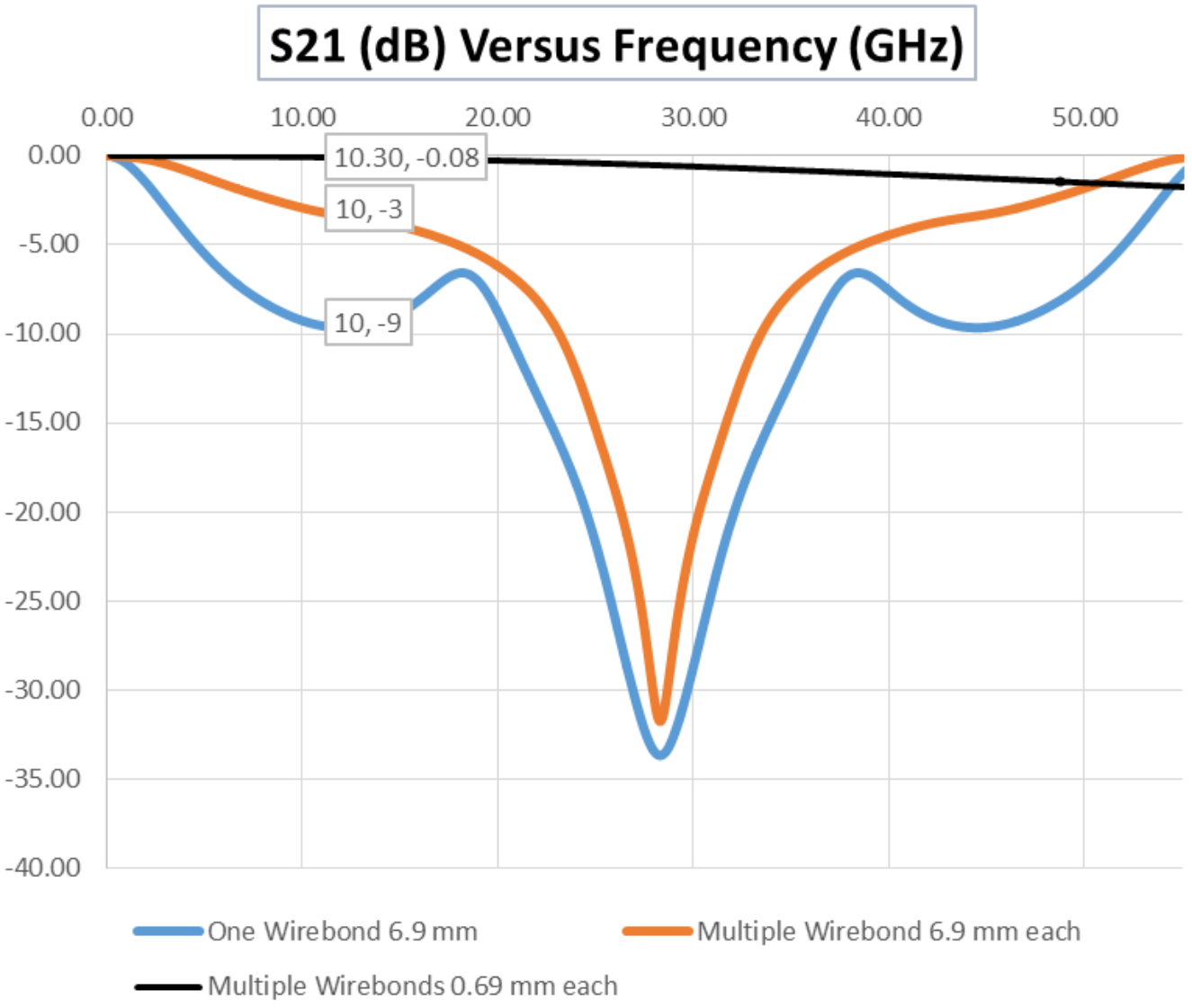


CONTENTS

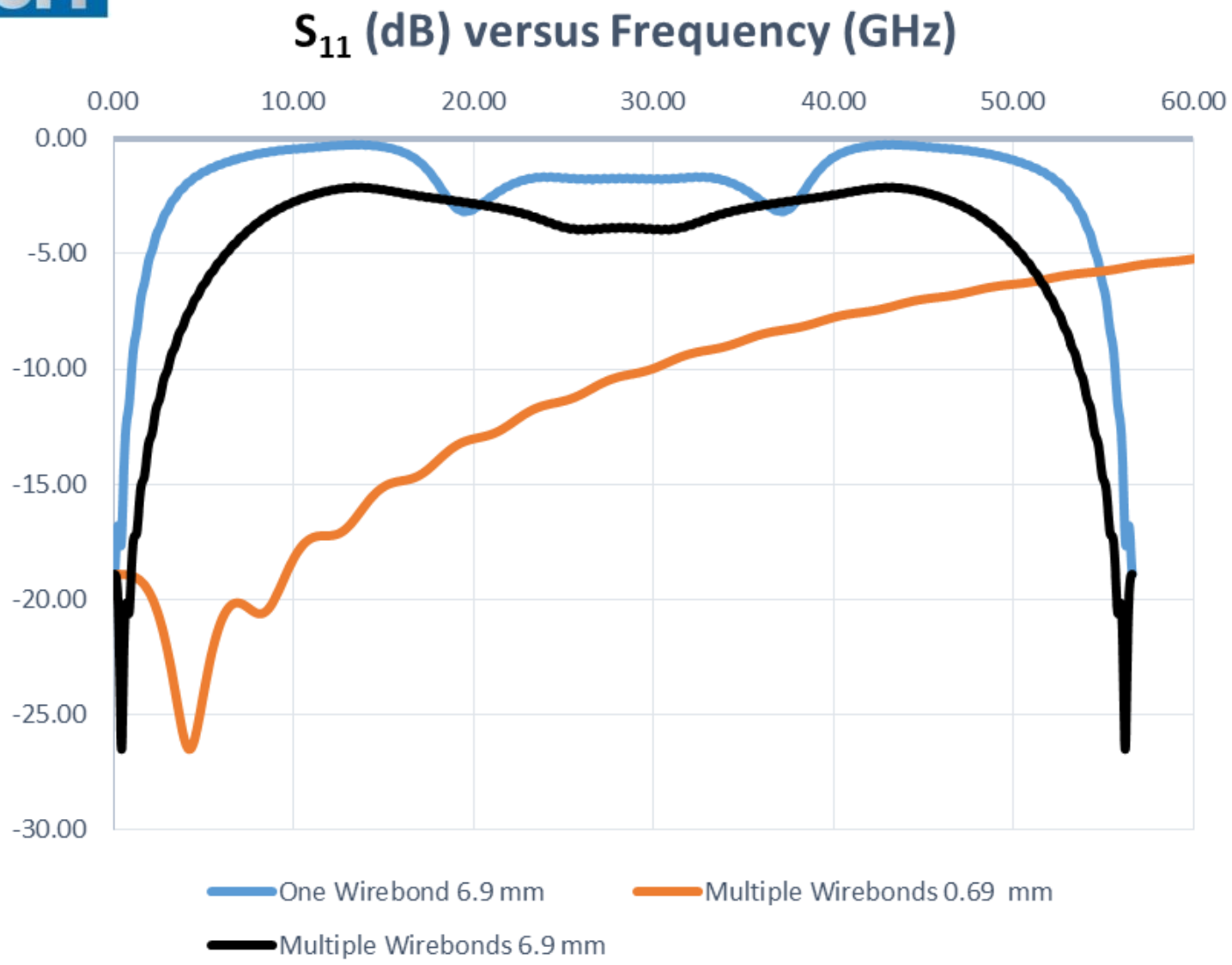
NUMBER OF W/B's & LENGTH



S21 XMISSION LINE ANALYSIS



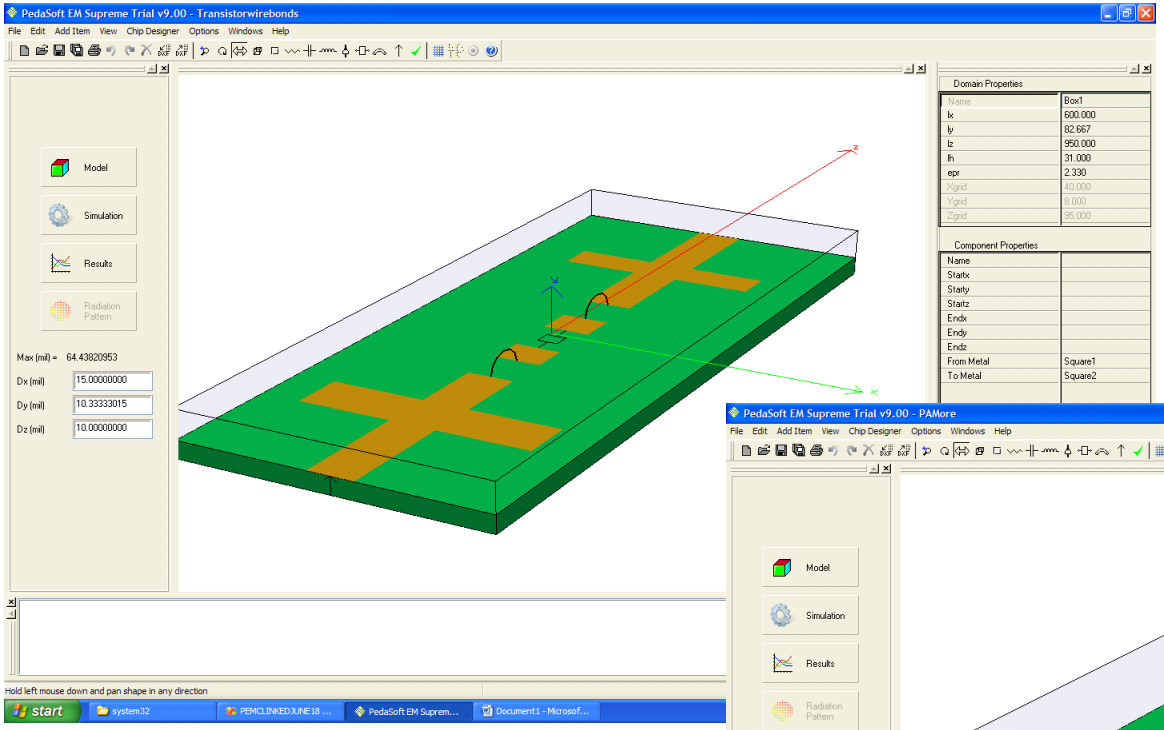
S11 XMISSION LINE ANALYSIS

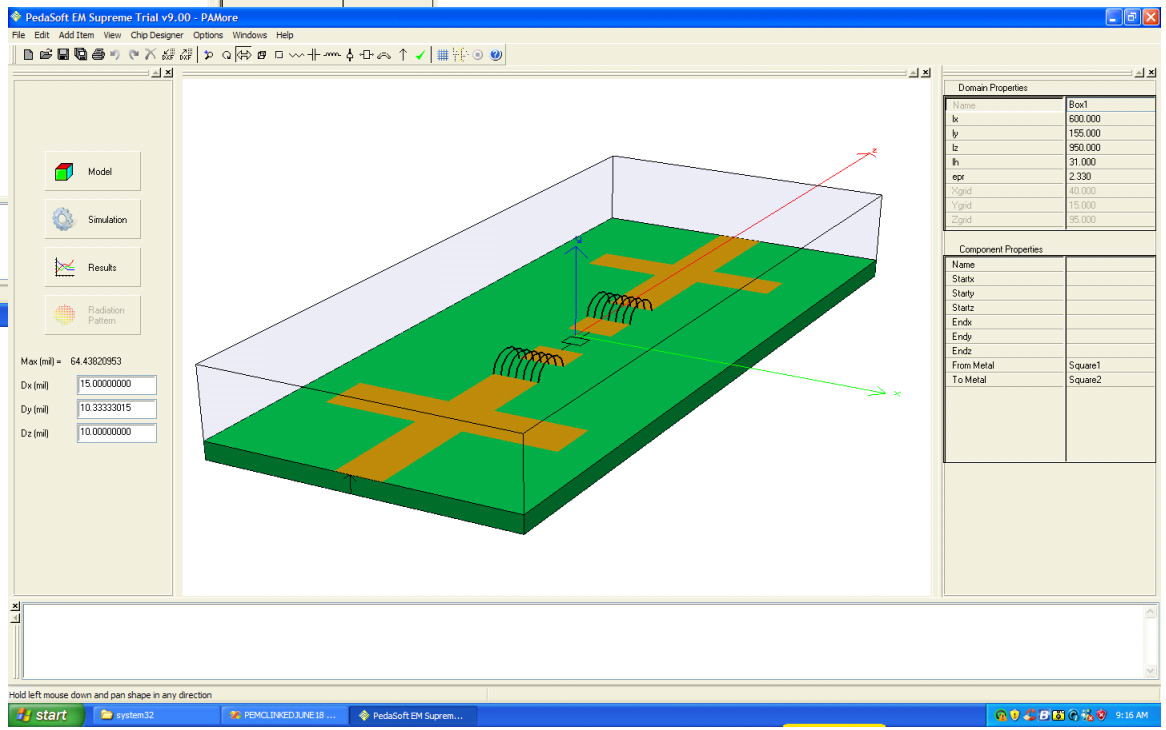


W/B CONCLUSIONS

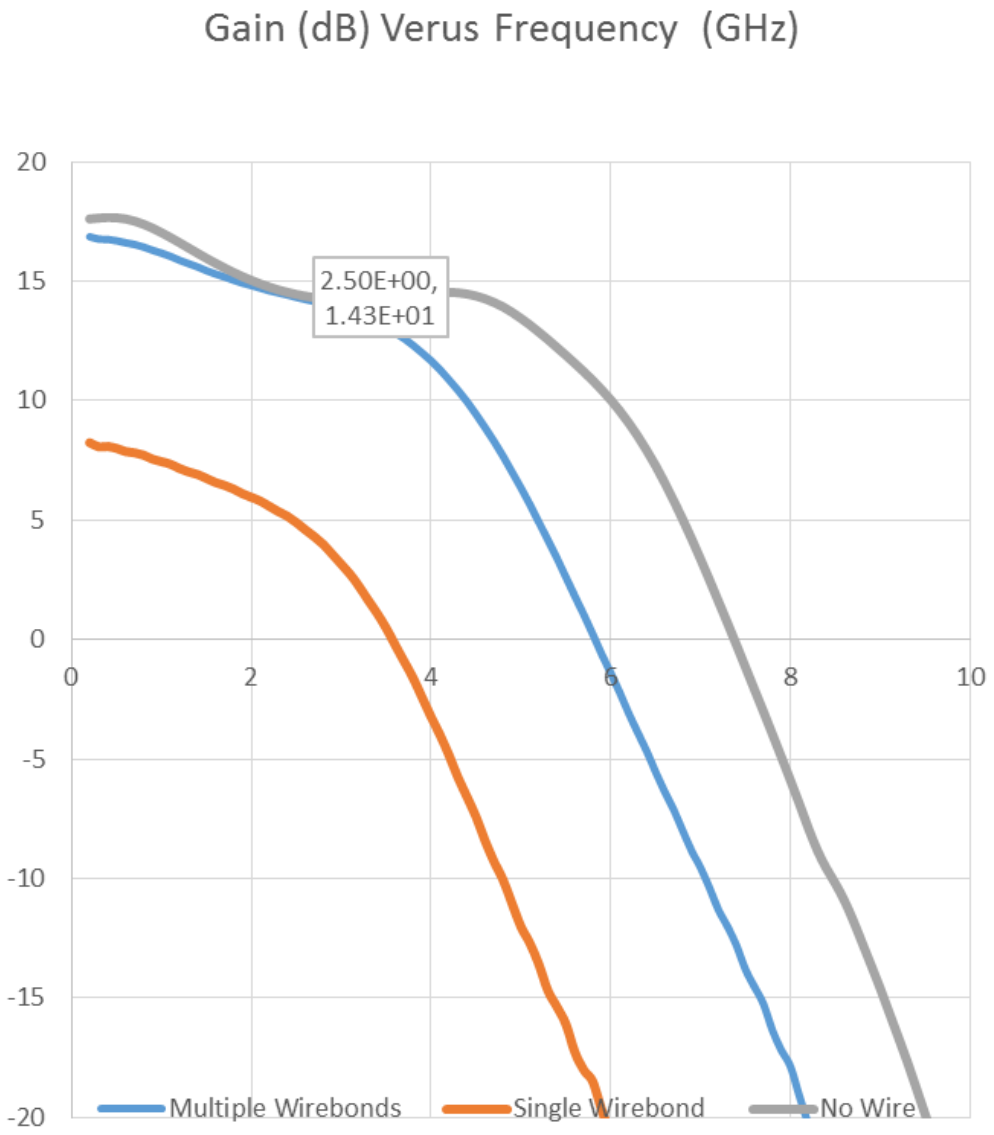
- Smaller wire lengths are better since they provide lower inductances and therefore their effect is dominating only at higher frequencies.
- Multiple wires are better since they provide lower inductances and impedances and therefore will have better Insertion Loss for L-Band (1-2 GHz), S-Band (2-4 GHz) , and up to C-Band (4-8 GHz).
- The structure is resonating somewhere in the 30 GHz band for 6.9 mm wires so it should not be used for either K and Ka Band (18-40 GHz)
- Multiples wires should be used in the mid X-band (~10 GHz) over single wires
- 0.69 mm wires should be used for V-Band (75-110 GHz)

NUMBER OF W/B's ANALYSIS

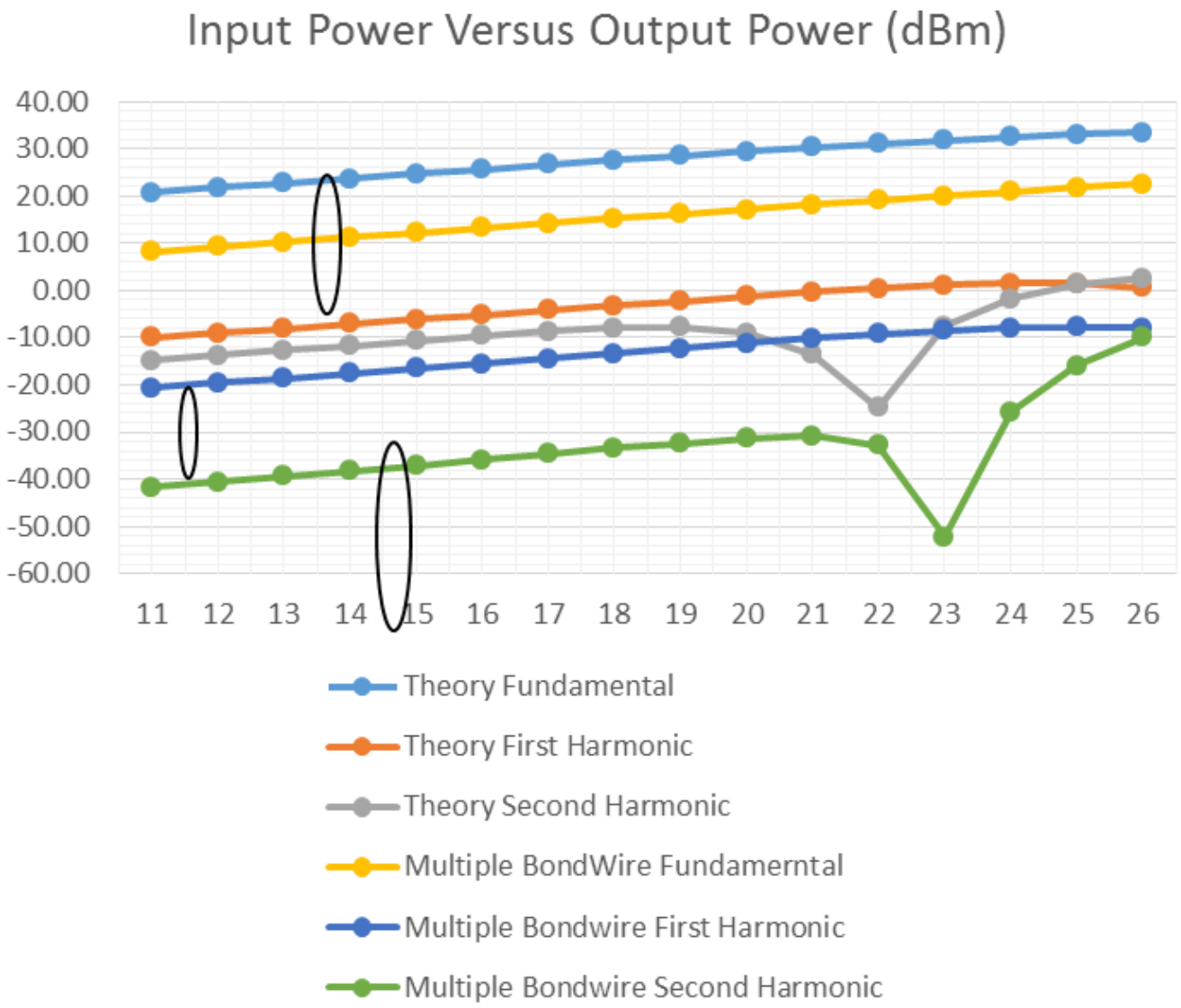




S21 ANALYSIS



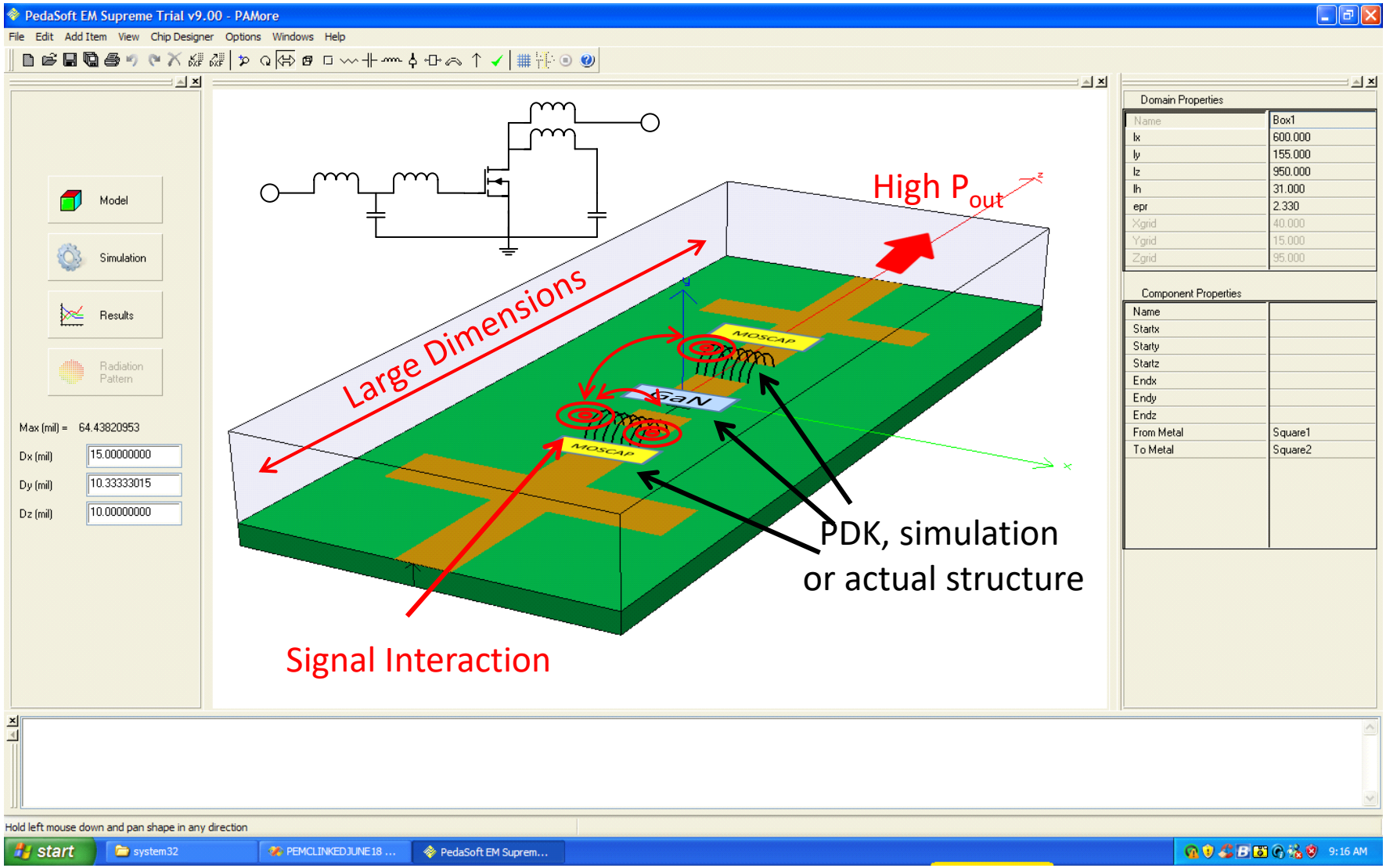
W/B f_n EFFECTS



W/B CONCLUSIONS

- Adding a single wire on both sides of the transistor drops the gain by 10 dB.
- Adding multiple wires of the same length optimizes the gain for L- and S-bands “i.e. up to 4 GHz.”
- For frequency > 4 GHz, the gain reduces dramatically which emphasizes the need to optimize the structure by reducing wire lengths and possibly employing different wire shapes.
- Gain as well harmonics can all be optimized by PedaSoft’s EM-supreme using several variations including wire shape, number, and length as well as transistor technology and passive manifolds around the PA.

RF POWER TRANSISTOR



RF POWER TRANSISTOR

POTENTIAL PROJECTS

- Hardware Company1 – wants a MOSCAP model for customers
- Hardware Company 2 – wants an effective simulation solution
- PedaSoft – wants to extend its model and develop a more comprehensive capability to accurately address this market.

CONTENTS

- ✓ Introduction
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- ✓ PA Example
- ✓ RF Power Transistor Application
- ➢ Summary

SUMMARY

There are endless possibilities of EM coupling and radiation that need to be modelled for transistors embedded. Therefore a complete and full EM solution should be employed. Examples of EM coupling include but not limited to:

- Coupling between bond-wires on the PA input-side as well as between wires at input and output sides of the same PA and different PA's
- Coupling between the Gate and Drain as well as Gate/Drain bond wires blocks
- Coupling between Gate, Drain, Source as well as bond-wires

EM-Supreme imports the models of MOSCAP as well as the PA and then the passive manifolds are created or imported as DXF. The whole structure is simulated including the PA and passives in one run using full wave model. The PA and MOSCAP models can be based on any of the following:

- Measurements (behavior)
- Foundry
- Model can be functions of dimensions A,B,C, etc as well as temperature and power dependent
- New models developed

For EM-Supreme Download or Support or to enquire about steps required to engage with our *RF design services*, feel free to call or email us at:

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THANK YOU!