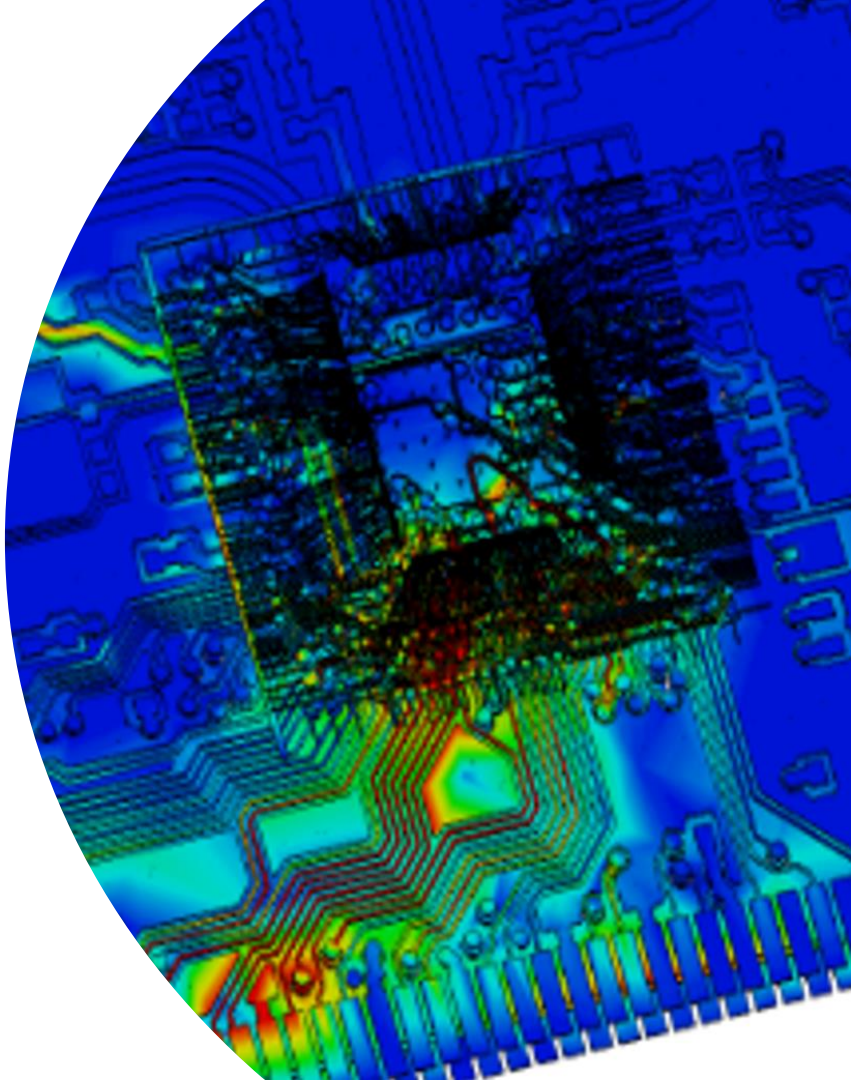
3DEXPERIENCE®

Meeting the Challenges of High Frequency Simulation

日期：2022年11月17日 14:05 - 14:35

型式：研討會

主講：Philip Williams



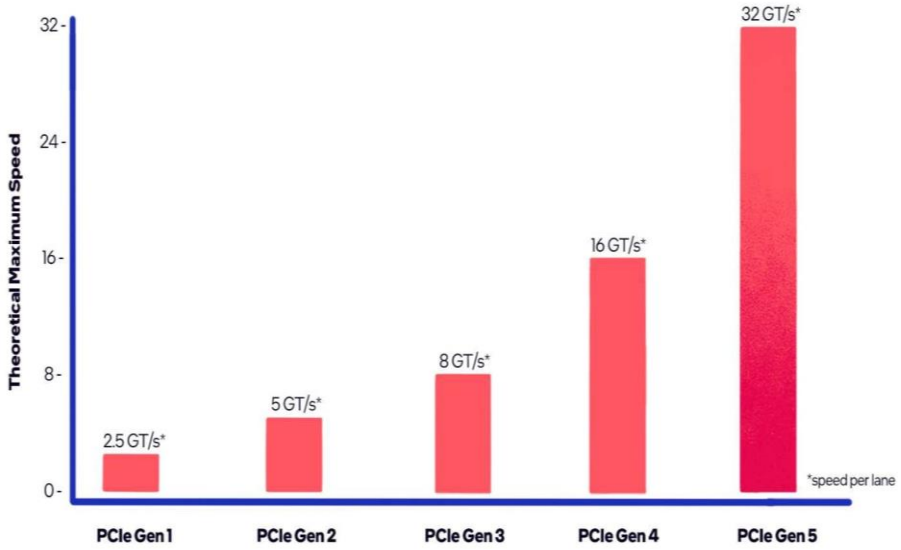
DASSAULT SYSTEMES The 3DEXPERIENCE® Company

Outline

- Challenges in HF Simulation
- Geometry
- Materials
- Analysis Settings
- Summary

High Frequency Requirements

- There has been a significant increase in the performance requirements for signal and communication.
  - PCIe Gen 5 operating at 32 GT/s
  - Testing and simulation required up to 50 GHz
- Simulation is an essential part of component and system design.
- Components and systems should be validated early in the design process.
- Can only be achieved through simulation.



https://www.intel.com/content/www/us/en/gaming/resources/what-is-pcie-4-and-why-does-it-matter.html

SIMUTECH 士盟科技

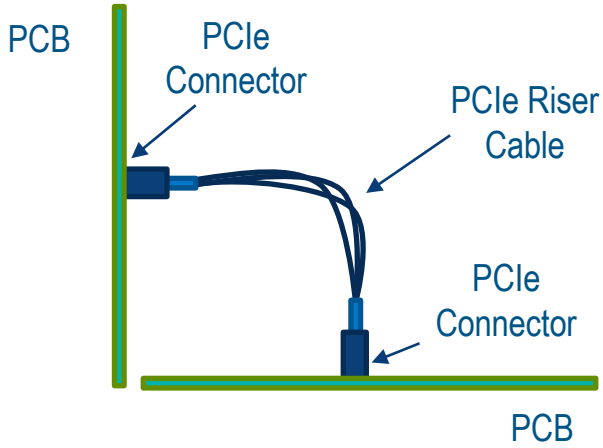
SIMULIA

What are the challenges in high frequency simulation?

- Components to consider:
  - PCB
  - Connector
  - Riser cable
  - Connector
  - PCB

PCIe Riser Cable

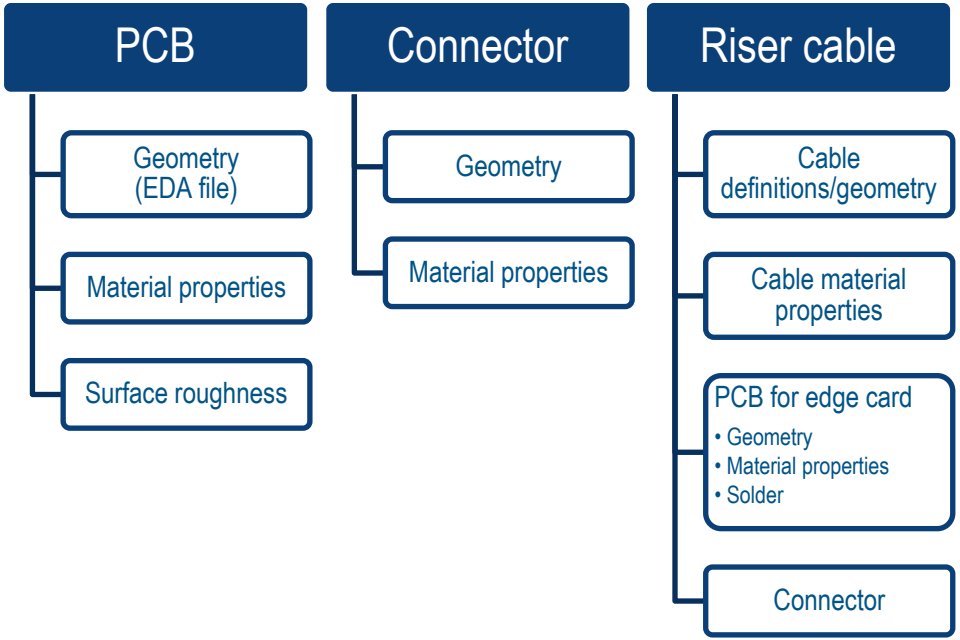
https://www.samtec.com/products/pciec-g5



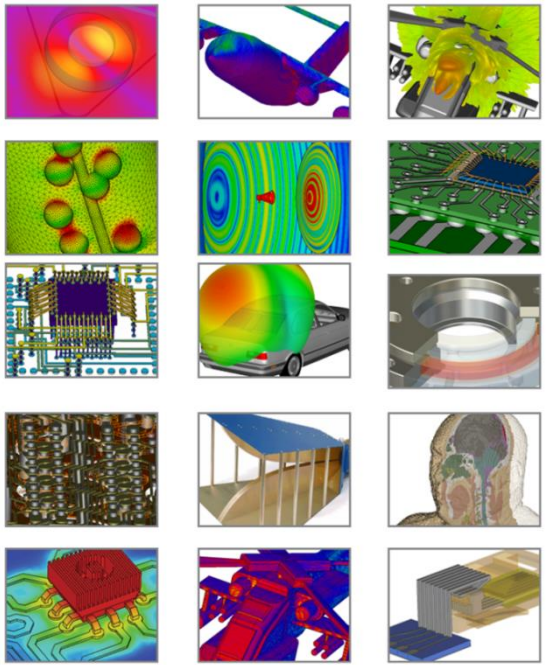
- To perform the full simulation we need detailed information about all components and properties. Often not available – need to use datasheet or test data.
- How can we address these challenges?

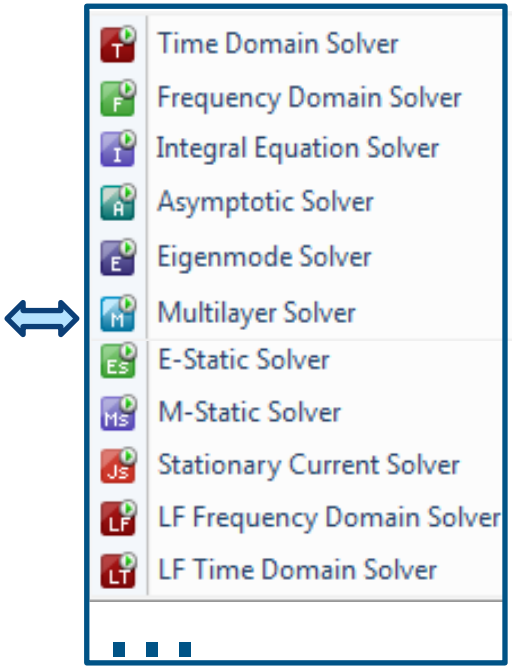
What are the challenges in high frequency simulation?

- What information do we need for accurate simulation?



- Geometry
- Material properties
  - Complex, frequency dependent
- Ports (many)
- Mesh for accurate simulation
- Solver
  - High frequency – 50 GHz
  - Broadband simulation
- Post-processing





Complete Technology

Offer the most appropriate simulation technique for each type of application

- 4 general purpose solvers +20 application-specific solvers
- Covering EM + circuit + multiphysics
- Seamlessly integrated in the same intuitive user interface
- High performance computing

CST STUDIO SUITE Products

CST MICROWAVE STUDIO
Our Flagship Product for 3D EM Simulations for high frequencies

CST CABLE STUDIO
For signal integrity and EMC/EMI analysis of cable harnesses

CST EM STUDIO
3D EM Simulation for statics and low frequencies

CST PCB STUDIO
For signal and power integrity and EMC/EMI analysis of PCBs

CST PARTICLE STUDIO
Interaction of EM Fields with Free Moving Charges

CST BOARDCHECK
For signal integrity and rule-checking of PCB layouts

CST MPHYSICS STUDIO
Thermal and Mechanical Effects of EM Fields

CST DESIGN STUDIO
Circuit Simulator, Coupling of 3D Models, System Assembly Modeling

Geometry

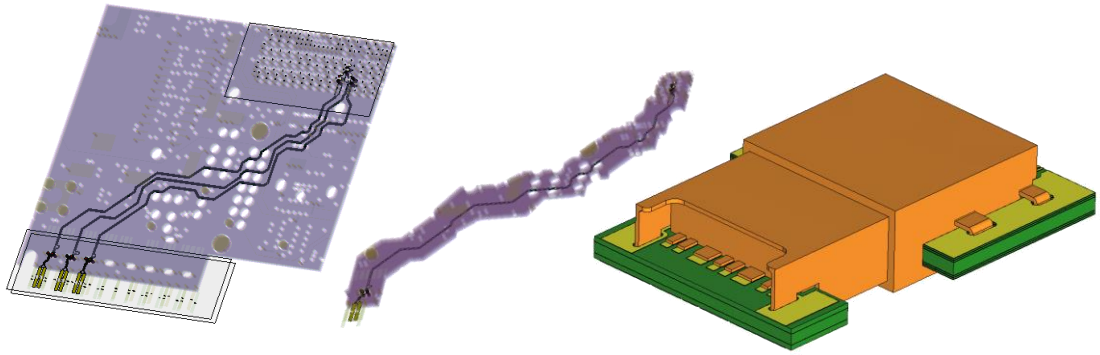
- What do we need?
- What do we have?
- What can we get?
- What is important?

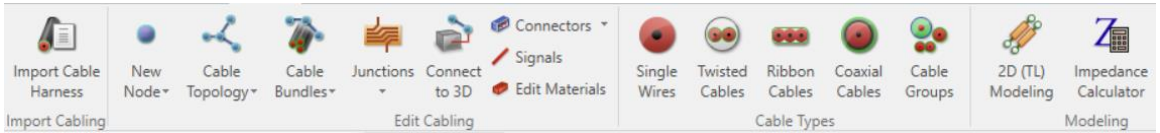
- Import from CAD, EDA
- What to do if we don't have the geometry?
  - Use Touchstone or SPICE model in system simulation
  - Get protected model from the supplier?
- How can the Riser cable be included in the simulation?
  - 3D model – how much to include?
  - Is the bending and twisting of the cable important/significant?

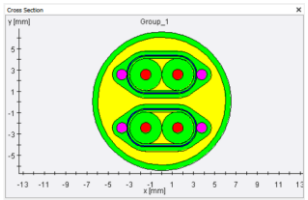
Geometry

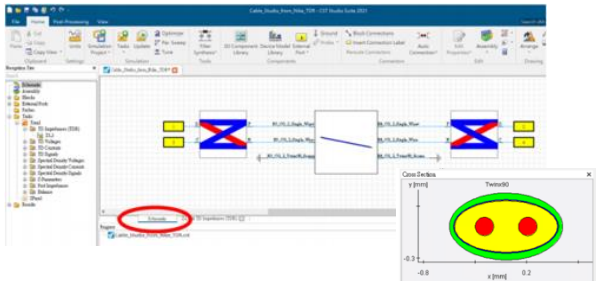
CST Studio Suite

- EDA import function – build 3D PCB model
- Import from CAD
  - Any 3D geometry
  - Import from 3DEXPERIENCE
- CST Protected Model
- CST Cable Studio
- CST Design Studio
  - Circuit – 3D co-simulation
    - Multiple 3D models
    - Touchstone or SPICE files









SIMUTECH 士盟科技

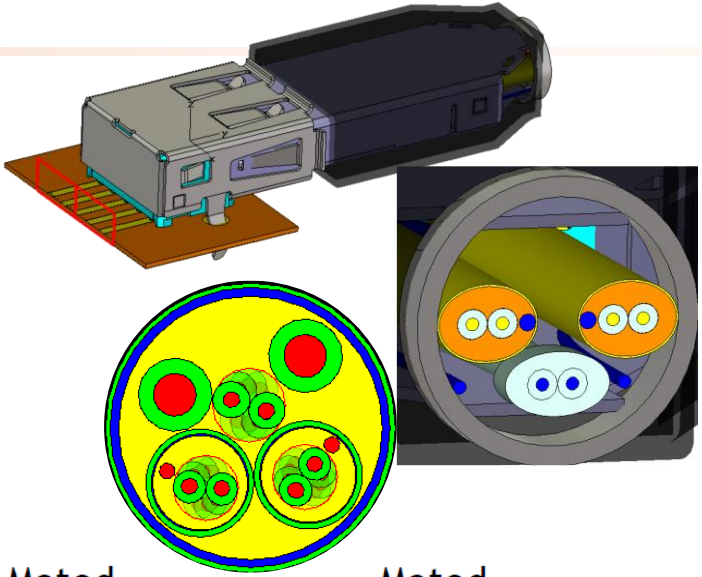
SIMULIA

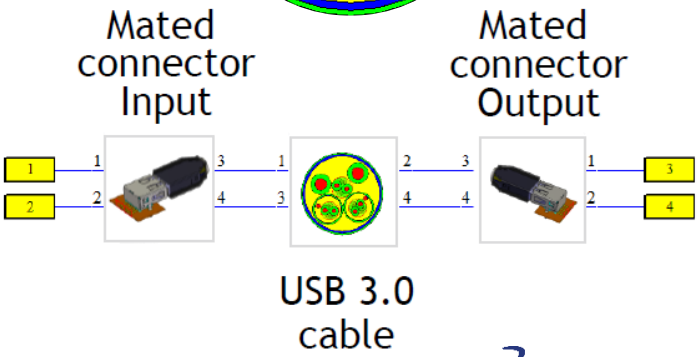
Geometry

Riser Cable

- Connector and/or edge cards
  - 3D geometry
- Cables
  - Start and end of cable – could be 3D for greater detail
  - Use cable studio representation for more efficient modelling
    - Co-simulation between cable model and 3D model
  - Consider twisting or bending of the cables?

https://www.samtec.com/products/pciec-g5

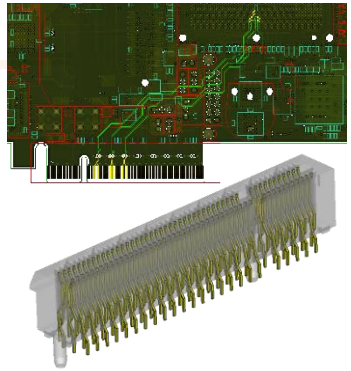


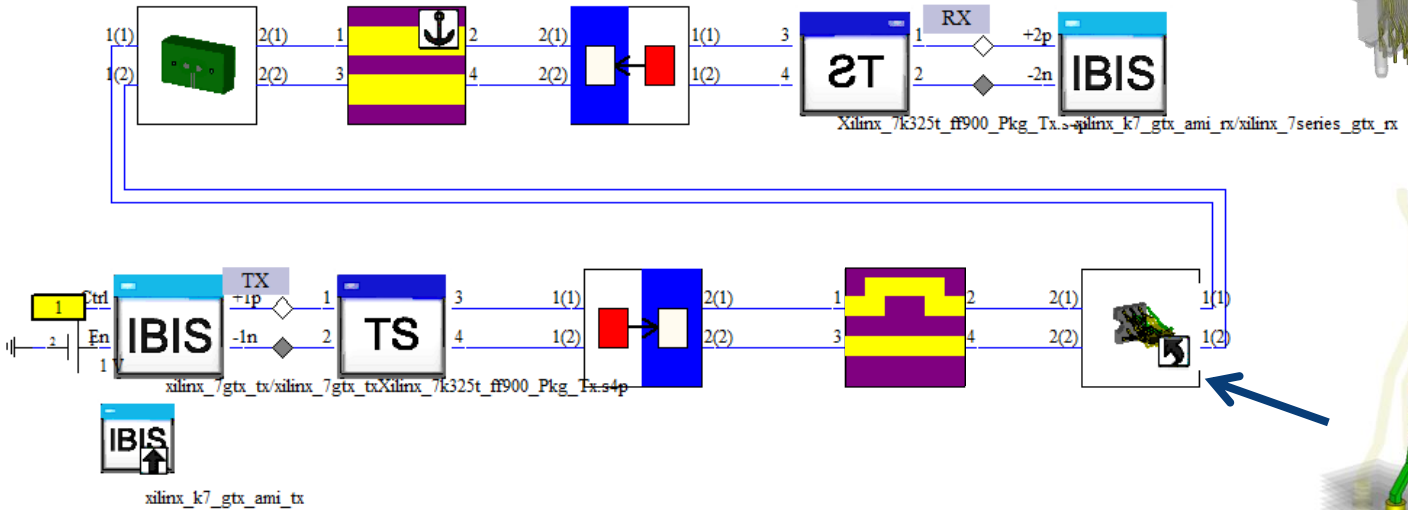


SIMUTECH 士盟科技

SIMULIA

Example: Full Channel Simulation



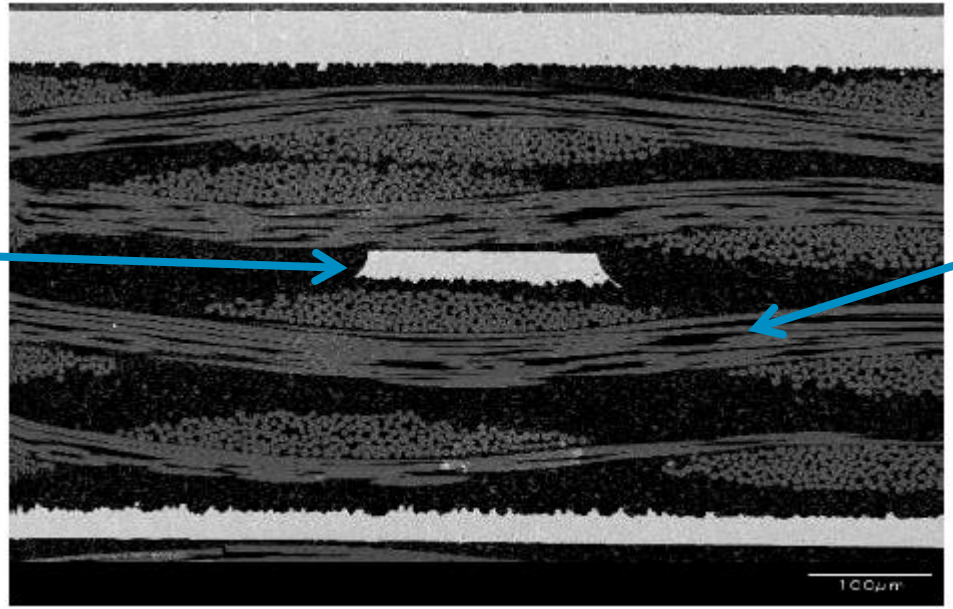


SiMUTECH 士盟科技

SIMULIA

Material Properties

Metal
- Conductivity
- Roughness



Dielectric
- Permittivity (f)
- Loss Tangent (f)

Material Characterization – Data Sheet

isola

FR408HR

Lead Free, Mid Loss Laminate and P

Tg 190°C Td 360°C Dk 3.68 Df (

Typical Values Table

Property		Typical Value	Units Metric (English)	
Glass Transition Temperature (Tg) by DSC		190	°C	
Decomposition Temperature (Td) by TGA @ 5% weight loss		360	°C	
Time to Delaminate by TMA (Copper removed)	A. T260 B. T288	60 >30	Minutes	
Z-Axis CTE	A. Pre-Tg B. Post-Tg C. 50 to 260°C, (Total Expansion)	55 230 2.8	ppm/°C ppm/°C %	
X/Y-Axis CTE	Pre-Tg	16	ppm/°C	
Thermal Conductivity		0.4	W/m·K	ASTM E1952
Thermal Stress 10 sec @ 288°C (550.4°F)	A. Unetched B. Etched	Pass	Pass Visual	2.4.13.1
Dk, Permittivity	A. @ 100 MHz B. @ 1 GHz C. @ 2 GHz D. @ 5 GHz E. @ 10 GHz	3.72 3.69 3.68 3.64 3.65	–	2.5.5.3 2.5.5.9 Bereskin Stripline Bereskin Stripline Bereskin Stripline
Df, Loss Tangent	A. @ 100 MHz B. @ 1 GHz C. @ 2 GHz D. @ 5 GHz E. @ 10 GHz	0.0072 0.0091 0.0092 0.0098 0.0095	–	2.5.5.3 2.5.5.9 Bereskin Stripline Bereskin Stripline Bereskin Stripline
Volume Resistivity	A. After moisture resistance B. At elevated temperature	4.4×10^7 9.4×10^7	MΩ-cm	2.5.17.1
Surface Resistivity	A. After moisture resistance B. At elevated temperature	2.6×10^6 2.1×10^8	MΩ	2.5.17.1
Dielectric Breakdown		>50	kV	2.5.6B
Arc Resistance		137	Seconds	2.5.1B

Dk, Permittivity	A. @ 100 MHz	3.72
	B. @ 1 GHz	3.69
	C. @ 2 GHz	3.68
	D. @ 5 GHz	3.64
	E. @ 10 GHz	3.65
Df, Loss Tangent	A. @ 100 MHz	0.0072
	B. @ 1 GHz	0.0091
	C. @ 2 GHz	0.0092
	D. @ 5 GHz	0.0098
	E. @ 10 GHz	0.0095

Material properties on datasheet may not cover full frequency range required

https://www.isola-group.com/wp-content/uploads/data-sheets/fr408hr.pdf

SIMUTECH 士盟科技

SIMULIA

Material Properties

CST Studio Suite

CST STUDIO SUITE® provides a user-friendly and automatic way to extract broadband material properties from measured data

Macros/Material/*Extract complex permittivity from measured S-Parameters (broadband)*

CST Material Extraction Macro

Macro Features

► 3D EM extraction

- Broadband extraction of complex permittivity
- Broadband extraction of surface impedance
- Removing the effect of connectors from THRU and LINE samples (7 term error model)
- Automatically selected or user defined frequency points
- Extraction from shorter section

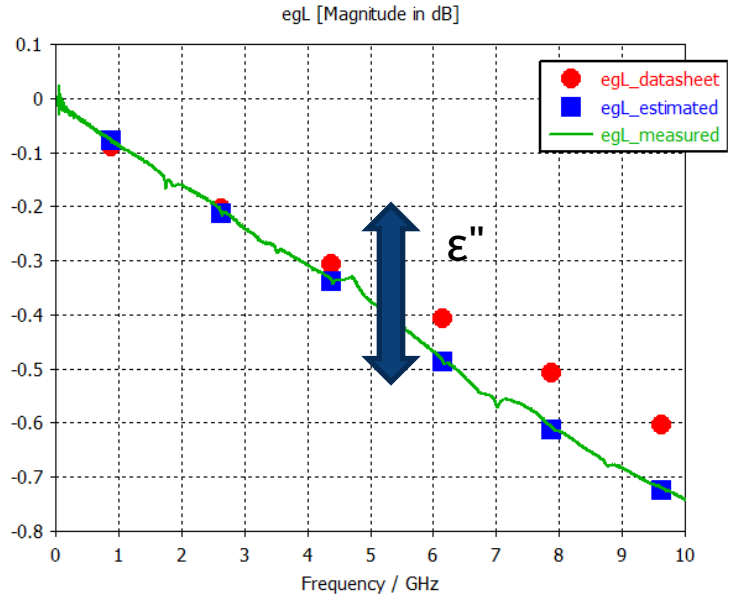
► TL5e w/o extraction

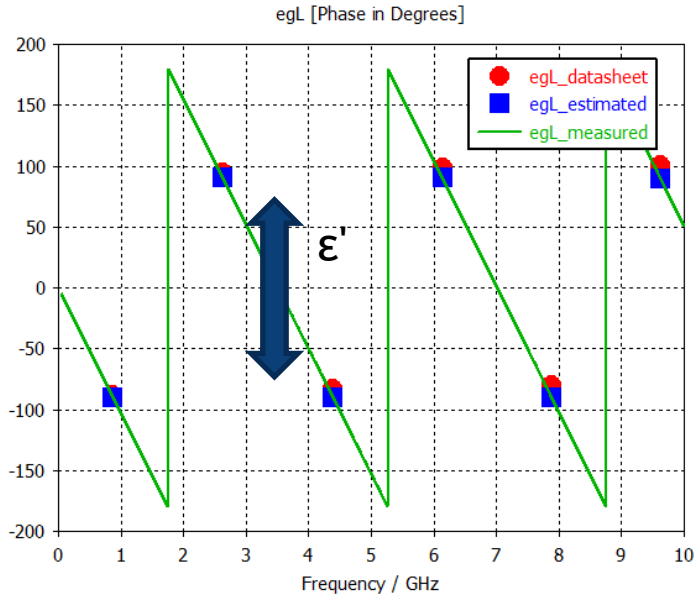
- Removing the effect of connectors from THRU and LINE samples (5 term error model)
- Calculate DUT S-parameters
- Calculate error terms

CST Material Extraction Macro

Extraction Process

S_{21} is equal to exp(-ΓL) or “egL”





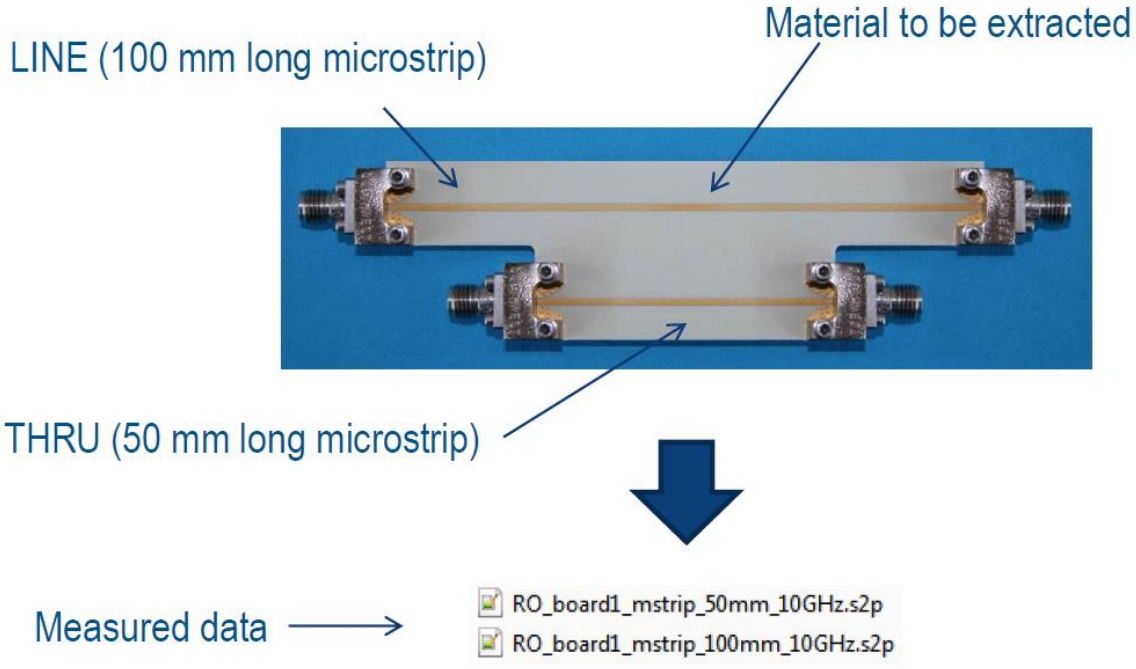
Macro iteratively changes material properties at each selected frequency until estimated value matches measured value.

SIMUTECH 士盟科技

SIMULIA

CST Material Extraction Macro

Example: Substrate Permittivity Extraction

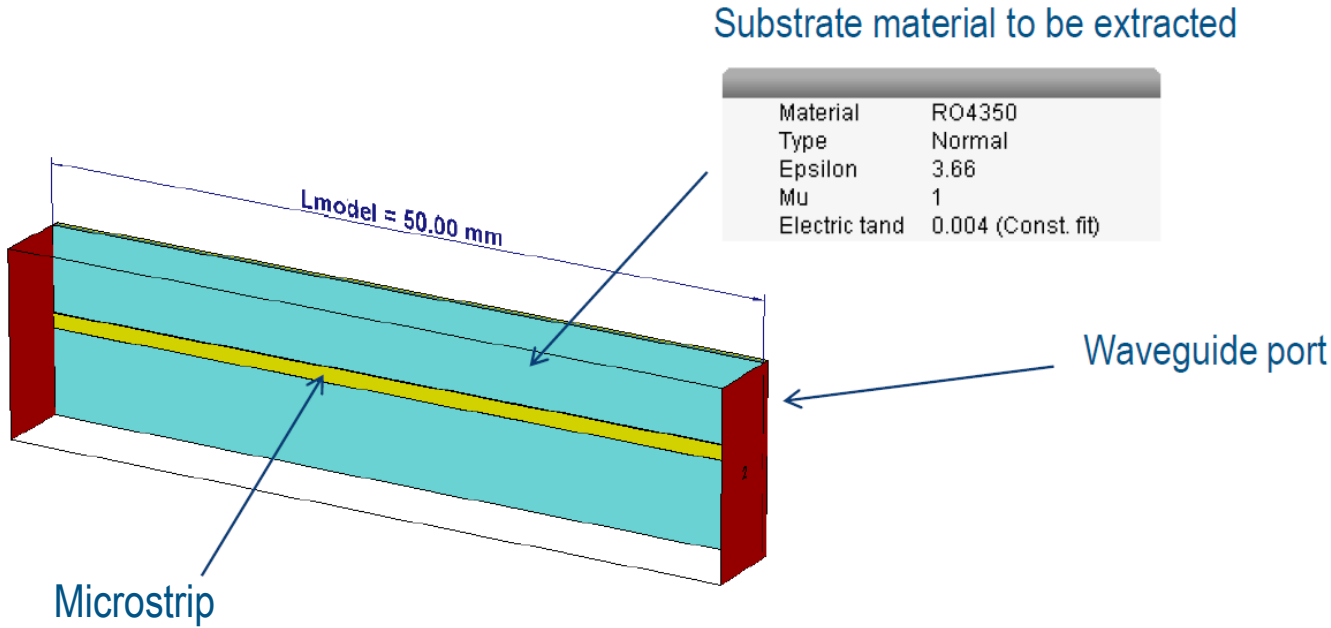


SIMUTECH 士盟科技

SIMULIA

CST Material Extraction Macro

CST Model

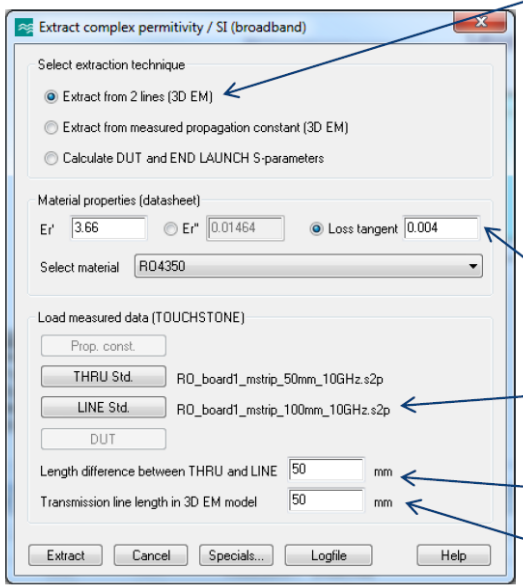


SiMUTECH 士盟科技

SIMULIA

CST Material Extraction Macro

Macro Dialog



High quality end-launch connectors are recommended for Extraction from 2 lines in order to keep constant error model of the transitions

Initial values for extraction (datasheet)

Measured data (data from uncalibrated VNA can be used if Extract from 2 lines is selected)

Corresponds to physical sample

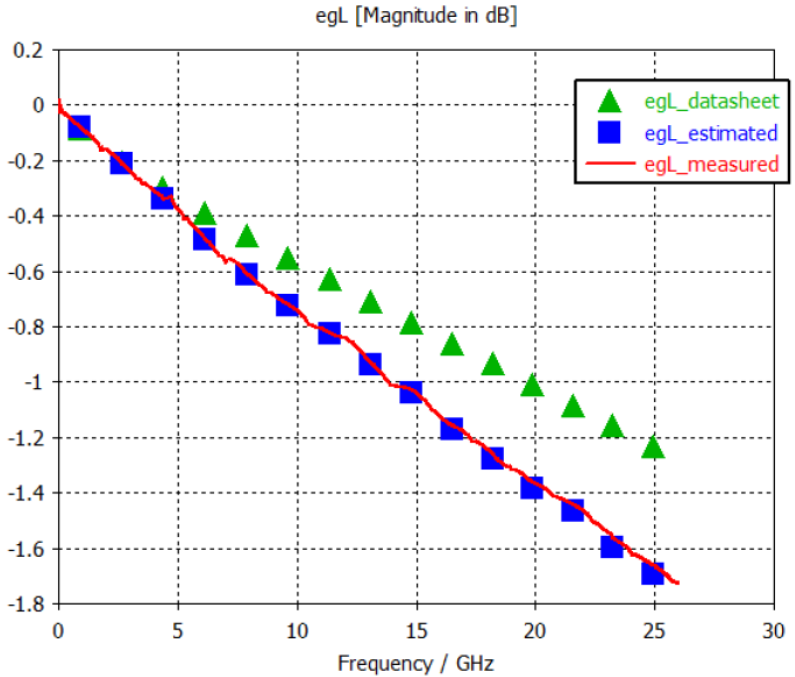
Corresponds to CST model

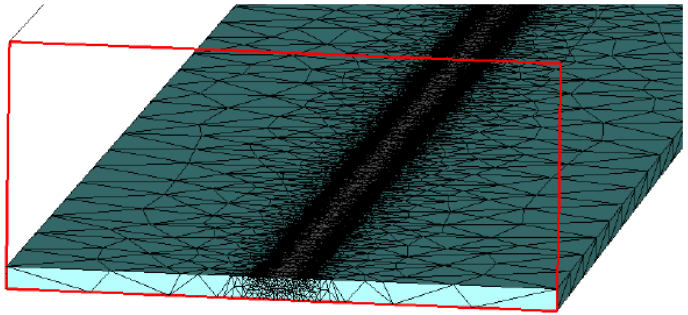
SIMUTECH 士盟科技

SIMULIA

CST Material Extraction Macro

Extraction Progress





High Frequency Mesh	
Tetrahedrons:	82190
Symmetry Planes:	XZ

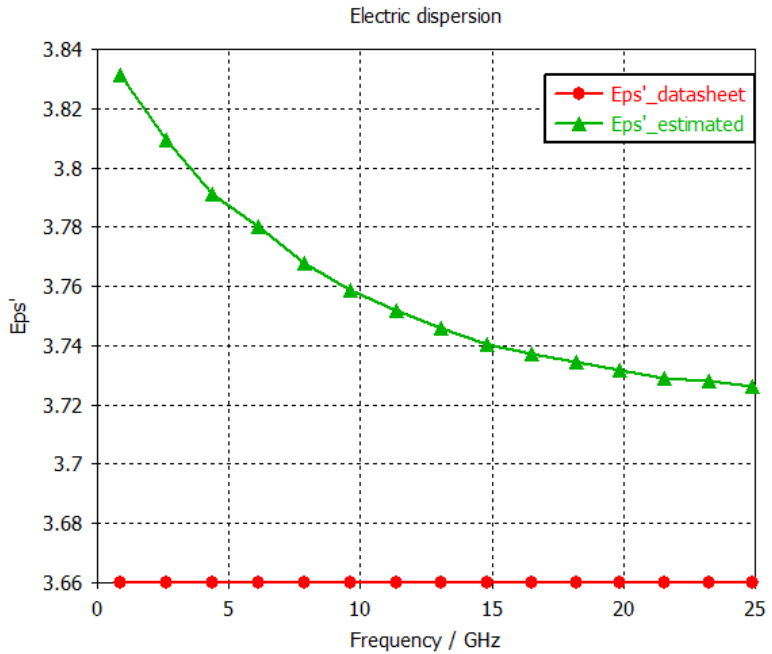
SIMUTECH 士盟科技

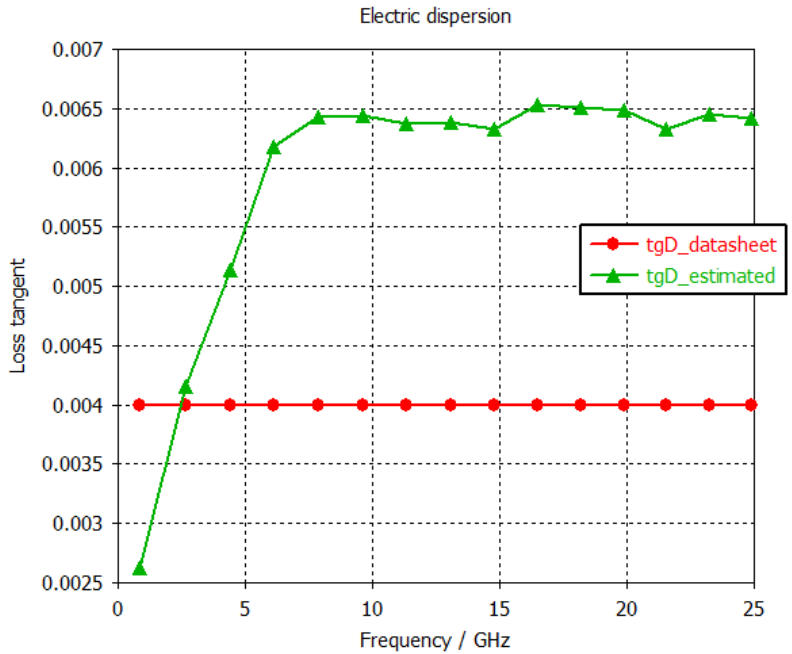
SIMULIA

CST Material Extraction Macro

Extracted Material

Small ripple of the dispersion of the extracted material reflects the ripple in the measured data



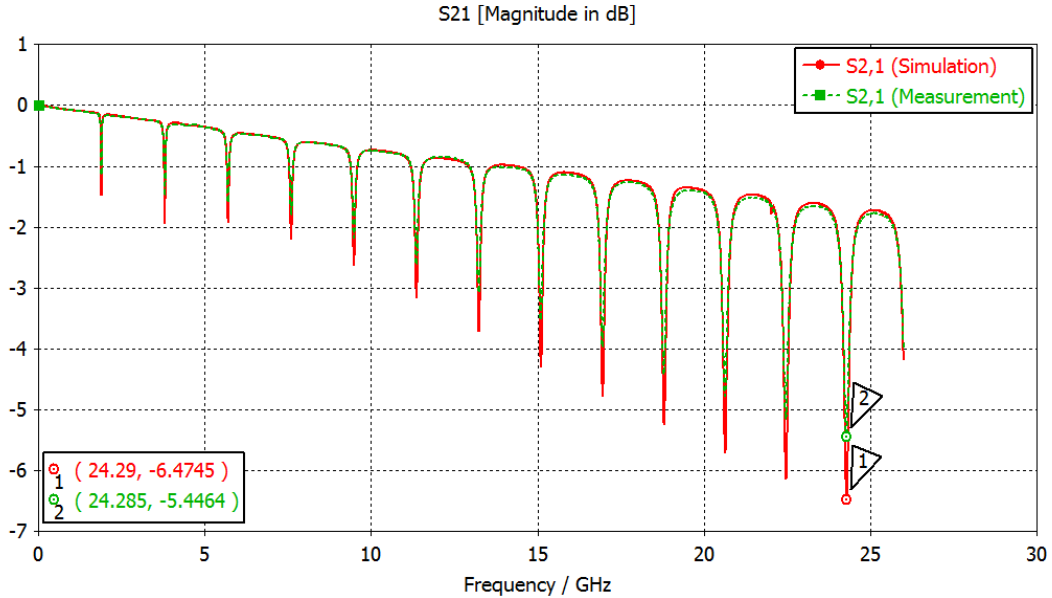


SIMUTECH 士盟科技

SIMULIA

CST Material Extraction Macro

Verification by Ring Resonator



Position of the peaks is extremely sensitive to ε' of the substrate.

Bandwidth of the resonances as well as the attenuation between the resonances is sensitive to the losses in the structure.

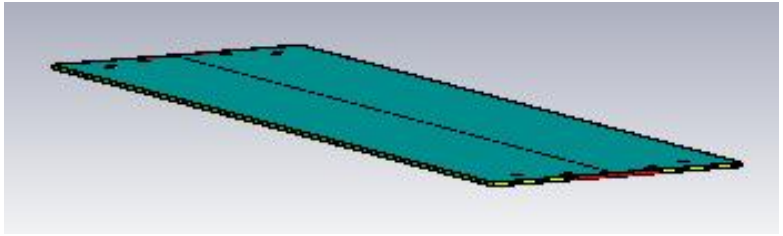
An **excellent agreement** between simulation and measurement has been achieved except for the resonance minima level.

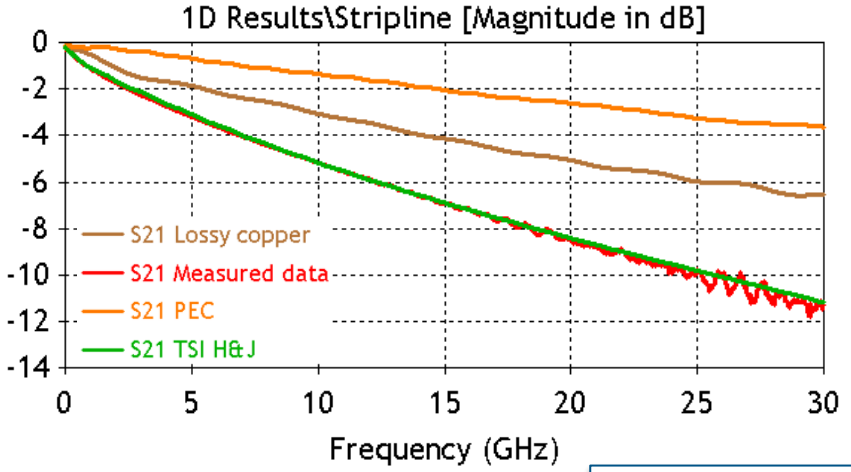
SIMUTECH 士盟科技

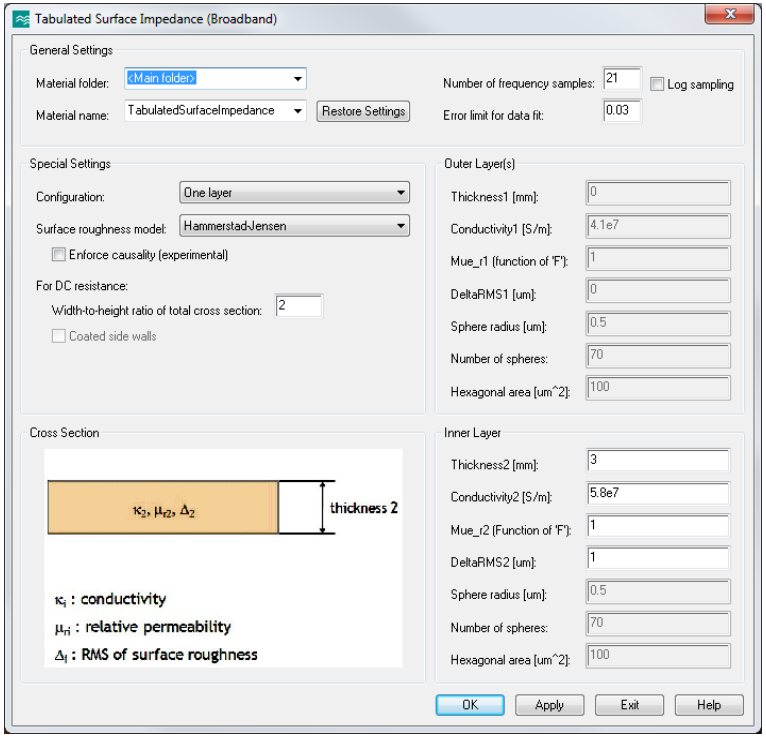
SIMULIA

Surface Roughness

50 mm long stripline model

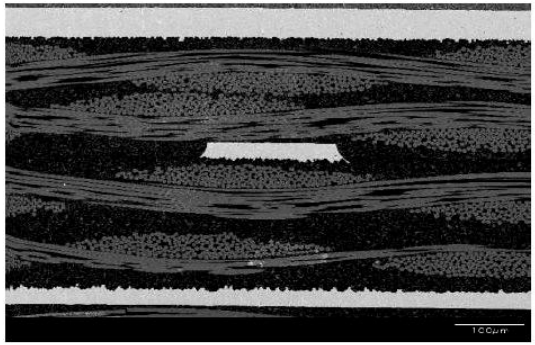




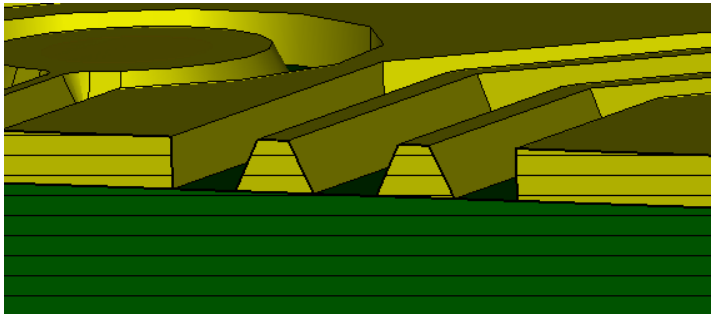


FR4 dielectric substrate –εr=3.5, tg δ=0.06

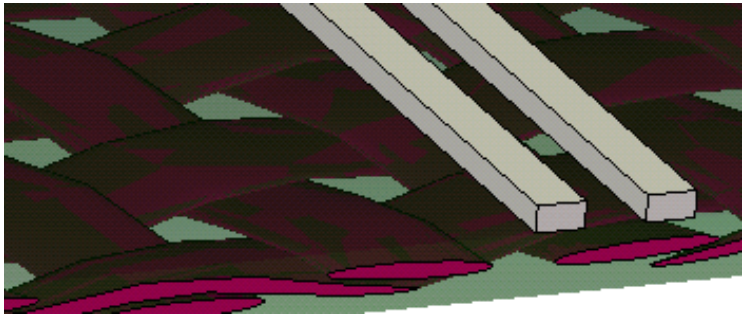
Other Geometric Uncertainties



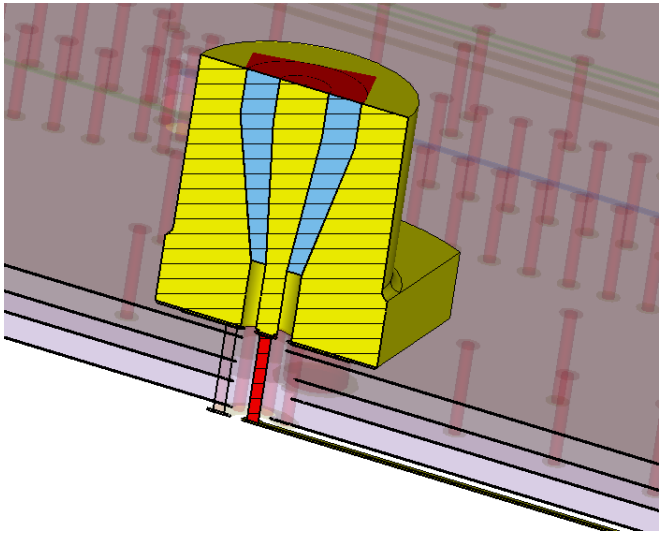
Etch



Glass Weave

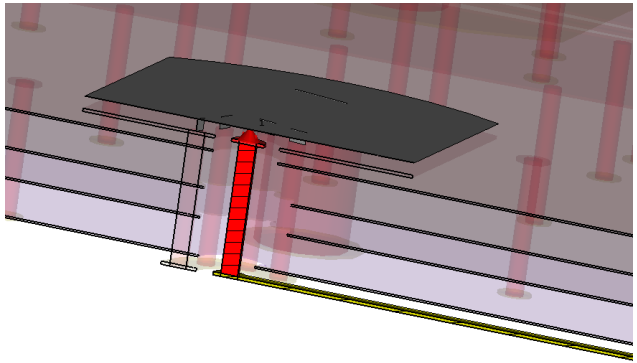


Port Definition



Waveguide Port + Connector

- Away from Discontinuity
- Similar to Measurement
- Not always appropriate (e.g. BGA)
- Detailed CAD model of connector normally not available



Discrete Port + Reference Plane

- Near Discontinuity
- Different from Measurement
- Always feasible
- General geometry -> Can be automated

Mesh for accurate simulation

- Must ensure that there is sufficient mesh to capture the electromagnetic fields
  - In the port regions
  - Between the transmission lines and ground
- Make use of adaptive mesh to make sure that the solution is accurate
  - Ensure that the adaptive mesh procedure has converged

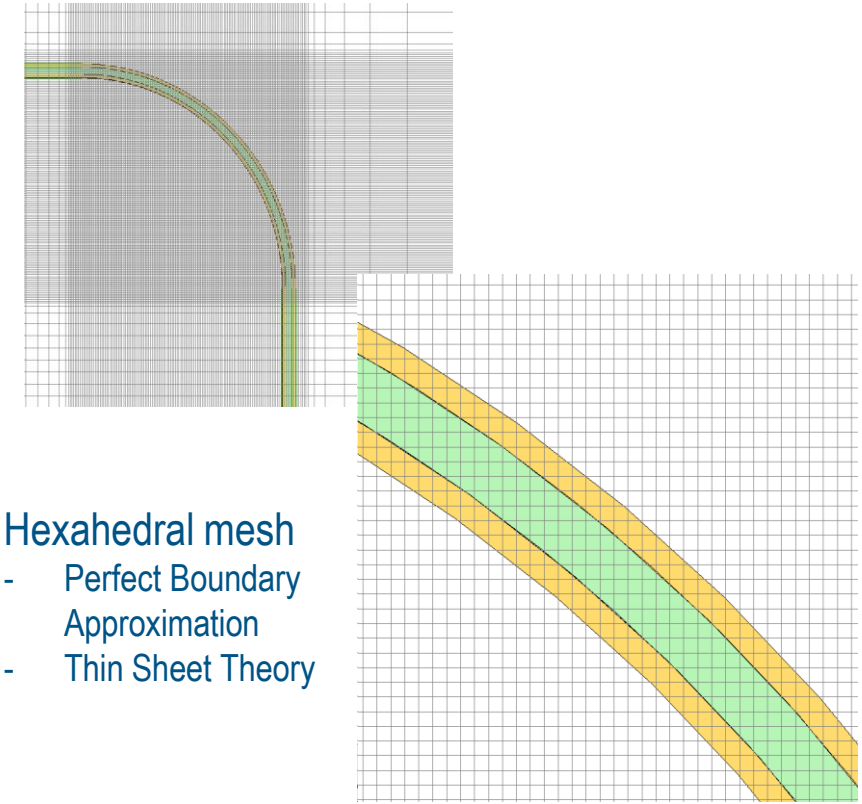
- Solver
  - Must be suitable for wideband simulation up to 32 GHz
  - Can we use High Performance Computing to speed up the analysis?

Mesh

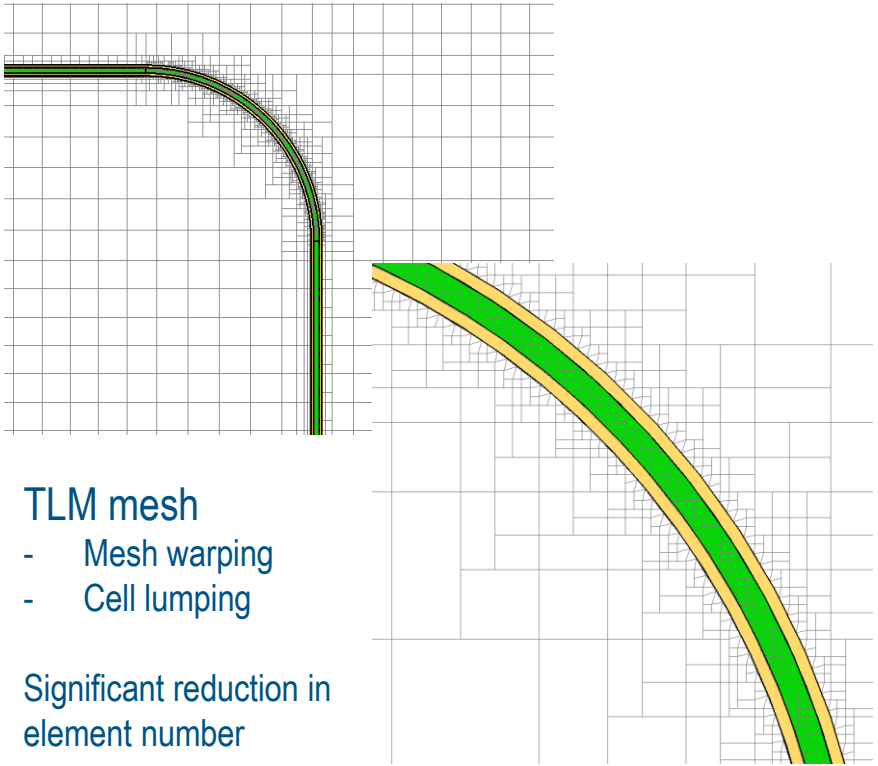
CST Studio Suite

- Mesh and solver are closely related
- Time domain simulation has an advantage for wide band applications
  - Input a time domain pulse which represents a wide band frequency data
  - Automatic Fourier Transform to convert to frequency domain
  - Time domain solver uses hexahedral mesh
  - Further development to use TLM solver technology

Hexahedral and TLM Meshing



Hexahedral mesh
- Perfect Boundary Approximation
- Thin Sheet Theory



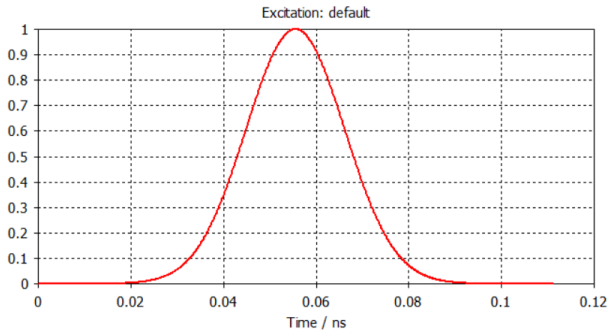
TLM mesh
- Mesh warping
- Cell lumping

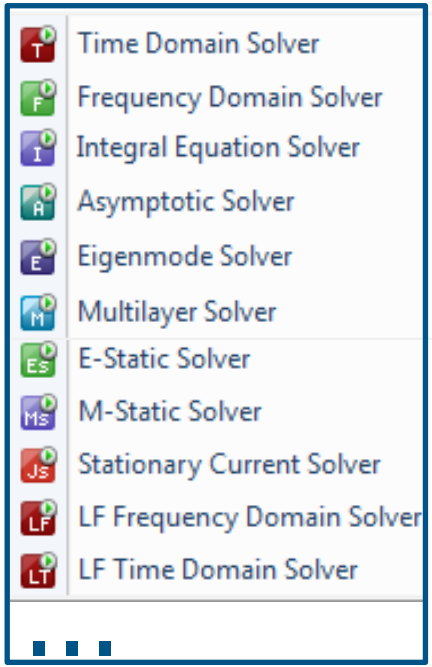
Significant reduction in element number

Solver

High frequency, broadband simulation

- Solver must be suitable for wideband simulation up to 32 GHz
- CST Studio Suite has a toolbox of different solvers
  - Always have the right tool for the job
- Time domain solver is a good a good choice
  - Well suited to high frequency, broadband simulations
  - Excited with a broadband pulse





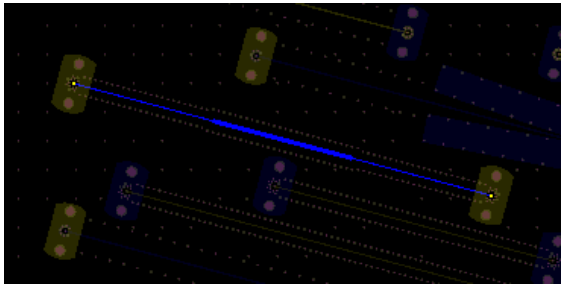
SIMUTECH 士盟科技

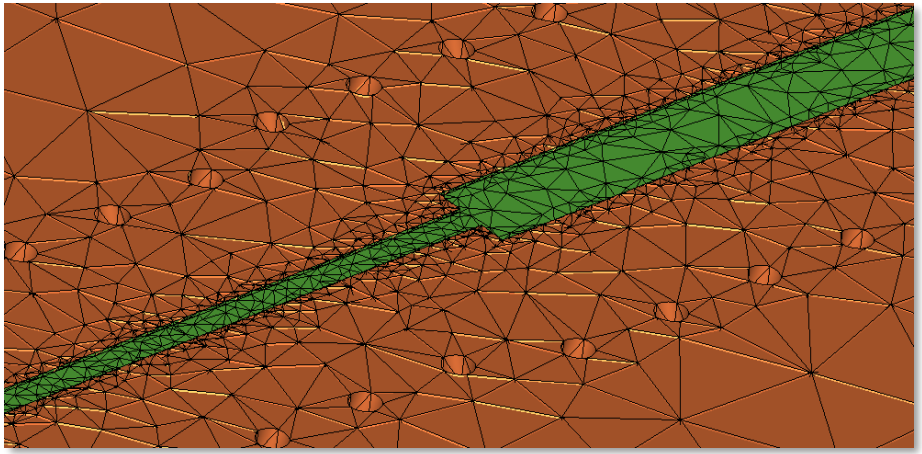
SIMULIA

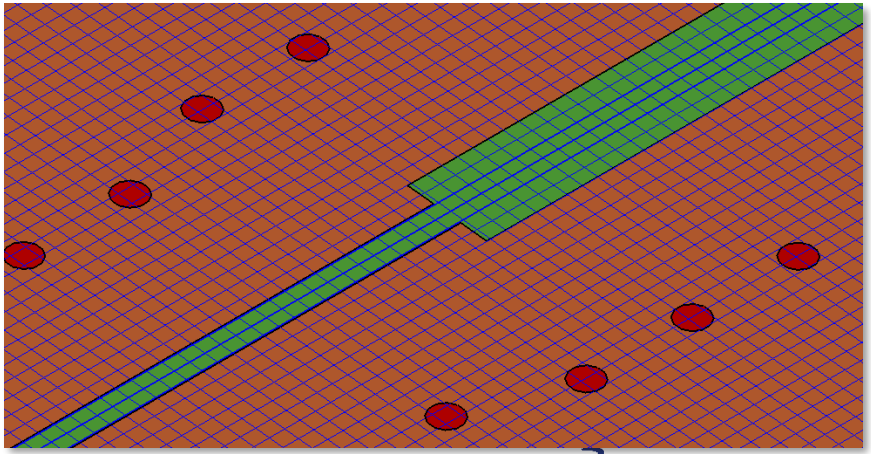
Solver Choice

- 25 Ω Beatty Standard stepped impedance transformer

* Not to scale

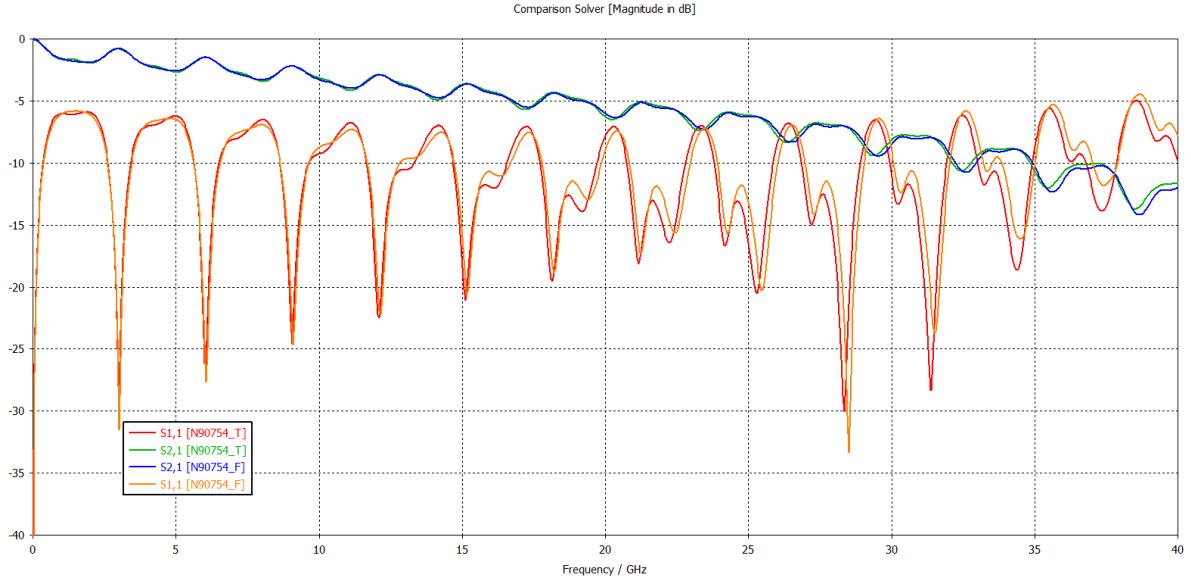


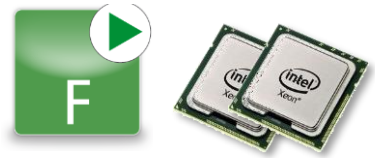


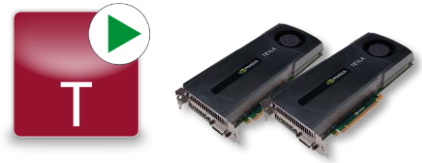


Solver Choice

Complete Technology







SIMUTECH 士盟科技

SIMULIA

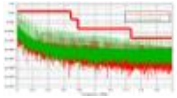
Summary

- Increasing demand for throughput in cables, PCBs and connectors
- Simulation is required in the design phase, in order to meet these requirements
- Accurate simulation using 3D models, datasheets, testing, data files
- CST Studio Suite is the ideal tool to realise the simulation
  - Time domain simulation
  - Hexahedral and TLM meshing
  - Cable Studio
  - EDA import
  - Circuit and 3D EM co-simulation in Design Studio

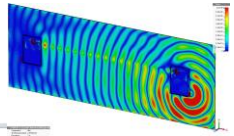
ELECTRONICS DESIGN ANALYSIS

Overview

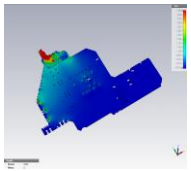
Circuit-EMAG Simulation
Multi-scale 3D electromagnetic field solver and circuit simulation takes into account the effect of PCB, connectors, cables and enclosures as well as switching circuits.

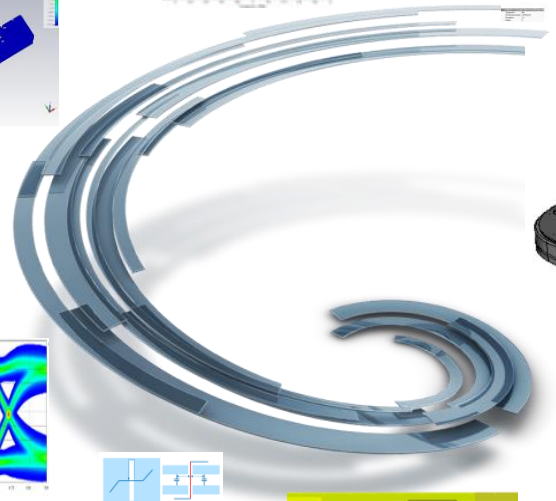


EMC Compliance Check
Compliance and safety - Ensure the product fulfills the required electronic certification standards and works in the intended environment.

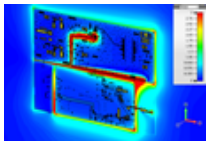


Power Integrity
Simulate DC Drop and High Frequency Noise on power supply nets and optimize decoupling capacitors for impedance minimization.

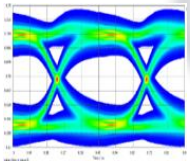


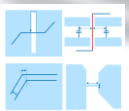


EMAG PCB Losses
Make sure the PCB is working efficiently and according to the specifications.

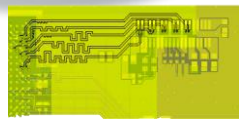


Signal Integrity
Predict the reliability of serial high-speed (PCIe, SATA, ….) and parallel data (DDRx) links.

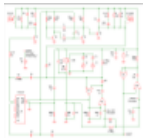




Design Rule Checker
Verify that layout rules to prevent SI, PI and EMC interference are properly applied to printed circuit board.



3D Layout Import
Validate PCB Designs.



Circuit Simulation
Rapid and easy prototyping.

SIMUTECH 士盟科技

SIMULIA

歡迎聯絡我們

士盟科技股份有限公司

www.simutech.com.tw

台北 02-2511-7600

台中 04-2452-7874

士盟粉絲團