Analyzing high-speed signal PCB with multi-physics approach

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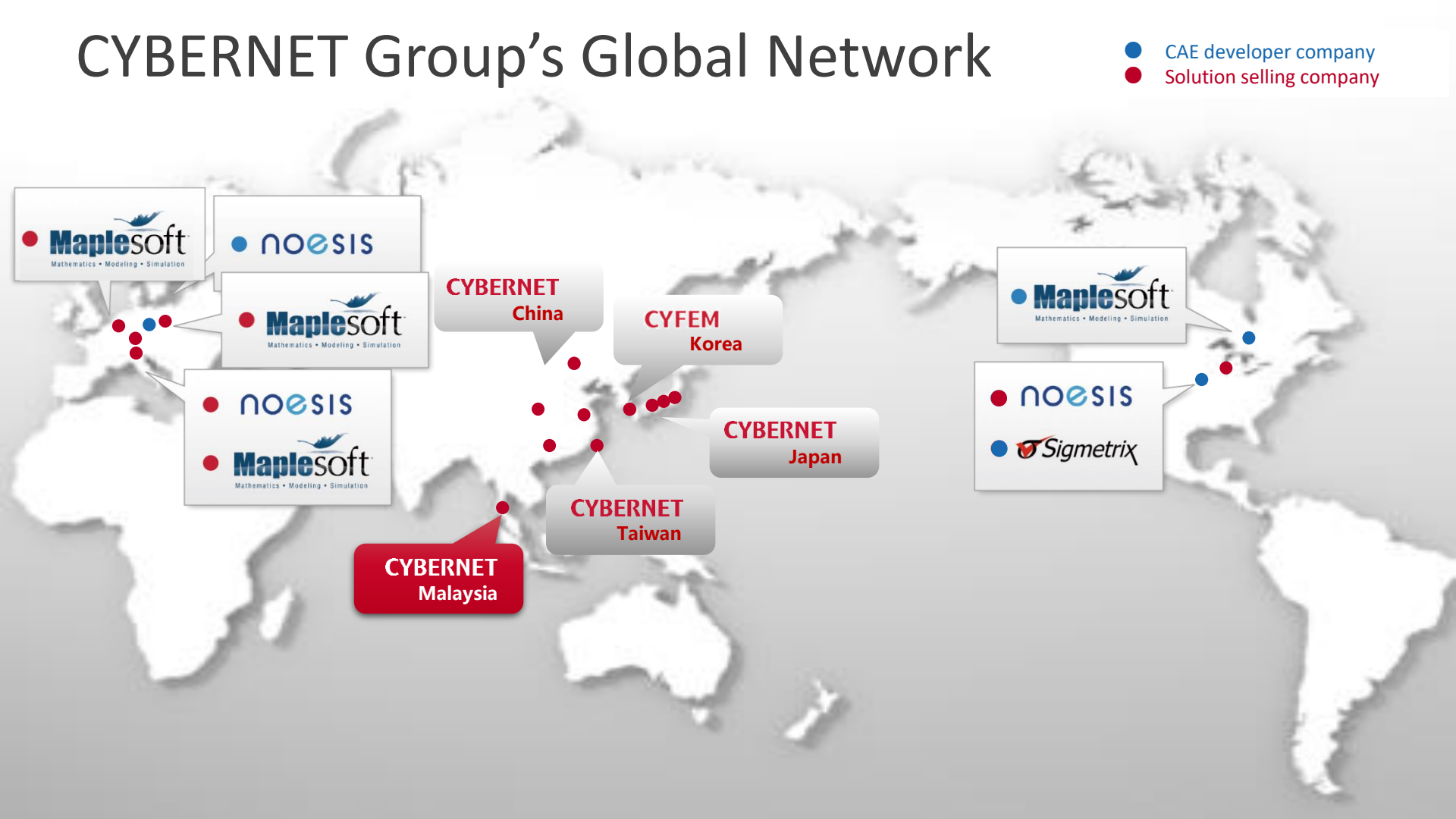
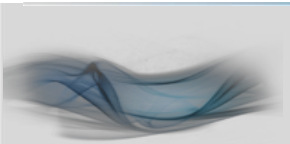
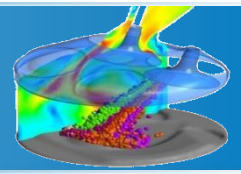


Breadth of Technologies

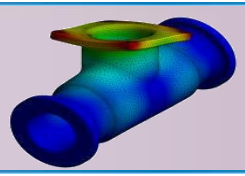


Fluid Mechanics:
From Single-Phase Flows

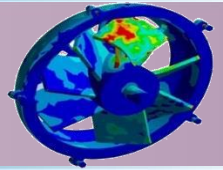
To Multiphase Combustion

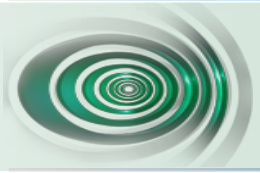


Structural Mechanics:
From Linear Statics

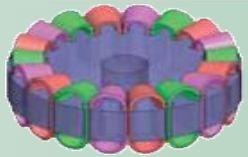


To High-Speed Impact

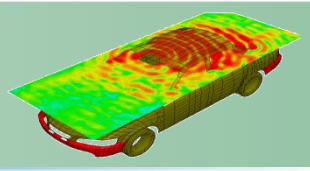


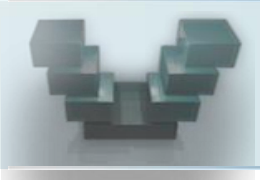


Electromagnetics:
From Low-Frequency Windings

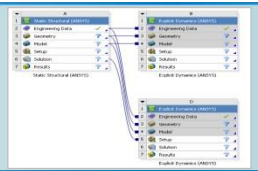


To High-Frequency Field Analysis

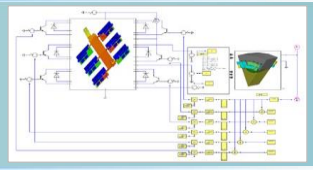




Systems:
From Data Sharing



To Multi-Domain System Analysis



Agenda

Introduction

- The 5G Paradigm Change
- Analyzing multi-physics by ANSYS
- PCB Reliability Workflow

High-speed signal

- Cable/connector
- BGA/PCB

Thermal with SIwave,Q3D,HFSS

Conclusion

The 5G Paradigm Change

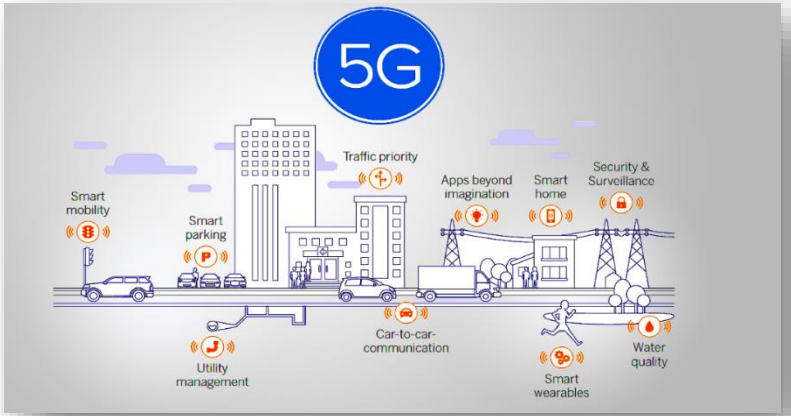
1G — Voice

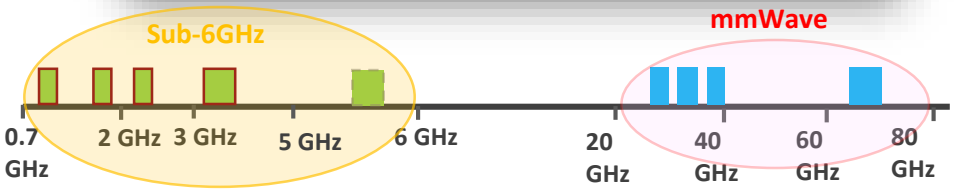
2G — Voice & Text

3G — Voice & Text & Internet

4G — Voice & Text & Internet & Multi-Media

5G — Smart Environment, IoT, Self-Driving Cars, …





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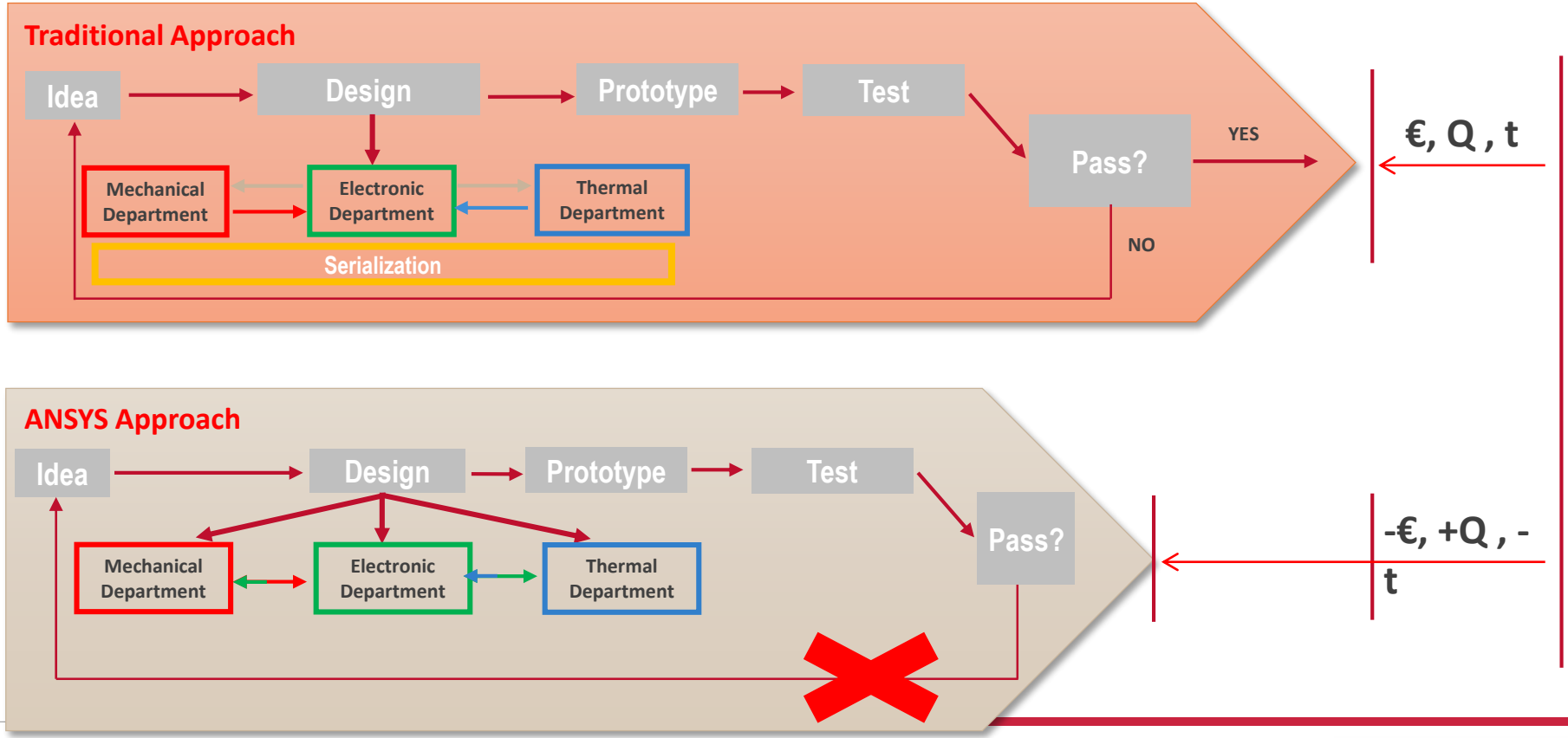
PCB Reliability Workflow



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Analyzing multi-physics by ANSYS

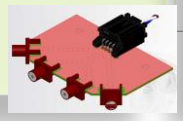
High-Speed Signal

ANSYS

HFSS

Socket、Connector、Via

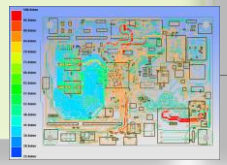
- 3D full wave
- Extract 3D model
- Radiation
- EMC/EMI
- System
- Roughness
- Material characteristic



SIwave

Package、PCB Trace

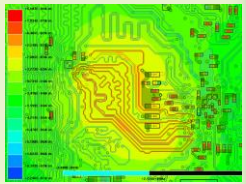
- 2.5D solution
- SI/PI
- EMI
- Differential pair
- SSN noise
- Roughness



Icepak

3D model、mechanical

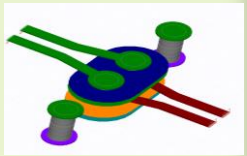
- Thermal



Q3D

Connector、Cable、Socket

- Quasi-static
- Extract RLGC
- EMI
- Differential pair



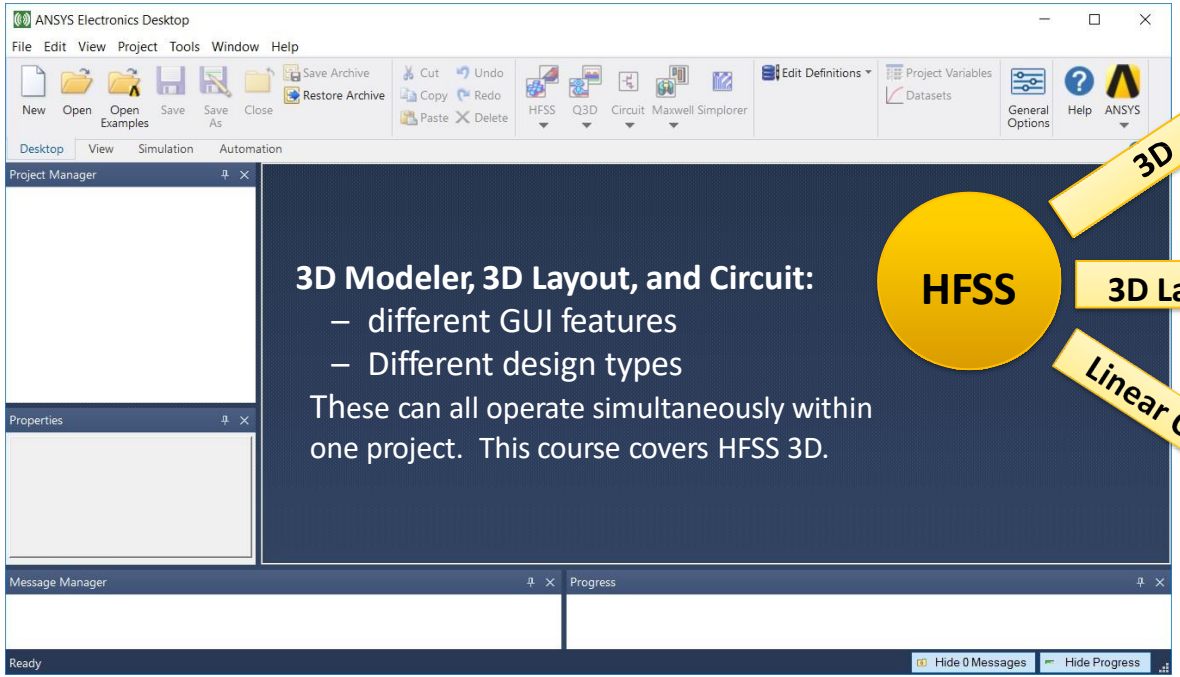
Sherlock

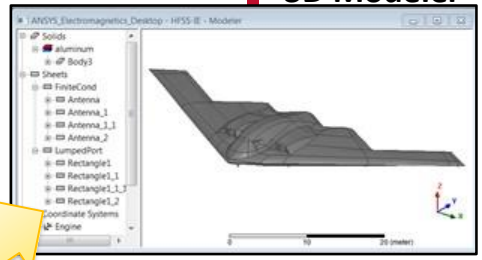
PCB、Solderball、Via Crack

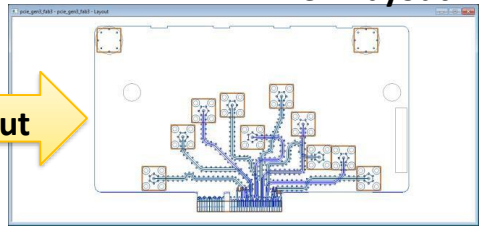
- Solder Fatigue
- Thermal Fatigue
- Random Vibration
- CAF Failure
- Drop Test

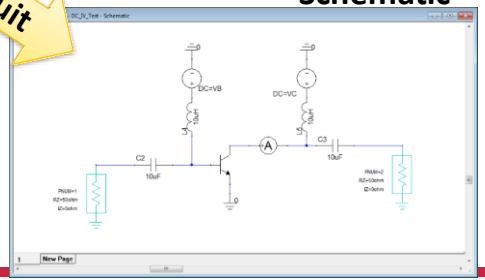
HFSS in ANSYS Electronics Desktop (AEDT)

3 Basic Interfaces - 1 Desktop









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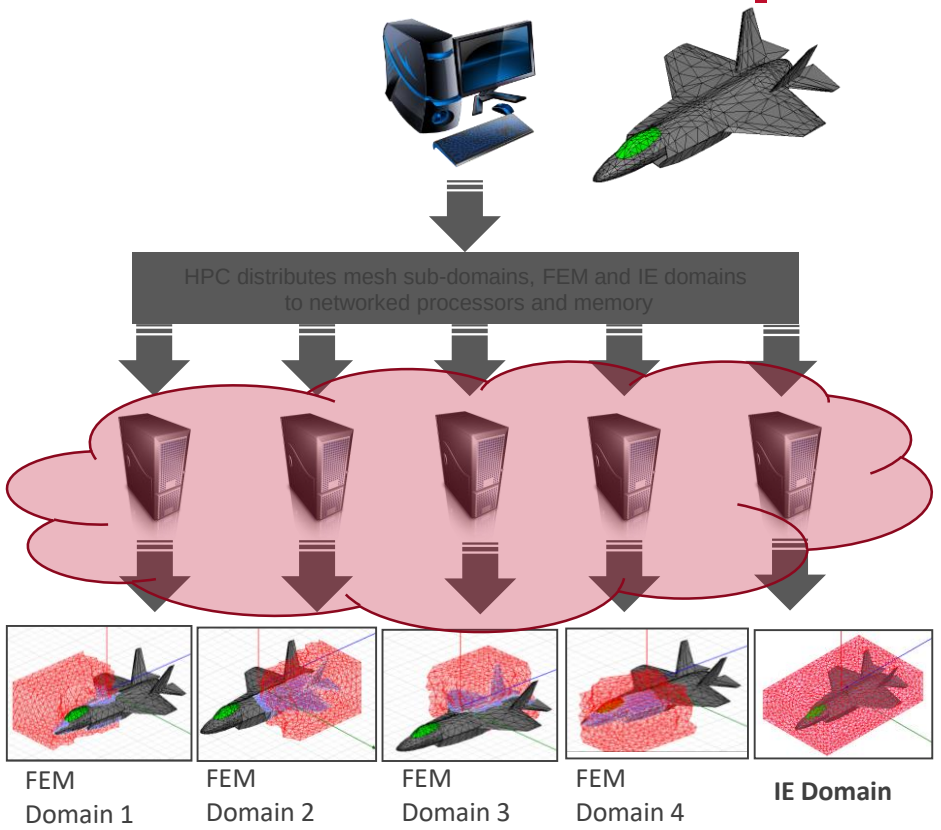
Leveraging High Perf. Computing (HPC)

- Multi-solver aware
  - Hybridization in context of a single solve
- Domain Decomposition (divide space and conquer)
- Frequency division (divide solution points and conquer)
- Automated parameter sweeps and optimization processes (divide solution space solutions)
- 2-Level and 3-Level distributed computing
- Increased capacity
- Increased scalability

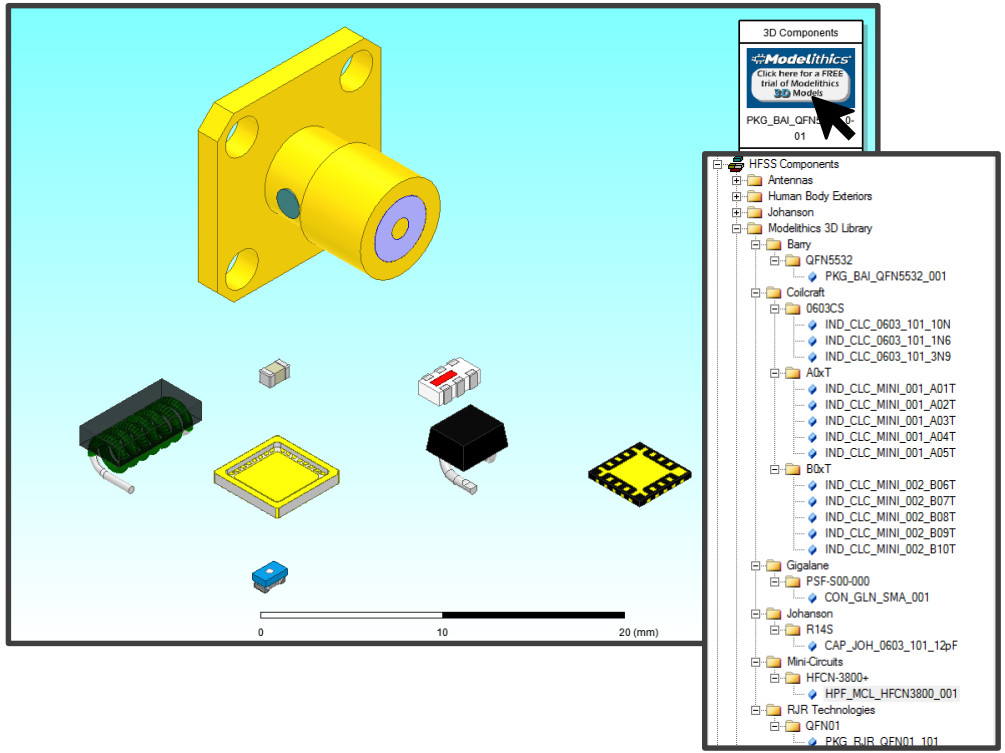
ANSYS Cloud access as a desktop client

- **Scalable, high-capacity HPC**
- **Access on demand for short-term project demands**



3D Component Library (2020 R1)

- 18 New 3D Components from Modelithics
  - https://www.modelithics.com/
  - Licenses from Modelithics required to run
- Free Trial Licenses for Modelithics 3D Components @
  - https://www.modelithics.com/mvp/hfss
  - Click on component logo in 3D modeler to launch website



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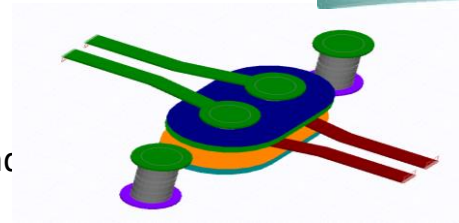
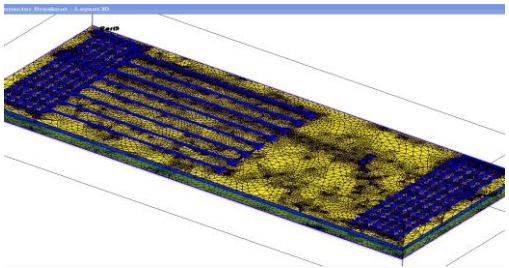
SerDes Design (SI)

- **Objective: High-Speed Signal Transmission**
  - Develop modern electronic devices with high-speed signal transmission rates to provide greater bandwidth
- **ANSYS Solution**
  - Use ANSYS HFSS to study via transitions, package routing and connector breakouts
  - Use HFSS to design 3-D connectors
  - Use SIwave to study entire package and PCB layouts in the time and frequency domain
  - Use SIwave to understand the impact of time domain equalization
- **Value of Simulation**
  - Simulation of SerDes busses using ANSYS starts with design concepts, includes the influences of manufacturing, and allows detailed evaluation of signal net routing, time domain equalization (IBIS-AMI), connector and via breakouts.





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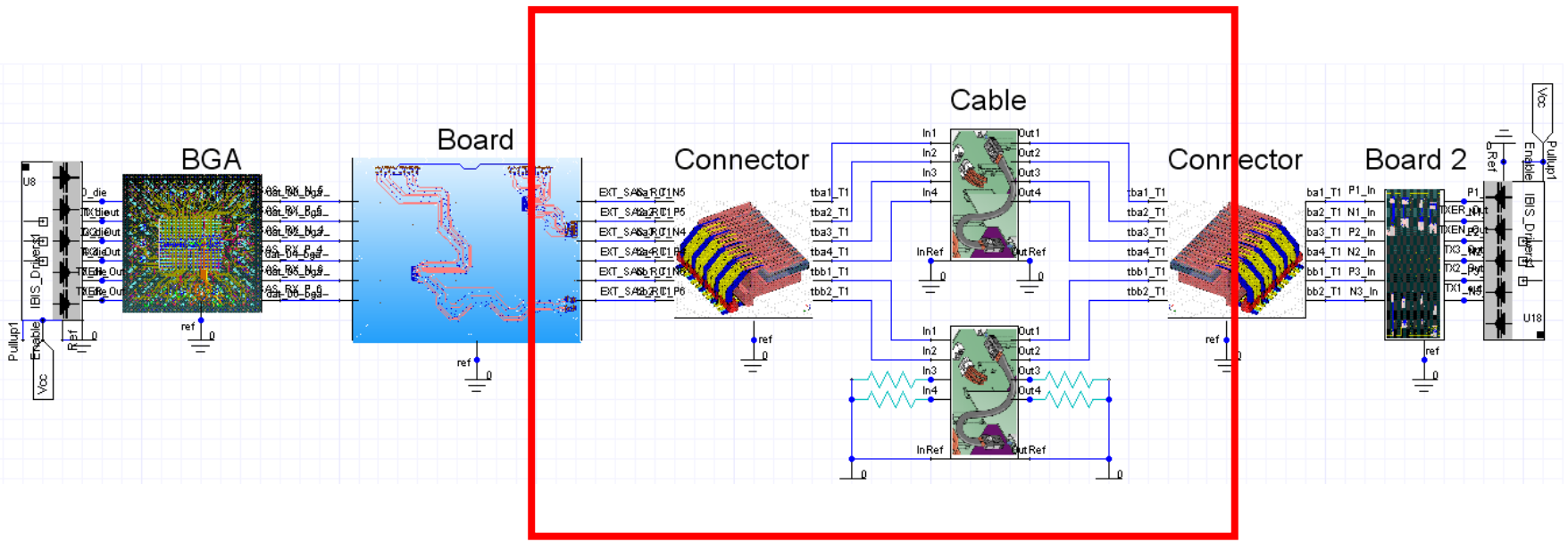
Cable/Connector Simulation

System

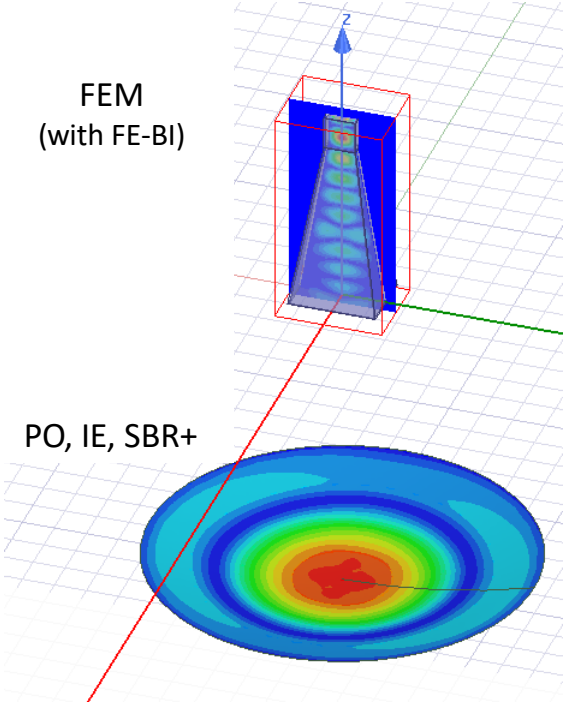


HFSS Includes Multiple EM Solvers

- **HFSS FEM (Finite Element Method)**
  - Fully arbitrary 3D - the whole simulation space gets meshed
  - Used for microwave, antenna, and PCB signal integrity applications
  - HFSS is also a “design type” within the HFSS product.
- **HFSS IE (Integral Equation) Solver**
  - 3D surface meshing – but only meshes surfaces
  - Commonly used for antenna applications
  - Available within the HFSS design type
- **HFSS PO (Physical Optics) and SBR+ (Shooting Bouncing Ray) Solvers**
  - Approaches wave propagation in terms of rays
  - Commonly used for antenna applications
  - Available within the HFSS design type
- **HFSS Transient Solver**
  - Time domain formulation that can employ pulsed excitations
  - Commonly used for applications such as EMI (electromagnetic interference)
- **HFSS Eigenmode Solver**
  - Used to obtain fields in cavities and periodic structures along with the associated dispersion curves
  - No excitation needed - not a driven solution

FEM
(with FE-BI)

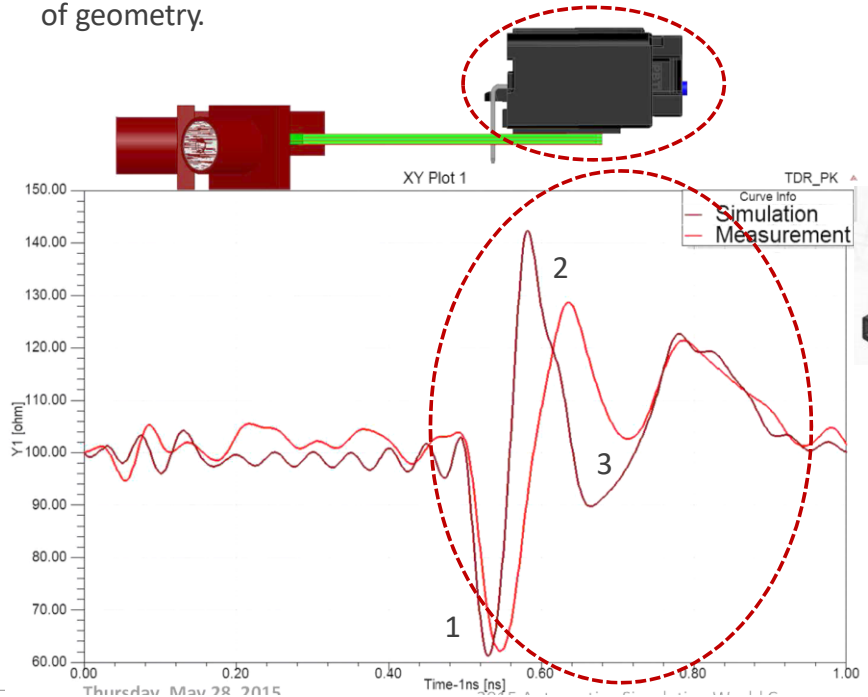
PO, IE, SBR+

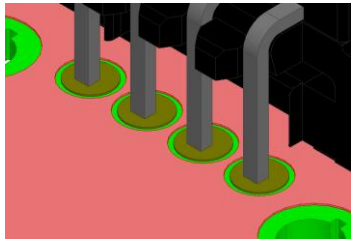


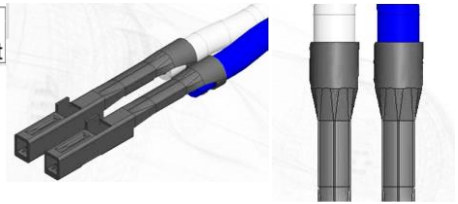
HFSS FEM is the subject of this course.

TDR (25 ps) Simulation vs. Measurement

TDR with 25 ps filter is used to observe the impedance variation of geometry.







1. Capacitance between antipad and via.
2. Inductance around the connection pin in the waterfall region.
3. Capacitance between two crimps of terminals.

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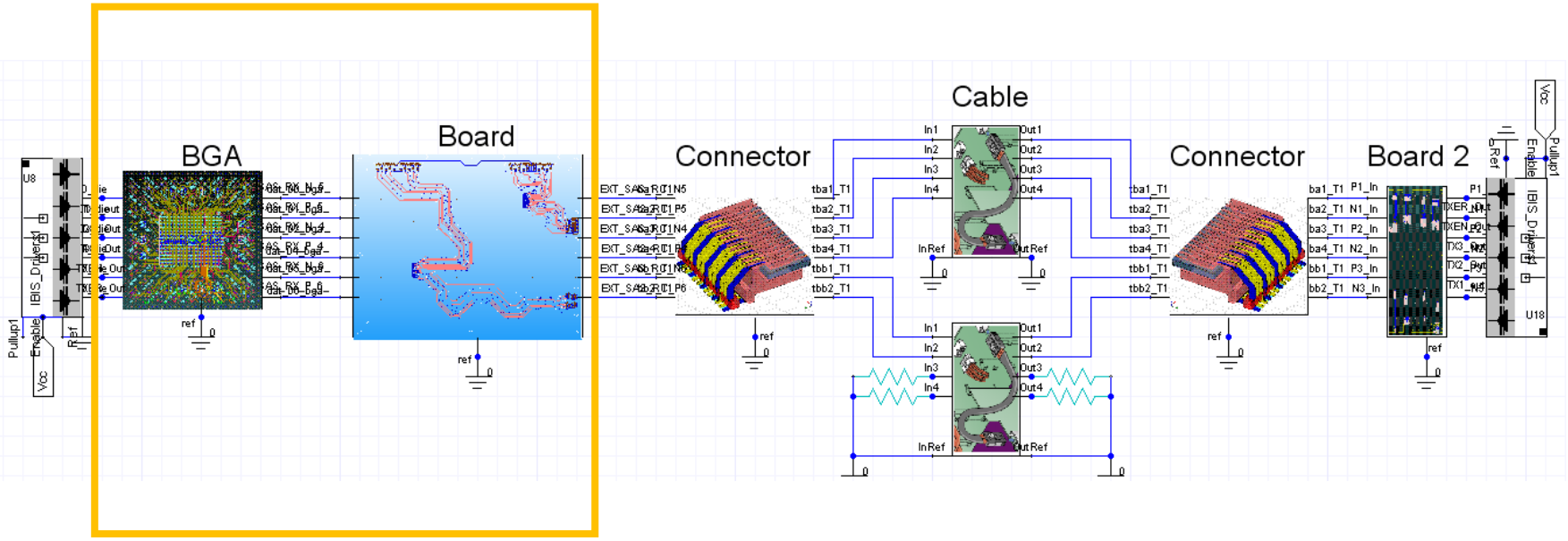
BGA/PCB Simulation

System

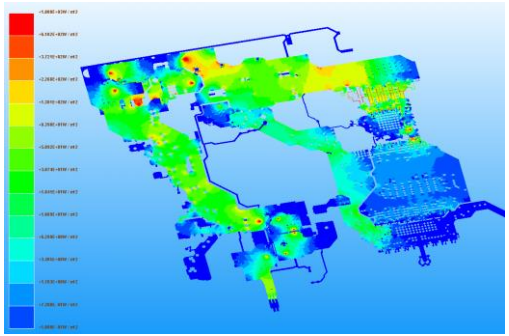


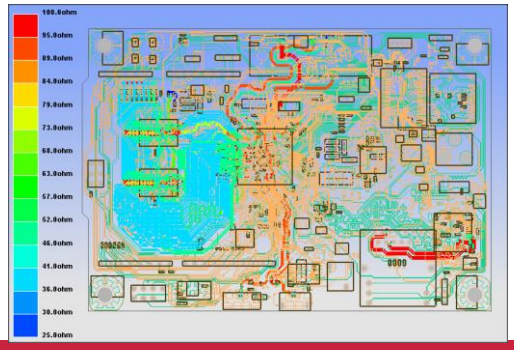
SIwave

Specialized design platform for analyzing signal integrity, power integrity, and EMI analyses of IC Packages and full PCBs

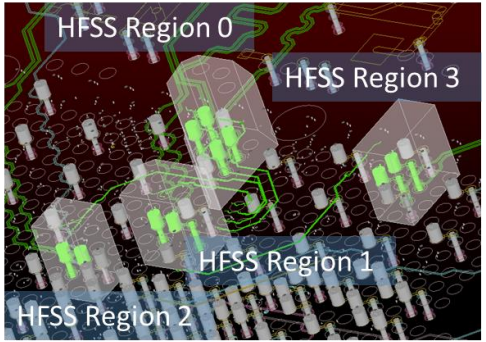
Features:

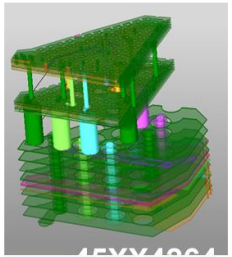
- ECAD import
- Multiphysics Couplings
- IBIS & IBIS-AMI SerDes Analysis
- DDR3/4 Virtual Compliance
- Decoupling Capacitor Optimization
- Impedance Scanning
- Crosstalk Scanning
- SIwave with HFSS regions



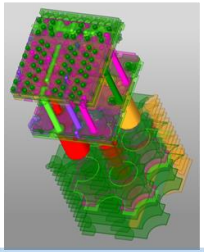


SIwave - Parallel HFSS Regions

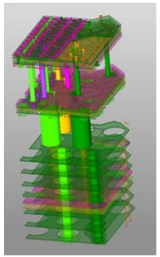




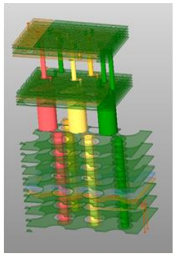
HFSS Region 0



HFSS Region 2



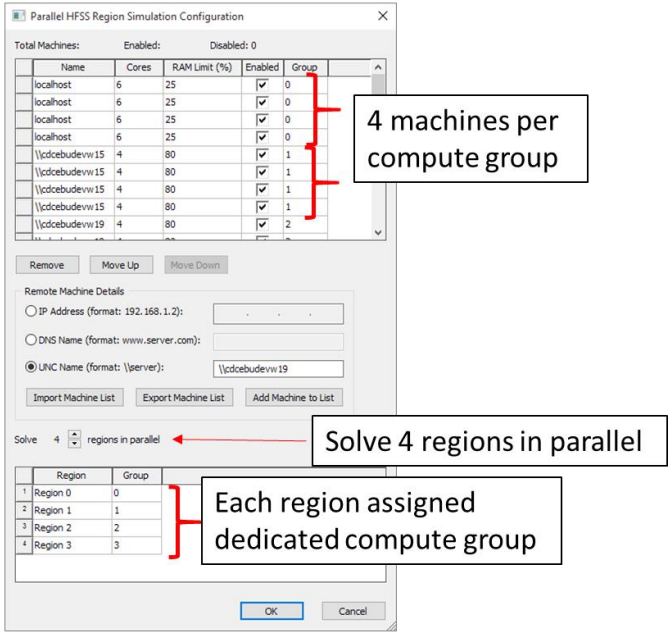
HFSS Region 1



HFSS Region 3

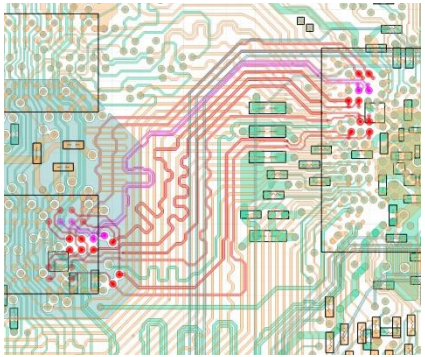
HFSS Region simulations can be launched in parallel

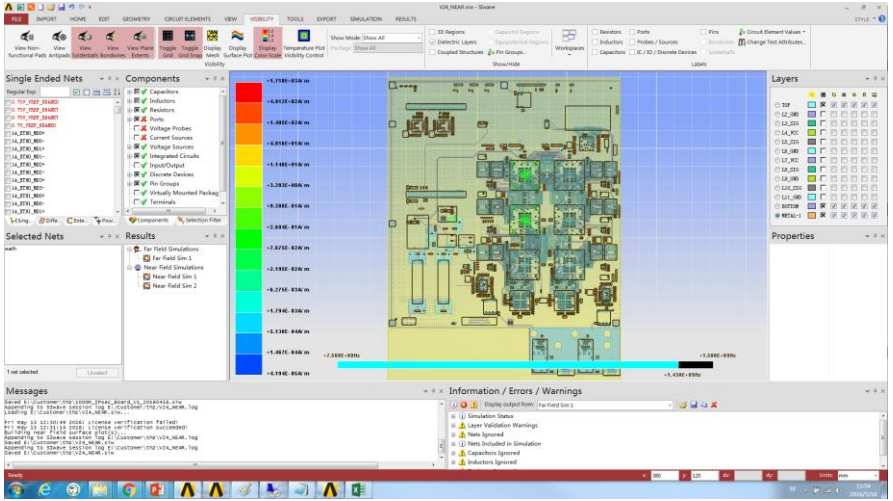
- Each region can be distributed across multiple machines

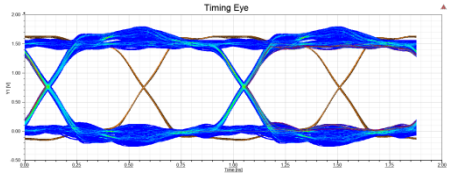


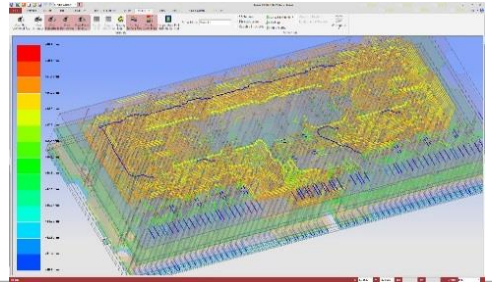
Currently limited to SIwave UI
Coming soon to 3D Layout interface in AEDT

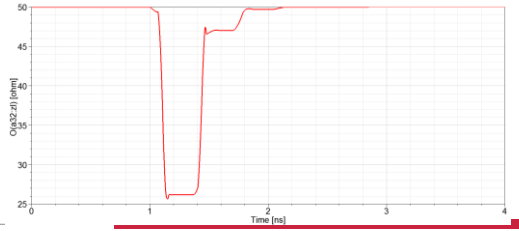
Package and PCB layouts in the time and frequency domain for SIwave

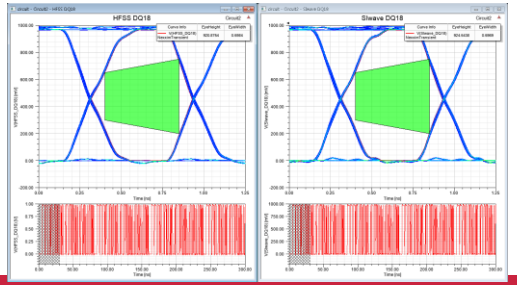












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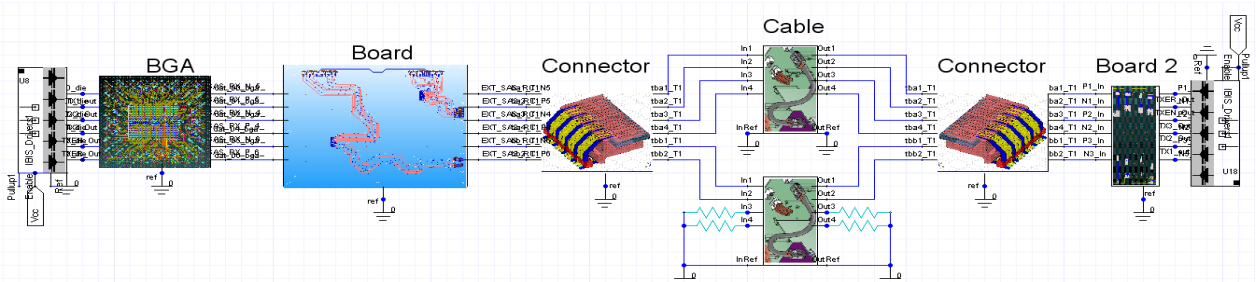
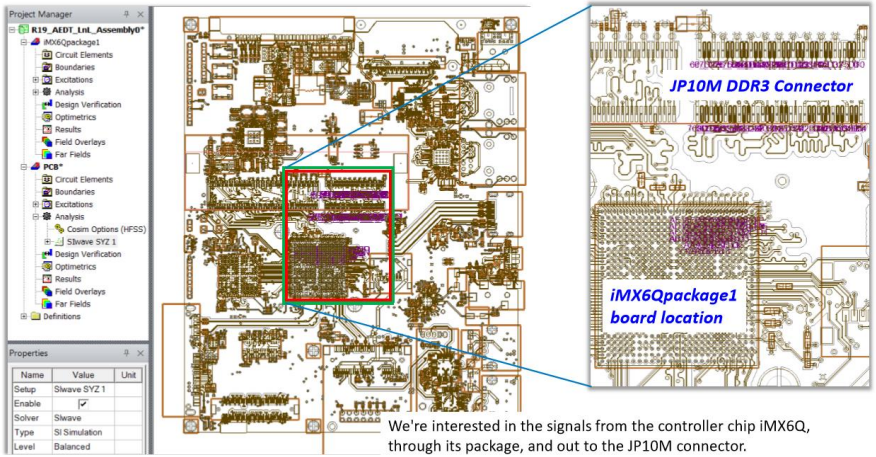
ANSYS SIwave /3D layout

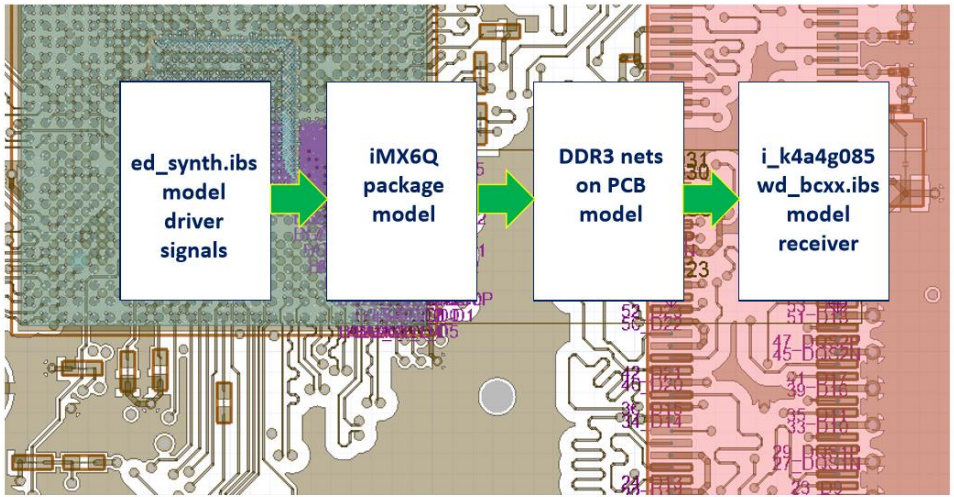


Nexxim Circuit Simulation Block Diagram and Signal Flow

Starting Point - iMX6Q and PCB Connector



We're interested in the signals from the controller chip iMX6Q, through its package, and out to the JP10M connector.



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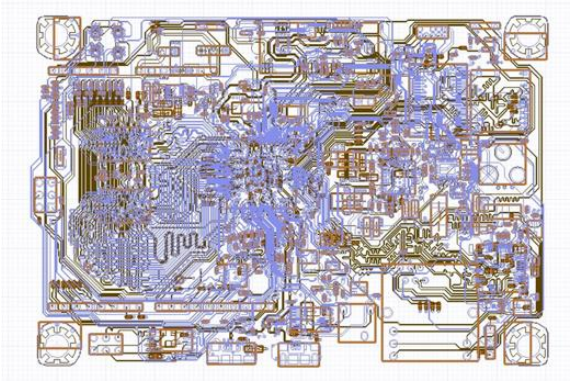
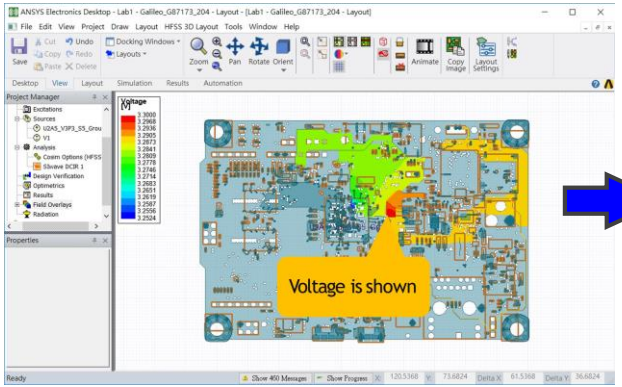
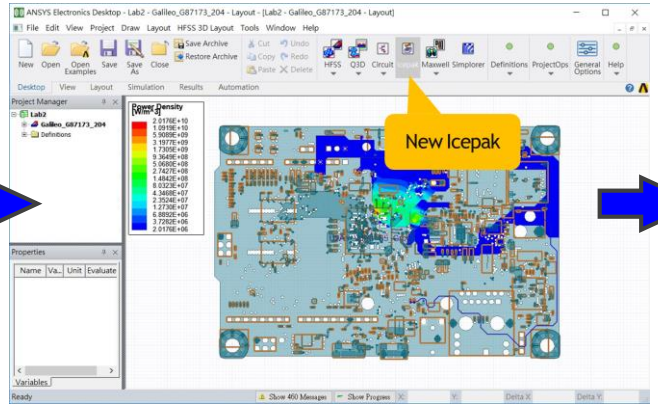
Thermal with SIwave,Q3D,HFSS

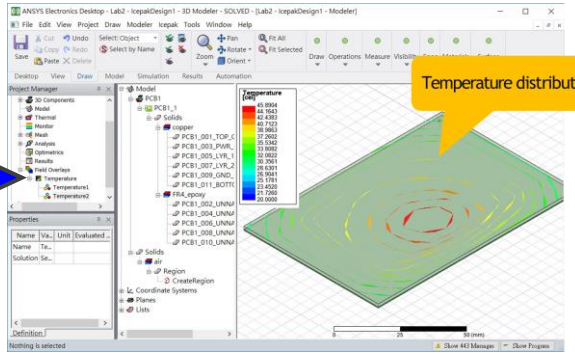
ANSYS SIwave → ANSYS Icepak Bidirectional Coupling

- SIwave analysis the IR-drop, turn the loss to the source and link it into Icepak, analysis the thermal distribute



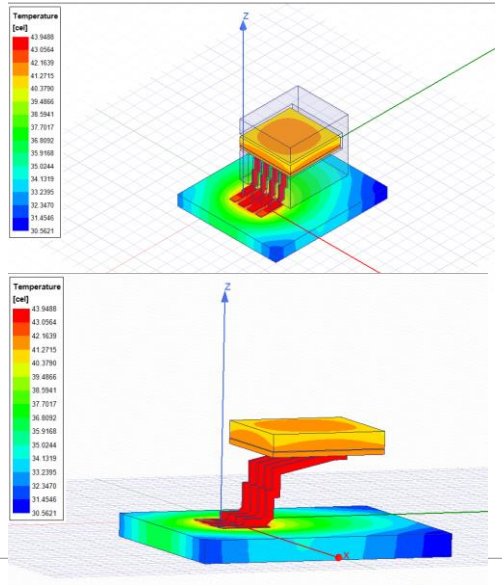


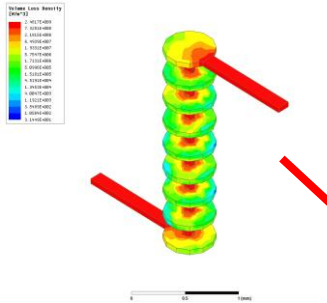




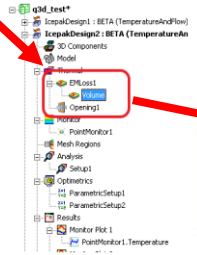
ANSYS Q3D → ANSYS Icepak Bidirectional Coupling

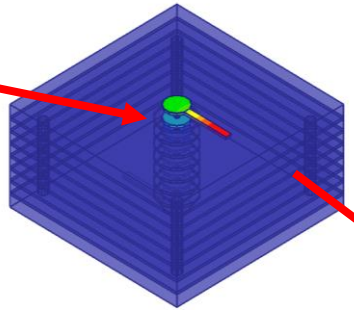
With Q3D Qusai-static simulate the EM loss than link to Icepak to do the Thermal analyze



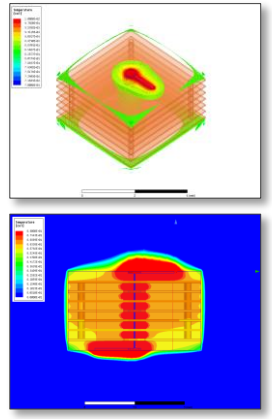


Q3D EM Loss

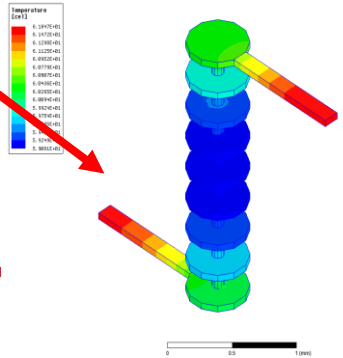




Icepak Dynamic Link

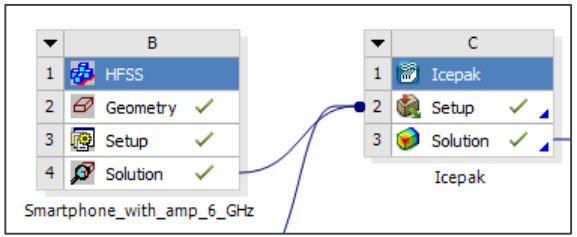


Icepak Thermal with EM loss



ANSYS HFSS → ANSYS Icepak Bidirectional Coupling 1/2

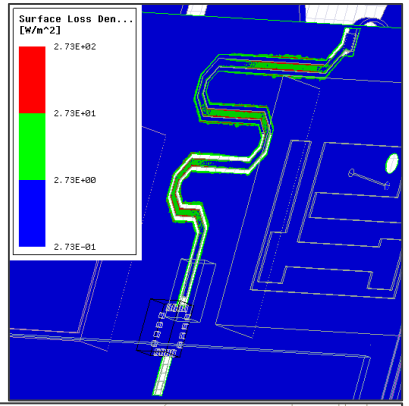
- Transfer the antenna metal and dielectric losses from ANSYS HFSS to ANSYS Icepak via the ANSYS Workbench based coupled, automated workflow.

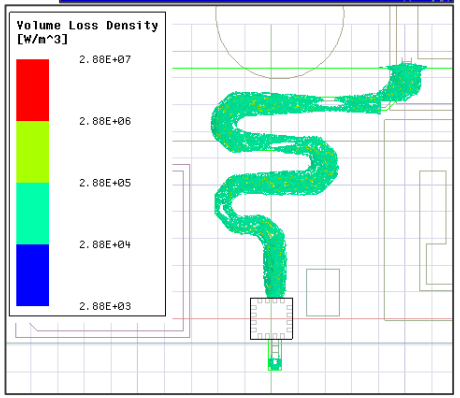


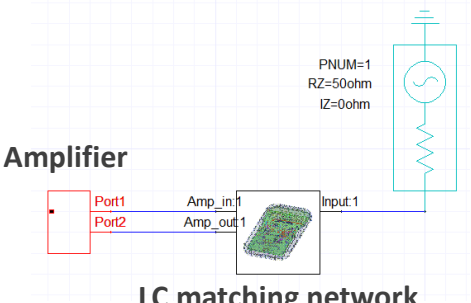
Total RF heat load ~ 8 mW

- **PCB: 6 mW**
- **Metals: ~ 2 mW**

Not significant enough to affect Temperature

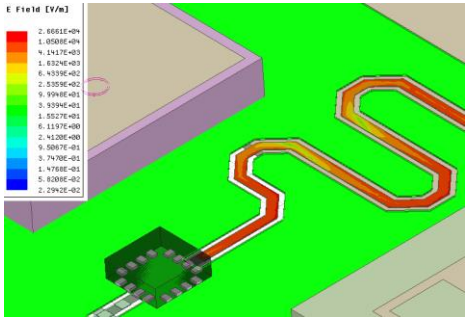






LC matching network built-in to HFSS model

RF source controls input power level



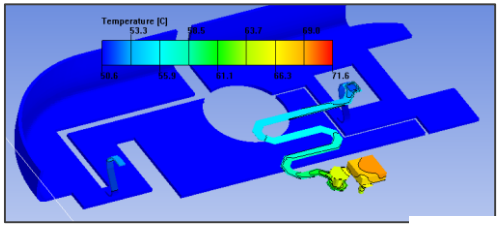
"Push excitations" from circuit model into HFSS to compute actual thermal power loss densities

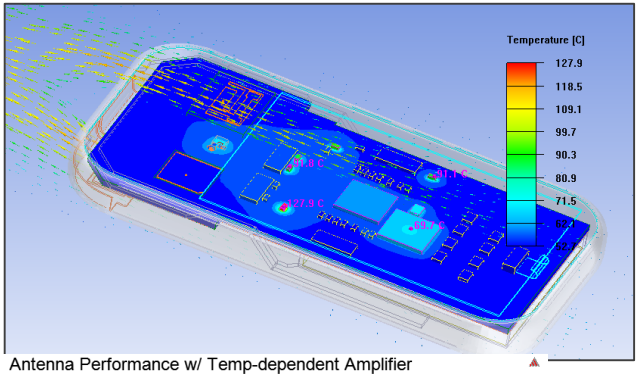
ANSYS HFSS → ANSYS Icepak Bidirectional Coupling 2/2

RF/Antenna performance can be affected by temperature rise due to PCB components

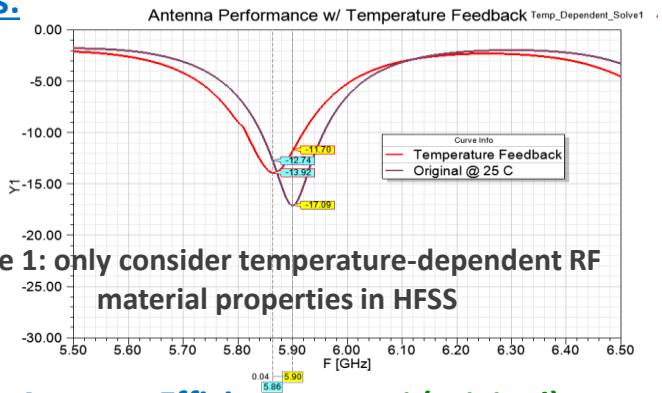
Thermal Conditions:

- Gravity driven
- Ambient air at 45°C
- Radiation heat transfer On

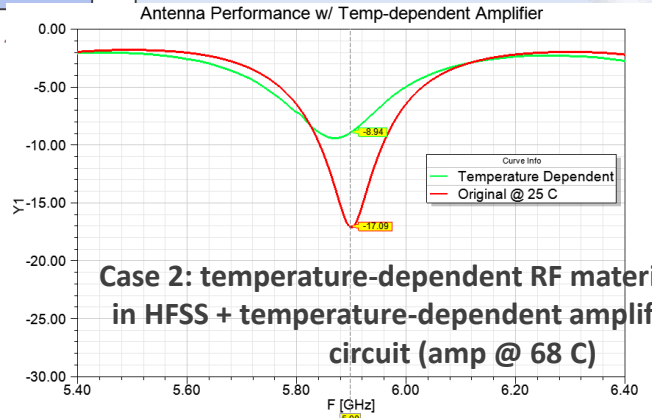




Antenna Return Loss:



Case 1: only consider temperature-dependent RF material properties in HFSS



Case 2: temperature-dependent RF material properties in HFSS + temperature-dependent amplifier model in circuit (amp @ 68 C)

Antenna Efficiency: **47% (original)** → **32% (with Temperature feedback)**

CYBERNET

Conclusion

- ANSYS Electronics Desktop (AEDT)
- High-Speed Signal
- ANSYS Multiphysics Simulation
- High-Performance Computing (HPC)
- System Integration

Solve it, with CYBERNET

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