Asian IBIS Summit

Modeling and Simulation for Multi-Gigabit Interconnect System

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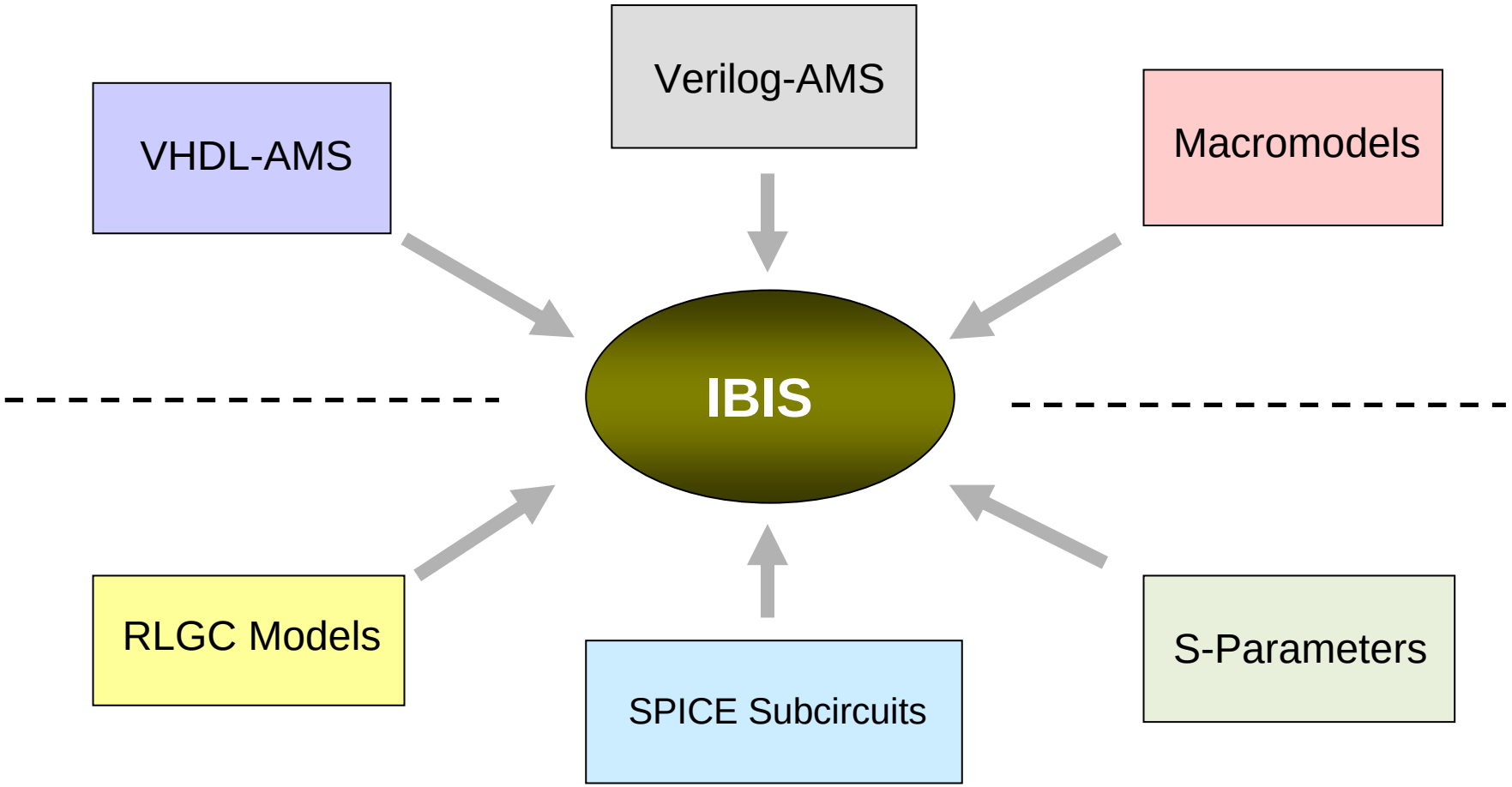
Agenda

- Modeling Methodologies
- Behavioral-level Interconnect Modeling
- Lab Correlation for Macromodels and S-parameters
- Eye diagram analysis and design margin budget
- Conclusions

Modeling Methodologies

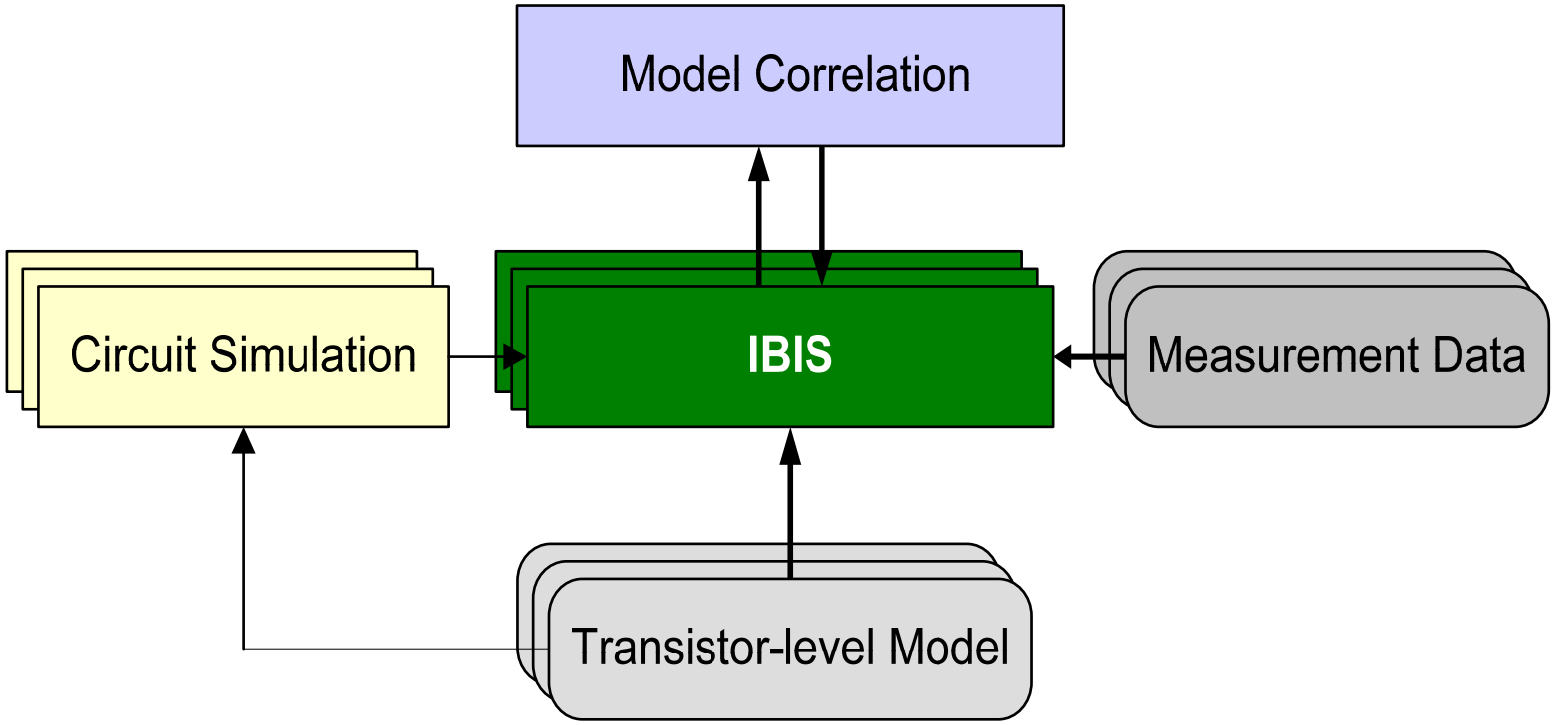
- There are behavioral IBIS and structural Spice modeling for active devices. Spice model is appropriate for demanding situations, while IBIS model is often used in system and board level simulation.
- Choose an appropriate modeling method is critical for simulation. Otherwise simulation may not be accurate enough or too complex and time consuming.
- For multi-gigabit interconnect system design, behavioral-level model enables much faster simulation time than transistor-Level spice model.
- Modeling covers active devices as well as passive devices, such as package, transmission line, connector, via, and plane etc..
- Modeling methods have tradeoffs and are suitable for different applications. Multi-Gigabit Interconnect System design requires that the interconnect modeling must be valid over a wide bandwidth.
- For behavior-level modeling,correlation is necessary.

IBIS Multi-lingual Modeling

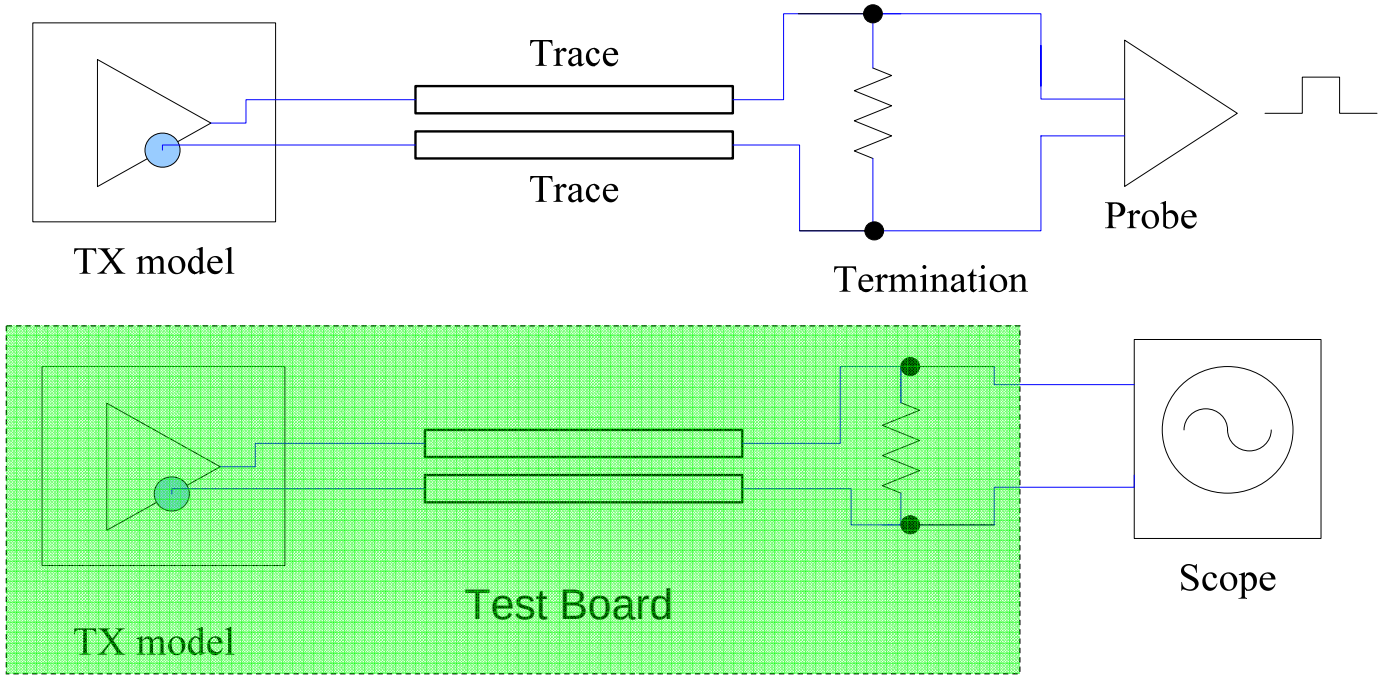


Passive interconnects modeling

Modeling and its Correlation Flow



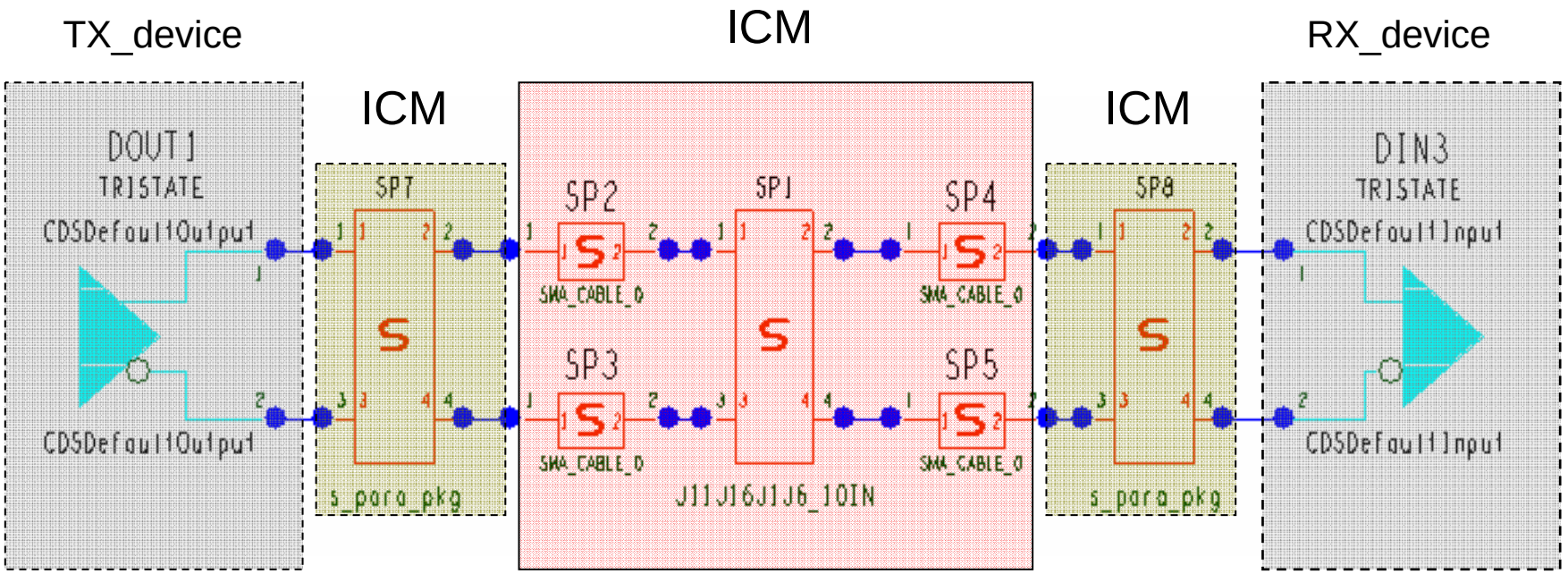
Model Validation Setup



Correlations with lab measurements and HSPICE simulations

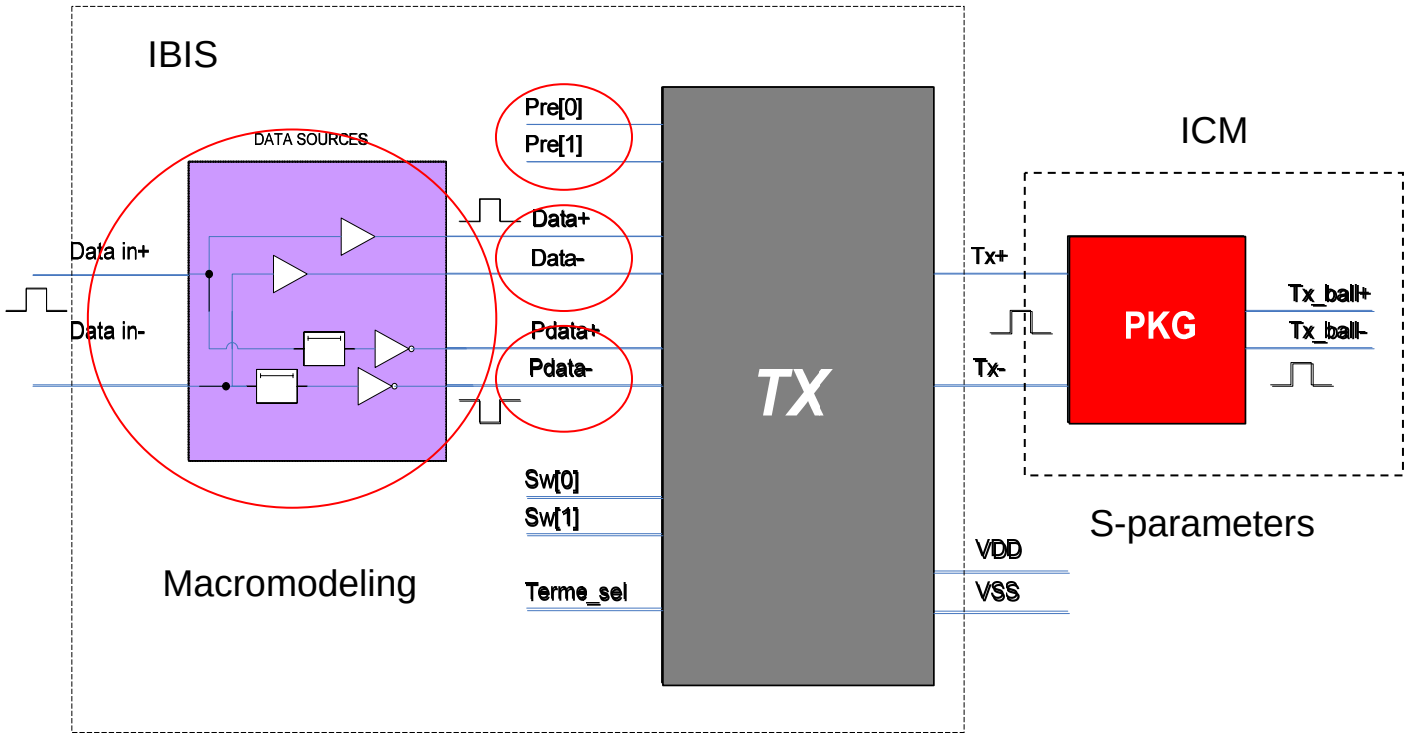
Behavioral-level Interconnect Modeling

- Transceiver Buffer Modeling
- Transceiver Package Modeling
- Interconnect (Traces, Vias, Connectors) Modeling
- Lab Correlation



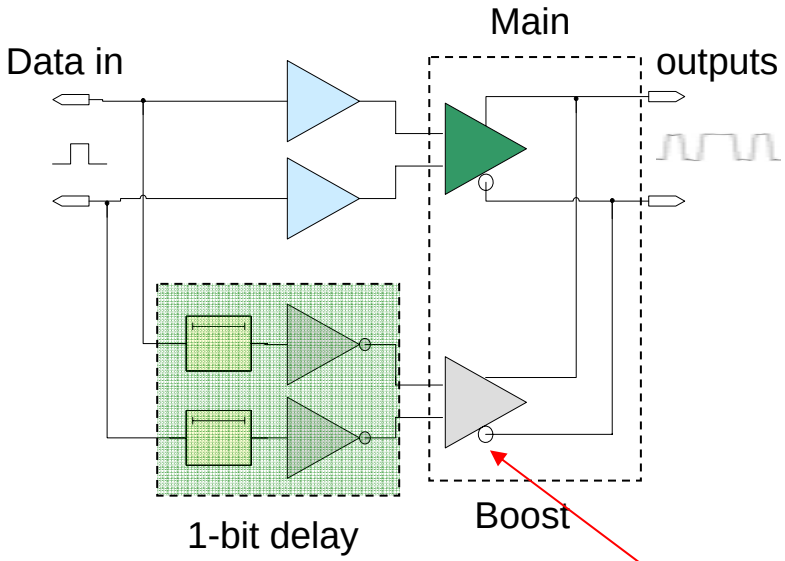
Multi-Gigabit Interconnect System

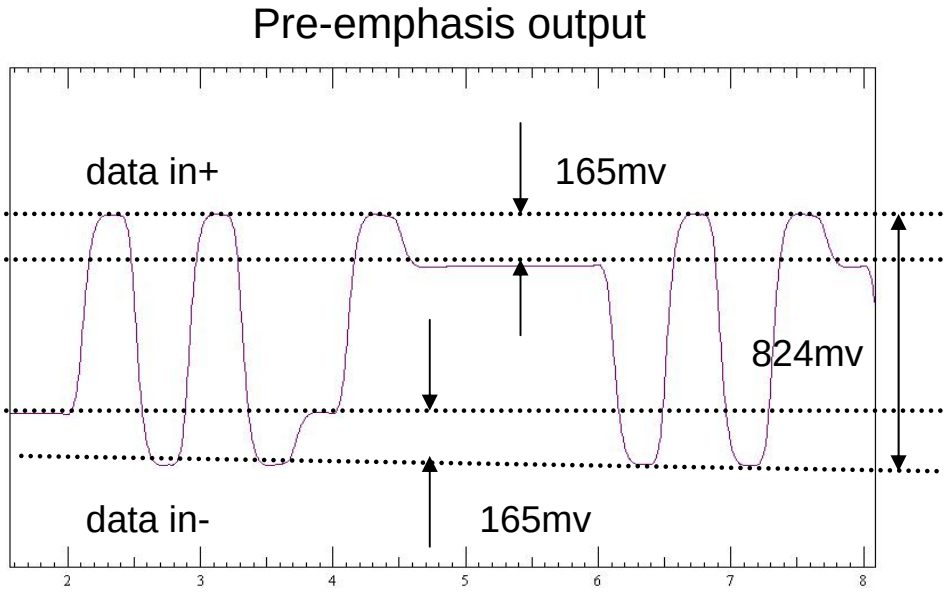
Behavioral-level Modeling of SERDES



The structure of transmitter device

Pre-emphasis





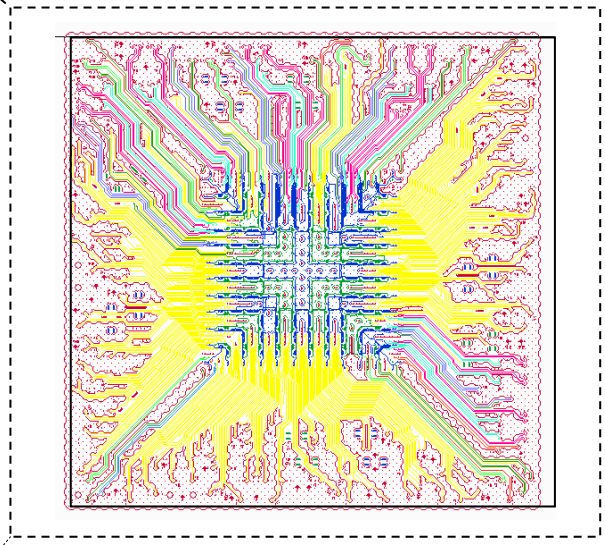
pre-emphasis inputs

UI=400ps Scale=824mv Eqdb=165mv

Package Modeling using S-parameters

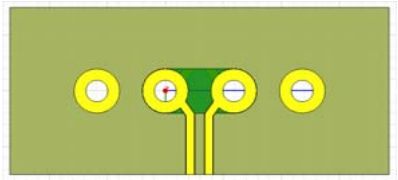
```
("../../../Pkg_models/s_para_pkg.dml"
 (PackagedDevice
  (s_para_pkg
   (ESpice ".subckt s_para_pkg 1 2 3 4
Xs_para_pkg_4Port 1 3 2 4

.subckt s_para_pkg_4Port_Data 1 2 3 4
S1 1 2 3 4 algorithm=default
DATAPOINTS SPARAM
R=50.000000
DATAUNIT=HZ
FREQUENCY=0.000000e+000
.
. END SPARAM
.ends s_para_pkg_4Port_Data
.ends s_para_pkg_4Port" )
   (PinConnections
.
       (NumberOfPorts 4 )
   (SubType SPARAM ) ) )
 (LibraryVersion 136.2 ) )
```

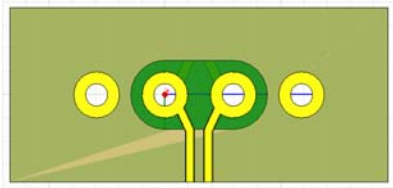


S-parameters can be added to Cadence DML file.

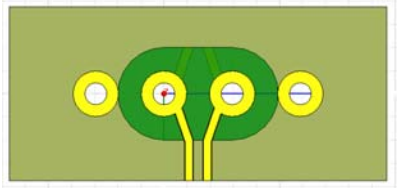
Vias Modeling and Optimization



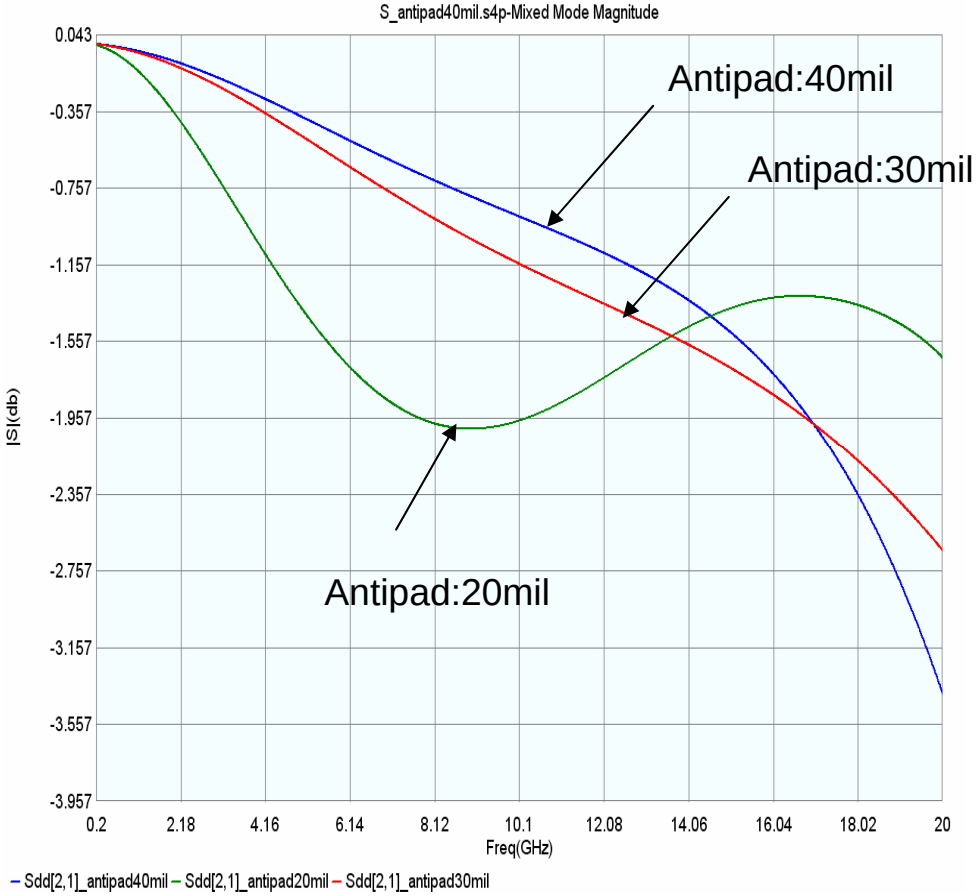
Antipad:20mil



Antipad:30mil

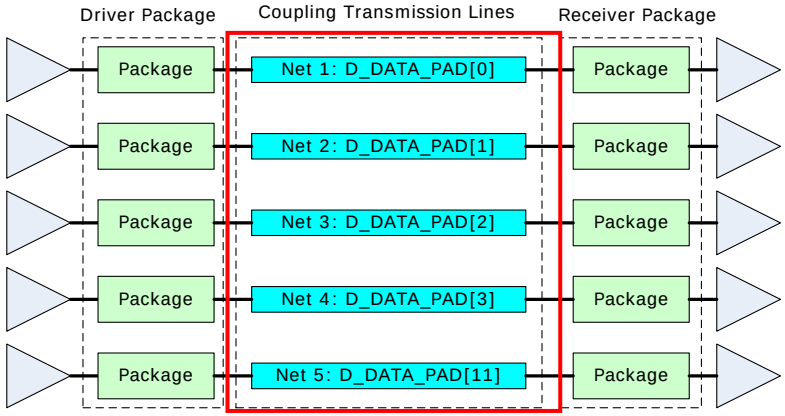


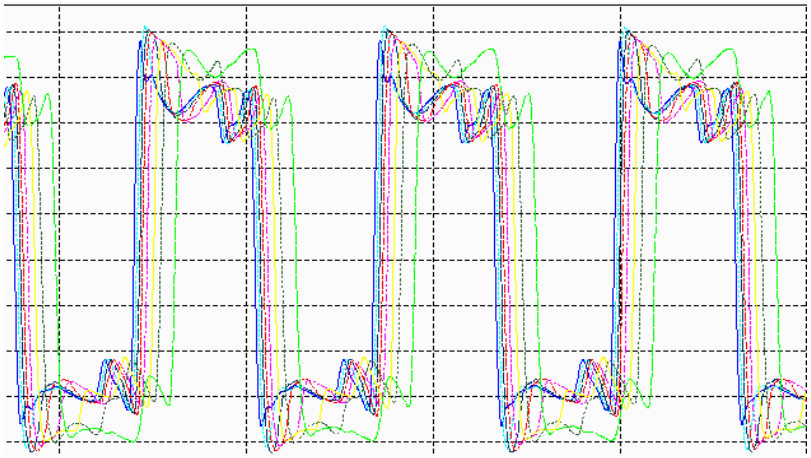
Antipad:40mil



Traces Modeling and Optimization

- Extracting S-parameters using 2D/3D EM field solver





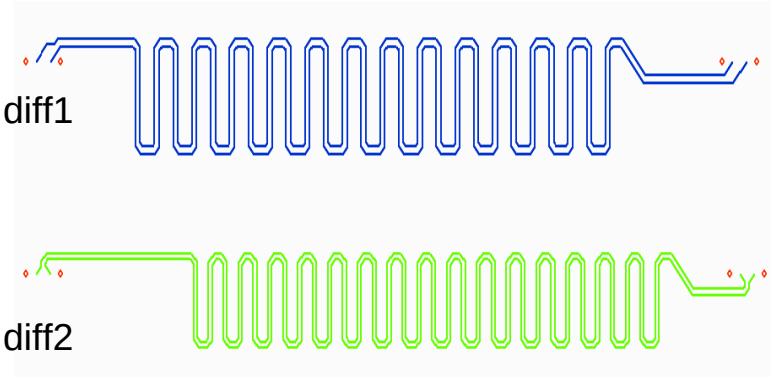
.alter change transmission line length = 38.1mm
.param len=38.1mm
.alter change transmission line length = 50.8mm
.param len=50.8mm
.alter change transmission line length = 62.5mm
.param len=62.5mm
.alter change transmission line length = 76.2mm
.param len=76.2mm
.alter change transmission line length = 88.9mm
.param len=88.9mm
.alter change transmission line length = 101.6mm
.param len=101.6mm
.alter change transmission line length = 127mm
.param len=127mm

.param lo=0v
.param hi=1.32v
.param dl=1ns
.param tr=30ps
.param ui=25.72ns

VA a 0 pulse 0 hi dl tr tr 'ui/2-tr' ui

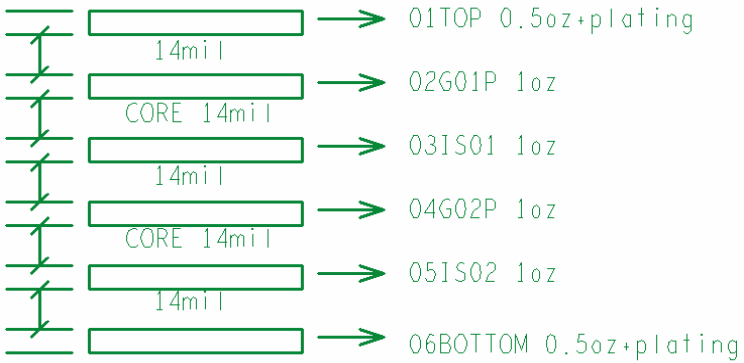
Time domain simulation and optimization using S-parameters.

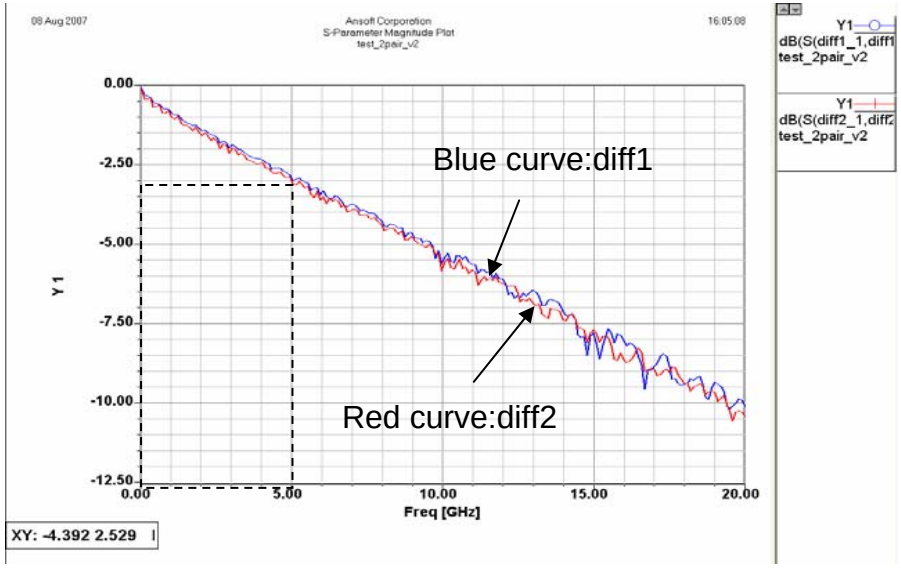
Traces Modeling and Optimization



Trace width ： 10mil

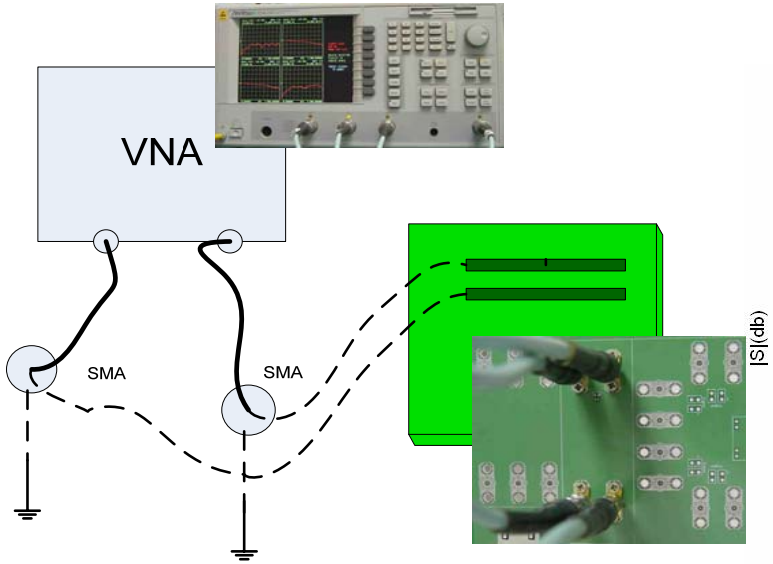
Trace width ： 8mil

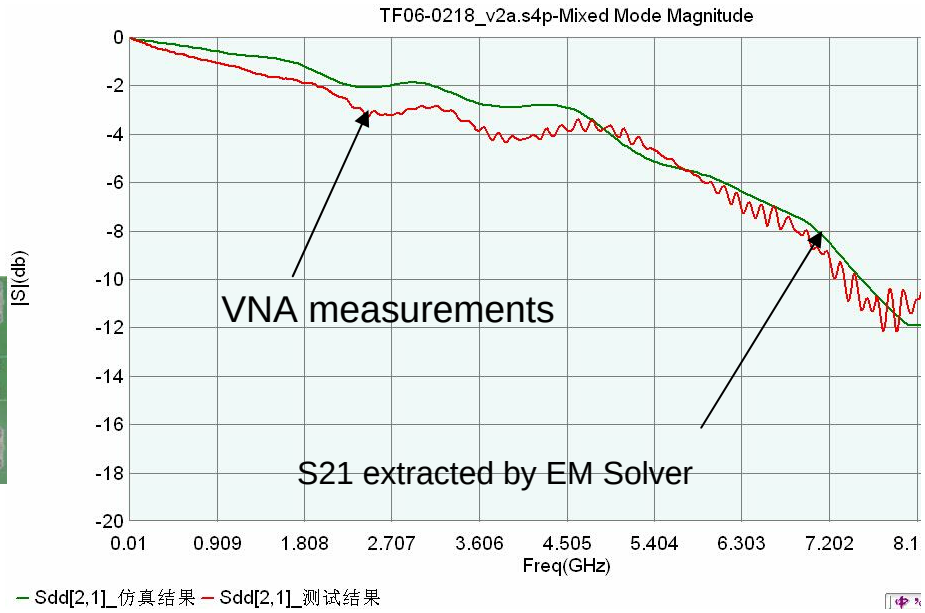




Lab Correlation for S-parameters

- Correlation based on VNA measurements

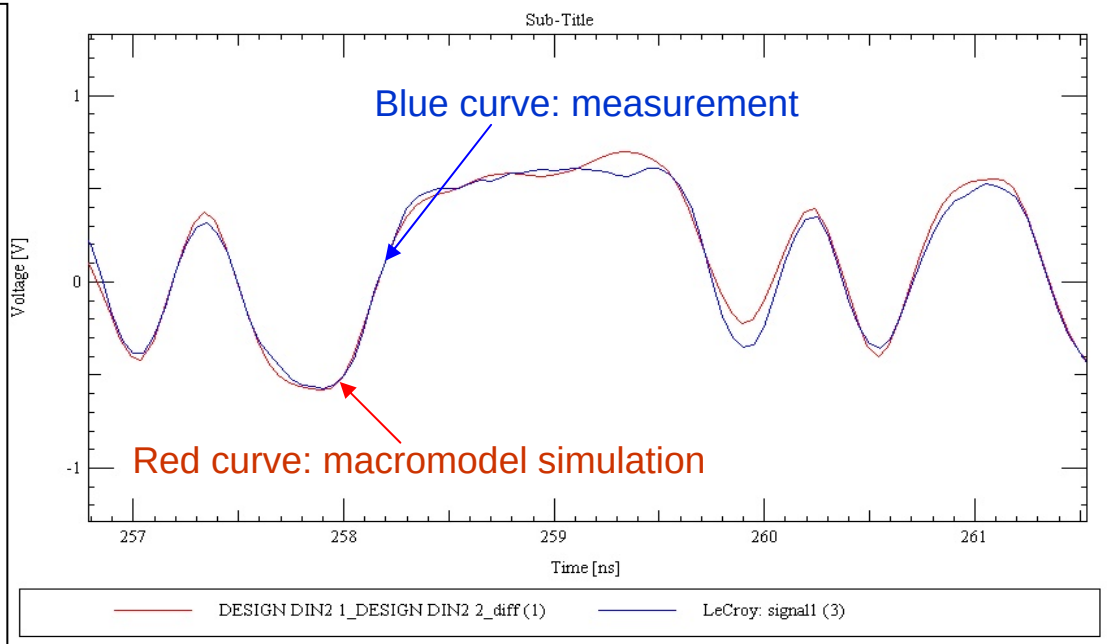




Lab Correlation for Macromodels

```
*  This is the top-level subcircuit for this
MacroModel.
*  It MUST have the same name as the
IOCell, or it will not work.
.subckt Tx nvdd outp ngnd in en  pcl  gcl
outn  BUFF=BUFF ibis_file=ibis_models.inc
+ bitp=400p
+ inv0=0
+ inv1=1
+ scale=1
+ eqdb=-0.5
+ cf0=1
+ rt=50

*  Some parameters are derived for use in
the MacroModel.
.param adj='eqdb*0.58'
.param eqf='1.0 - (10.0 ^ (adj/20.0))'
.param cf1='cf0 * eqf'
```



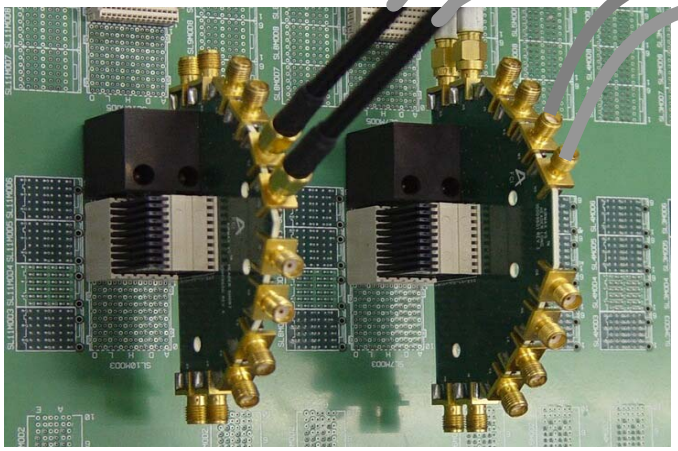
10% Pre-emphasis

For behavior-level modeling, correlation is necessary.

Lab Correlation Steps:

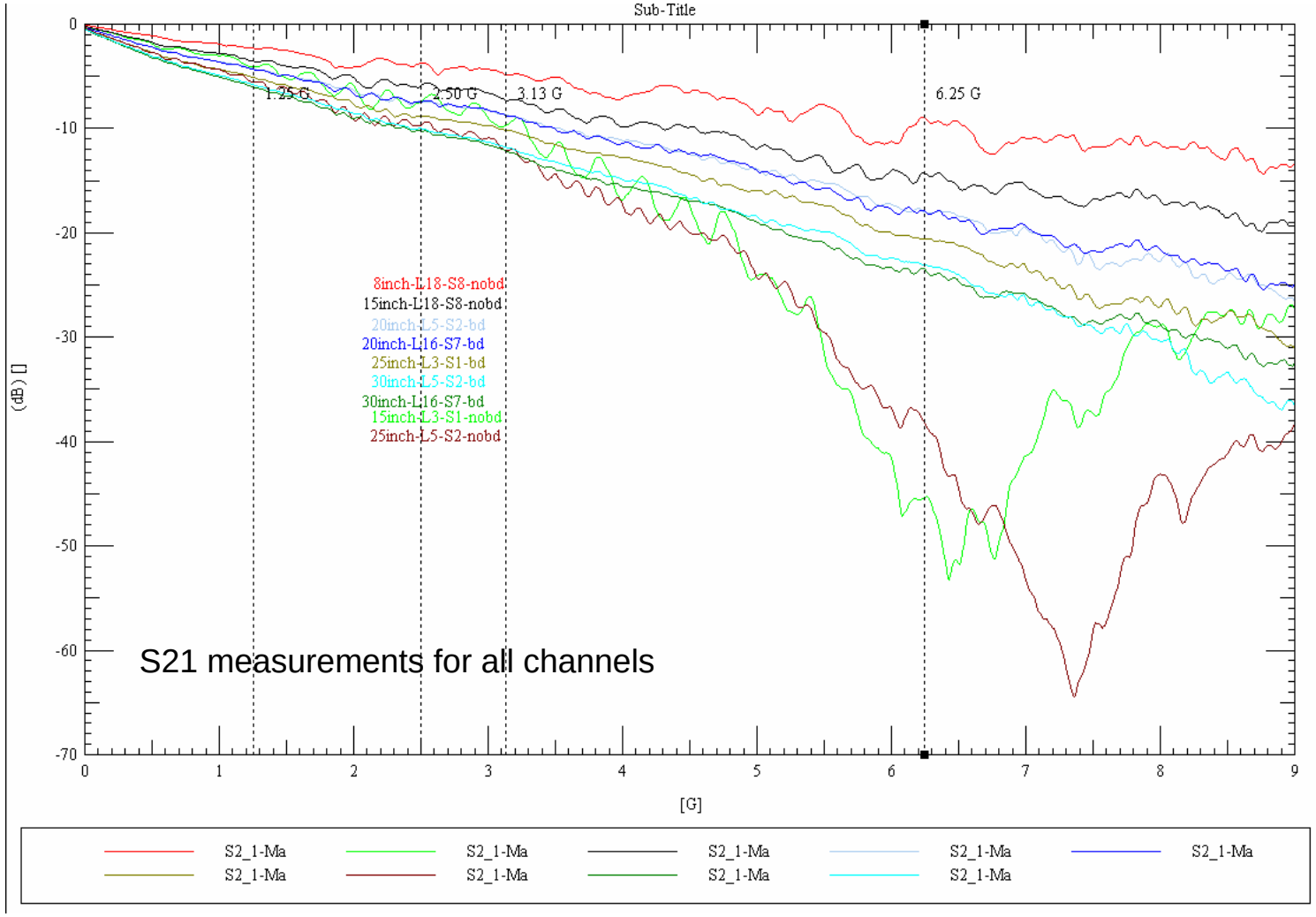
1.Simulation using HSPICE models
2.Simulation using macromodels
3.Correlate with laboratory measurement

Lab Correlation and Multi-gigabit System Measurement

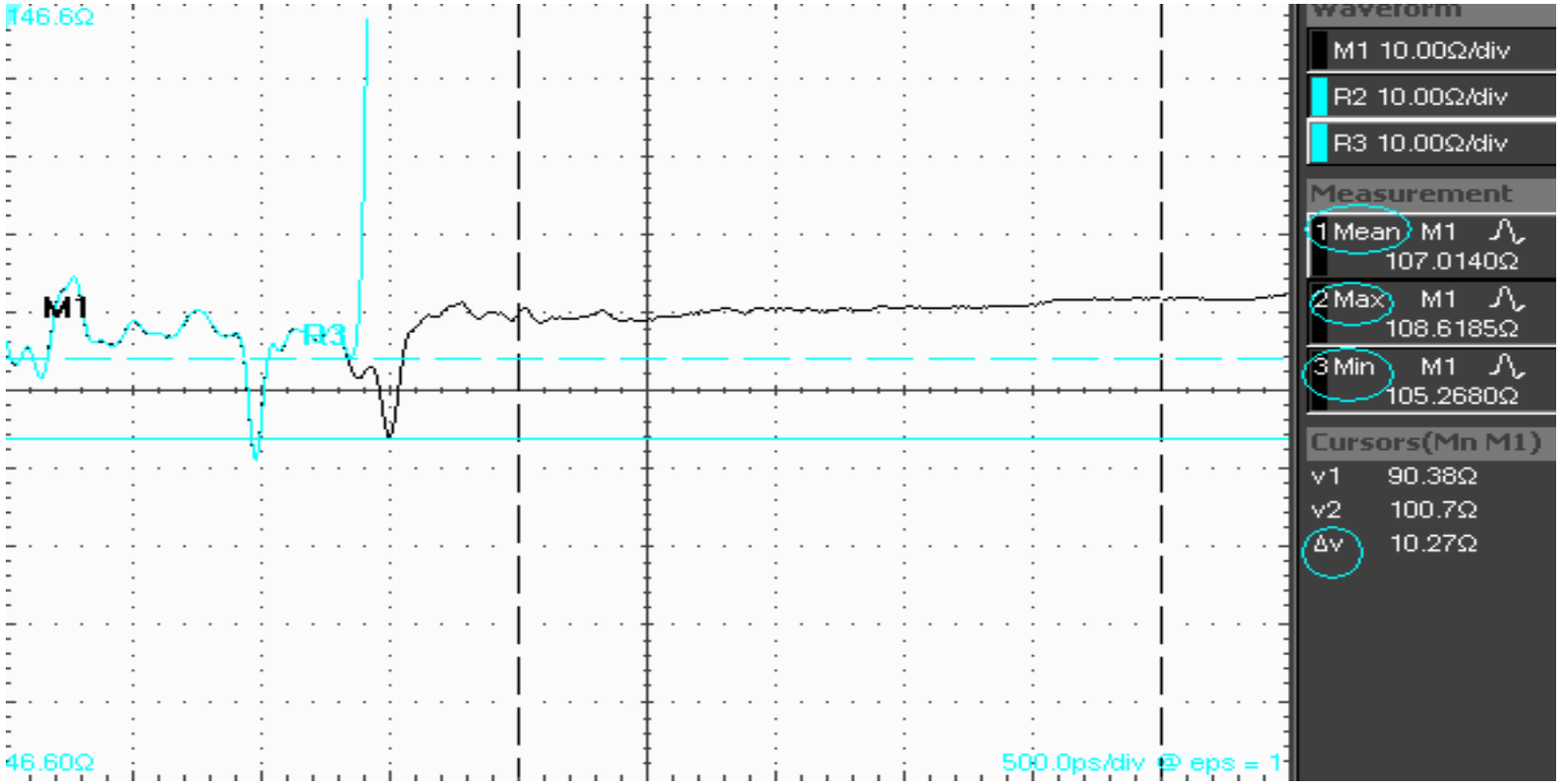


- **Measurement Setup**
  - Backplane: 8’’- 40’’stripline;
  - Daughter card: 3” stripline;
  - PRBS: K28.5
  - Data rate: 3.125Gb/s

S-parameters Measurement for Channels



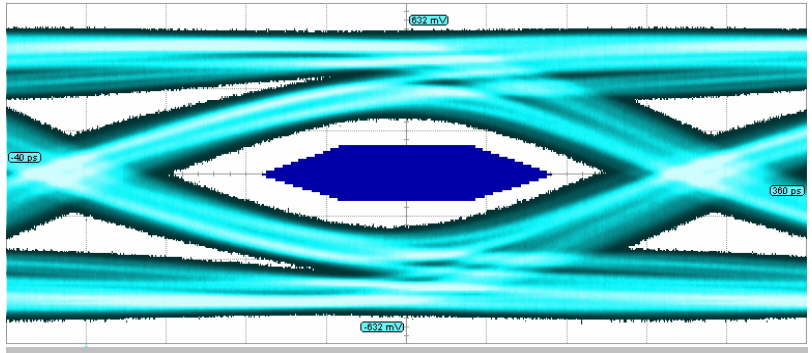
TDR Measurement



Stub Length	Mean(ohm)	Max(ohm)	Min(ohm)	ΔV(ohm)
35.3mil	107.01	108.6	105.27	10.27

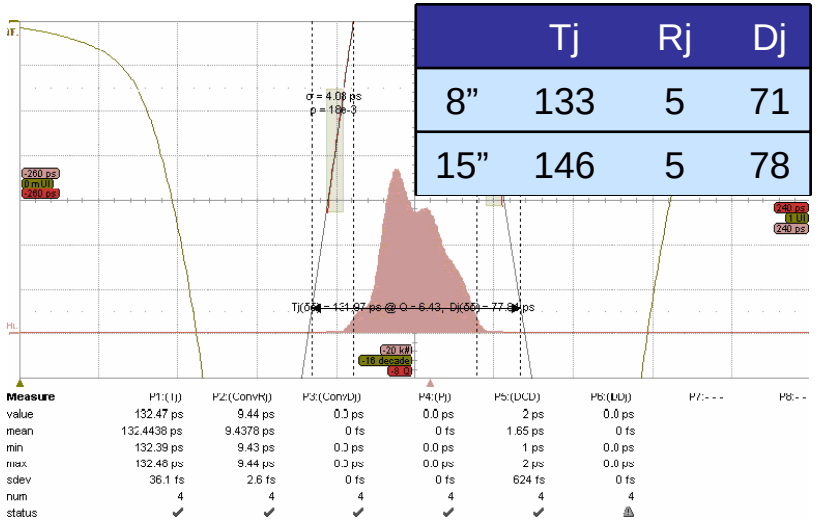
Eye Diagram Analysis and Design Margin Budget

8” stripline Stub=34mil

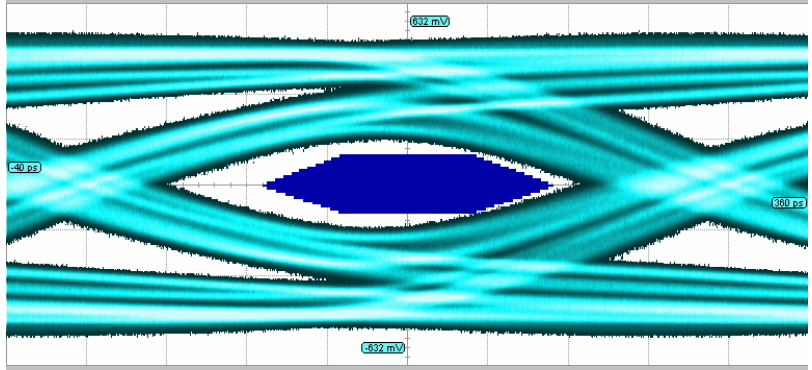


No pre-emphasis

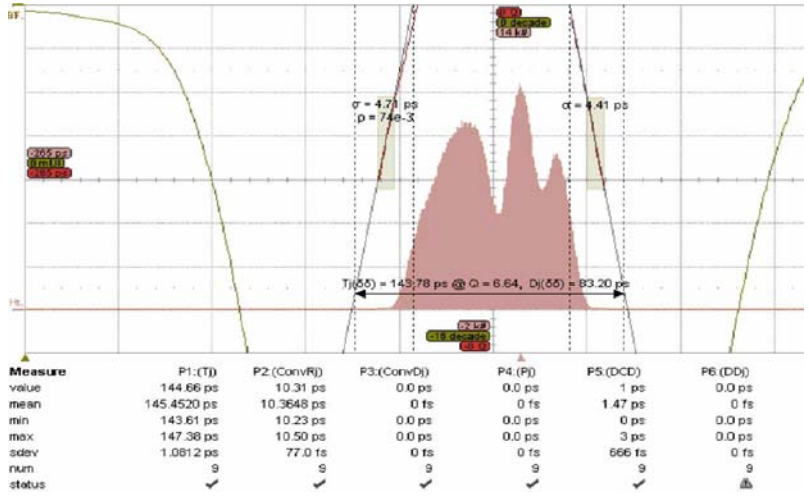
	Tj	Rj	Dj
8”	133	5	71
15”	146	5	78



15” stripline Stub=34mil



No pre-emphasis



Conclusions

- For Multi-gigabit channel optimization, it is a good practice to use marcomodels for active devices and EM solver derived S parameter models for passive elements, provided the behavioral models have been correlated by lab measurement.
- Measurement correlated MacroModel enables much shorter simulation time than transistor-level spice model for pre-emphasis simulation and fine tuning.
- S-parameter is an accurate and efficient way for interconnect modeling. They can be used with confidence after being generated from EM solver and correlated with VNA measurement.

Thanks

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