Thermal Analysis of a PCB Assembly

Clinton Smith PhD, Senior Mechanical Engineer
Jim Peters, CAE Services Manager

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Challenges

• Resolving heat flow in densely-populated boards requires large, high-fidelity models
  – Vendor-supplied $\theta_{jc}$ and $\theta_{jb}$ values are idealized
  – Thermal interaction between closely-spaced, powered components invalidates single-component characterizations

• Sizing problem
  – Footprint of electronic devices is shrinking
  – Higher component density on boards
  – Less thermal mass available
  – Complex cooling solutions required

• Traces/vias control the model size
  – Restrictive length-scales compared to overall device length-scale
Outline

• Background – ANSYS Icepak

• Computational methods

• Results

• Summary
Background - ANSYS Icepak

- Fluid dynamics software for thermal management of electronic systems
- Vertical application
  - Built on CFD solver
  - Coupling to FEA solvers available
  - Time-saving capability
- Package-level analysis to system-level analysis
- Differing levels of detail available
  - Build entire models using Icepak objects
  - Import ECAD and MCAD data
- Object-based approach
  - Blocks, plates, sources
  - Packages, PCBs, heatsinks, fans, blowers, etc.
Background - ANSYS Icepak

- Macros
  - Heatsinks
  - Packages
  - PCBs
  - Heat pipes

- Object Libraries
  - Off-the-shelf components
  - Updated at each revision
  - Users can create their own libraries of custom components
Simulation overview

- Thermal analysis of a PCB-mounted package with traces
  - Heat generated by 0.5 W power source in package
  - PBGA read in from TCB (Cadence) package file

- Heat transfer modes
  - Conduction
  - Natural convection
  - Radiation

- Steady analysis of fluid + thermal solution
Computational domain – PCB assembly

- Heat sink
- TIM
- PBGA
- PCB
- Air volume
- Solder balls
- Substrate
- Die pad
- Die
- Wire bonds
- Traces
- Solder balls
- Substrate
Computational domain - PBGA
Computational domain - PBGA
Computational domain

- PCB traces
- heatsink
- opening boundaries
- gravity
Mesh

~255,000 nodes
~241,000 elements
Results – Flow field

Streamlines of velocity colored by temperature
Results – Flow field

Thermal plume
Results - Temperature
Results - Temperature
Results - Temperature
Results - Temperature
Results – Temperature
Results – Temperature

X = -7.36 mm

gravity

X = -5.504 mm
Results – Temperature

X = -3.79 mm

X = 0.383 mm
Results – Package conductivity from traces

Traces + vias in PBGA
Results – Package conductivity from traces

In-plane conductivity, $k_x$
Results – Package conductivity from traces

In-plane conductivity, $k_y$
Results – Package conductivity from traces

In-plane conductivity, $k_z$

Thermal vias captured by mesh
Results – Heat flux on PBGA

Listing of values for variable: Heat Flux (W/m²)

Object: package “package.1” Sides: minx maxx miny maxy minz maxz bot -----

Heat flux = 1135.87 W/m²
Surface area = 0.00039534 m²

Pointwise Heat Flux

1020 nodes:
- min: -2.8519e-012
- max: 6.74379e-009
- mean: 1.16911e-011
- std dev: 2.6601e-010

Object: package “package.1” Sides: minx maxx miny maxy minz maxz bot ----

Done
Results – Line plot of temperature
Summary

• Challenges in electronics thermal analysis
  – High fidelity models needed to solve real-world cases
  – Range of length-scales must be resolved
  – Traces/vias control the lengthscale

• ANSYS Icepak
  – Vertical application built on CFD technology
  – Import ECAD data and compute conductivities
  – Differing levels of detail available

• Package-level analysis with ANSYS Icepak
  – Characterize max temperatures in the device
  – Investigate conductivities, heat flux, lineplots