Bridging the Gap Between Electrical and Mechanical, and More

An-Yu Kuo, PhD
Sr. Group Director
October 2018

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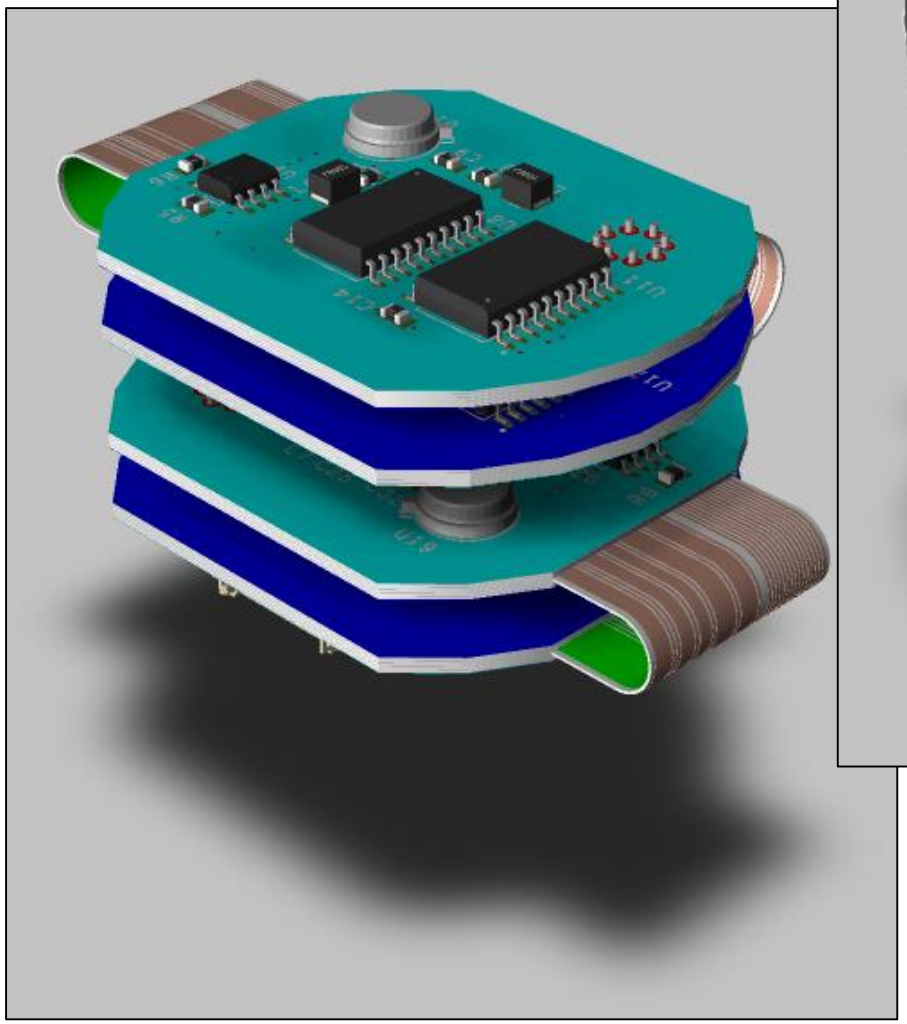
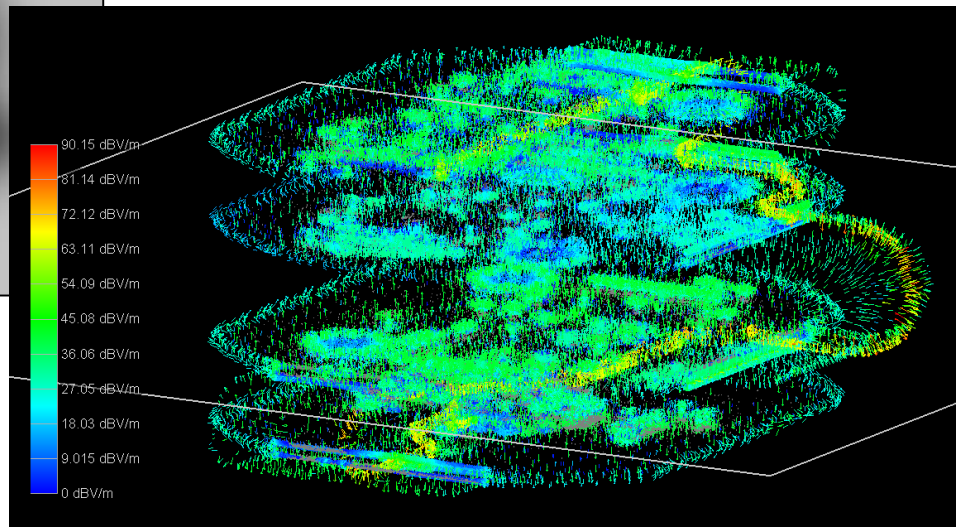
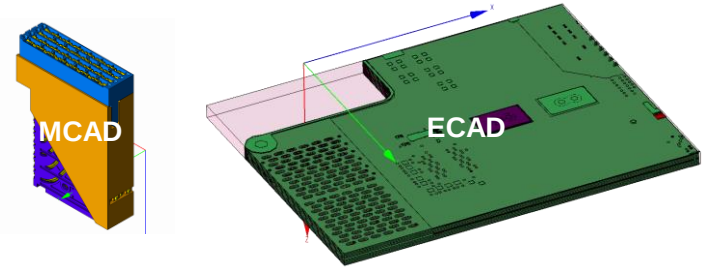
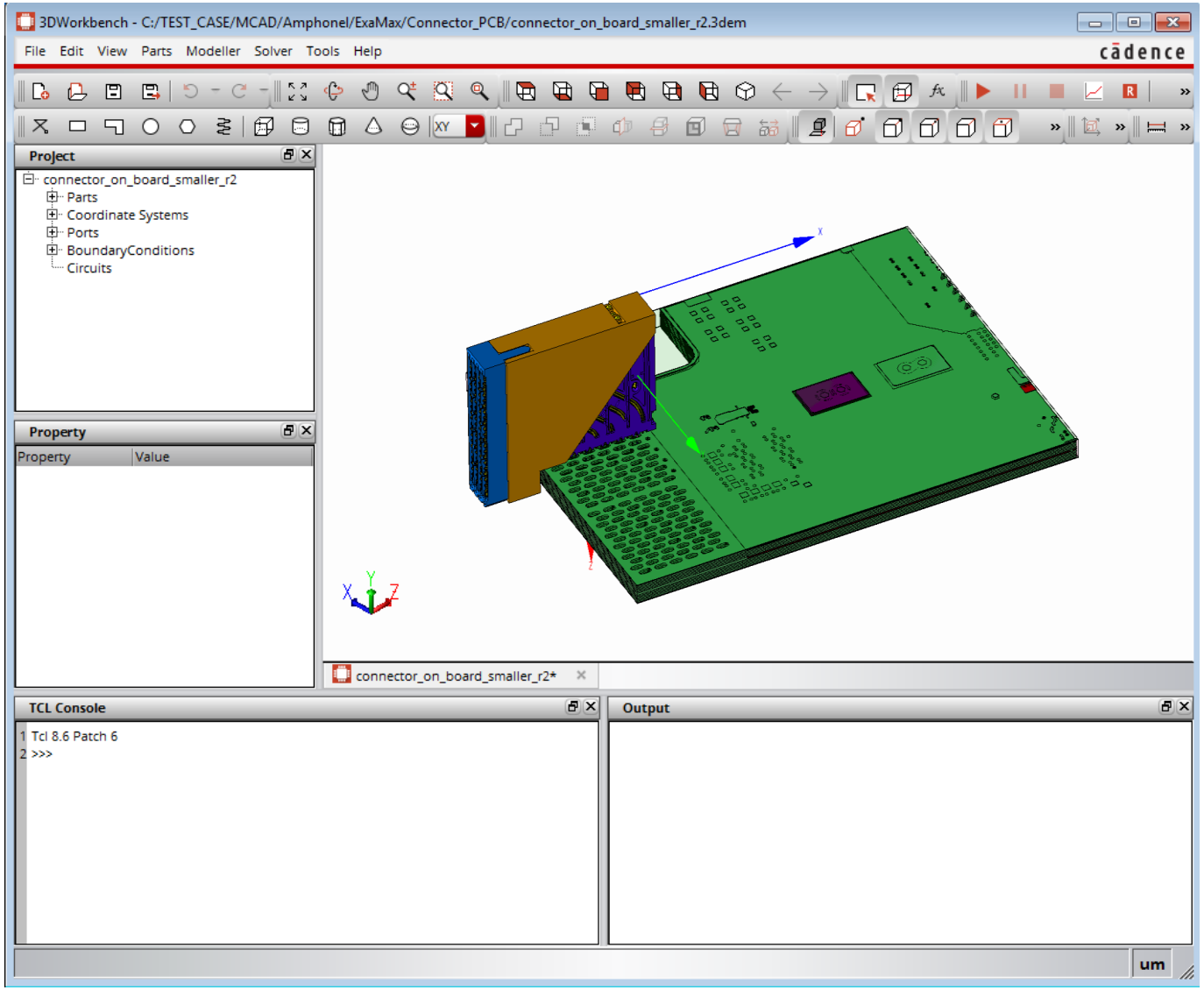




Three Challenges for Modern System Design Tools



- Connect MCAD designs and ECAD designs together for engineers of all disciplines
- Enable engineers of all disciplines to meet multi-physics design requirements
- Automation, automation, automation



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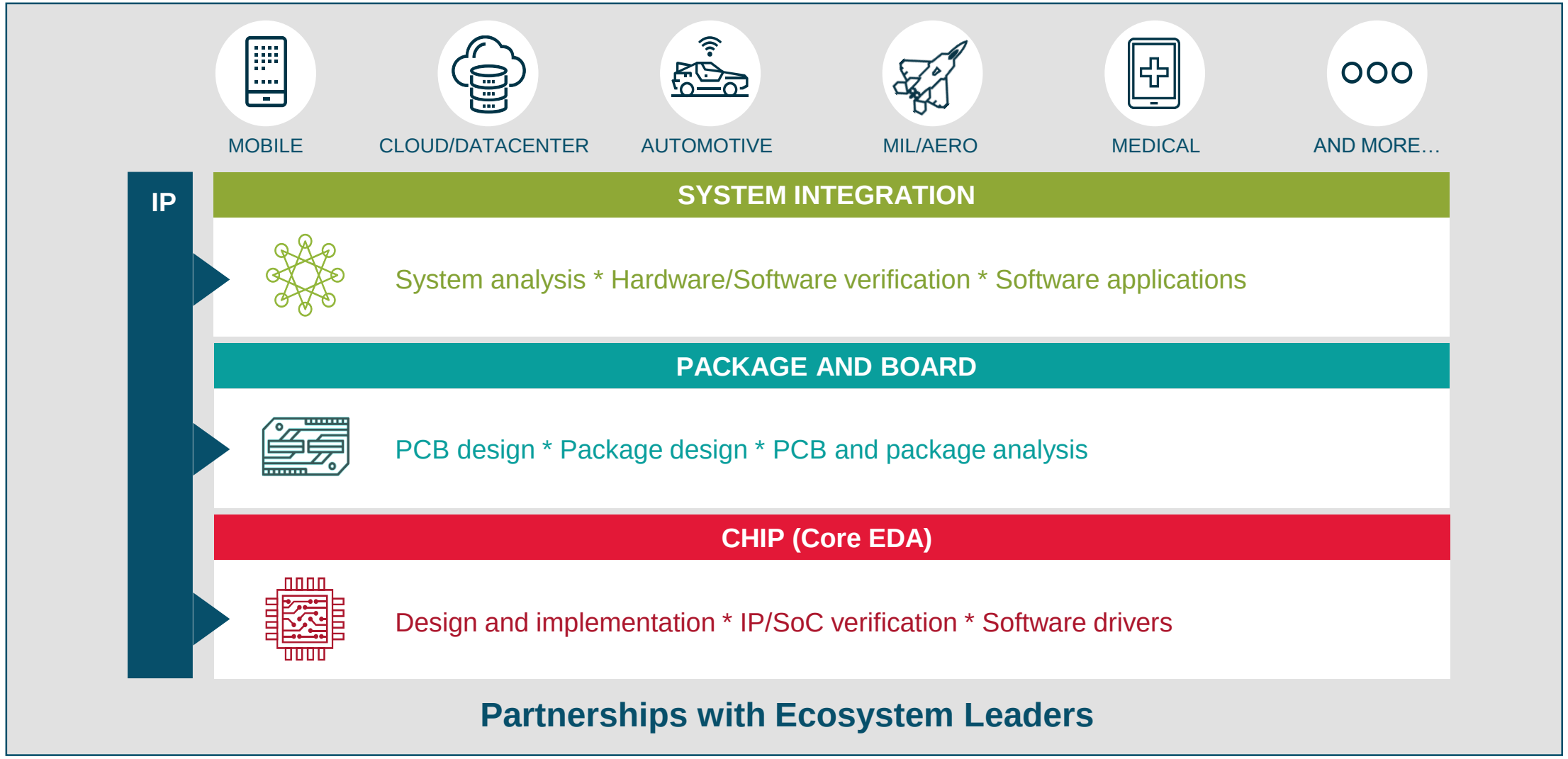
Outline

- System Design Enablement
- Integrated ECAD/MCAD for System Design Optimization
- Multi-Physics Co-Simulation
  - Novel System-Level Thermal Solution
  - Efficient and Accurate System Level-Level EMI Solution
- Tight Integration of Design/Simulation Tools

System Design Enablement: Connection, Interaction, Integration



System Design Enablement

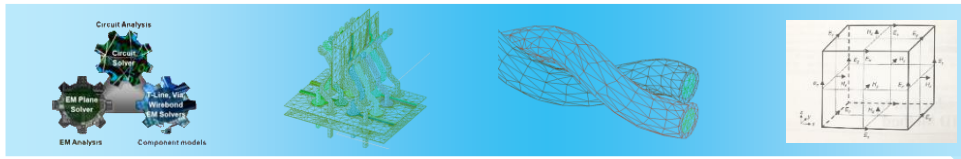
Convergence of technologies

Hybrid Solver

Finite Element Method

Boundary Element Method

Finite Difference Method



Solver Technologies

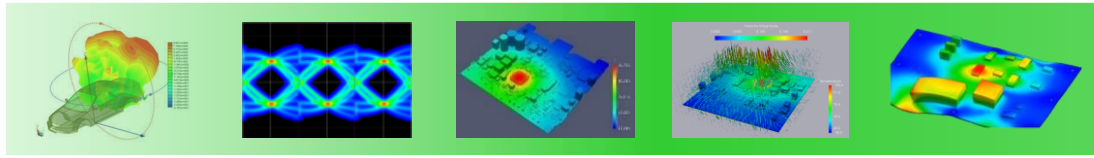
Electro-Magnetics

Circuit Analysis

Heat Transfer

Fluid Dynamics

Solid Mechanics



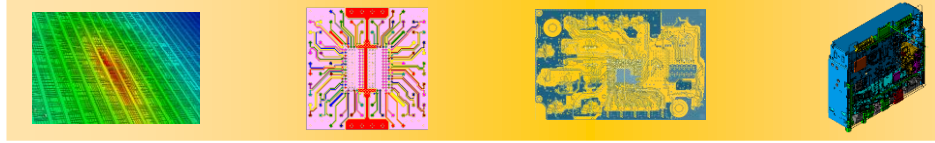
Multi-Physics

Chip
- GDSII
- OA

Package
- Allegro PD/SiP
- DXF

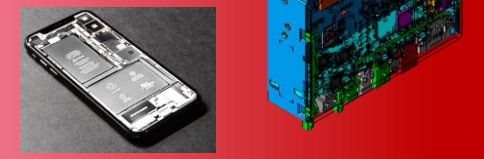
Board
- BRD
- ODB++

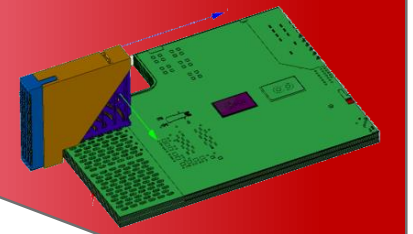
Chasis
- STEP
- ACIS



Design Interfaces

System Design Optimization





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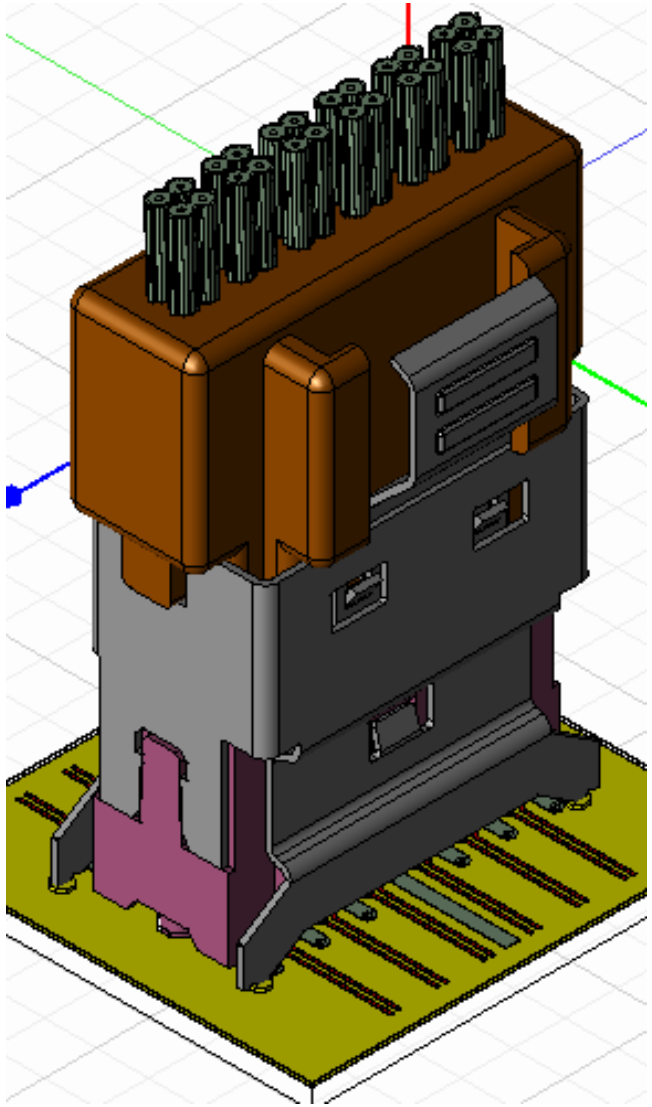
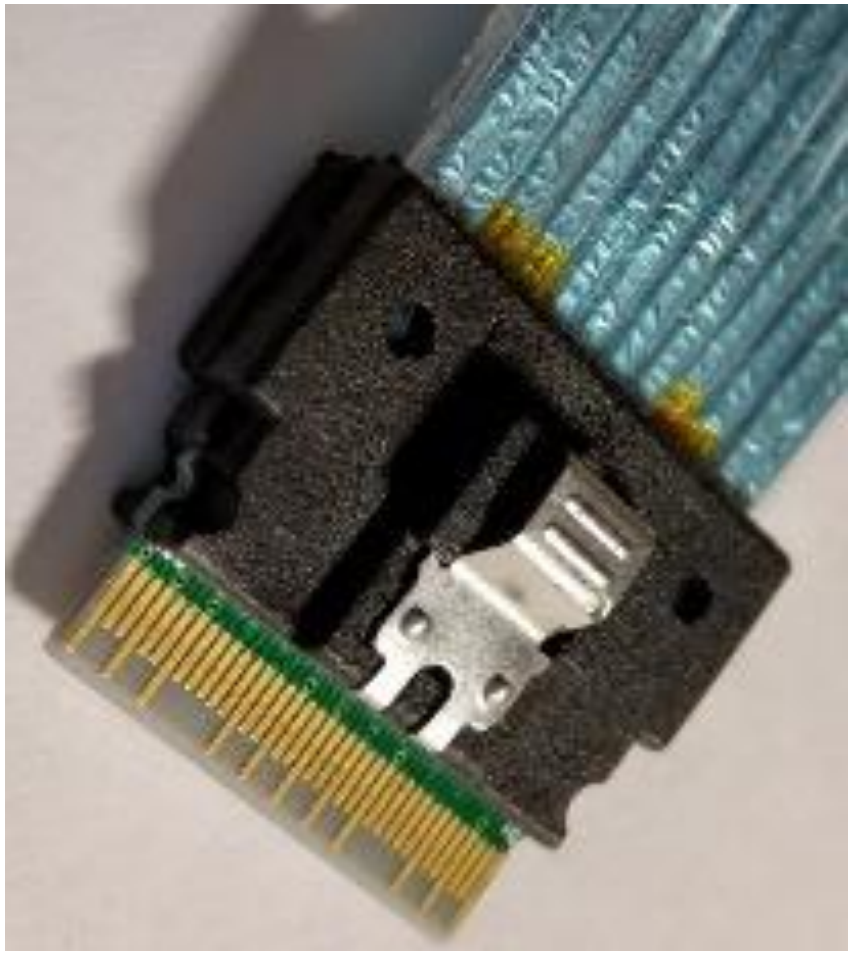
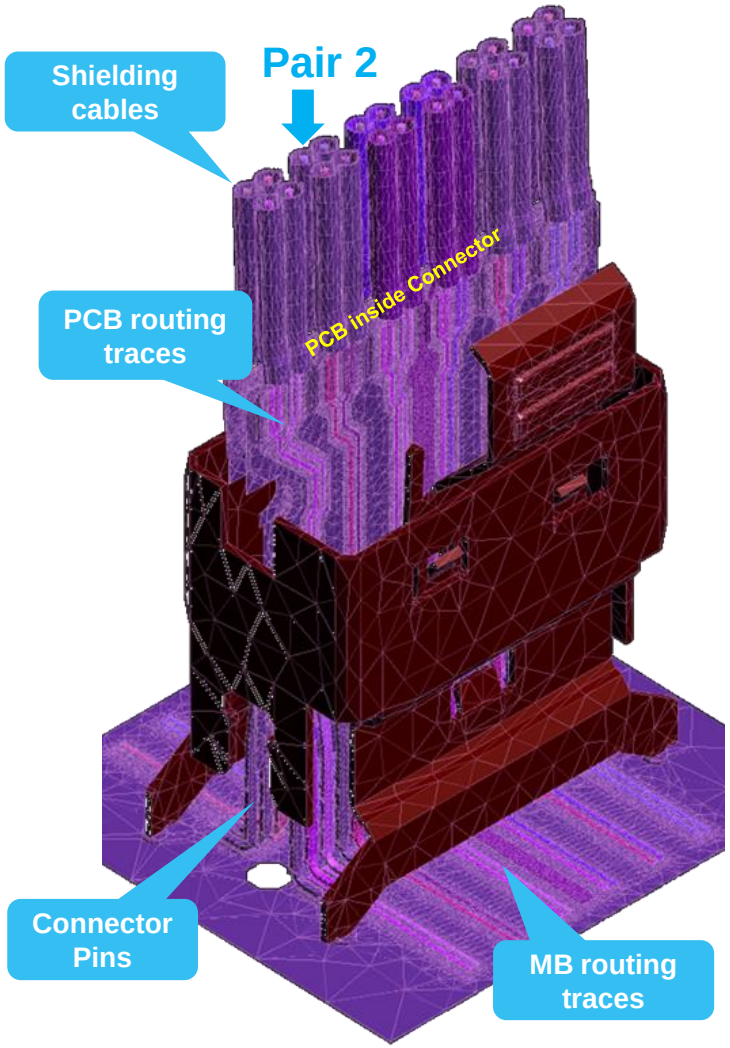
PCIe 8Gbps or SAS 12Gbps

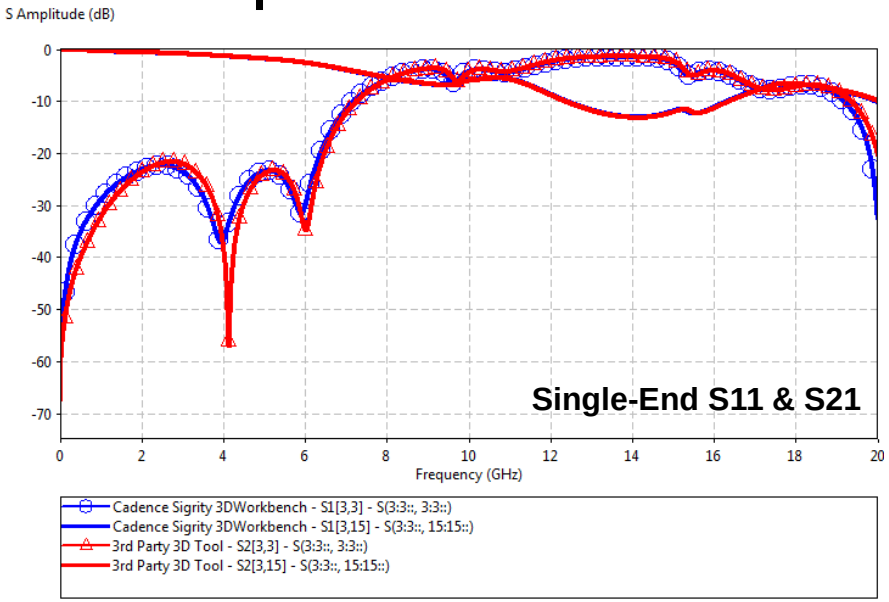


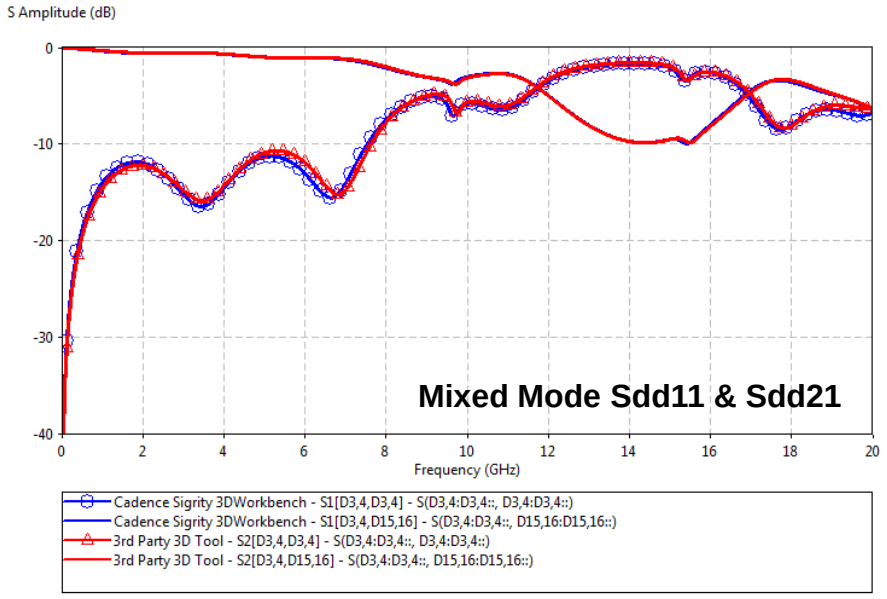


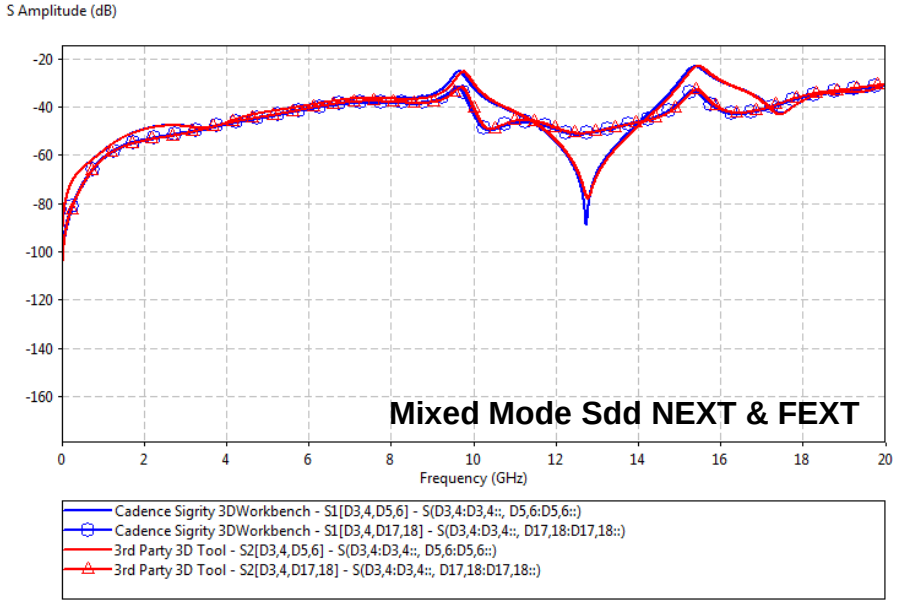
PCIe 8Gbps or SAS 12Gbps

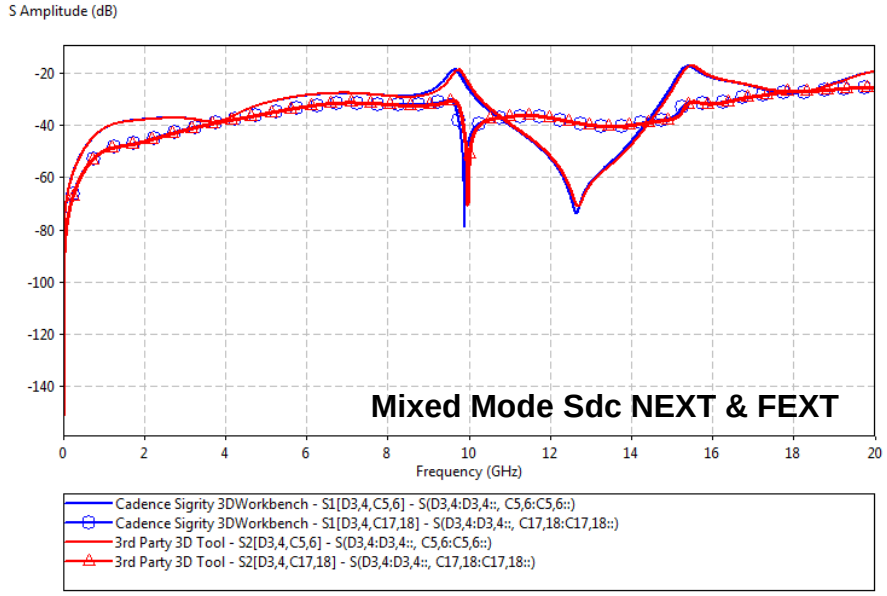
Correlation





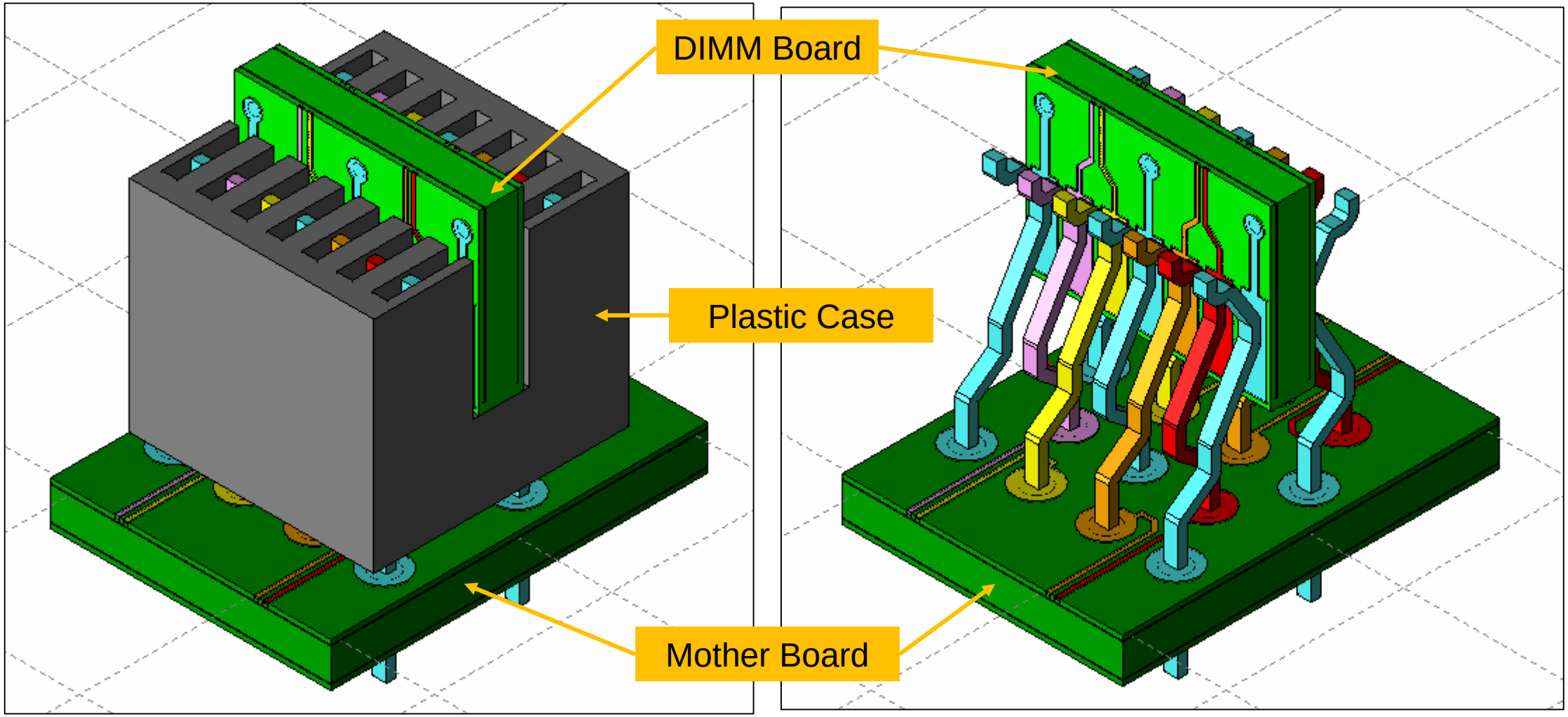






DIMM Connector plus Boards

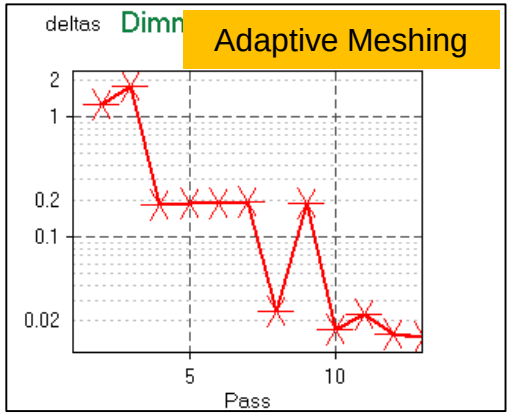
Geometry



DIMM Connector plus Boards

Results and performance

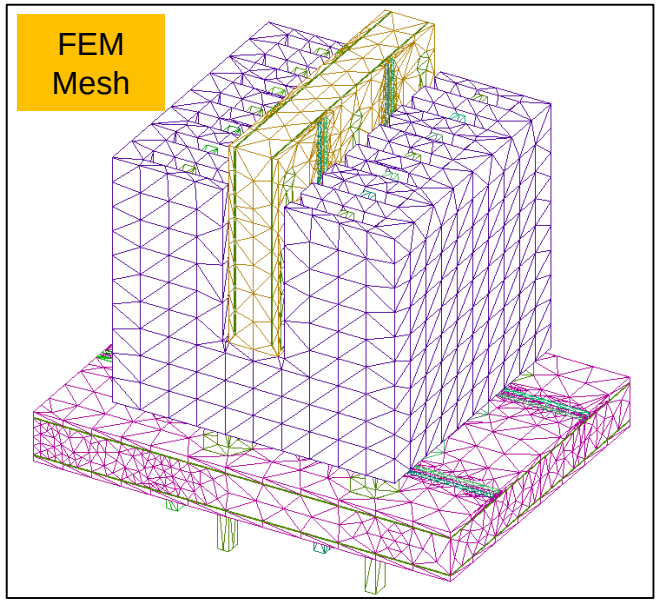
Adaptive Meshing



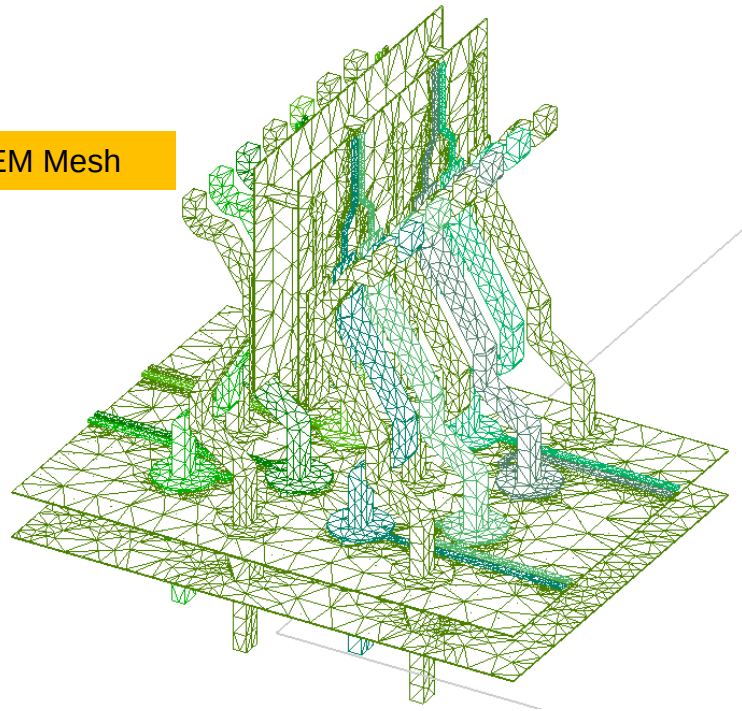
Performance

- Lenovo T560
- 31 min 6 sec
- 13.35 GB peak memory

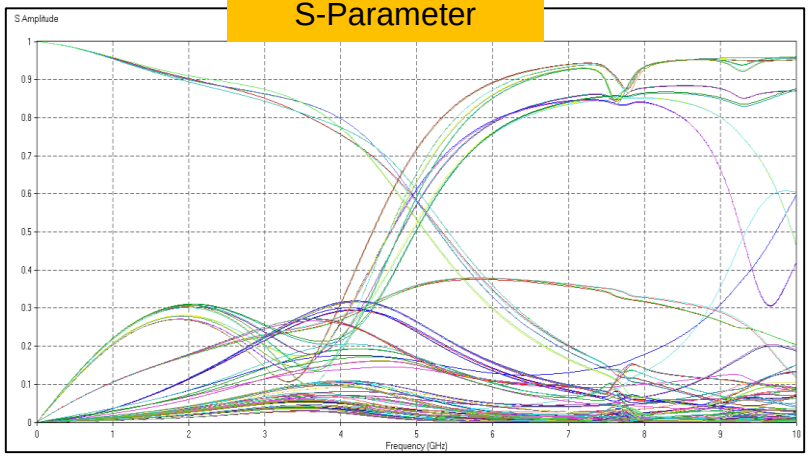
FEM Mesh



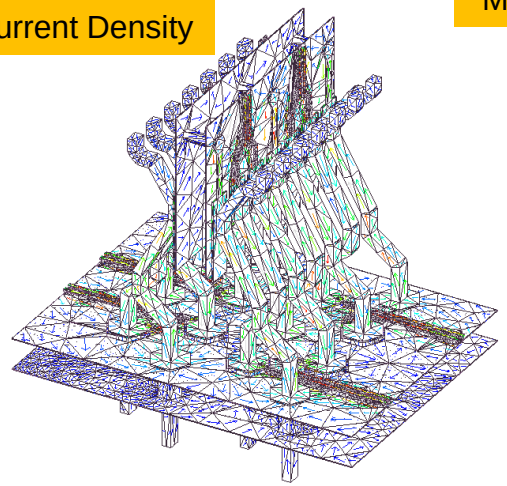
FEM Mesh



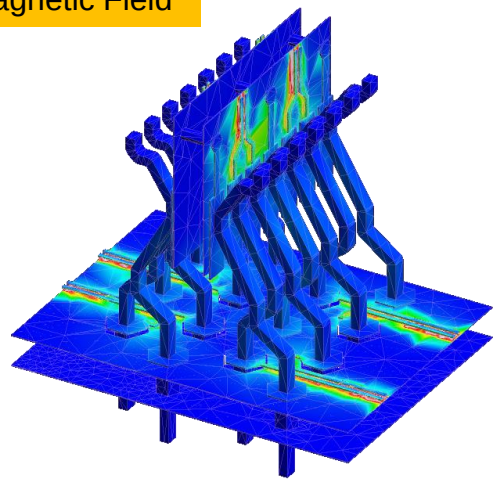
S-Parameter



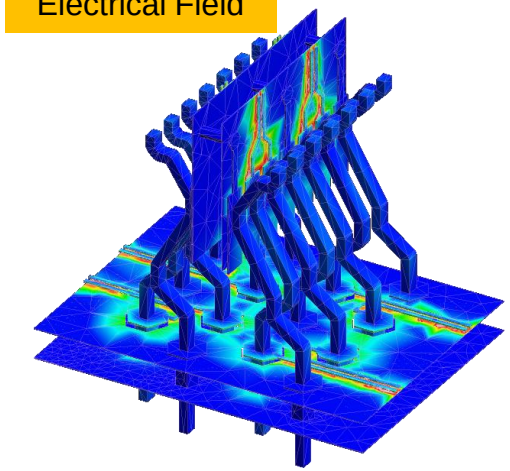
Current Density



Magnetic Field



Electrical Field



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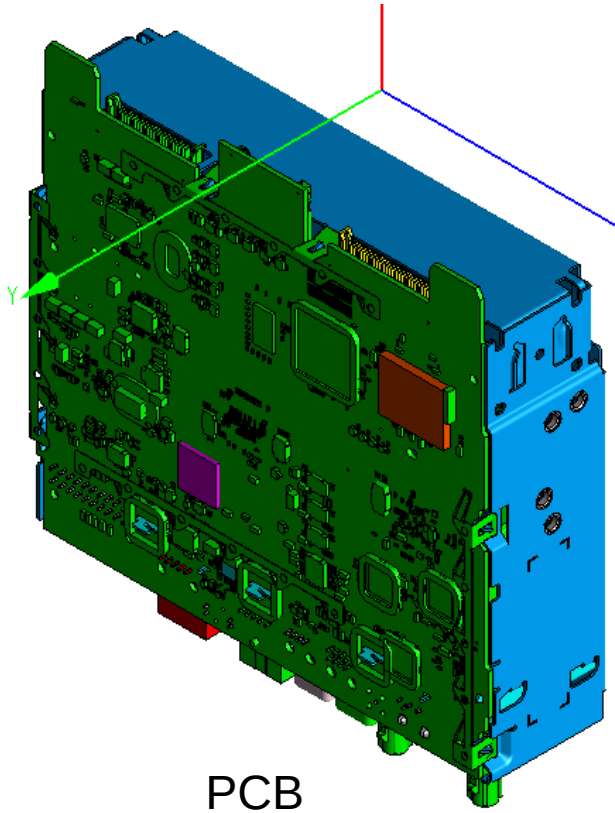
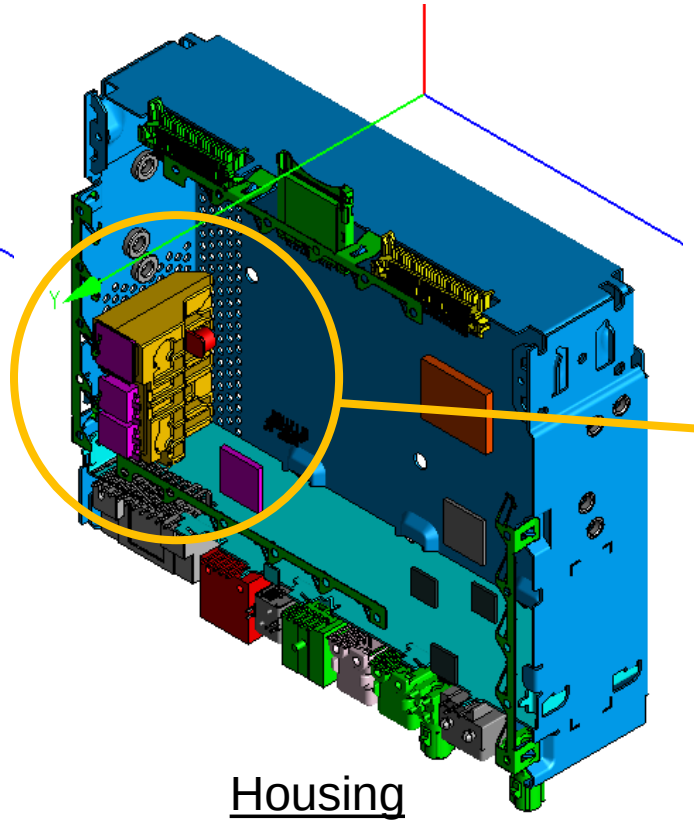
EMI/Thermal Co-Design of an ECU Design



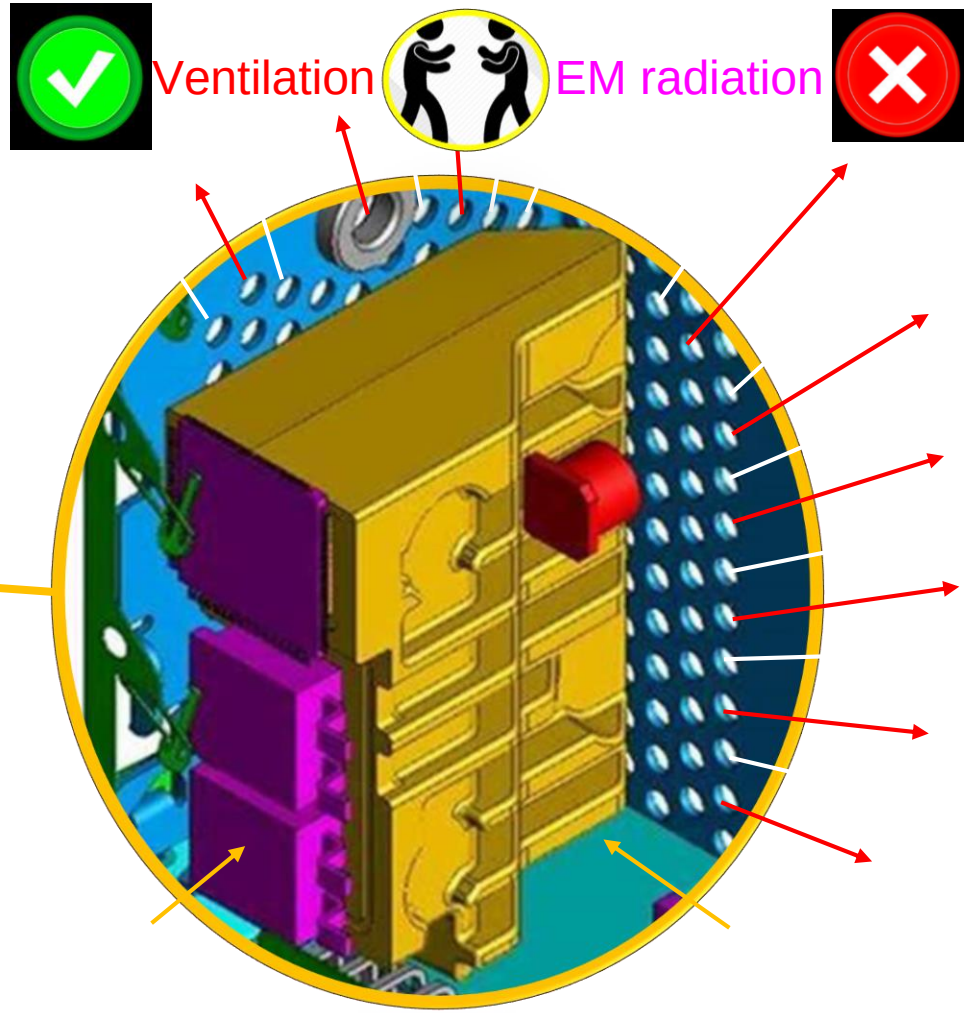
PCB

Multiple EM and thermal aggressors



Housing

EM and thermal internal reflections



Drillings

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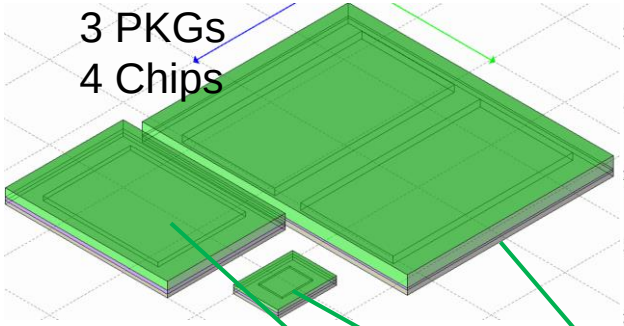
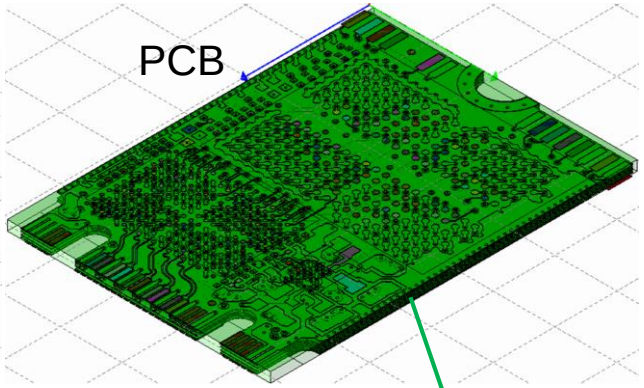
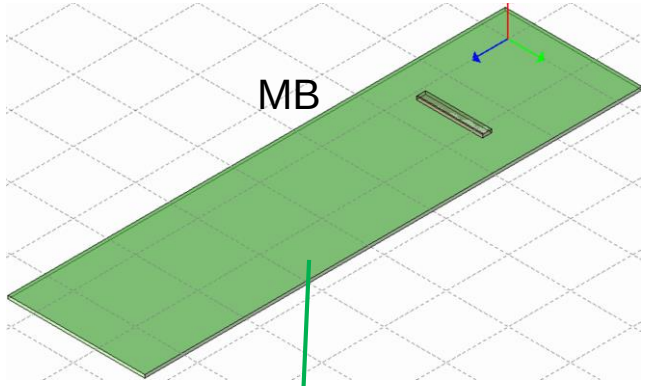
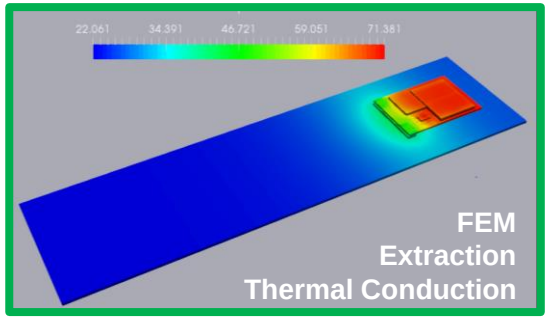
System-Level Transient Thermal

- **Extract thermal models of three PKGs, PCB, and motherboard**



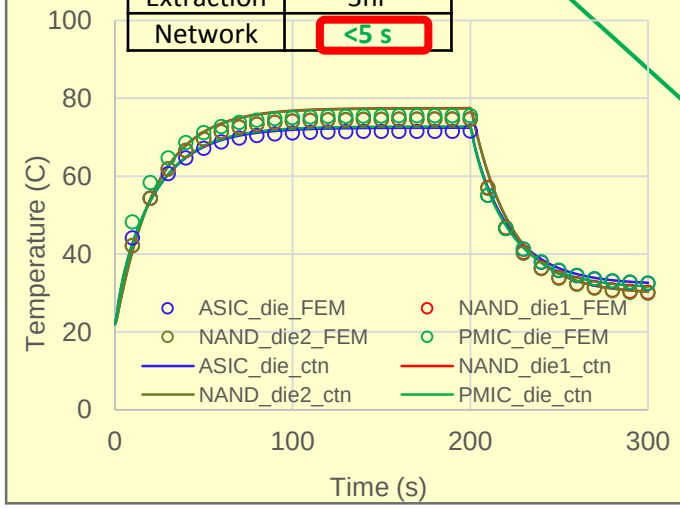


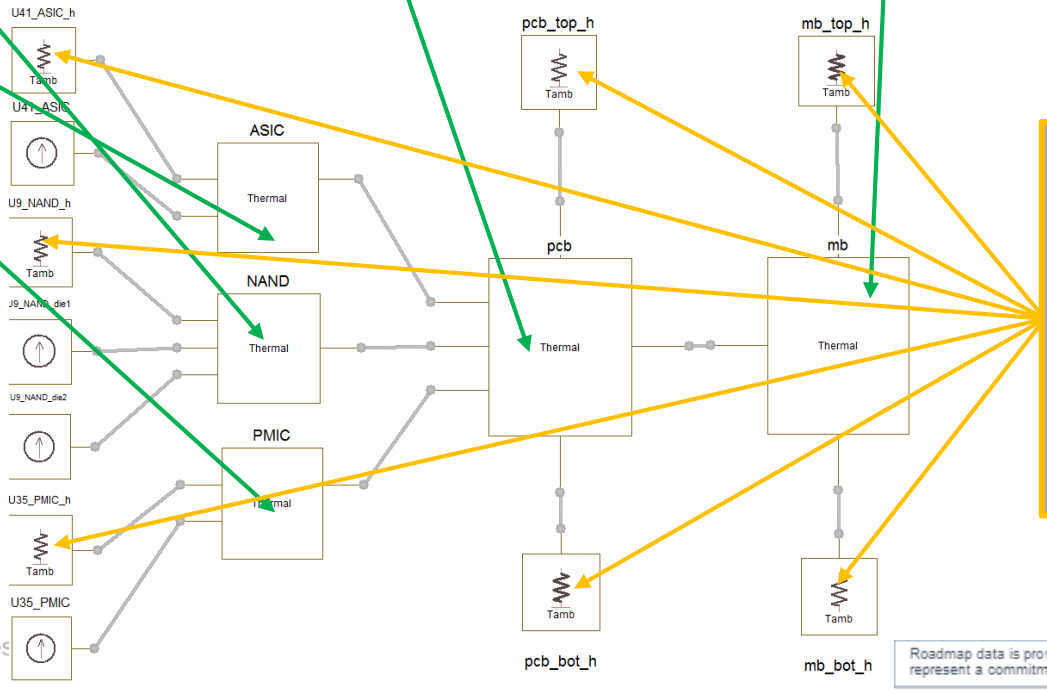


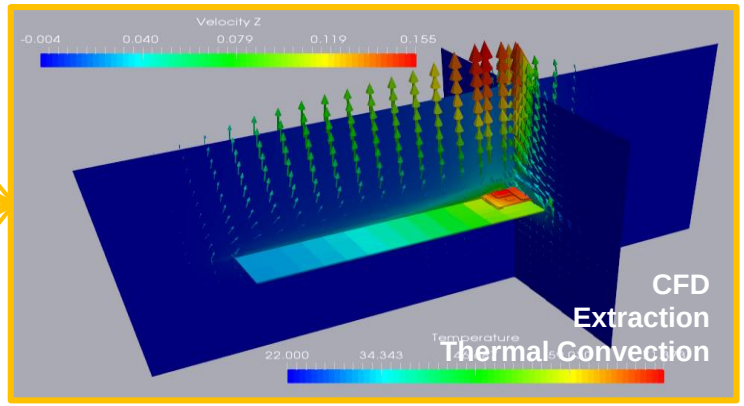


- **Assemble and run a network (3 PKGs + PCB + MB)**

Solver	Time
100% FEM	3hr
Extraction	3hr
Network	<5 s







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A Joint Paper with TI Presented in the 33rd Semi-Therm (March, 2017)

System-Level Electro-Thermal Analysis of $R_{DS(ON)}$ for Power MOSFET

Rajen Murugan[1], Nathan Ai[2], and C.T. Kao[2]

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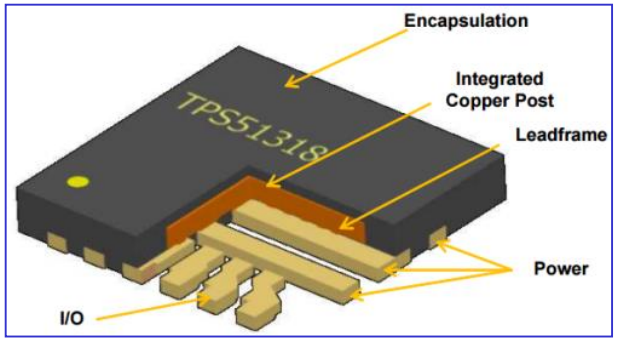
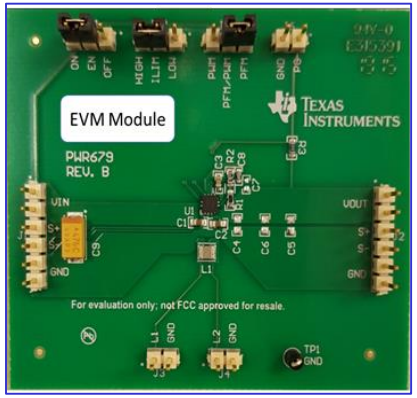
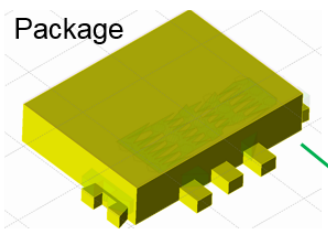
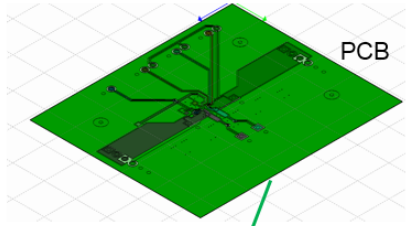
Abstract

A coupled-electro-thermal $R_{DS(ON)}$ (drain to source ON resistance) co-analysis methodology for Power MOSFET is proposed. The methodology contains two functional modules: 1) physical field solvers and 2) equivalent circuit/network solver. The field solver resolves the electrical and thermal field variables by the conventional 3D finite-element method, while the network solver can achieve accurate and efficient results by connecting the equivalent electrical, thermal and flow circuits that are extracted from the system through advanced numerical computational schemes. The integrated equivalent network can then be solved by a generic circuit solver for steady state and transient responses. The methodology is demonstrated, via simulation and measurement, on a 2.5MHz DCDC buck-boost converter. Good correlation between co-analysis methodology and laboratory measurements is achieved.

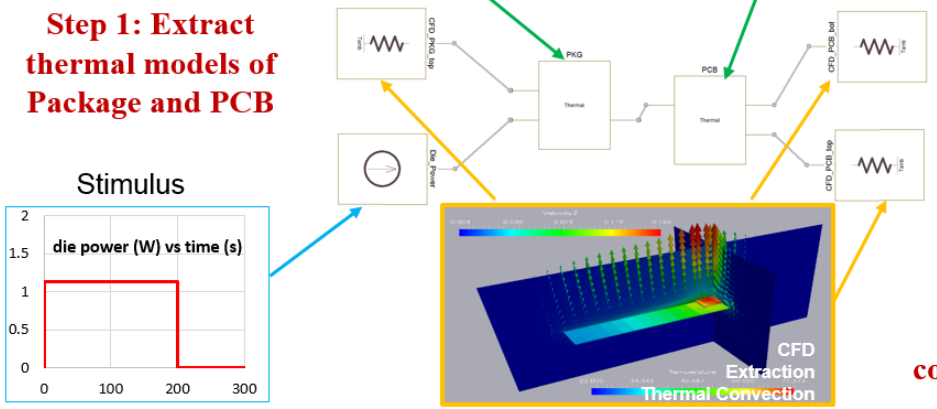






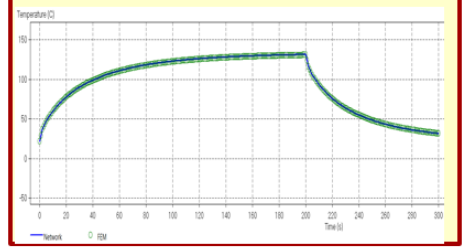


Step 1: Extract thermal models of Package and PCB



Run time comparison

Solver	Time
100% FEM	1.5hr
Extraction	1.5hr
Network	<5 s



Step 2: Assemble and run the combined system thermal network

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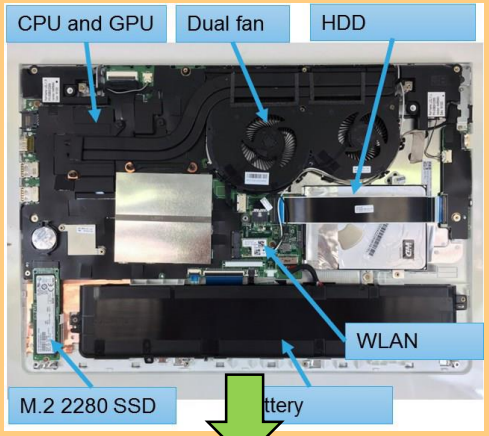
Thermal Innovation: Thermal Model

Modularized, reusable, two orders of magnitude faster

Notebook Computer



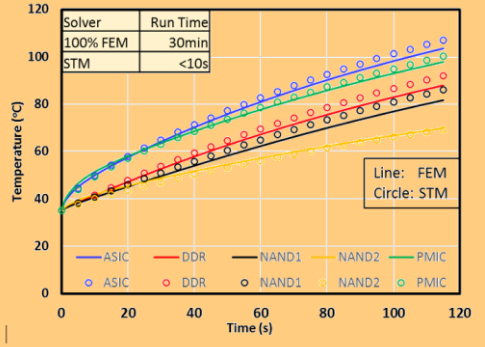
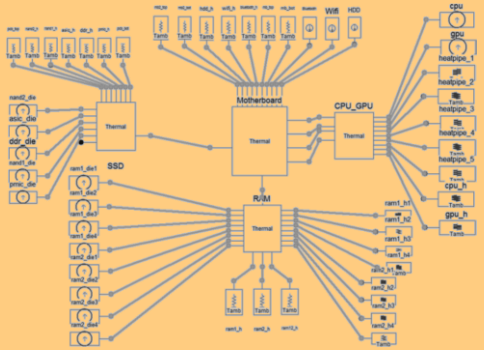
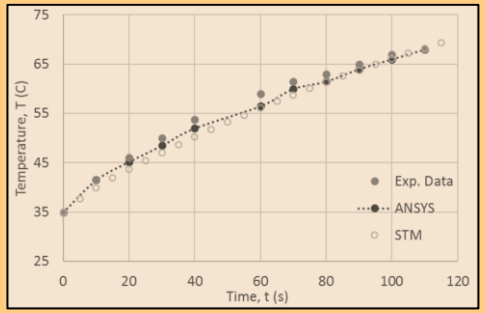


Fig. 11 Transient temperature trends of key SSD components: comparison of network thermal model vs FEM solutions





Server Box

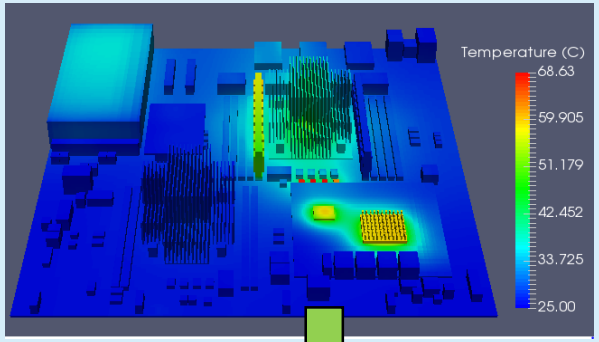
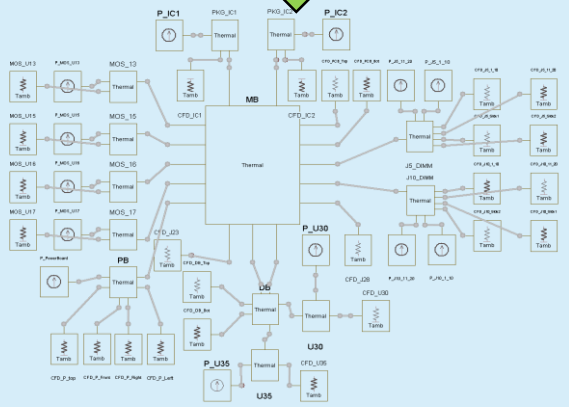
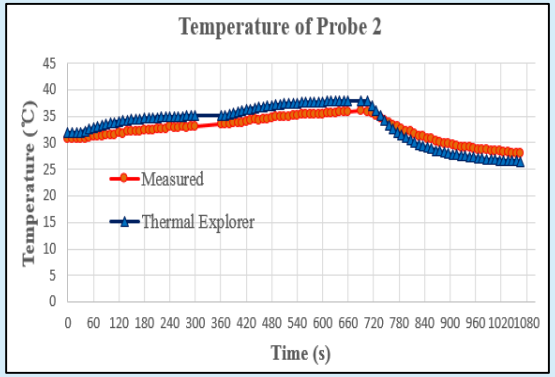


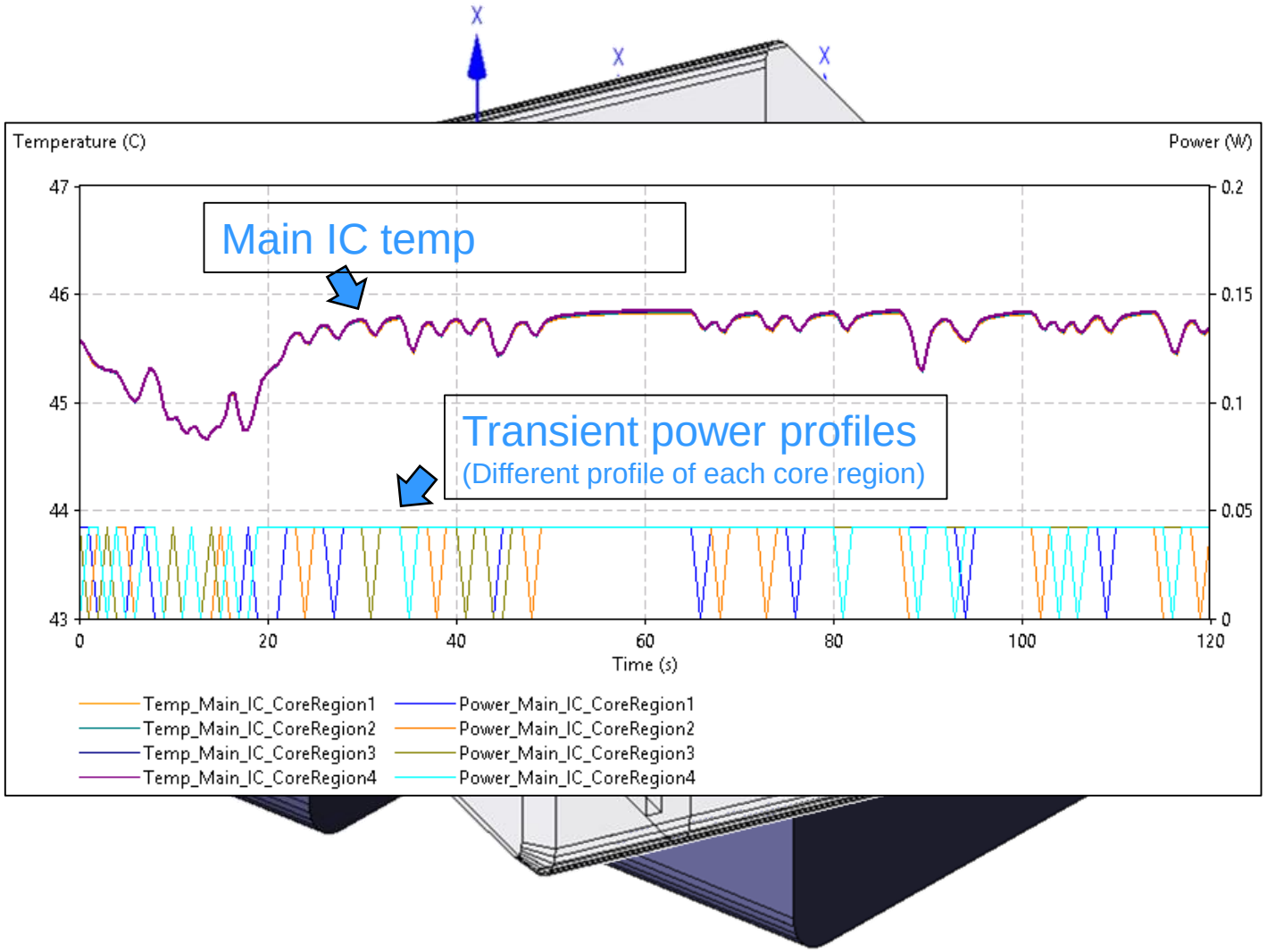
Table 6: Measured and thermal model simulated temperature of different power dissipation.

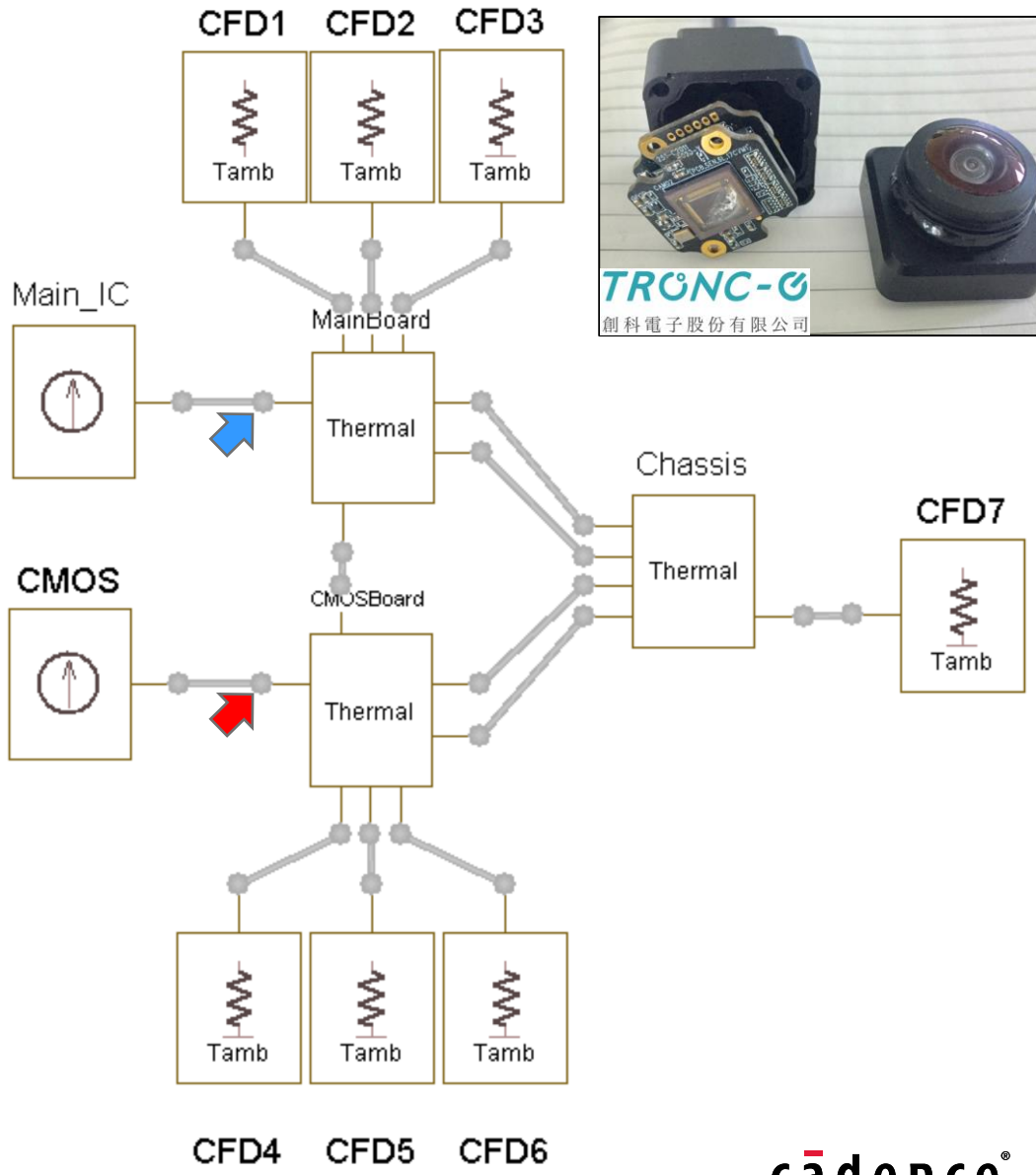
Temp	P1-31W	P2-41.8W	P3-64.5W	P4-82.4W
		Probe1		
Measurement	35.02 °C	39.10 °C	46.86 °C	53.00 °C
Thermal Model	36.40 °C	40.39 °C	47.94 °C	54.31 °C
ΔT_Probe1	**-1.38 °C**	**-1.29 °C**	**-1.08 °C**	**-1.31 °C**
		Probe2		
Measurement	30.60 °C	30.70 °C	34.55 °C	35.75 °C
Thermal Model	30.11 °C	31.74 °C	35.18 °C	37.89 °C
ΔT_Probe2	**0.49 °C**	**-1.04 °C**	**-0.63 °C**	**-2.14 °C**





Thermal Simulation of a Camera Module (TRONC-E)





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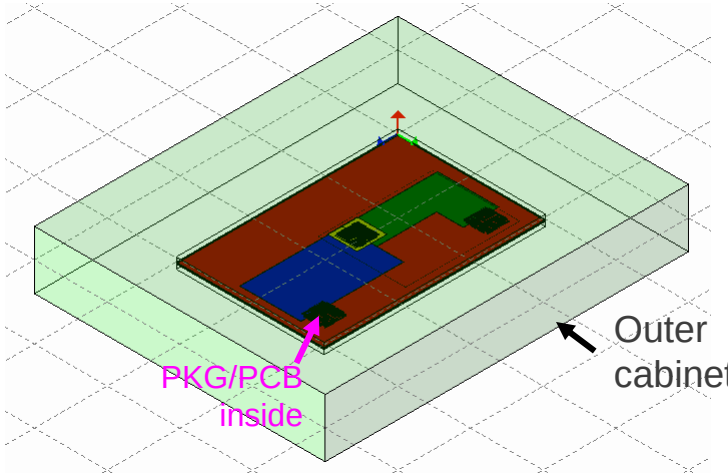
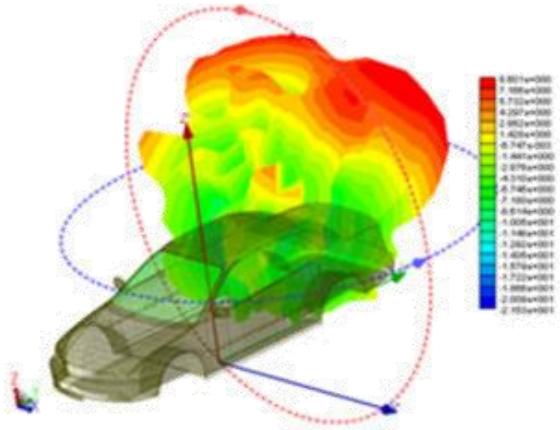
System-Level EMI/EMC Solution

Innovative local/global approach

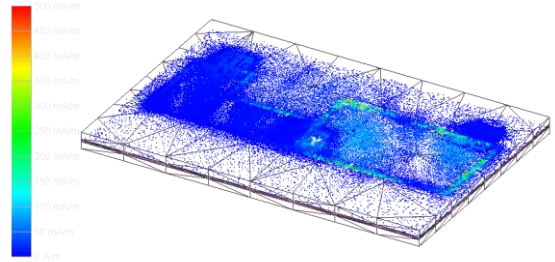
- **Local field EM solvers can model small design feature (vias, wires, ..) precisely, but cannot handle large space problems due to capacity limitation**
- **Global field EM solver can handle large space problems but is not accurate enough for important small design features**





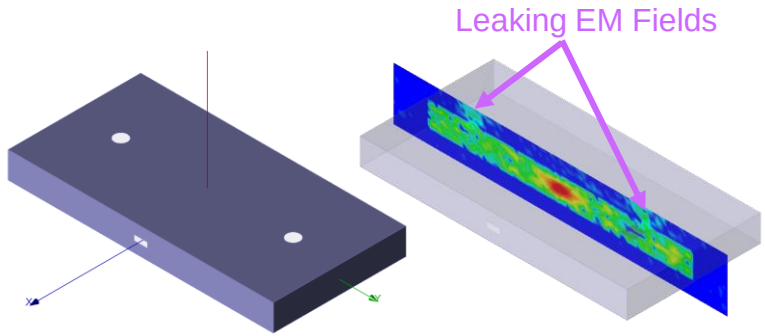
Local Field EM Solvers

- ✓ *Sigrity™ PowerSI® technology* freq domain (hybrid solver)
- ✓ *Sigrity 3DEM* freq domain (3D FEM full-wave)
- ✓ *Sigrity SPEED2000* time domain (hybrid solver)



- Aggressor: Generate and export EM fields on simulation box for use by the global field solver
- Victim: Import EM fields generated by the global solver as boundary conditions

Global Field EM Solver



- Import EM fields on simulation box of aggressor as global field excitation
- Generate and export EM fields on simulation boxes of victims for use by local field solvers

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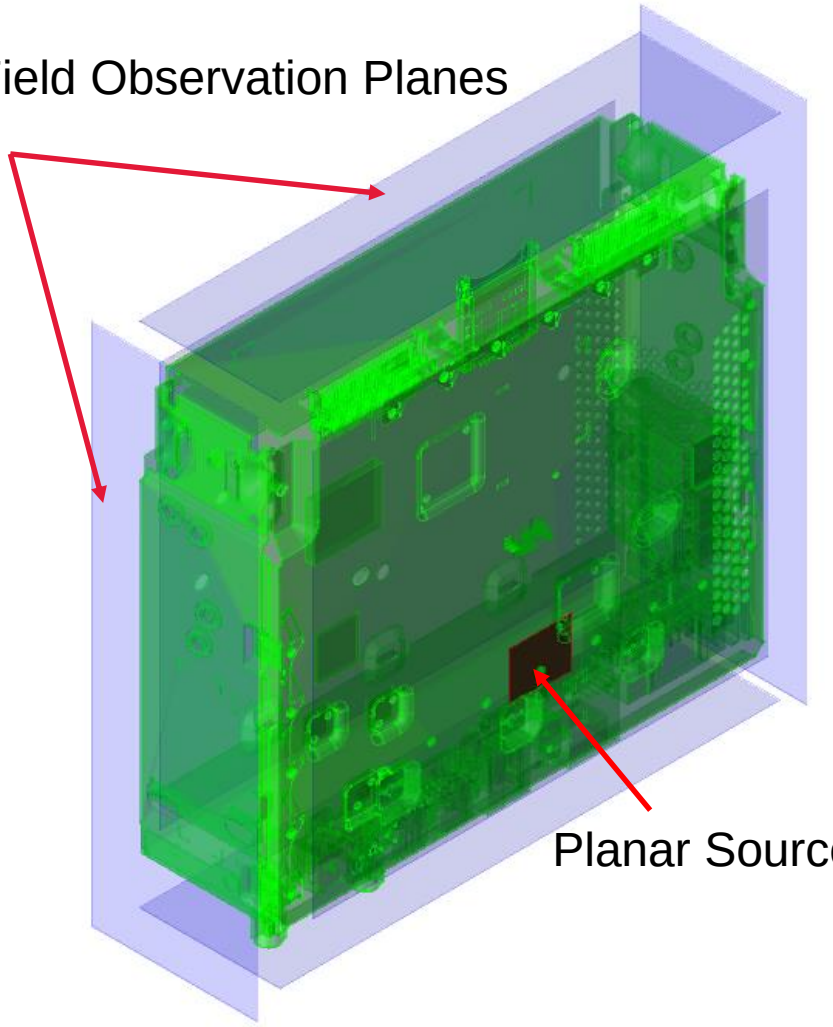
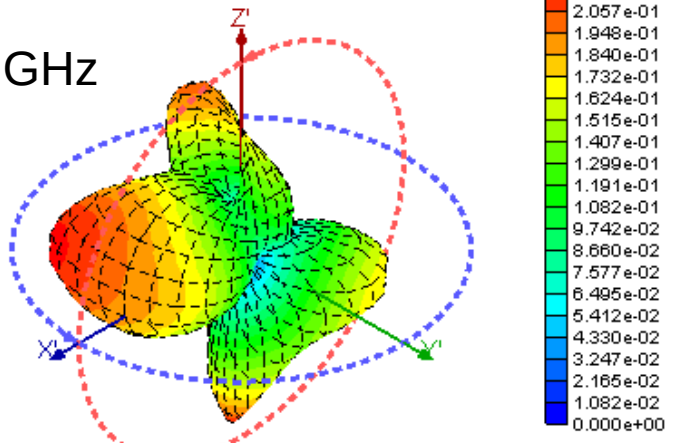
Housing with Red Plane Source (Far Field)

Six Near-Field Observation Planes

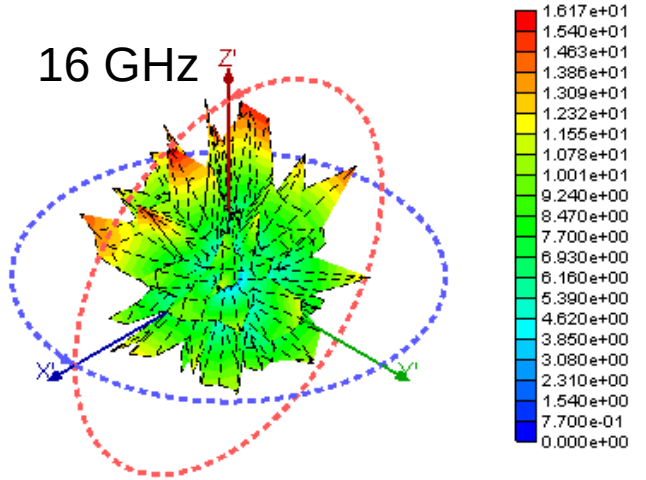


Planar Source

1 GHz

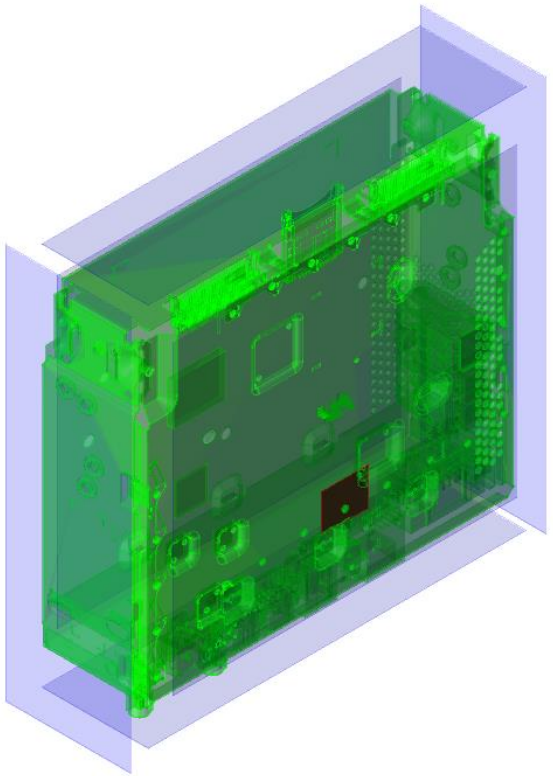


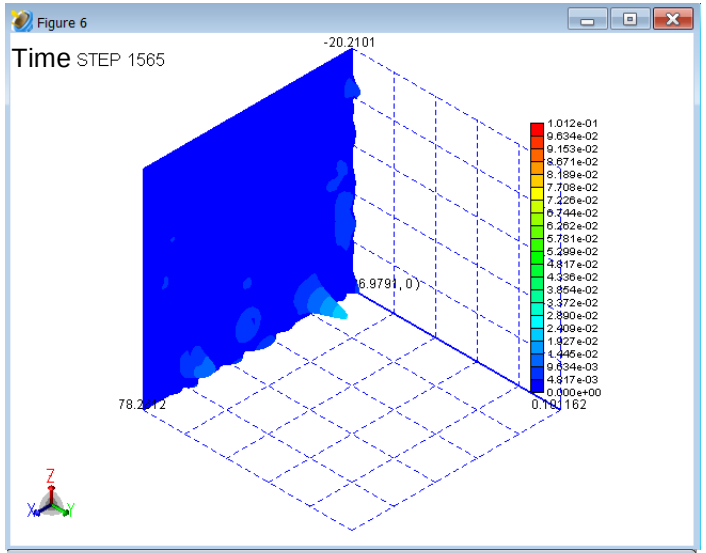
16 GHz

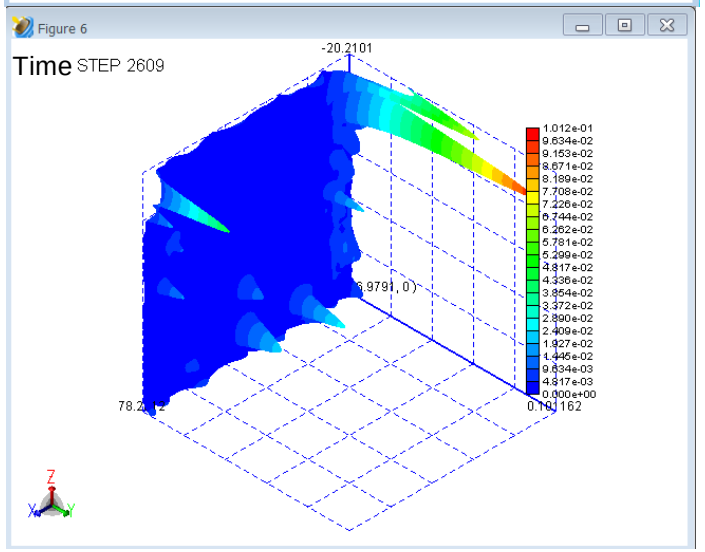


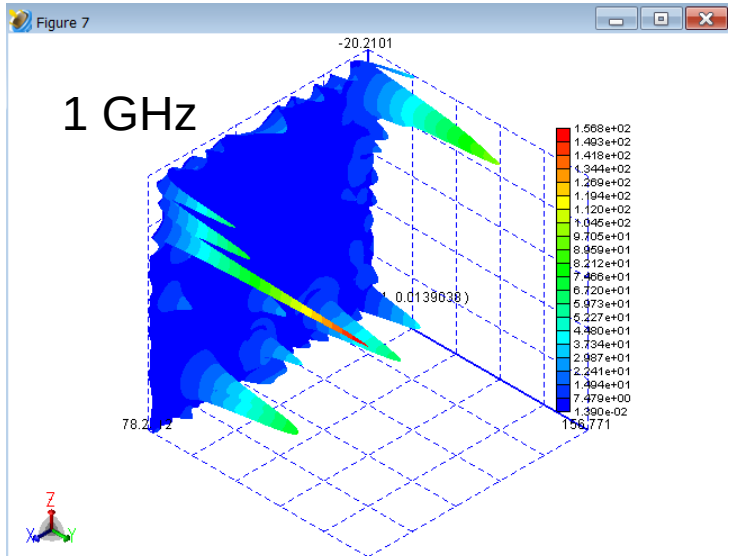
cadence

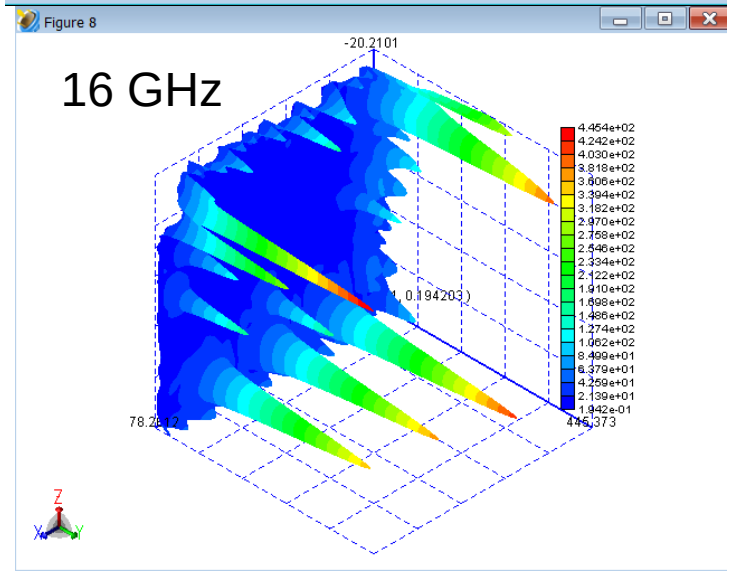
Near-Field Radiation at the XZ Back Plane



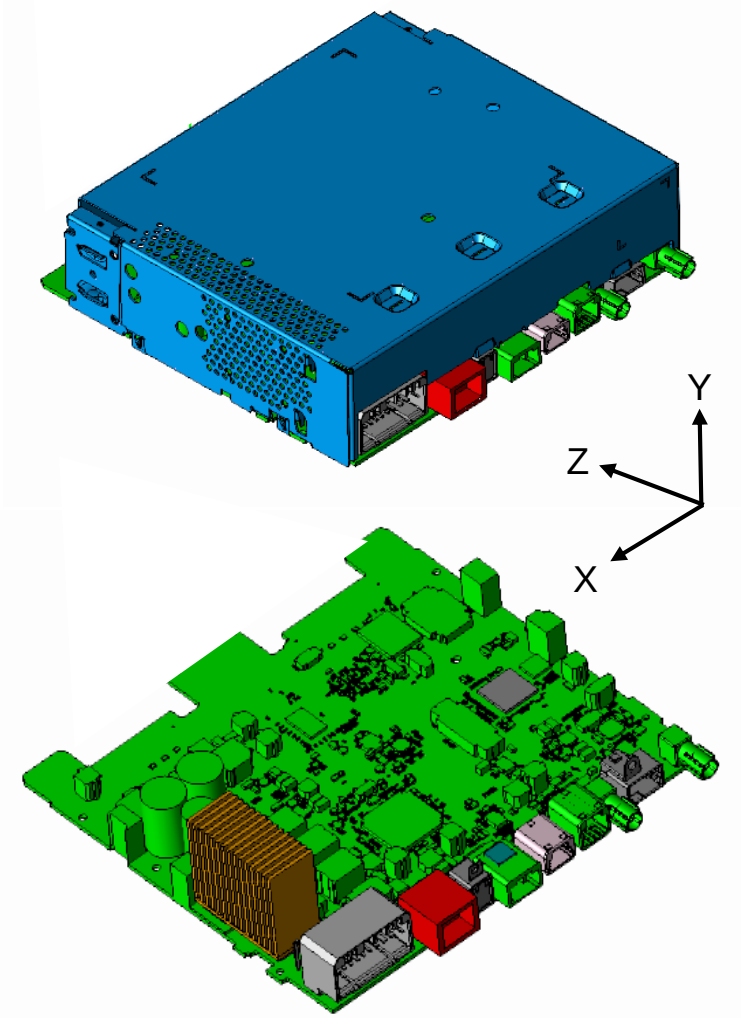


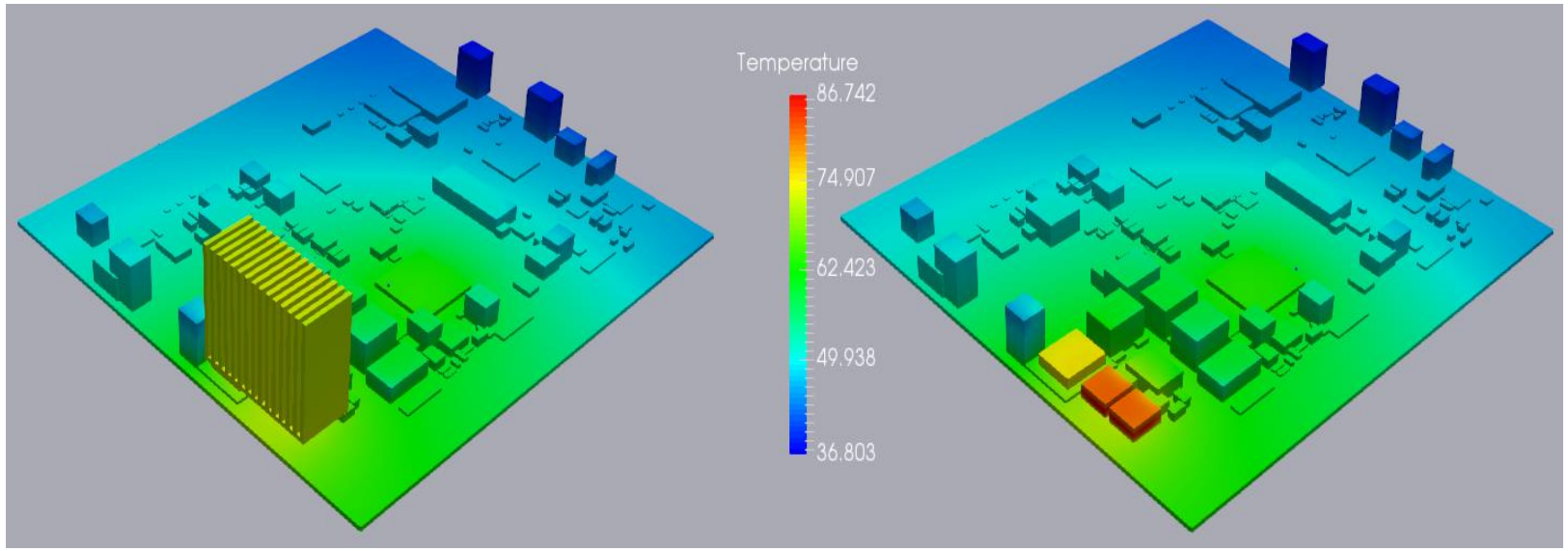


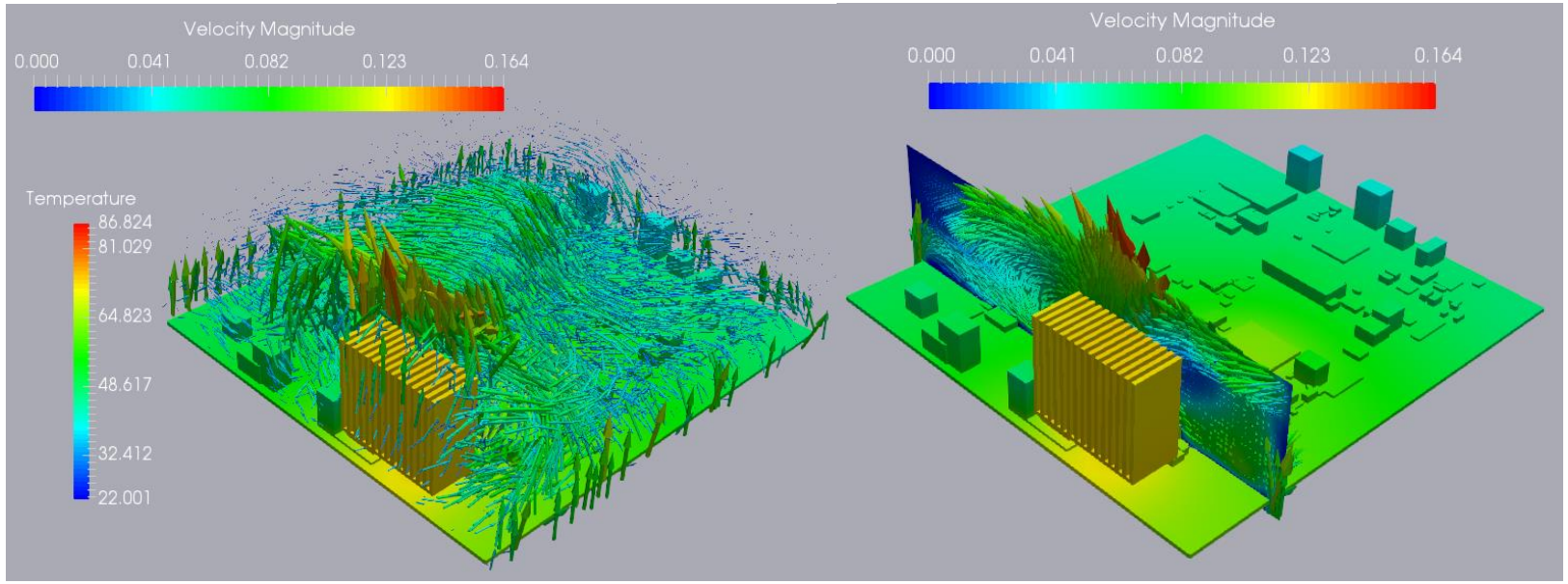




Thermal Simulation of ECU

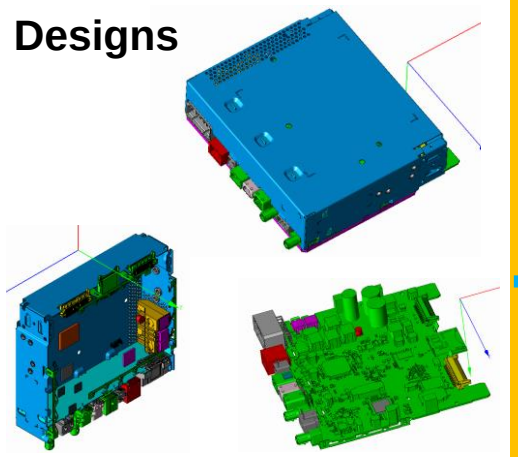




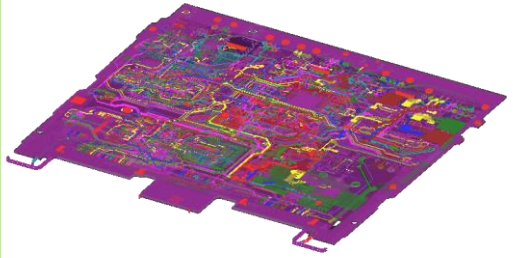


Complete System Thermal and EMI Optimization Flow

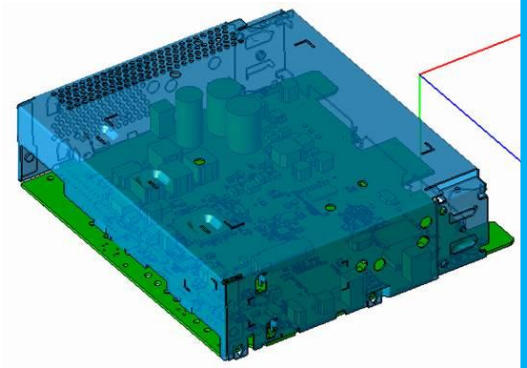
3D MCAD Designs



PCB/PKG Designs

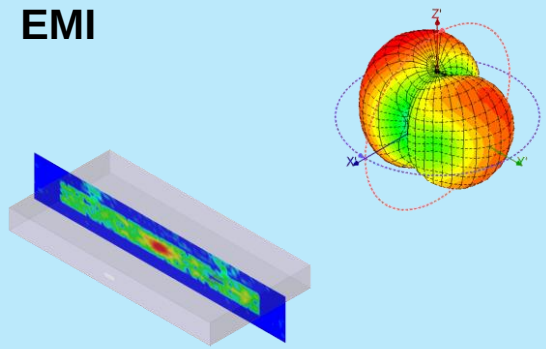


3D Simulation Model

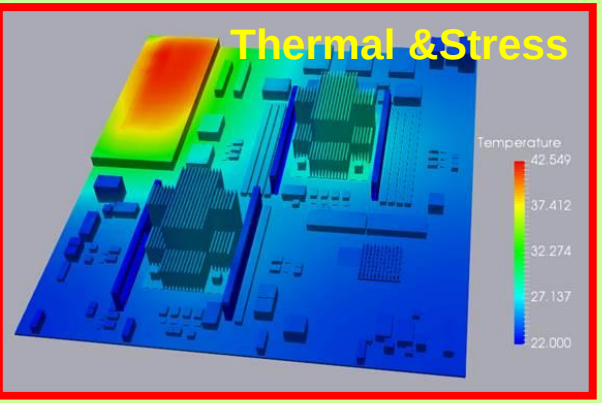


Multi-Physics Optimization

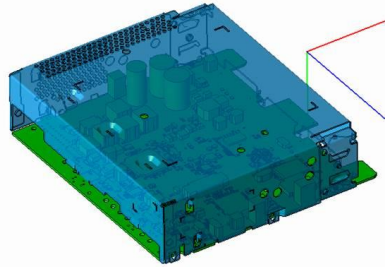
EMI



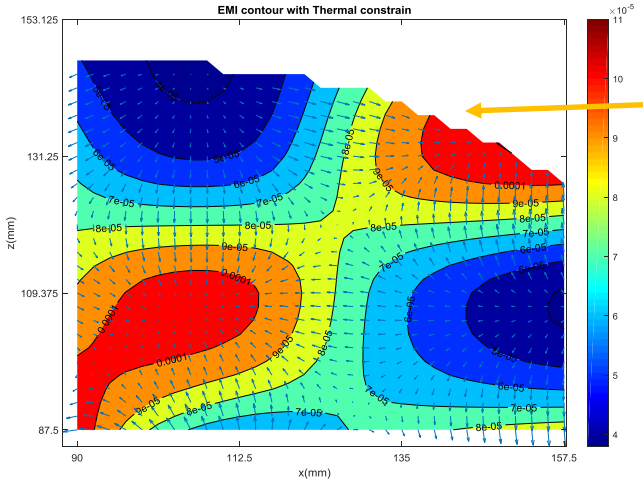
Thermal &Stress



Optimized System Design

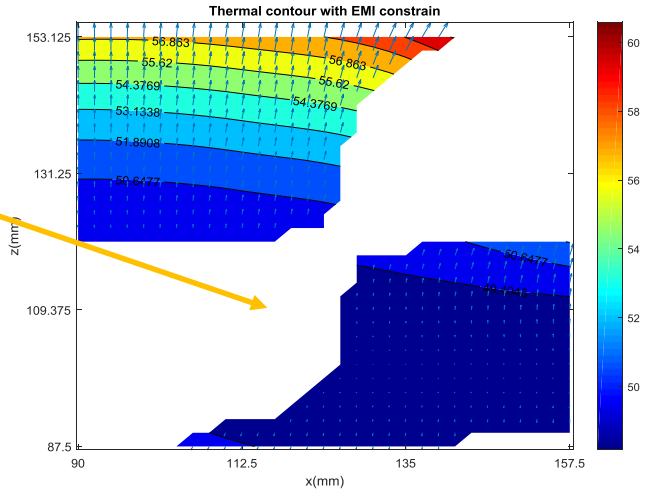


EMI and Thermal Optimization Example

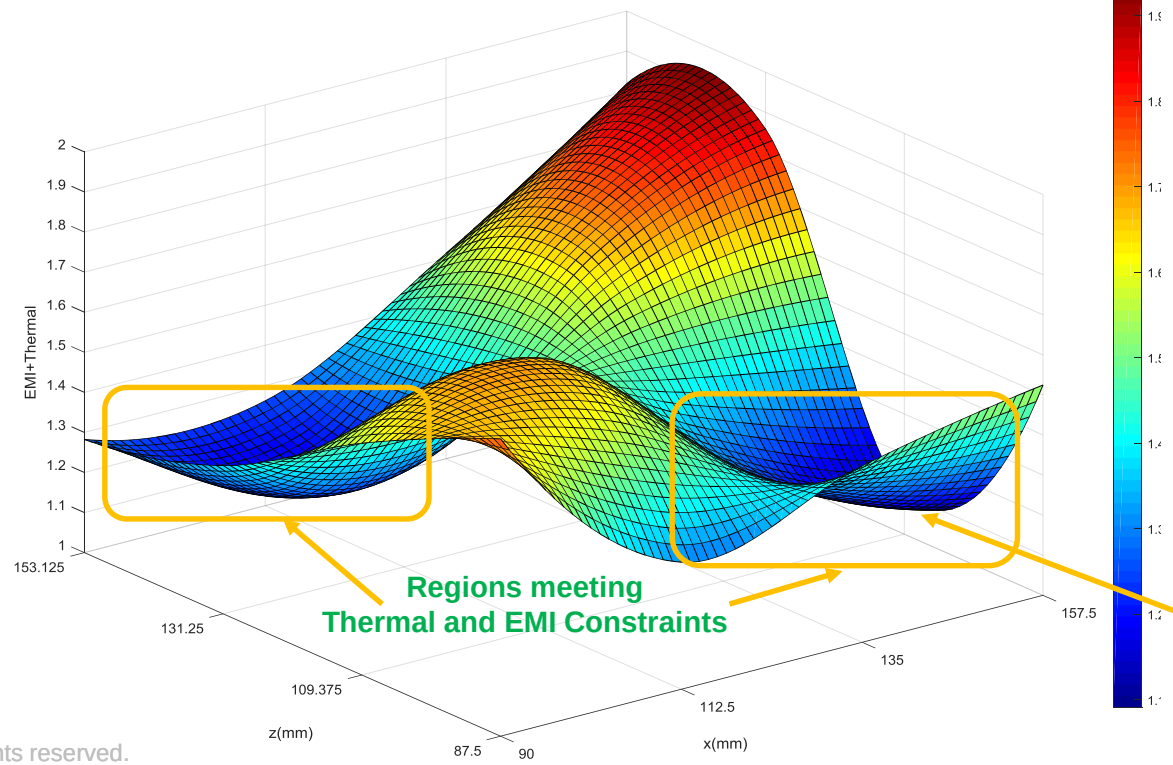


Bad Thermal Region

Bad EMI Region



Normalized Thermal + Normalized EMI



Regions meeting
Thermal and EMI Constraints

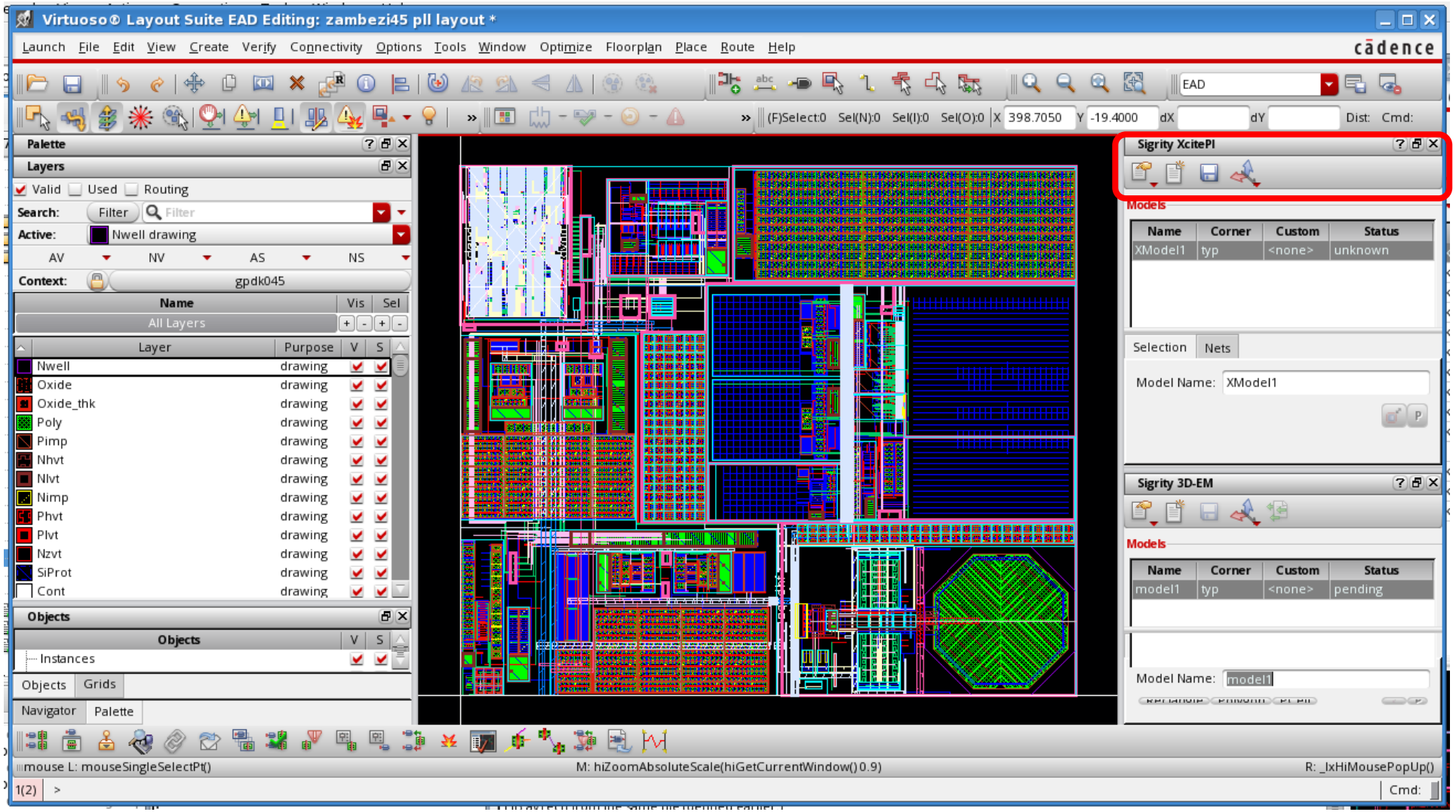
Optimum Thermal and EMI position

Outline

- System Design Enablement
- Integrated ECAD/MCAD for System Design Optimization
- Multi-Physics Co-Simulation
  - Novel System-Level Thermal Solution
  - Efficient and Accurate System Level-Level EMI Solution
- Tight Integration of Design/Simulation Tools

Sigrity EM/SI/PI Solvers Inside Virtuoso Layout Suite EAD

Chip-Level Integration



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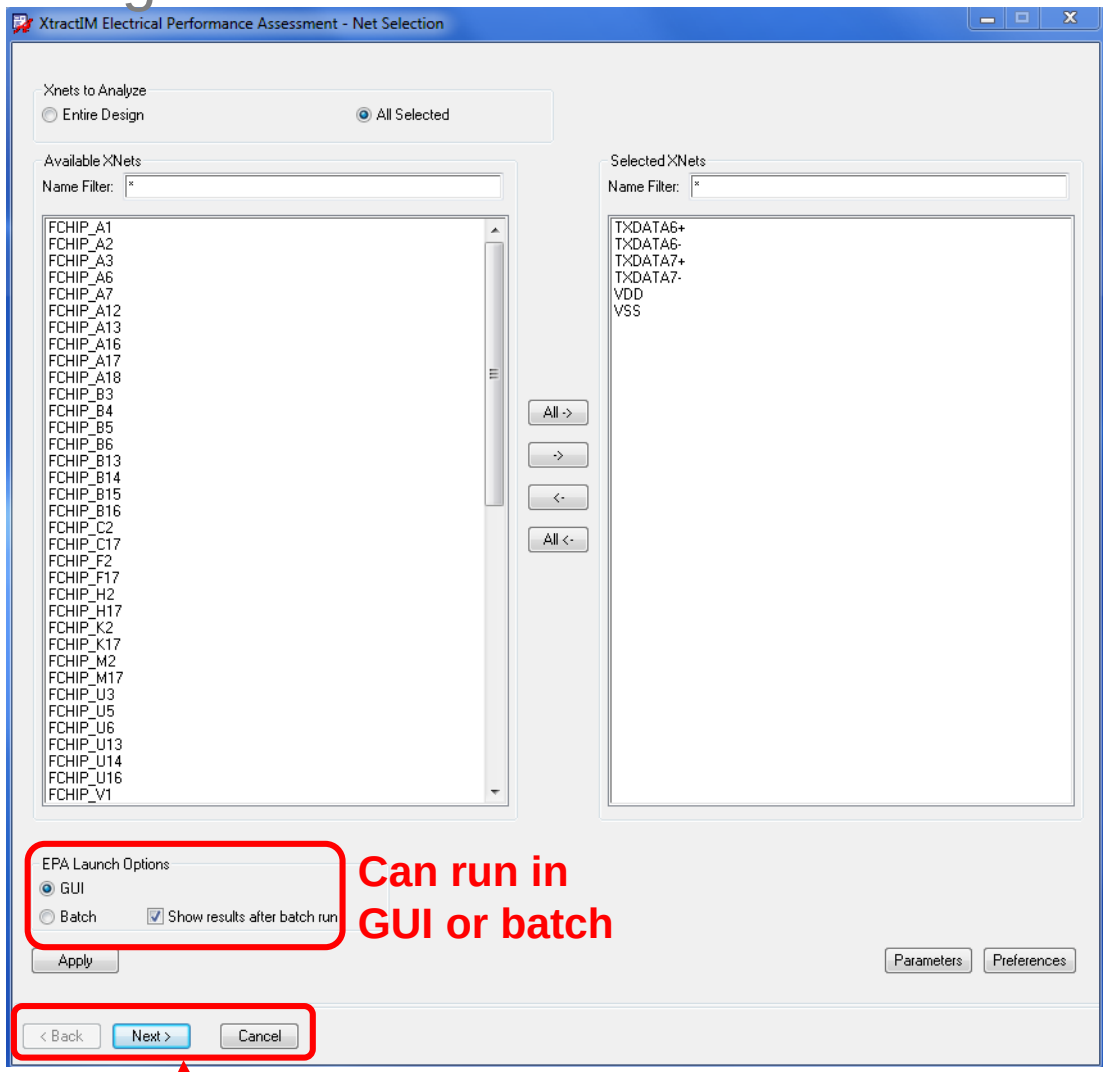
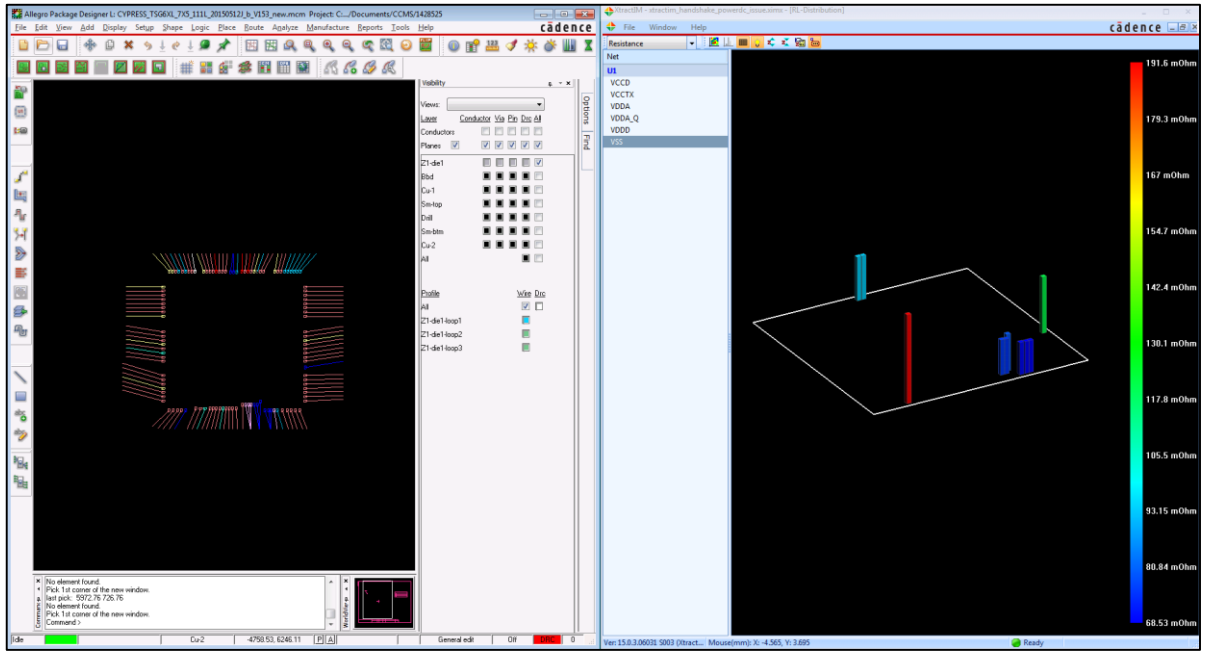
Sigrity XtractIM Inside Allegro Package Designer/Cadence SiP Layout

Package extraction and assessment

Package-Level Integration



Can run in GUI or batch



Step-by-step Sigrity™ XtractIM™ technology setup wizard inside Cadence® SiP Layout

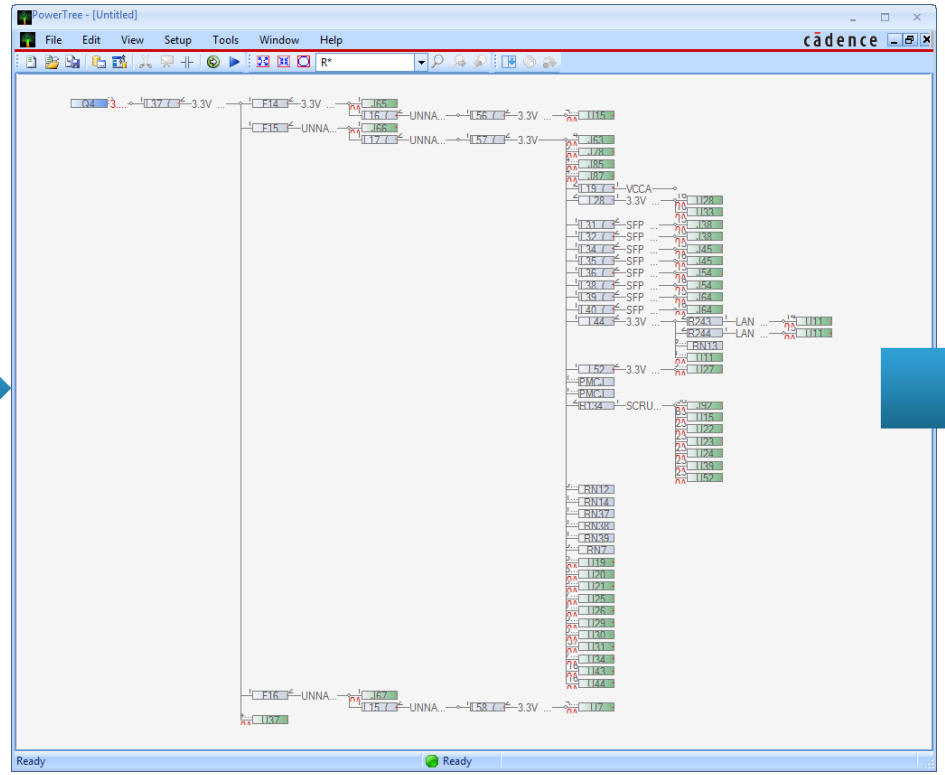
Allegro PowerTree Technology for PI Analysis Automation

PCB-Level Integration

Connection between Allegro/OrCAD schematic and Sigrity PowerDC/OptimizePI technology

Allegro® netlist data

AMM library data



Allegro PowerTree™ Technology creates and edits schematics of PDN

Simulation setup for Sigrity™ PowerDC™ or Sigrity OptimizePI™ technologies

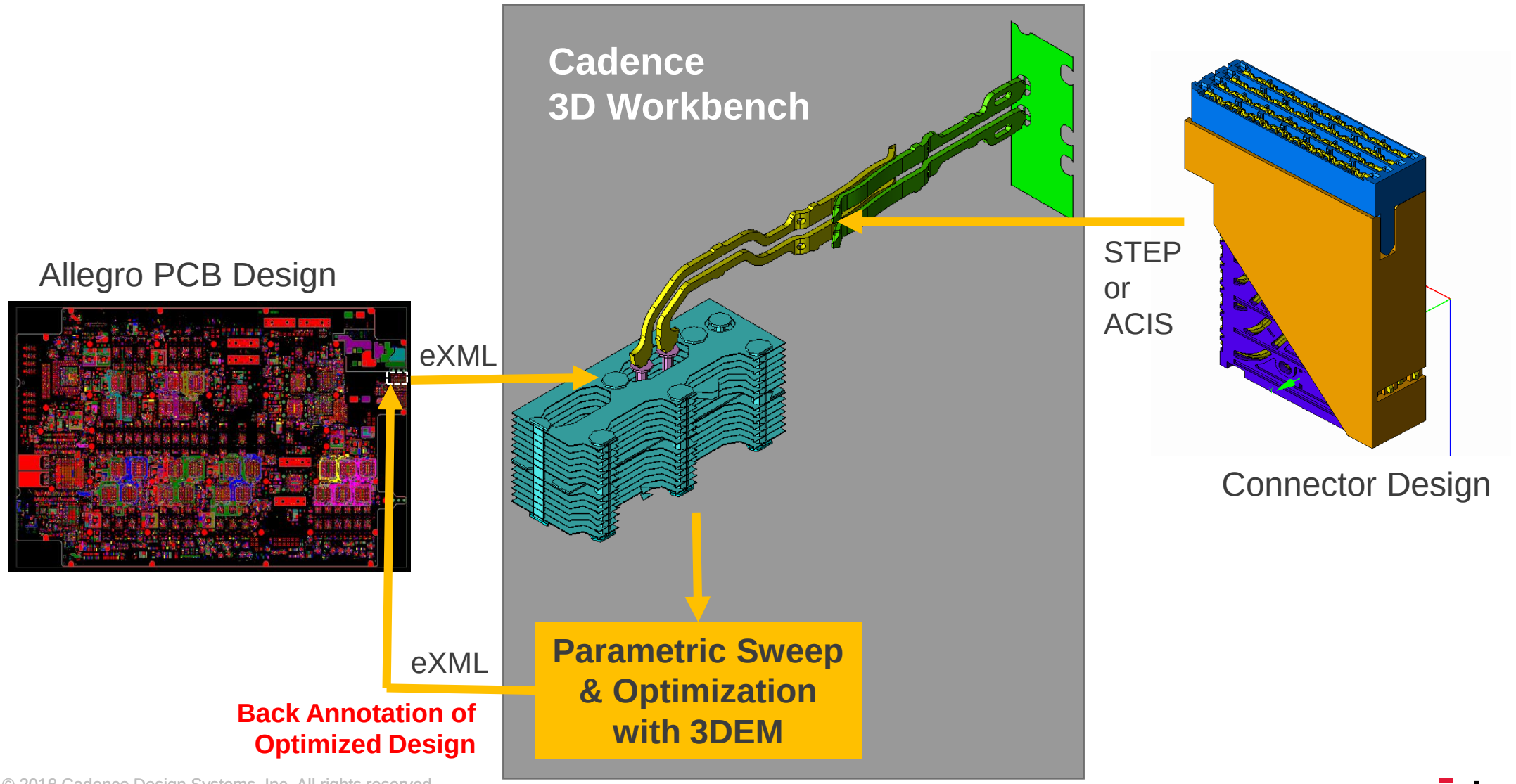
Settings for reuse

cadence

High-Speed Structure Optimization (HSSO) Flow

Cadence Palladium Board and Amphenol Connector

PCB-Level Integration

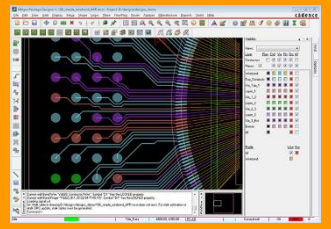


cadence

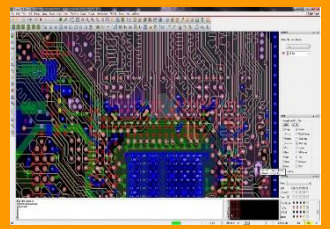
System Design Enablement
The Cadence Advantage

Tightly Integrated

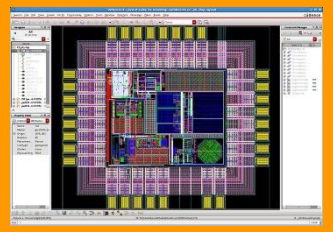
Allegro® Technology



Allegro Package Designer/Cadence® SiP



Virtuoso® Technology

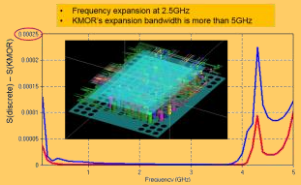


Voltus™ Technology

Quantus™ Technology

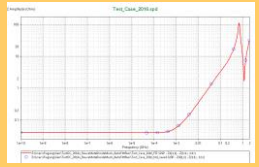
Innovative

Fast KMOR Frequency Expansion

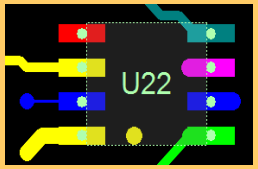


Cut-and-Stitch for Long Nets

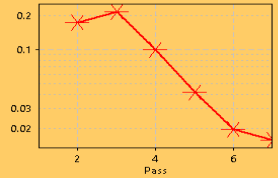
Low Frequency Solution Stability



Co-Sim of EM and Multi-Node Circuit



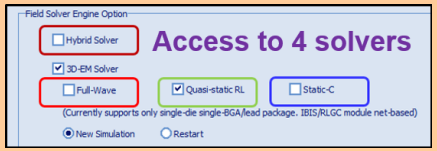
Adaptive Meshing for Accuracy



User Friendly

User Configurable Workflow

All Solvers in One Canvas



TCL Commands for Automated Batch Runs

Open, Save,
Edit, Record, Play

Outline

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  - Novel System-Level Thermal Solution
  - Efficient and Accurate System Level-Level EMI Solution
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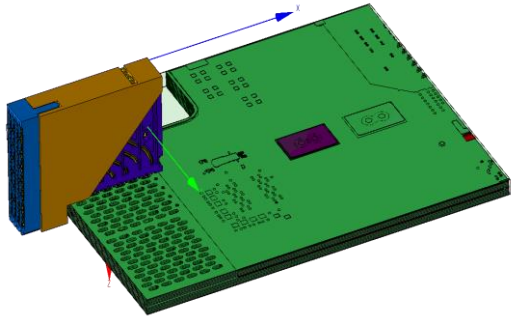

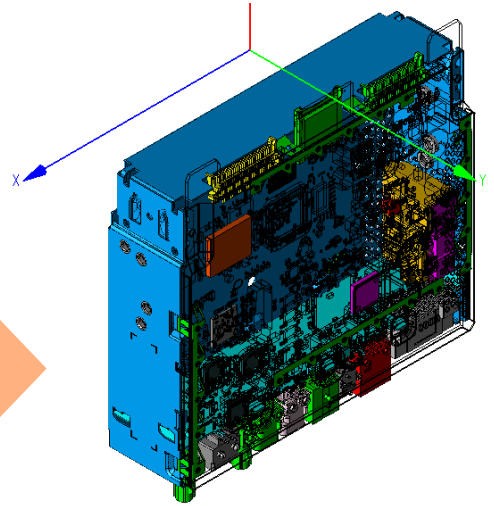

Thank You