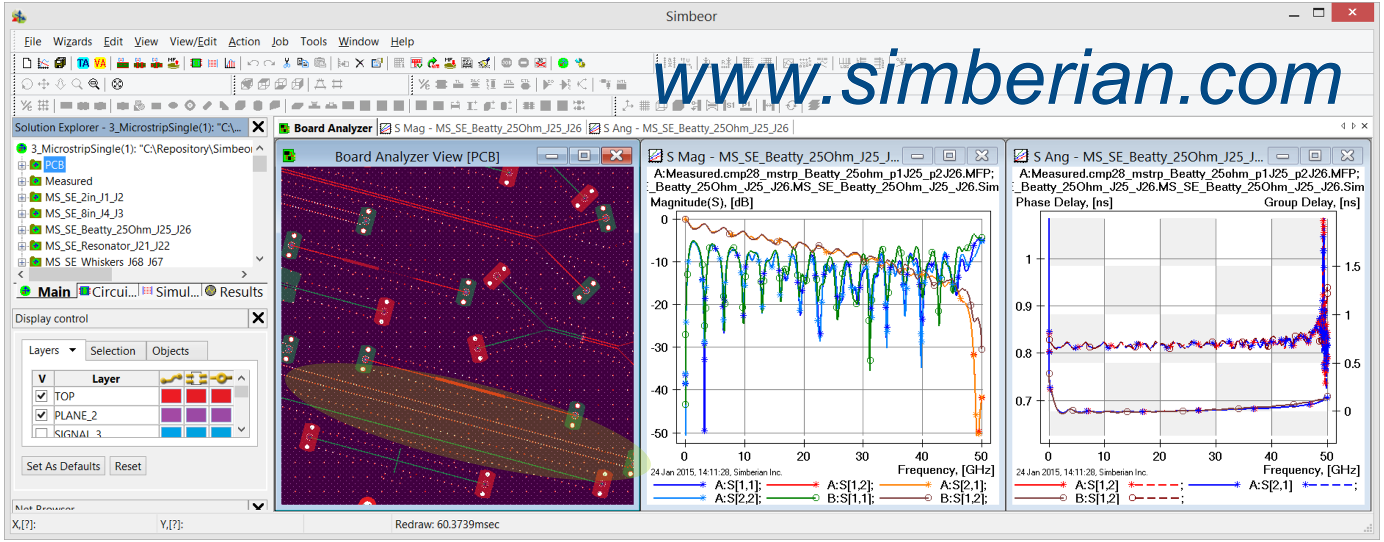
Simberian
Electromagnetic Solutions

Simbeor

Electromagnetic Signal Integrity Software to Design Predictable PCB Interconnects



www.simberian.com

Simbeor®: Accurate, productive, cost-effective… www.simberian.com

Simbeor is complete solution for ALL PCB interconnect analysis tasks

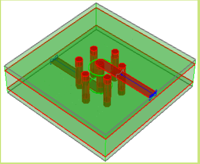
*Simbeor enables **geometry synthesis** for controlled impedance transmission lines and via-holes, has **geometry import** and selection capabilities, and **3D geometry editor***

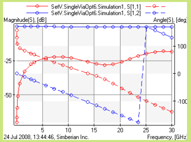
EMSAT EMC&SI Violations

Geometry Synthesis, Editing, Processing

Geometry: ODB++, Allegro, hyp-files

Simbeor Solvers & Tools





Touchstone models XML models & scripts

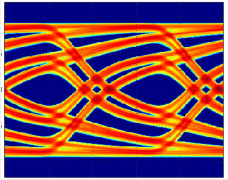
Compliance Metrics (plots & CSV)

Broadband SPICE Touchstone models

SPICE W-element RLGC(f) models

Excel CSV-files: Dk(f), LT(f) TD Response Matrix

System-Level Simulator: ADS, Allegro HyperLynx+Eldo HSPICE, MSIM, Matlab, QCD…



Simbeor is one-stop solution for passive interconnect pre and post-layout analyses with advanced electromagnetic models, for macro-modeling and material parameters identification tasks, and de-embedding

Available for 15-day trial at www.simberian.com

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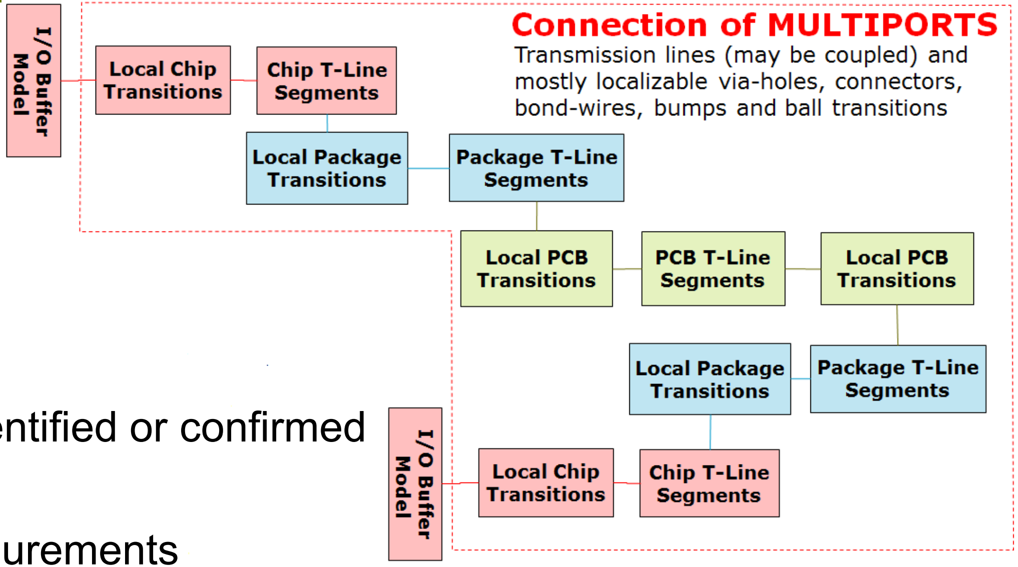
De-compositional analysis of interconnects

1) Quality of S-parameter models is ensured

2) Simulation in isolation is possible or coupling is accounted, and models are de-embedded

3) Broadband material models are identified or confirmed

4) Simulators are validated with measurements



4 necessary elements of design success supported in Simbeor software – see App Notes #2018_03, #2013_03 and #2013_05 at http://www.simberian.com/AppNotes.php

Simbeor solvers and algorithms

- Simbeor 3DML – full-wave 3D analysis tool for multi-layered geometries
  - Hybrid solver: Method of Lines + Trefftz Finite Elements + Method of Simultaneous Diagonalization (de-embedding)
  - Analysis of discontinuities and transmission lines with high-frequency (non-TEM) dispersion and anisotropy (any planar cross-section)
- Simbeor 3DTF – full-wave 3D analysis with Trefftz finite elements
- Simbeor 3DML and 3DTF solvers are parallelized locally and with distributed computing
- Fast EM solver for via geometry synthesis (infinite planes)
- Simbeor SFS – unique quasi-static field solver for large t-line cross-sections (any planar cross-section)
  - MoM, supports all dispersive isotropic material and roughness models
- Linear Network Solvers – unique port-based analysis
  - 7 solvers for FD and TD analysis of multiport networks based on Y or S-parameters – sparse solvers for extremely large networks
  - **Material parameters identification, test fixture extraction and de-embedding capabilities**
- Rational Compactor – converts discrete S-parameter models into frequency-continuous rational macro-models

Simbeor tools

- Touchstone Analyzer™ – S-parameters plotting, quality assurance and macro-modeling
- Transmission line wizard – fast synthesis of any single-ended and differential line geometry (strip, micro-strip, CPW, CBCPW,…)
- Via Analyzer™ – fast synthesis of via-holes and launches geometry
- Multi-layered geometry editor for pre and post-layout analyses
- Linear Network editor to draw multiport networks (link path models)
- SiTune™ – via, t-line geometry, linear network optimization, material model identification
- Eye Analyzer™ - measurements on eye diagram
- ICN Analyzer™ - for Integrated Cross-talk Noise (ICN) computation
- Board Analyzer™ - post-layout de-compositional analysis
  - DeComposer™ - post-layout analysis of coupled and skewed links
- Violation Browser™ - viewer for EMSAT rule checker
- SPP Analyzer – material model identification with TDT or short pulse measurements

Available for 15-day trial at www.simberian.com

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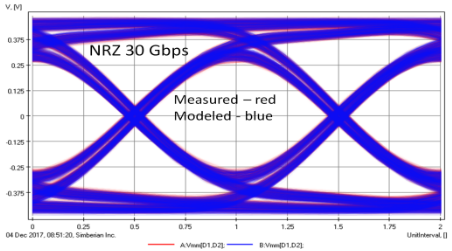
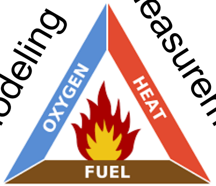
How to Design of Predictable Interconnects

Design success "fire triangle"



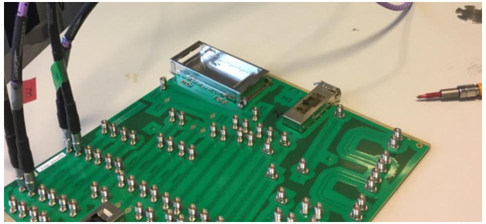
Accuracy of EDA tools must be systematically validated (most are not)

modeling



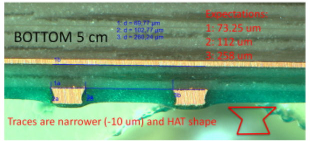
measurements

manufacturing



VNA measurements from MHz to 40-50 GHz are required (difficult)

Material models and manufacturing adjustments must be identified (PCBs are not manufactured as designed)



Geometry Adjustments +
Material Models +
Validated Software =
Predictable Interconnects

Requires Systematic Validation Process…

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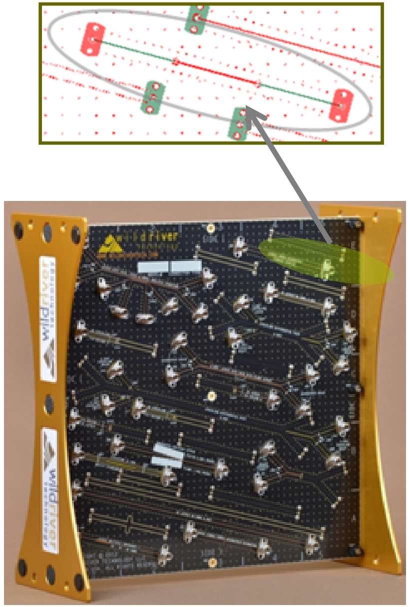
Systematic validation process

1. Select materials and define PCB stackup with the manufacturer
2. Design test structures with the EM analysis (simple links, launches, vias,…)
3. Manufacture the board, mount connectors (if any)
4. Measure S-parameters and validate quality of the measurements
5. Cross-section the board and identify the manufacturing adjustments (if any)
6. Identify broad-band dielectric and conductor roughness models with GMS-parameters or SPP Light techniques
7. Simulate all structures with the identified or validated material models and confirmed adjustments consistently and compare S-parameters and TDR with the measurements (no further manipulations with the data)

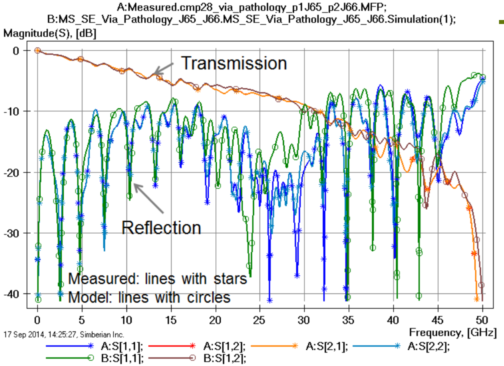
Y. Shlepnev, Sink or Swim at 28 Gbps - The PCB Design Magazine, October 2014, p. 12-23.
M. Marin, Y. Shlepnev, 40 GHz PCB Interconnect Validation: Expectations vs. Reality, DesignCon 2018

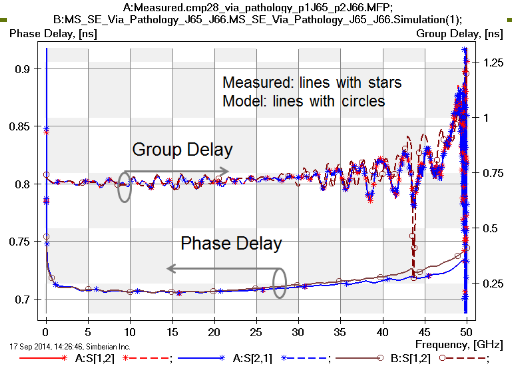
Simbeor is formally validated up to 50 GHz

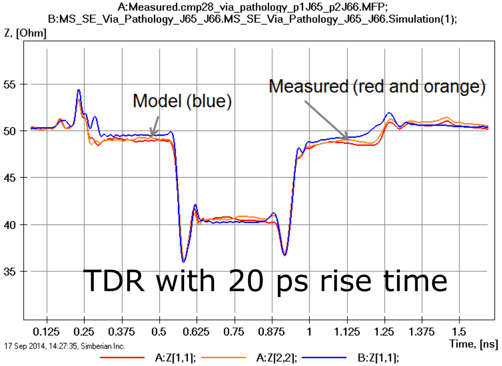
EXAMPLE

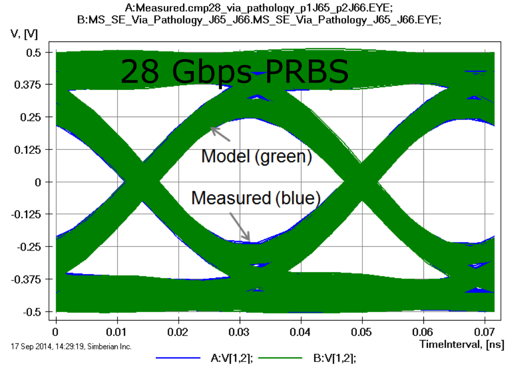


CMP-28 Channel Validation Platform from Wild River Technology LLC





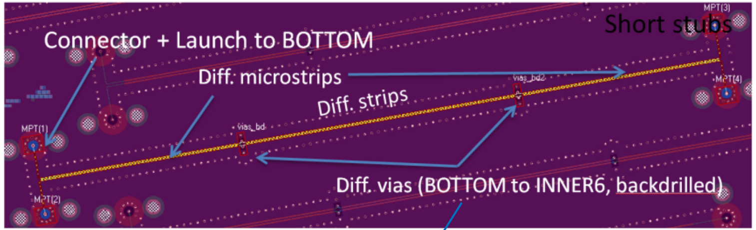




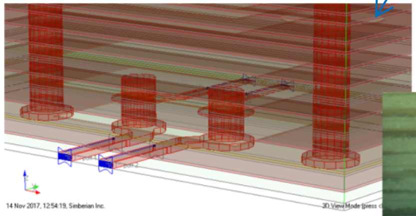
See Webinar #4. Complete description of CMP-28/32 platforms with all results is available at **http://www.simberian.com/Presentations/CMP-28_Simbeor_Kit_Guide.pdf**

Example of systematic validation with EvR-1 test board from Infinera

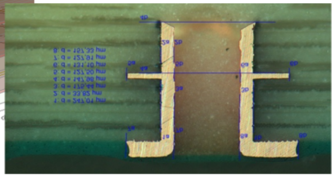
1.1 in microstrips – vias – 1.5 in strips – vias – 1.1 in microstrips



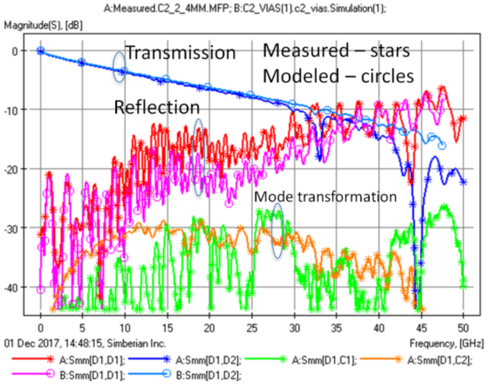
Backdrilled vias model

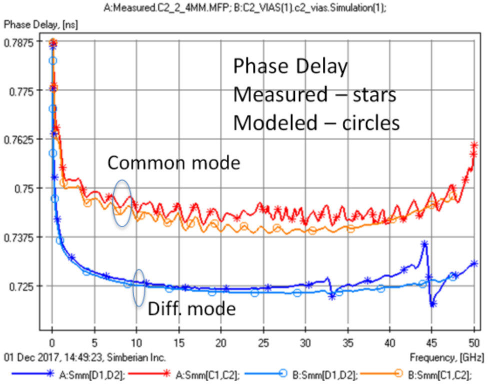


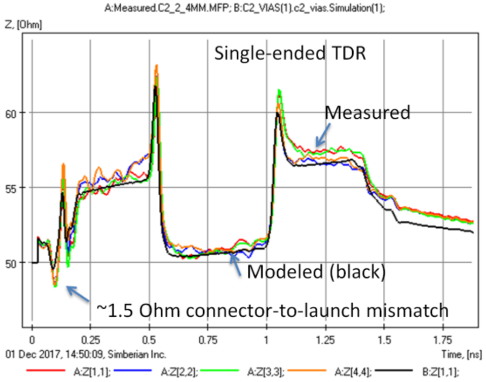
De-compositional EM analysis
Shape and size of all traces and backdrilling position are adjusted…

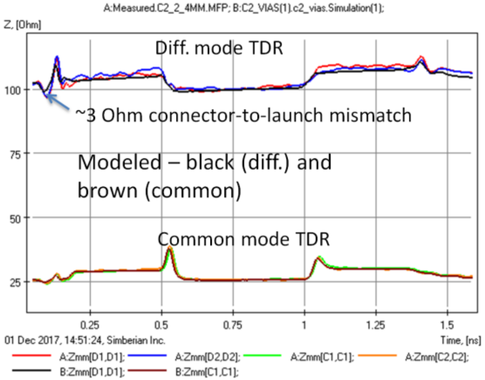


Complete report #2018_01 at http://www.simberian.com/AppNotes.php

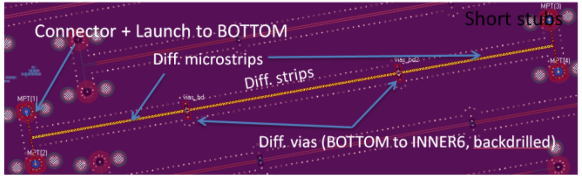




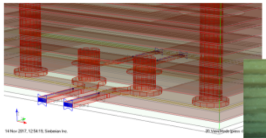




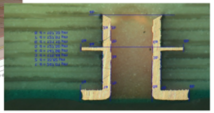
28 Gbps NRZ, PRBS-32, 15 ps rise time

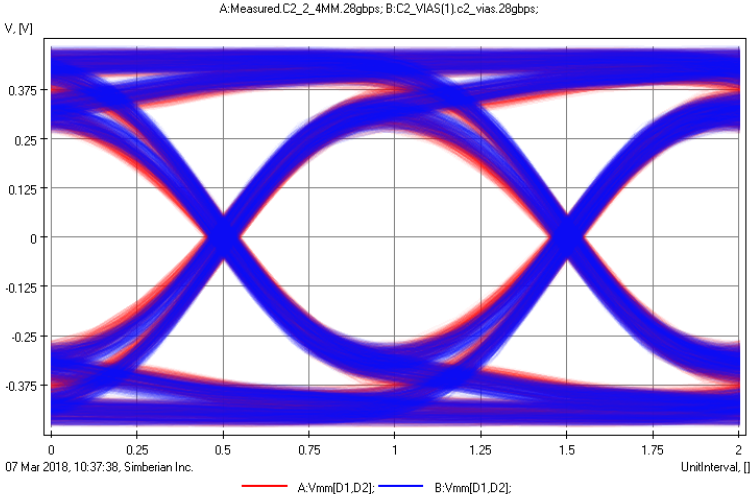


Backdrilled vias model



De-compositional EM analysis
Shape and size of all traces and backdrilling position are adjusted…





Eye Analyzer

Show Eye Metrics: Selected ☑ Auto-open

Parameter	Measured.C2_2_4M...	C2_VIAS(1).c2_vias....
Eye Level Zero (V)	-0.370953	-0.373448
Eye Level One (V)	0.371227	0.375322
Eye Level Mean (V)	-8.25219e-005	0.00123696
Eye Amplitude (V)	0.74218	0.74877
Eye Height (V)	0.504704	0.526895
Eye Width (UI)	0.883814	0.898891
Eye Opening Factor	0.680029	0.703681
Eye Signal to Noise	6.45773	6.10486
Eye Rise Time (20-80) (UI)	0.459316	0.42801
Eye Fall Time (80-20) (UI)	0.460037	0.427404
Eye Jitter (PP) (UI)	0.116186	0.101109
Eye Jitter (RMS) (UI)	0.0279181	0.0240858

28 Gbps NRZ: model – blue, measured – red; 5.5% difference in eye heights and 1.5% in heights

EvR-1 test board – see complete report at Complete report #2018_01 at http://www.simberian.com/AppNotes.php

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Material model identification in Simbeor

Using measured and simulated GMS-parameters:

a) Identify copper resistivity by matching GMS IL at lowest frequencies

b) Identify dielectric Dk by matching GMS phase delay (GMS PD)

c) Identify LT by matching GMS IL at lower frequencies

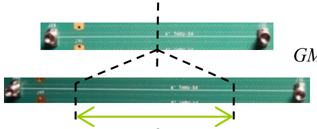
Re-adjust Dk to match GMS PD

d) Identify roughness model parameters by matching GMS IL at high frequencies

Re-adjust Dk to match GMS PD

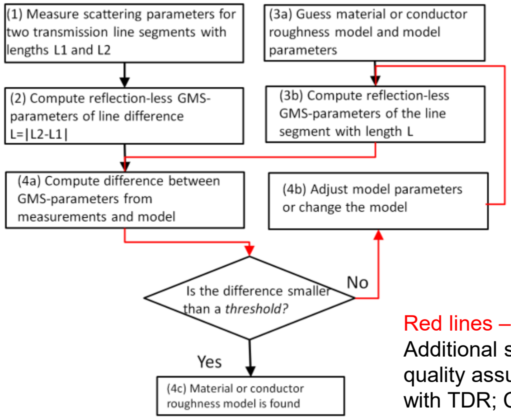
e) Do it for all unique dielectrics

$$GMS = \begin{pmatrix} 0 & \exp(-\Gamma \cdot L) \\ \exp(-\Gamma \cdot L) & 0 \end{pmatrix}$$

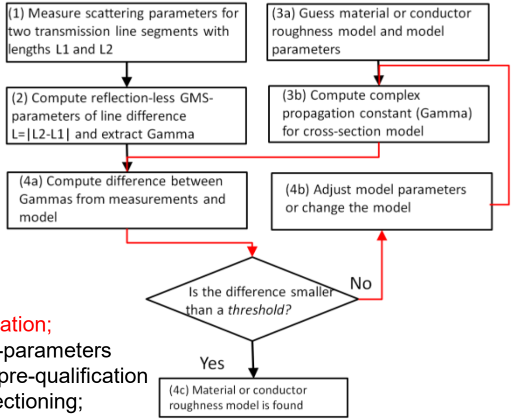


$$GMT = eigenvals\left(T2 \cdot T1^{-1}\right) = \begin{pmatrix} \exp(-\Gamma \cdot L) & 0 \\ 0 & \exp(\Gamma \cdot L) \end{pmatrix}$$

Use of raw GMS-parameters



Gamma extraction – "SPP Light"



Red lines – optimization;
Additional steps: S-parameters quality assurance; pre-qualification with TDR; Cross-sectioning;

Y. Shlepnev, Broadband material model identification with GMS-parameters, EPEPS 2015.
Y. Shlepnev, Y. Choi, C. Cheng, Y. Damgaci, Drawbacks and Possible Improvements of Short Pulse Propagation Technique, EPEPS 2016.

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Dielectric models supported in Simbeor

- Non-causal loss model with constant dielectric constant and loss tangent over any frequency band;
- One-pole Debye model (OnePoleDebye type) - useful for pure glass, sapphire, alumina and water - see "Dielectric models" chapter in Simbeor Manual for more on that model;
- Wideband Debye (aka Djordjevic-Sarkar or Swensson-Dermer) (WidebandDebye type) or continuous spectrum model - **it is suitable for most of the PCB and packaging dielectrics** (see details at How to define Wideband Debye dielectric model?);
- Multi-pole Debye (MultiPoleDebye and MultiPoleDebyeRegular) with real relaxation poles to describe polarization losses over wider frequency band - see details at How to define multi-pole Debye model?
- Generic multi-pole model with real and complex poles defined by measurements of DK and LT at a set of frequencies (MultiPoleGeneric) - see "Dielectric models" chapter in Simbeor Manual;
- Multi-pole Debye and Debye-Lorentz (MultiPoleDebyeLorentz) with real or relaxation and complex or resonant poles - see details at How to define Debye-Lorentz dielectric model?;
- Multi-pole Havriliak-Negami model (generalization of Cole-Cole and Cole-Davidson models) - see details at How to define Havriliak-Negami dielectric model?
- Dielectric mixtures (Wiener, Hashin-Shtrickman and Maxwell-Garnett - see more at How to define dielectric mixture model?)
- Anisotropic dielectrics with separate definition of Z, and XY-plane components of permittivity tensor to take into account layered structure of PCB dielectric - see details at How to describe anisotropic dielectric model?;
- Non-uniform dielectrics to simulate weave-effect (NUTL model in Linear Network) - see details at How to simulate fiber weave effect in Simbeor?;

Unified Roughness Model in Simbeor

$$K_{ri} = 1 + (RF_i - 1) \cdot F(SR_i, \delta_s)$$

$$\delta_s = (\pi \cdot f \cdot \mu \cdot \sigma)^{-1/2}$$ "skin depth"

RF>1 – Roughness Factor – maximal increase in loss due to roughness (common for all models);
SR – Surface Roughness parameter – defines roughness onset frequency, different for different RCCs;
$F(SR_i, \delta_s)$ - Roughness Transition Function (from 0 to 1), different for different RCCs;

$F_h(\Delta_i, \delta_s) = \frac{2}{\pi} \cdot \arctan\left[1.4\left(\frac{\Delta_i}{\delta_s}\right)^2\right]$	Hammerstad (*RF*=2) and Modified Hammerstad (*RF*)
$F_b(\Delta_i, \delta_s) = \tanh\left[\frac{\Delta_i}{1.8 \cdot \delta_s}\right]$	Bushminskiy aka Simbeor Original
$F_g(\Delta_i, \delta_s) = \exp\left[-\left(\frac{\delta_s}{2 \cdot \Delta_i}\right)^{1.6}\right]$	Groiss (*RF*=2) and Modified Groiss (*RF*)
$F_{hs}(r_i, \delta_s) = \frac{2}{\pi^2 r_i^2 \mu f \delta_s} \cdot \left\lvert \mathrm{Re}\left[\eta \frac{3\pi}{4k^2}(\alpha(1) + \beta(1))\right] \right\rvert - \frac{1}{2}$	Hemispherical (diverges at high frq)
$F_{hur}(r_i, \delta_s) = \left(1 + \frac{\delta_s}{r_i} + \frac{\delta_s^2}{2r_i^2}\right)^{-1}$	Huray snowball (1-ball case or "cannonball")
$F_{hb}(r_i, \delta_s) = \left(1 + (1-j)\frac{\delta_s}{2r_i}\right)^{-1}$	**Causal Huray aka Huray-Bracken**

All models are multi-level – see more at http://kb.simberian.com/browse_item.php?id=39

Effective Roughness Dielectric layer is also supported!

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Simbeor use case scenarios

- **Stand-alone**
  - Material parameters identification (with GMS and standard SPP)
  - S-parameter and compliance analyses of links (both pre and post-layout)
  - S-parameters model quality assurance and macro-modeling
  - De-embedding of test fixtures
- With a system-level tool (HSPICE, ADS, …)
  - Building advanced full-wave models of interconnects (pre and post-layout)
  - S-parameters model quality assurance and macro-modeling
- With HFSS or CST – Simbeor compliments with
  - Analysis of t-lines with advanced dielectric and conductor roughness models
  - Analysis of planar discontinuities, coupling through planes
  - S-parameters model quality assurance and macro-modeling
  - S-parameter and compliance analyses of links (hybrid pre-layout and post-layout with DeComposer tool)

Why use Simbeor?

1. **Provide systematic approach to design predictable interconnects!**
2. **Algorithms are systematically and independently validated with measurements up to 50 GHz!**
3. **Unique algorithms for material models identification**
4. **Unique de-embedding capabilities**
5. Advanced models of transmission lines
6. Fast and accurate pre- and post-layout de-compositional EM analysis
7. Quick compliance analysis in frequency domain
8. Unique quality assurance for Touchstone models
9. Unique macro-modeling capabilities for consistent FD and TD analyses
10. **Easy-to-learn and easy-to-use**

Simbeor is #1 in price-performance (accuracy and productivity)

What is next?

- To learn more visit www.simberian.com
  - Start learning from http://kb.simberian.com/browse_item.php?id=783
  - Check app notes and technical papers and presentations
  - Watch demo-videos and recorded webinars

- Or download and try Simbeor now
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  - No risk
  - No credit cards
  - 15-day free fully-functional version

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