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, ...

Voice

Voice & Text

Voice & Text & Internet

Voice & Text & Internet & Multi-Media

Smart Environment, IoT, Self-Driving Cars, ...

mmWave

Sub-6GHz

0.7 GHz 2 GHz 3 GHz 5 GHz 6 GHz 20 GHz 40 GHz 60 GHz 80 GHz

CYBERNET
PCB Reliability Workflow

**Traditional Approach**

- Idea
- Design
- Prototype
- Test
- Pass?
  - YES
  - NO

**Mechanical Department**

**Electronic Department**

**Thermal Department**

**Serialization**

**Prototype Test**

**Pass?**

**ANSYS Approach**

- Idea
- Design
- Prototype
- Test
- Pass?

**Mechanical Department**

**Electronic Department**

**Thermal Department**

**Prototype Test**

**Pass?**
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

Slwave
- 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

3D Modeler, 3D Layout, and Circuit:
- different GUI features
- Different design types

These can all operate simultaneously within one project. This course covers HFSS 3D.
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
18 New 3D Components from Modelithics
- [https://www.modelithics.com/](https://www.modelithics.com/)
- Licenses from Modelithics required to run

Free Trial Licenses for Modelithics 3D Components @
- [https://www.modelithics.com/mvp/hfss](https://www.modelithics.com/mvp/hfss)
- Click on component logo in 3D modeler to launch website
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.
Cable/Connector Simulation
System

HFSS
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

**Note:**
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.
BGA/PCB Simulation
System

SIwave
**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 simulations can be launched in parallel
- Each region can be distributed across multiple machines

Solve 4 regions in parallel
- Each region assigned dedicated compute group

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
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.
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
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
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

**Antenna Efficiency:** 47% (original)

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

32% (with Temperature feedback)
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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