Release 2023 R1 Highlights
Ansys Sherlock & Electronics Reliability

Agenda

- Introduction
  - Electronics Reliability High-Level Summary
  - Reliability Engineering Services (RES)
  - Ansys Sherlock Part Librarian Services Update
- Ansys Sherlock Updates:
  - Top 3 Updates
  - Sherlock-Workbench
    - Improved handling of Multi-Board Assemblies
  - Sherlock-AEDT Icepak
    - Improved Export options and handling of Multi-Board Assemblies
  - Thermal-Mech Enhancements
    - Support for Conduction Analysis in Thermal-Mechanical Studies
  - Sherlock Automation APIs
    - Increased Support for ICT Analysis Automation and handling of Life Cycle Phases and Events
- Ansys Mechanical Updates
- Resources
- Q&A

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Electronics Reliability – **High-Level Summary**

- **What** is Ansys Electronics Reliability?
  - Ansys Electronics Reliability is a set of multi-physics workflows using Ansys Mechanical, Sherlock, LS-DYNA, & Icepak to analyze PCBs for the major causes of failure: thermal, mechanical & electrical stress.

- **Why** is it important?
  - Almost all industries use electronics in some way. Ensuring PCBs (the backbone of electronic products) meet reliability standards, goals & warranty claims early in the design phase ensures cost-savings down the line and faster time-to-market.

- **How** do we do it at Ansys?
  - Integrations between Mechanical, Sherlock, LS-DYNA and Icepak software allows users to perform comprehensive analyses for PCBs within the Workbench interface. Passing analysis results into Sherlock provides users with lifetime predictions for each component on the board—facilitating quick design changes to improve reliability.

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Ansys RES Reminder

On top of simulation, Ansys also offers physical testing services to improve electronics reliability.

- **WHO:** Ansys Reliability Engineering Services (RES) is a team of reliability experts who solve the most complex product reliability problems in every industry vertical where electronics are used.
- **WHERE/HOW:** Our team works in a multi-million dollar, 20,000 ft^2 facility with top-of-the-line physical testing and lab equipment to analyze products from the concept to design to manufacturing to field phases.

LEARN MORE

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Sherlock Part Library Updates

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Sherlock Parts Library Updates

1.) With the latest 23 R1 software release, the **Sherlock Parts Library has increased from 250,000 to over 600,000 parts**. Upgrades include:

- Over 400,000 new resistor and capacitor part numbers added
- Expanded quality assurance to reduce errors and obsolete part numbers
- Frequent database update releases on the Ansys Customer Portal

2.) The Ansys Part Library team helps new users get their first few Sherlock models up and running by building the part definitions for their BOMs. **Users can request part builds by emailing:** partlibrary@ansys.com:

- Include a BOM file in excel format with manufacturer name and part number
- The library team will do the research and data entry, and send back a completed Sherlock part library file that can be used to update the part list in a Sherlock model
- For existing users, it is possible to build your own parts within Sherlock. Learn how by accessing the video tutorial on the Ansys Learning Hub (ALH). **ALH access required**

3.) The Sherlock Parts Library is updated every 6-8 weeks. To **access the latest parts database**, navigate to the Customer Portal *Ansys login required* > Downloads > Current Release > Add-On Packages > Sherlock Libraries

The Ansys Sherlock Parts Library allows users to automate the FEA model build process, making the E-CAD to reliability simulation workflow faster, more accurate & actionable.

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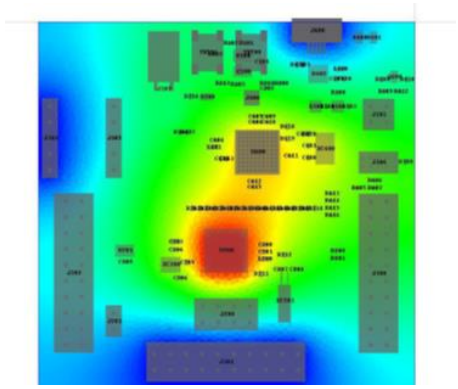
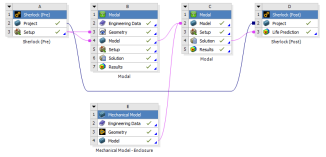
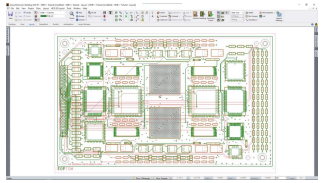
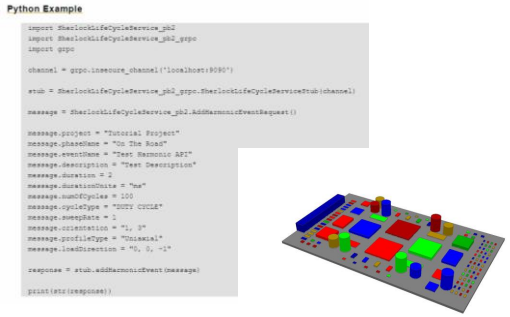
Ansys Sherlock Updates

Ansys Sherlock – 2023 R1 Software Updates









Thermal-Mech Conduction Support

- ✓ Sherlock can now perform thermal conduction analyses as a part of the Thermal-Mech workflow.
- ✓ Support for the following features:
  - ✓ Part Temp Rise
  - ✓ Thermal CSV Mapping
  - ✓ Thermal Image Mapping

Sherlock Integrations with Mechanical and AEDT Icepak

- ✓ Sherlock-Workbench
  - ✓ Improved handling of multi-PCB Assemblies
- ✓ Sherlock-Icepak
  - ✓ Import of Icepak Thermal Maps for multiple PCB assemblies.
  - ✓ Improved handling of PCB trace features(Arcs, Segments, etc.)
  - ✓ Compact Thermal Model (2R Network) Export option from Sherlock.

Sherlock Automation API Updates

- ✓ New APIs to support the automation of ICT Analyses
  - ✓ Test Point and Test Fixtures: Delete, Update and Export options available.
- ✓ APIs to delete Life Phases and Events

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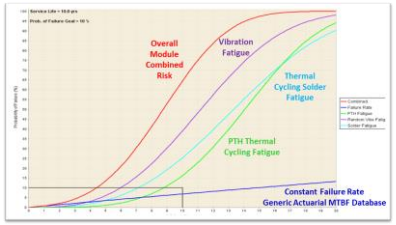
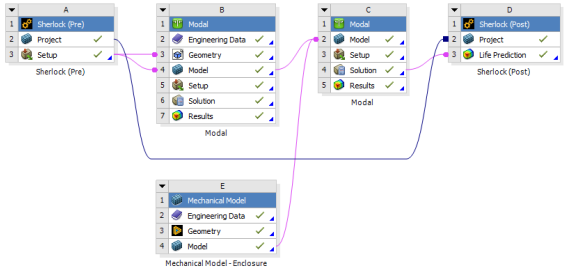
Sherlock-Workbench Updates

Sherlock to Workbench/Mechanical



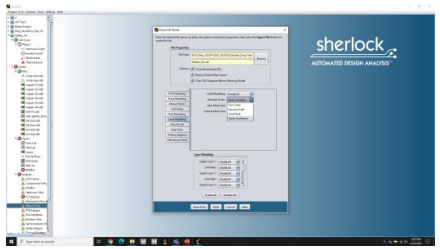


1. Workbench

Workflow/Schematic Setup for Assembly-Level Analysis

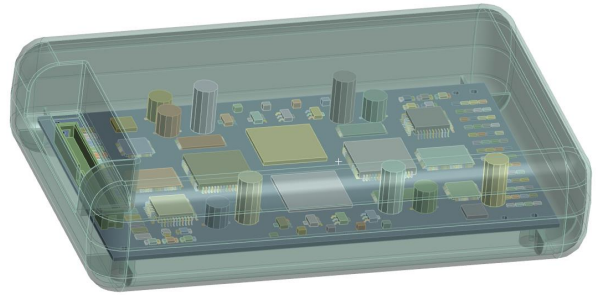
2. Sherlock

ECAD Import and PCB Modeling



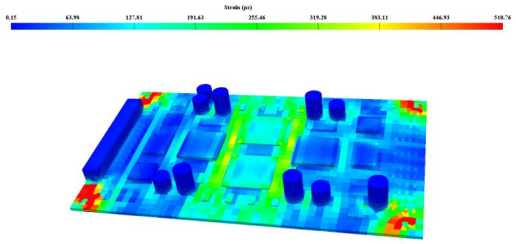
3. SpaceClaim/Mechanical

Create Enclosure Model



4. Mechanical

Solve and Post-Process



5. Sherlock

Import Results to Sherlock for Life Prediction

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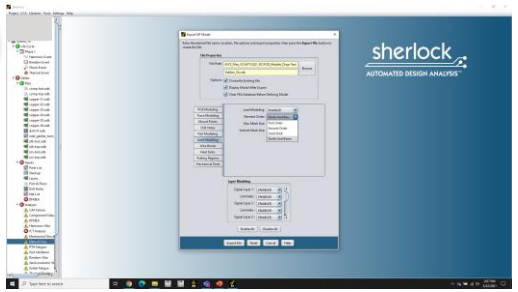
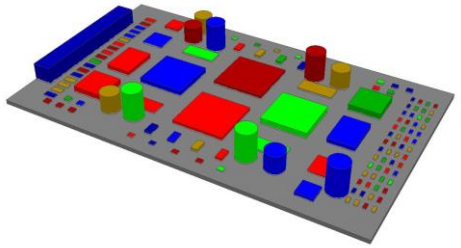
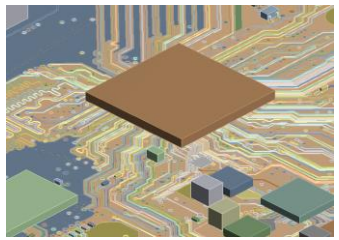
Sherlock-Workbench/Mechanical Workflow

1







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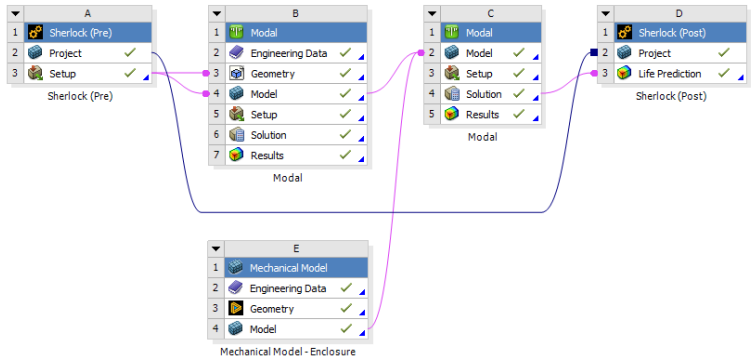

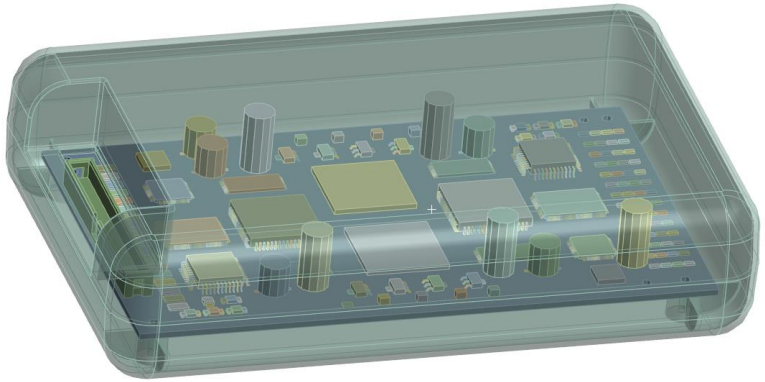

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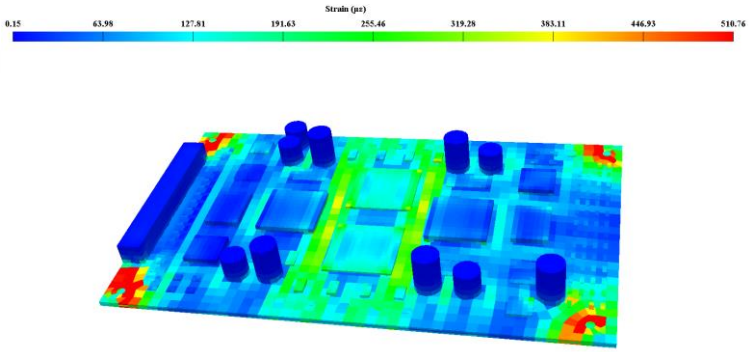

Random Vibe (221)

RefDes	Package	Part Type	Side	Solder	Max Disp	Strain	Damage	TTF (years)	Failure Prob	Score
U10	BGA676	IC	TOP	63SN37PB	5.1E-1	492.99	3.0E2	0.0	100.0	0.0
Q5	SOT-223	TRANSISTOR	TOP	63SN37PB	4.9E-1	423.20	2.1E2	0.0	100.0	0.0
Q3	SOT-223	TRANSISTOR	TOP	63SN37PB	4.6E-1	359.38	7.2E1	0.1	100.0	0.0
U9	BGA676	IC	TOP	63SN37PB	5.1E-1	386.86	6.3E1	0.1	100.0	0.0
Q7	SOT-223	TRANSISTOR	TOP	63SN37PB	4.8E-1	351.65	6.3E1	0.1	100.0	0.0
Q8	SOT-223	TRANSISTOR	TOP	63SN37PB	5.1E-1	322.60	3.6E1	0.1	100.0	0.0
Q6	SOT-223	TRANSISTOR	TOP	63SN37PB	5.1E-1	286.02	1.7E1	0.3	100.0	0.0
C8	C-BEND-3528-12	CAPACITOR	TOP	63SN37PB	8.6E-2	337.49	8.5E0	0.6	100.0	0.0
Q1	SOT-223	TRANSISTOR	TOP	63SN37PB	4.6E-1	241.76	5.7E0	0.9	100.0	0.0
U3	QFJ-68 (MO-087AD)	IC	TOP	63SN37PB	4.7E-1	419.08	3.8E0	1.3	100.0	0.0
C5	C-BEND-3528-12	CAPACITOR	TOP	63SN37PB	7.2E-2	285.68	2.9E0	1.7	100.0	0.0
Q4	SOT-223	TRANSISTOR	TOP	63SN37PB	4.9E-1	202.09	1.8E0	2.8	99.7	0.0
Q2	SOT-223	TRANSISTOR	TOP	63SN37PB	4.9E-1	185.17	1.0E0	4.8	67.2	0.0
U4	QFJ-68 (MO-087AD)	IC	TOP	63SN37PB	4.7E-1	302.16	4.7E-1	10.6	9.9	1.0
J1	DIP	JACK	TOP	63SN37PB	3.7E-2	238.52	2.5E-1	19.6	1.6	10.0
U14	TSOP-32 (MO-142...	IC	TOP	63SN37PB	4.4E-1	289.55	6.6E-2	>50	0.0	10.0
C25	SIP	CAPACITO...	TOP	63SN37PB	4.6E-1	397.82	4.0E-2	>50	0.0	10.0
U13	TSOP-32 (MO-142...	IC	TOP	63SN37PB	4.4E-1	262.75	3.5E-2	>50	0.0	10.0
C9	C-BEND-3528-12	CAPACITOR	TOP	63SN37PB	1.5E-1	140.88	3.2E-2	>50	0.0	10.0
C4	C-BEND-3528-12	CAPACITOR	TOP	63SN37PB	1.3E-1	137.94	2.8E-2	>50	0.0	10.0
C6	C-BEND-3528-12	CAPACITOR	TOP	63SN37PB	2.2E-1	126.02	1.5E-2	>50	0.0	10.0
C1	C-BEND-3528-12	CAPACITOR	TOP	63SN37PB	1.4E-1	123.66	1.4E-2	>50	0.0	10.0
U15	TSOP-32 (MO-142...	IC	TOP	63SN37PB	4.6E-1	218.96	1.1E-2	>50	0.0	10.0
R1	2512	RESISTOR	TOP	63SN37PB	7.7E-2	448.82	8.7E-3	>50	0.0	10.0
R103	1206	RESISTOR	TOP	63SN37PB	2.3E-2	617.55	7.6E-3	>50	0.0	10.0
C28	CAP-ALUM-G	CAPACITO...	TOP	63SN37PB	3.5E-1	286.63	4.6E-3	>50	0.0	10.0
C22	SIP	CAPACITO...	TOP	63SN37PB	1.4E-1	276.46	3.9E-3	>50	0.0	10.0
C21	SIP	CAPACITO...	TOP	63SN37PB	4.4E-1	262.71	2.8E-3	>50	0.0	10.0

Summary | Life Prediction | Random Vibe | Parts

Pre-Process in Sherlock

Assembly-Level Simulations in WB

Reliability Results in Sherlock

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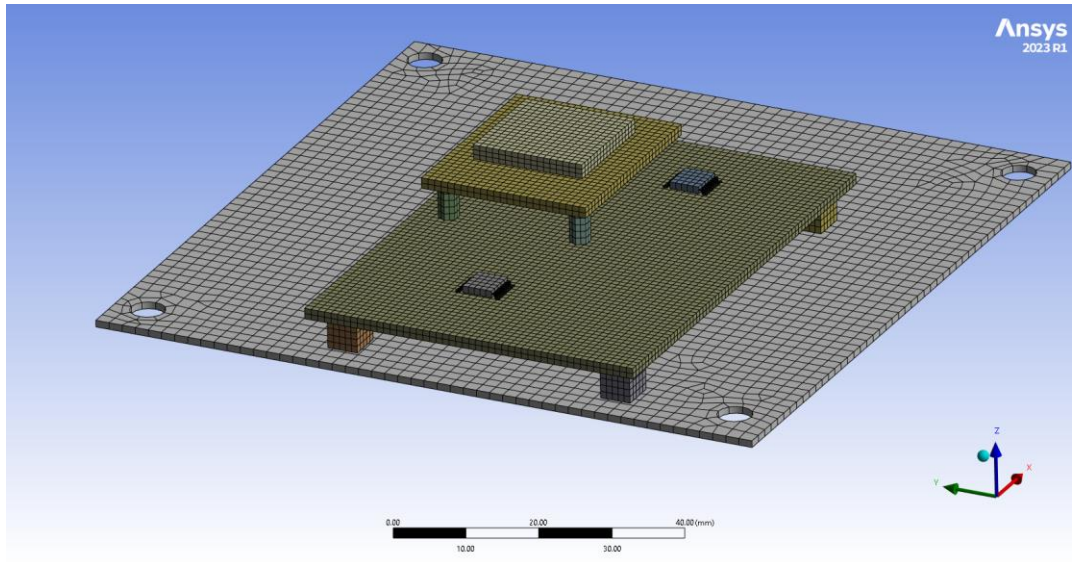
New in 2023 R1: Improved Handling of Multi-Board Assemblies

- In 2023 R1, the Ansys Sherlock-Workbench connection has been enhanced to streamline the reliability evaluation of multiple PCBs combined into an assembly.
- Examples include:
  - Motherboard and Daughterboard Assemblies
  - Multiple PCBs included within an Enclosure
- Boards can have the same name, and they can also come from projects of the same name.



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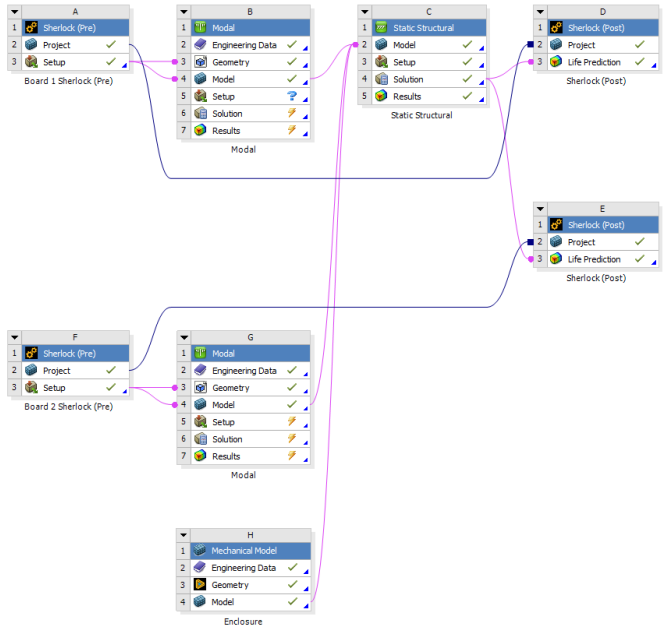
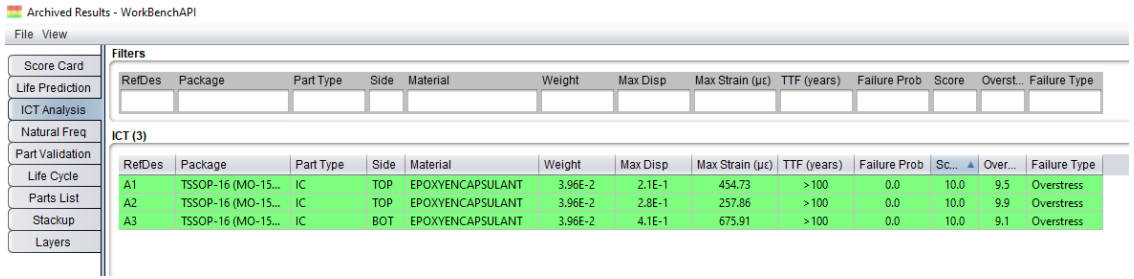
New in 2023 R1: Improved Handling of Multi-Board Assemblies

- When a user exports an FEA Model from Sherlock and selects the option to enable FEA Model ID, the Named Selections created will be prefixed by a unique id. This unique id can be found on the Edit Circuit Card Details properties form.
- Users should be able to import this model into Mechanical, run an FEA analysis, and successfully import the results back into Sherlock.





PCB 1 – Reliability Results

PCB 2 – Reliability Results

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Sherlock – AEDT Icepak

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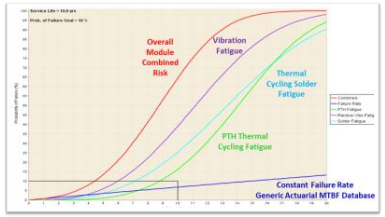
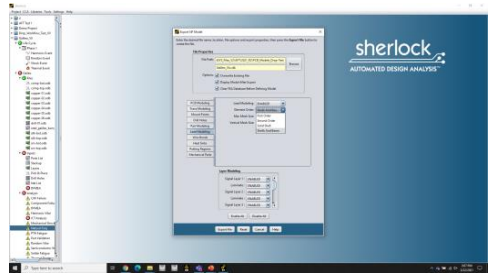
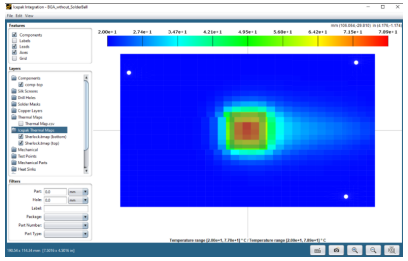
Ansys Sherlock-Icepak Workflow





Leverage Component Libraries and other features in Sherlock



1. Sherlock/Mechanical

ECAD Import and PCB Modeling

Export to EDB format

2. AEDT Icepak

Import EDB file generated using Sherlock

3. SpaceClaim

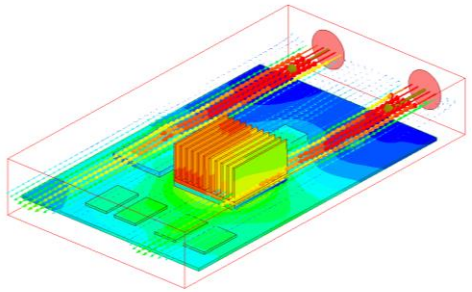
Build Enclosure and other components

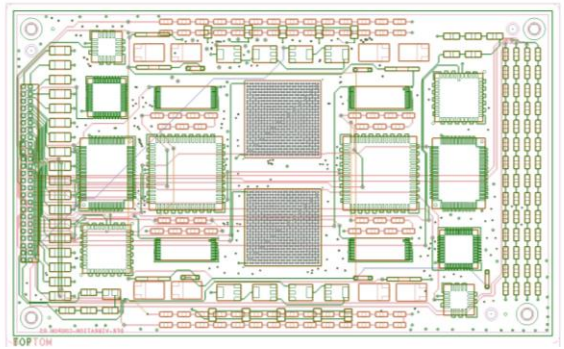
4. AEDT Icepak

Integrate PCB and Enclosure/Component Models and Run Simulations

5. Sherlock

Import Icepak Results into Sherlock for Solder Fatigue Predictions





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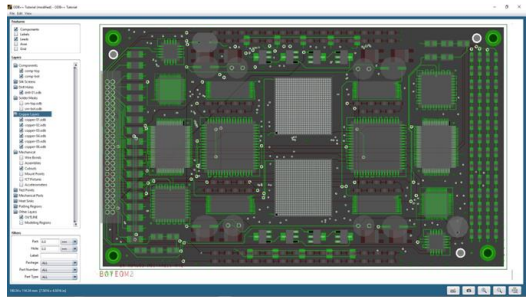
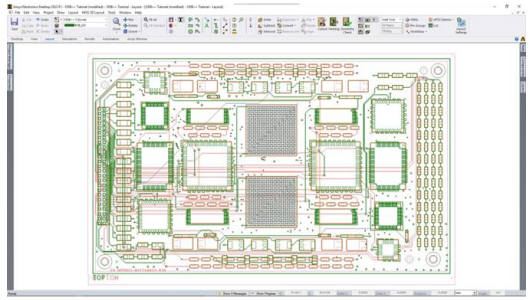
Sherlock-Icepak Workflow

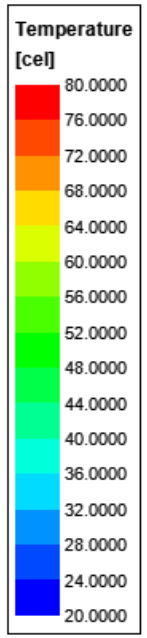
Direct Results Import Icepak >> Sherlock New in Ansys 2022 R2

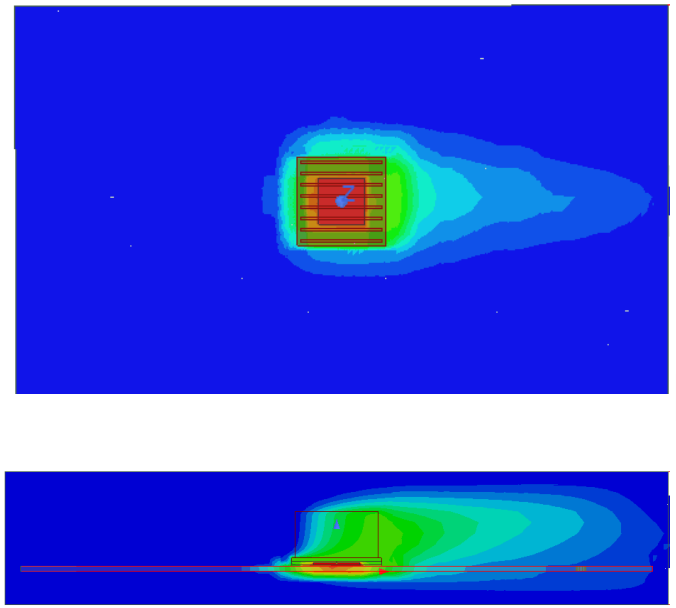


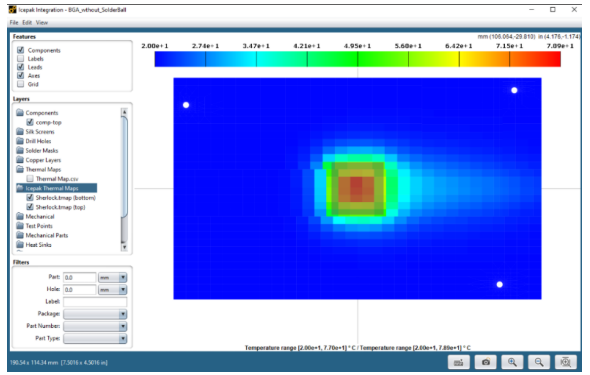
Ansys Sherlock

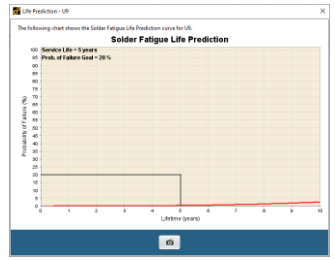


Ansys AEDT/Icepak









1.) Pre-Processing in Sherlock and AEDT Icepak

2.) Thermal Analysis in Icepak

Filters

RefDes	Package	Part Type	Model	S...	Material	Solder	Max dT (C)	Damage	TTF (years)	Cycles To Fail	Score

Table (1)

RefDes	Package	Part Type	Model	...	Material	Solder	Max dT (C)	Damage	TTF (years)	Cycles To Fail	Score
U9	BGA676	IC	BGA	...	EPOXYENCAPS...	SAC305	55.0	1.5E-1	33.87	12,371	10.0

3.) Post-processing and Reliability Predictions in Ansys Sherlock

Ansys Sherlock users can now import AEDT Icepack results directly. The resulting temperature results can be used as input to Solder Fatigue (Thermal Cycling) analyses.

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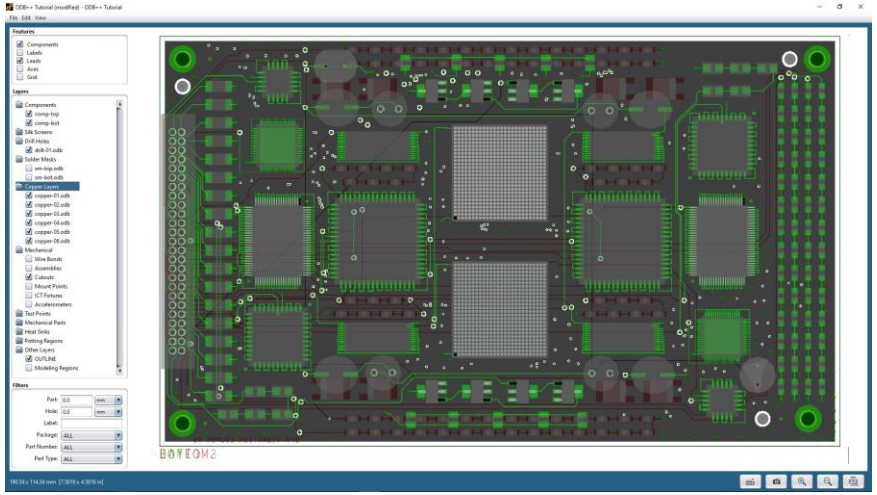
Sherlock Export to Ansys Electronics Desktop (AEDT)

- Users can export a CCA using the EDB format that is used by Ansys AEDT.
  - Ansys ECAD Database (*.def) file (Commonly referred to as an EDB file).

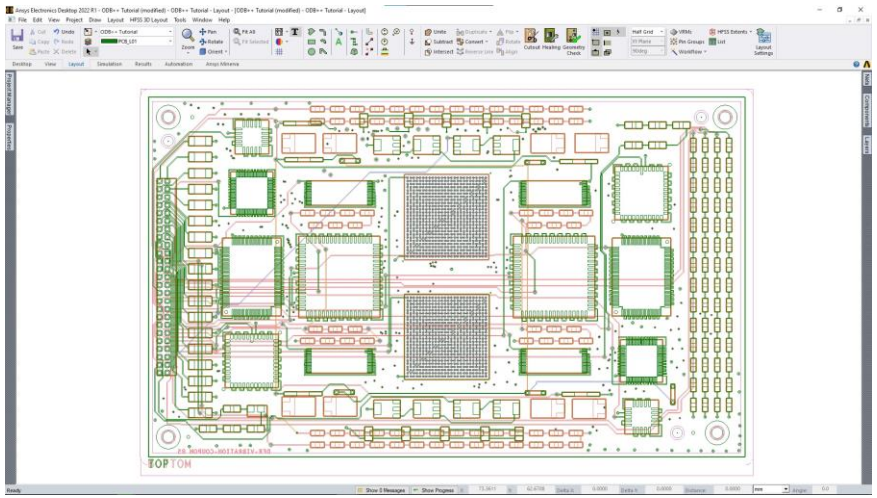
Supported Features:

- Stackup Layers
- Board Outline
- Holes
  - Vias
  - Plated Through-Holes
  - Non-Plated Through-Holes
- Traces
- Cutouts
- Components
- Pads (Stored as Pins)
- Material Properties
- Reuses packages in order to reduce the number of elements created and to improve performance.
- Exports nets.
- Sets the specific heat value of the exported material for components with multiple materials if the specific heat is known for those materials.
- Sets the anisotropic thermal conductivity values of the exported materials for components with multiple materials.
- Additional Enhancements related to Leaded Packages and more.

New items in 2023 R1 are shown on the following slides.



Ansys Sherlock



Ansys AEDT/Icepak

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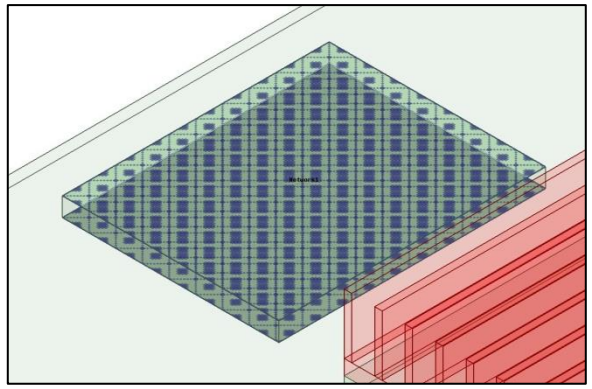
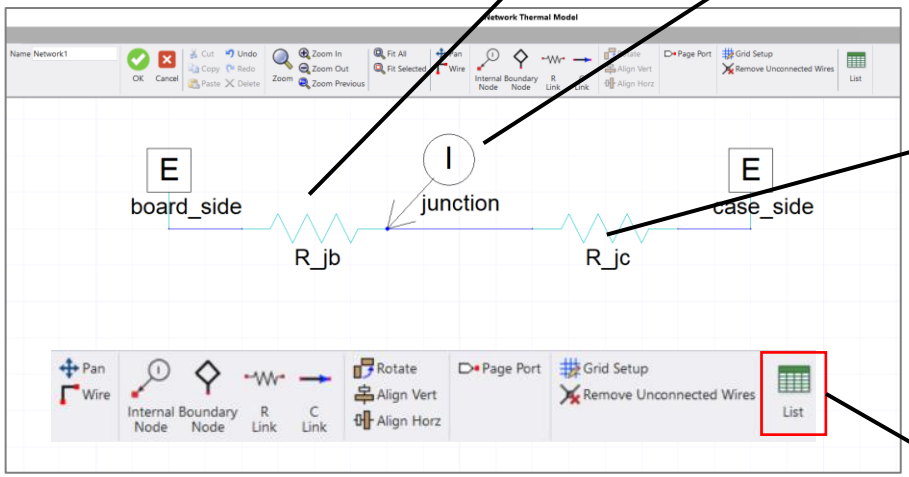
New Junction Resistance Fields in the Part Editor

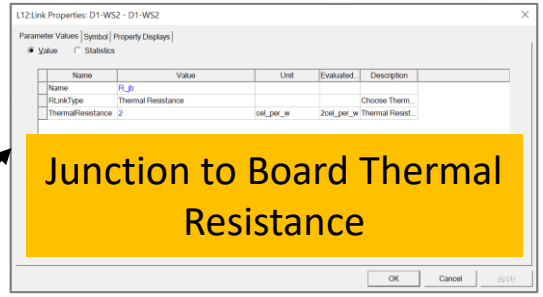
- In AEDT Icpeak, users commonly model complex objects using thermal networks.
- Two-Resistor (2R) models are especially popular.
- Required Input:
  - Junction to Board Thermal Resistance, Rjc (C/W)
  - Junction to Case Thermal Resistance, Rjc (C/W)
  - Junction Power (W)

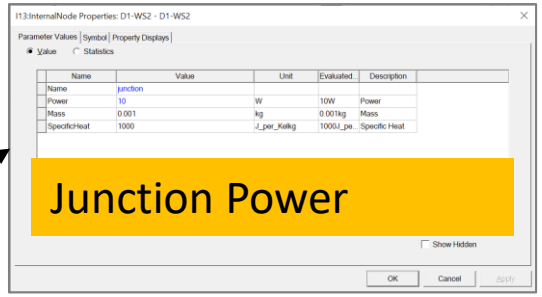


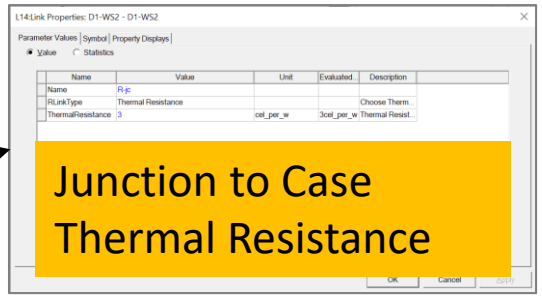
Resistance R-links

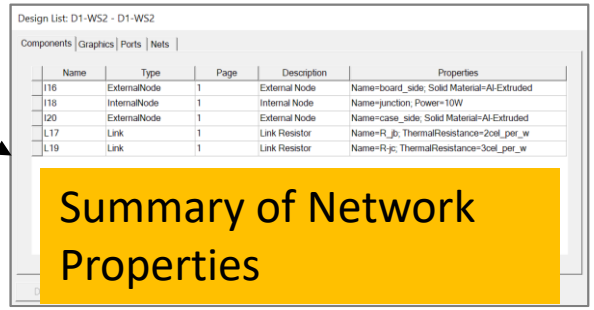


Thermal Network Model in AEDT Icepak









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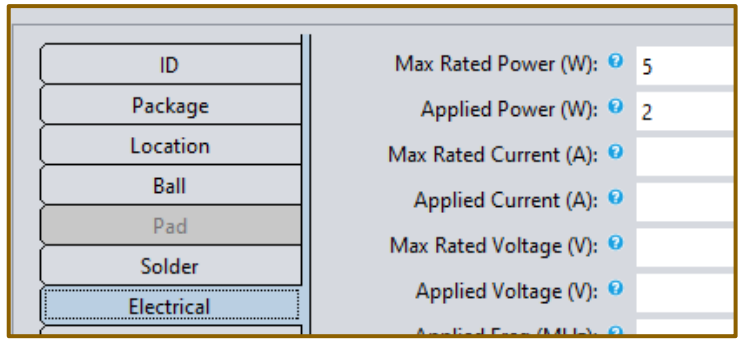
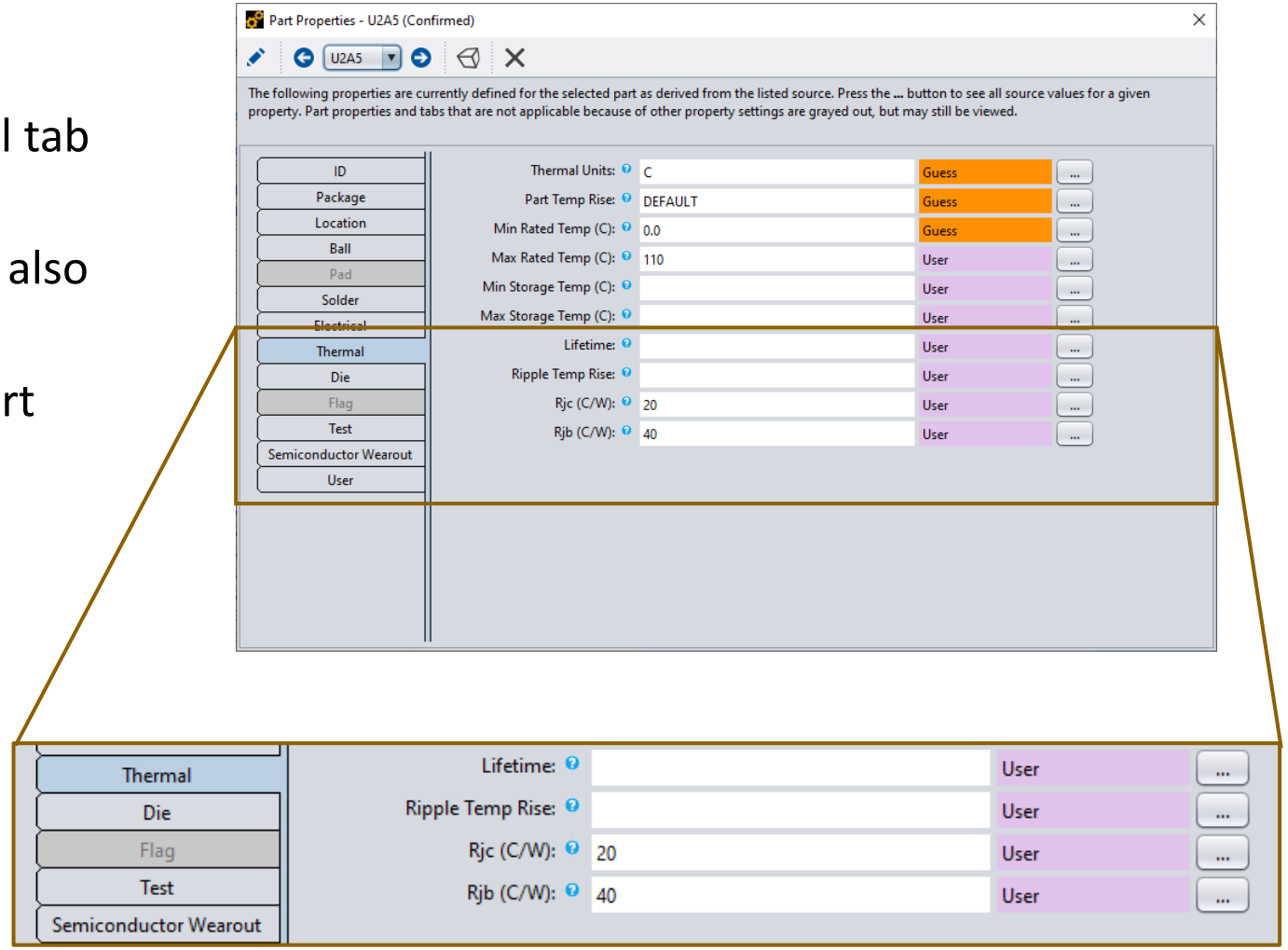
New Junction Resistance Fields in the Part Editor

- In Ansys Sherlock, users can now apply/edit values for Rjb and Rjc to parts in the Thermal tab in Part Editor window.
- Applied Power, Max Rated Power values can also be specified in the Electrical Tab.
- These values can also be exported via the Part List export option.



Max Rated Power and Applied Power



Junction Resistance Values

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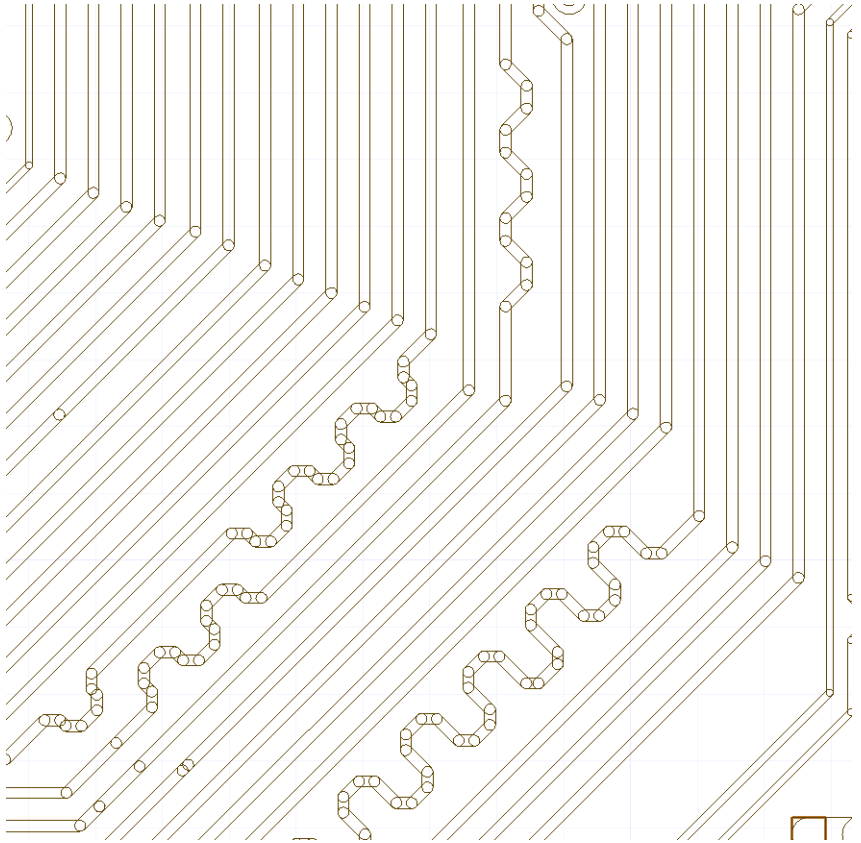
Improved Resolution of Traces for Increased Performance

- To support more accurate and efficient Icepak simulations, traces can now be exported from Sherlock to AEDT Icepak using their defined geometry (arcs and segments) rather than partitioning an arc into points in polygons.
- This will help the downstream solve loop robustness and performance.

Note:

- Traces are exported using segments and arcs for layers that don't have an image file for the traces
- For layers that have an image file, use that to export traces as polygons.



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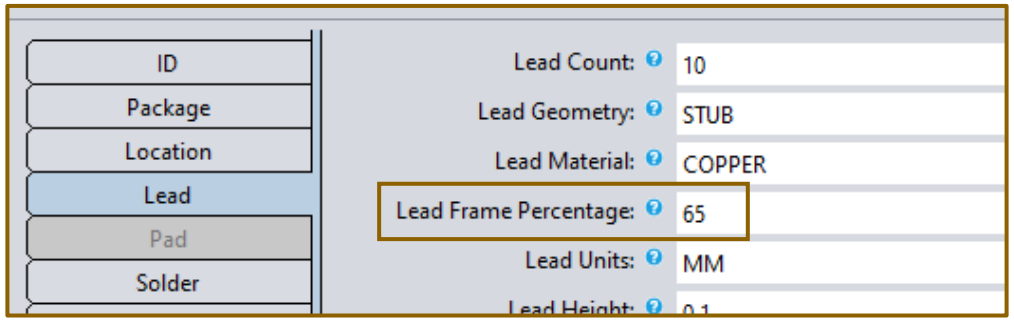
EDB Export: Ability to set Copper Percentage for Leaded Packages

- Users can now modify the copper distribution of the third layer for leaded packages. The value can be specified in the Lead tab for a given part in the Part Editor under the Lead Frame Percentage field.
- The default value is set to 65% copper.



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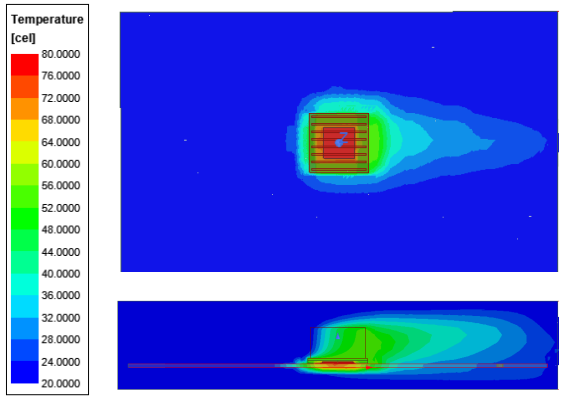
Importing Icepak Thermal Map File with Data for Multiple Boards

- In 2023 R1, Ansys Sherlock users can now import .tmap files from AEDT Icepak containing temperature data for multiple PCBs into Sherlock for downstream analyses, such as Solder Fatigue.

- This feature will allow users to more rapidly and easily perform solder fatigue assessments of larger systems that include multiple boards.

- Notes:
  - For convenience, files can be added through the Files item in the tree. They can also be added using a drag-and-drop operation.
  - If the imported .tmap file has data for multiple boards, Sherlock will recognize the relevant data for the PCB for which the user is importing the file and ignore any data within the .tmap not relevant to that PCBA (extra data won't be stored in the Sherlock project folder).
  - If multiple data sets exist within a .tmap for a single board (multiple instances of the board within a single Icepak simulation), Sherlock should import all thermal data with an appropriate naming convention.
    - Example: Thermal Map 1_Top, Thermal Map 1_Bot, Thermal Map 2_Top, Thermal Map 2_Bot,….



SherlockPCBname PCB1_1
[nodes]
54128, -0.076994, 0.013825, 0.002118
54127, -0.071834, 0.013825, 0.002118
54126, -0.071834, 0.009667, 0.002118
54125, -0.076994, 0.009667, 0.002118
131714, -0.079573, 0.009667, 0.002118
131733, -0.079573, 0.013825, 0.002118
…
…
SherlockPCBname PCB2_1
[nodes]
1165871, -0.038862, -0.019064, 0.002783
1165870, -0.041424, -0.021350, 0.002783
1165869, -0.043986, -0.021350, 0.002783
1165868, -0.043986, -0.019064, 0.002783
1169172, -0.046549, -0.019064, 0.002783
1167004, -0.046549, -0.016779, 0.002783

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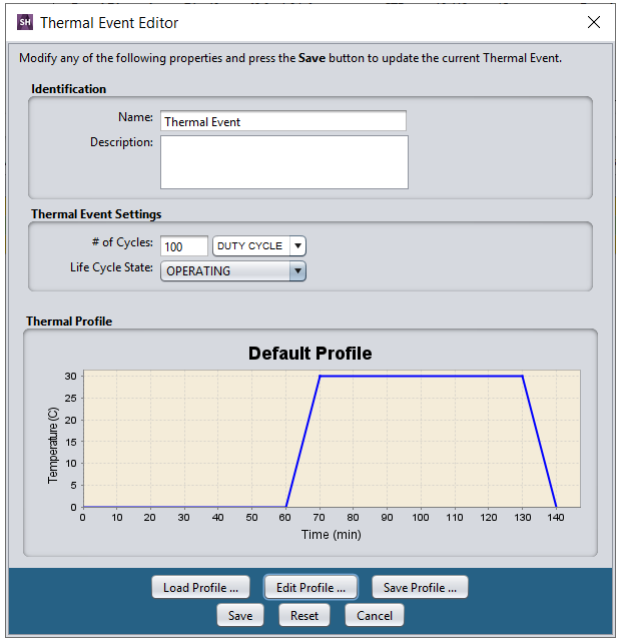
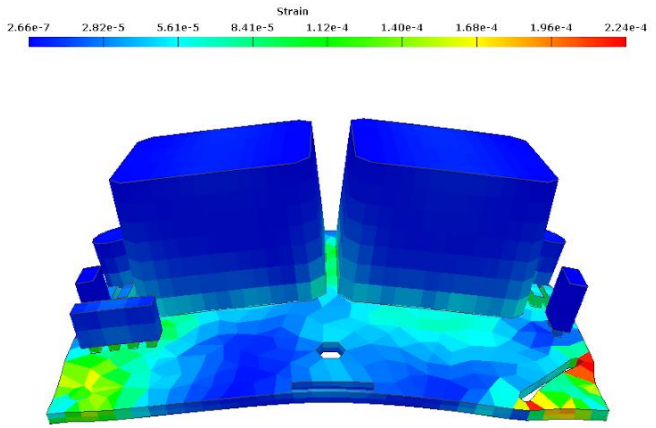
Thermal-Mech Updates

Review: Thermal-Mech

The **Thermal Mech Analysis Module** simulates structural deformation using a Finite Element Analysis (FEA) model of a PCB and the temperature-dependent properties defined in the Material Manager to determine the likelihood of solder joint failures for one or more temperatures.





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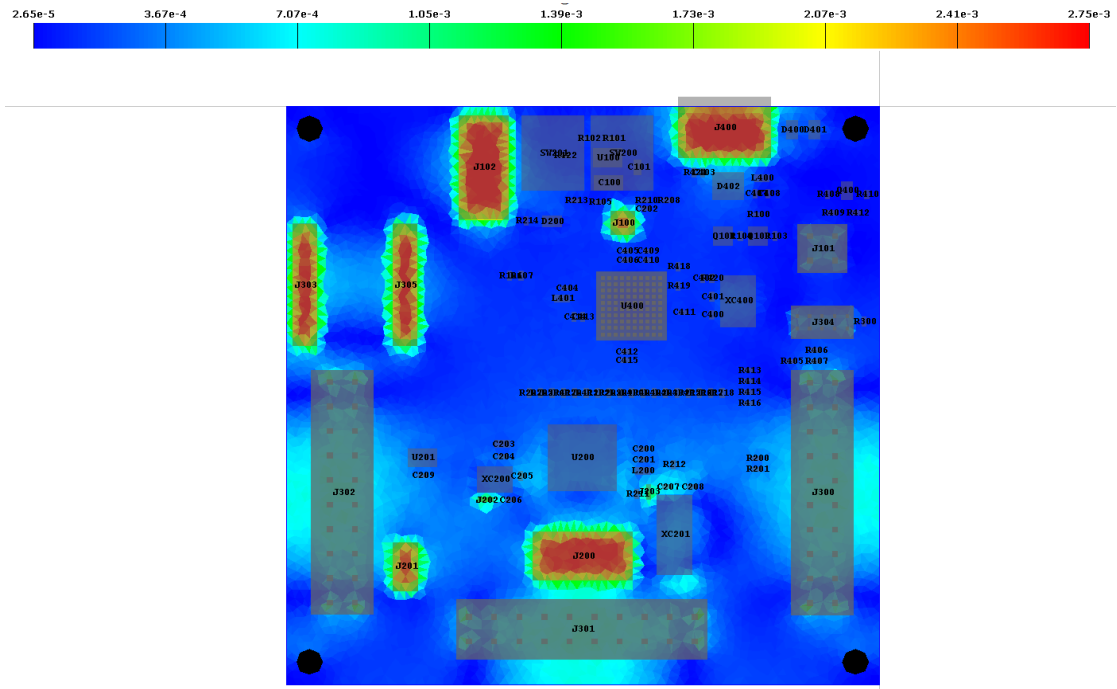
Review: Thermal-Mech

- Coupled thermal-mechanical simulations
  - Thermal conduction analysis (New in 2023 R1)
  - Mechanical stress analysis due to CTE mismatch
- Part and PCB displacement and strain from bending
- Bending causes tensile stresses to be imparted into the solder joints
- Thermal mechanical simulations in Sherlock are designed to identify risks due to external loads beyond just component and printed circuit board thermal expansion mismatch
  - Over constrained boundary conditions
  - Mirroring of components
  - Potting influences
  - Lead influences



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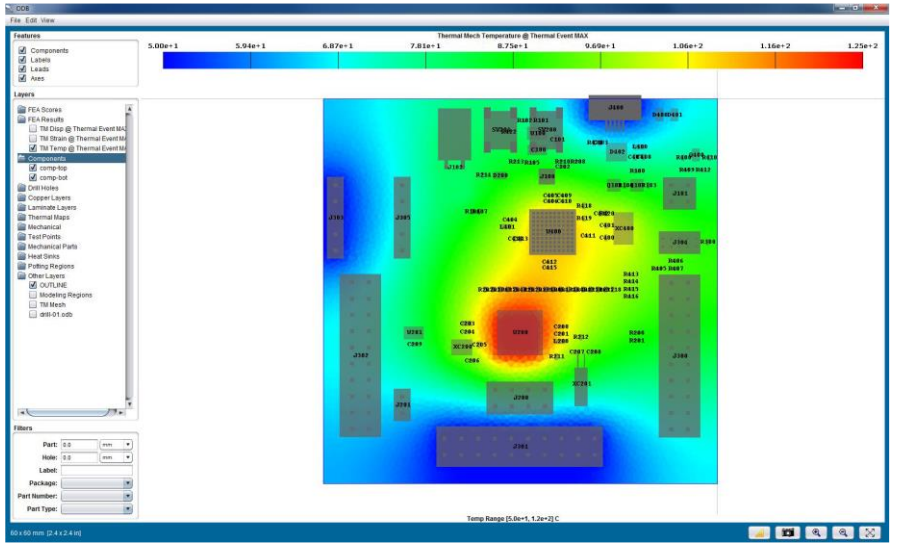
Thermal-Mech Updates in 2023 R1

- In Ansys Sherlock 2023 R1, users can now include thermal conduction as a part of their Thermal-Mech studies.
- Supported Options and Capabilities:
  - Part Temperature Rise:
    - When disabled, the Thermal-Mech analysis will be performed without conduction
    - When enabled the new thermal mech with conduction process will be performed.
  - Thermal Image Mapping-based Analysis
  - Thermal CSV-based Analysis
- Note: These new options overcome previous limitations that only allowed for uniform temperatures to be applied.



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Sherlock APIs – Automation Updates

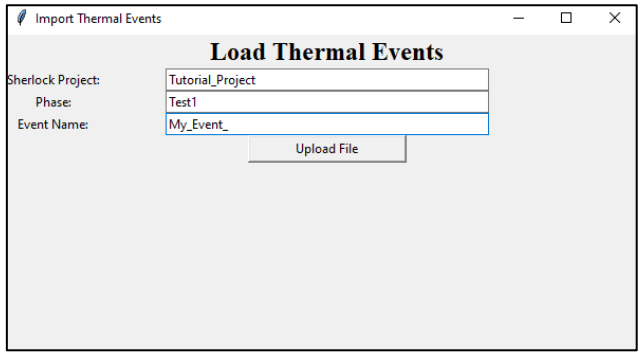
Ansys

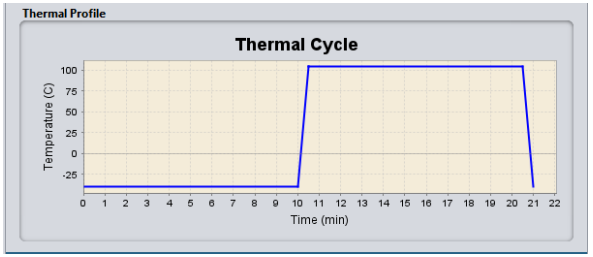
Sherlock Automation APIs

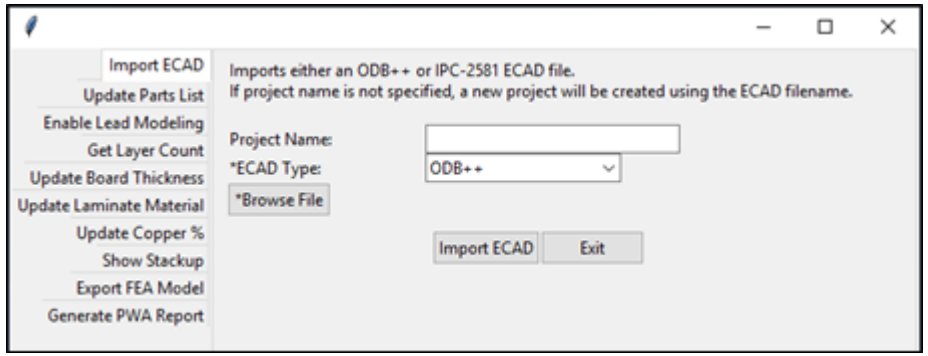
Day-to-Day Task Streamlining

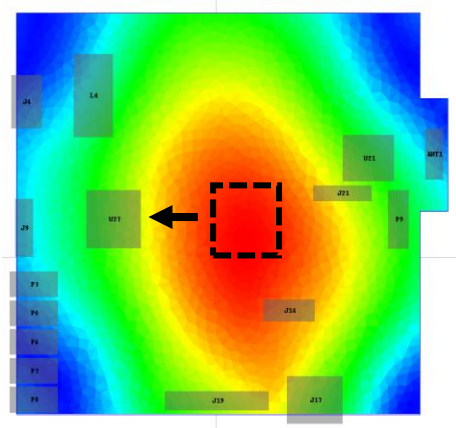
Workflow Automation

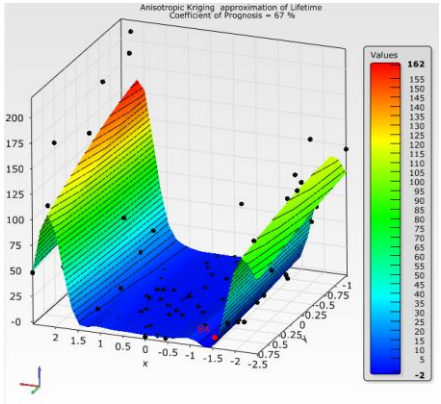
Design Exploration











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2023 R1 – Sherlock API Update Summary

- New APIs
  - Delete Life Cycle Phase
  - Delete Life Cycle Event
  - Update a list of Mount Points using gRPC input parameters
  - Update importPartsList() API to include setting “Import as User Source”
  - Update build process to create Python scripts for API users
  - Set multiple component locations via json request input
  - Update a list of Mount Points using gRPC input parameters
  - Delete all ICT Test Points on a board
  - Delete all ICT Fixtures on a board
  - New API to add or update one or more ICT Fixtures using a CSV file
  - New API to add or update one or more Test Points using a CSV file
  - New API to export (CSV) ICT Fixtures and their properties for a CCA
  - New API to export (CSV) Test Points and their properties for a CCA

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Review: In-Circuit Test (ICT)

- Tool to inspect for manufacturing defects
  - Test probes + support fixtures
- Exerts a mechanical force at each probe/support
- Can cause an overstress condition if there is excessive board flexure
  - Pad cratering, flex cracking

R. Reinosa, “Characterizing Mechanical Performance of Board Level Interconnects for In-Circuit Test,” International Test Conference (ITC), Austin, TX, November 2-4, 2010.

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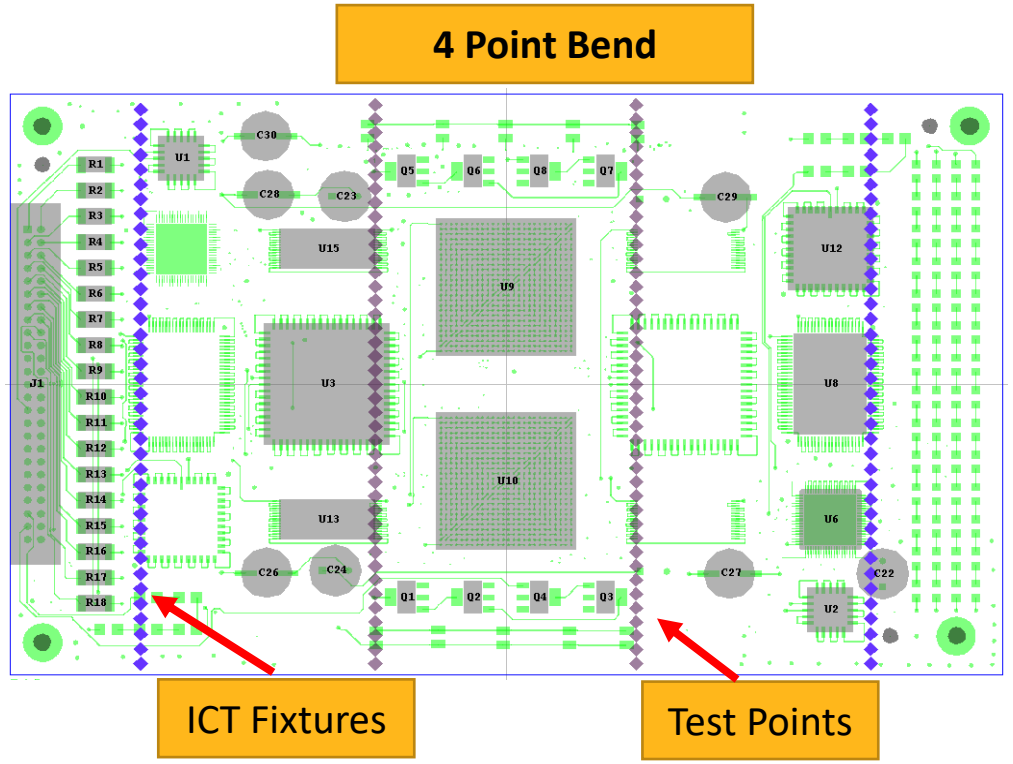
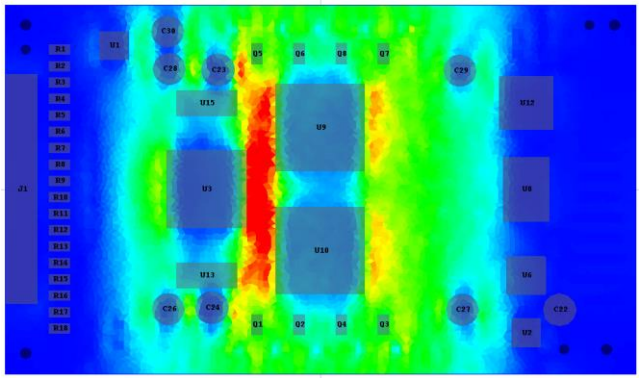
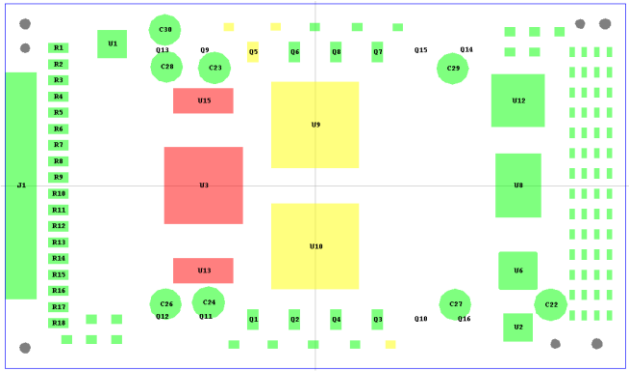
2023 R1 API Highlight: In-Circuit Test (ICT) Automation

- New APIs facilitate the automation of ICT Analyses:
- For both Test Points and Test Fixtures, users can now script the following operations
  - Delete
  - Add or Update
  - Export (to CSV files)g
- Users can go further by integration their script within Ansys optiSLang to perform Sensitivity and Optimizaton Studies.







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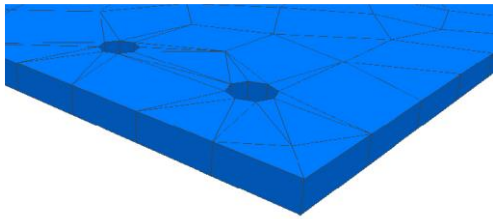
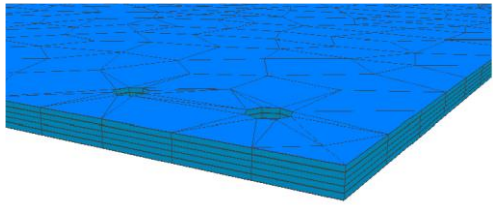
Ansys Mechanical & MAPDL Updates

Review: PCB Modeling Approaches

Homogenized/Lumped



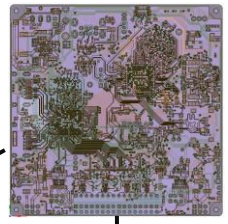
Lumped over entire board



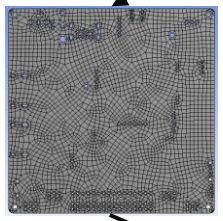
Lumped by Layer

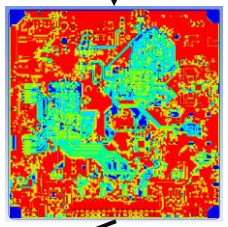
Trace Mapping

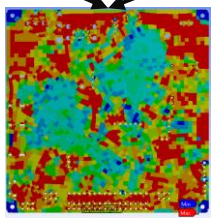
ECAD Data



Mesh



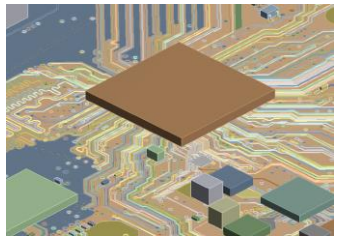




High resolution Cartesian metal map from ECAD

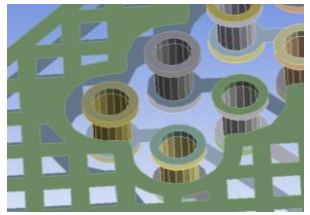
Element-wise material mapping

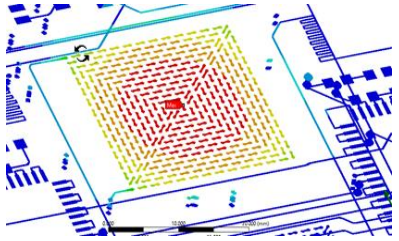
Reinforcements



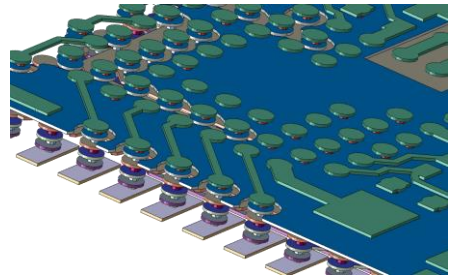
Embed surfaces (traces) and beams (vias) within a base mesh

Improved accuracy without full 3D Trace Modeling

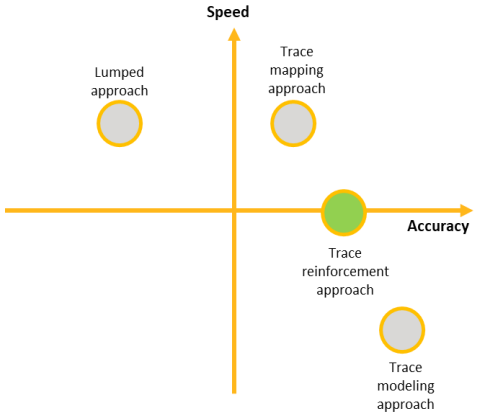




Trace Modeling



Full 3D Detail



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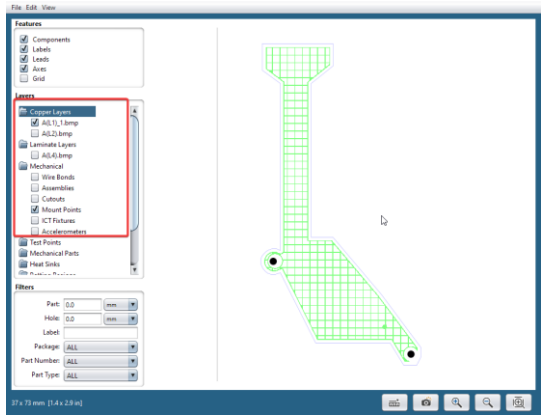
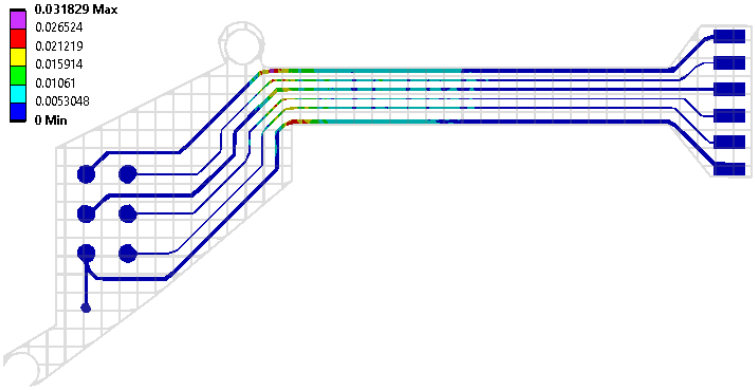
Review - Highlight: Ansys Solution for Flexible PCBs

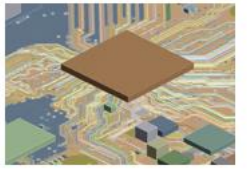
Reinforcements



Ansys Sherlock (Pre-Processing)

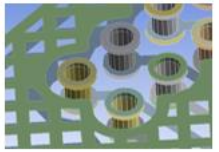


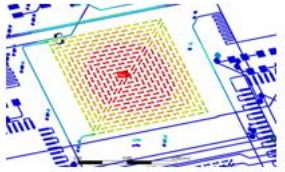
Ansys Mechanical (Solver and Post)



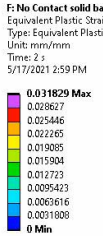
Embed surfaces (traces) and beams (vias) within a base mesh

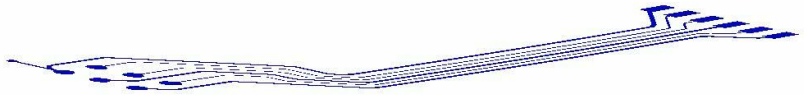
Improved accuracy without full 3D Trace Modeling





Key Technology: Reinforcement Elements





Trace Reinforcement modeling approach is a novel and highly efficient method in Ansys to model the ECAD data. It **provides a high level of accuracy without compromising** on computational time and resources.

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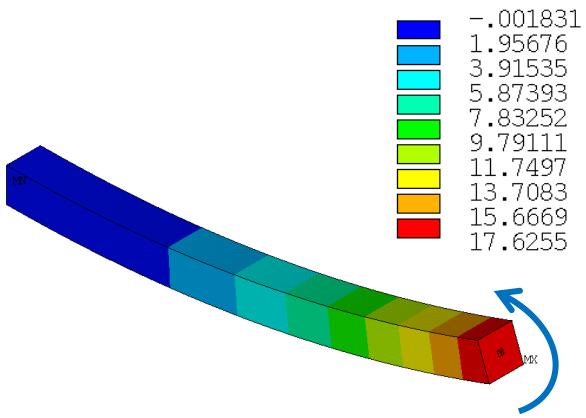
2023 R1 Update: Elements

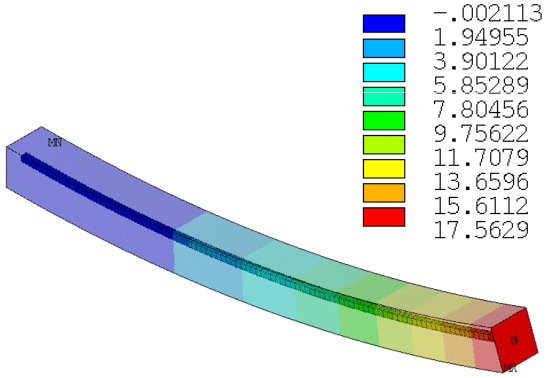
Bending & Torsional Stiffness for Discrete Reinforcing Element

- Discrete reinforcing element REINF264 capable of uniaxial stiffness only before R23.
- Bending and torsional stiffness required for embedded electronic (vias), civil (steel rebars), or biomedical (stents) components

Case 1: Reinforcing vs. full solid models



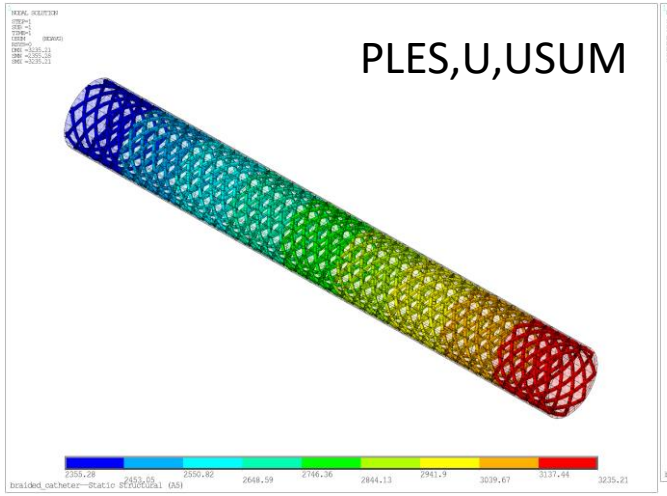
SOLID186 model

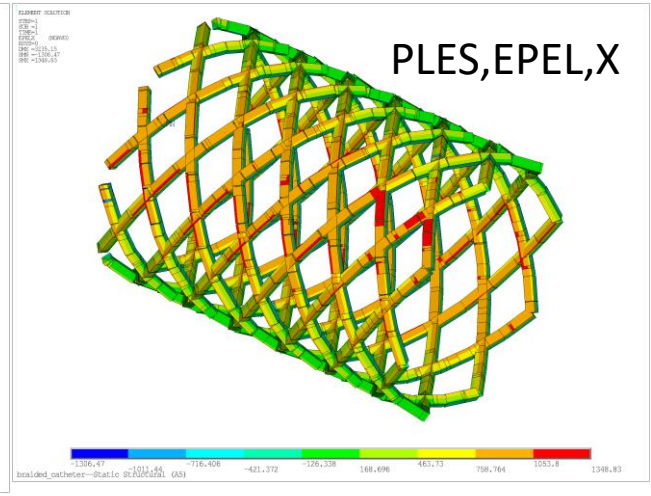


REINF264 model
w/ bending & torsional stiffness

Case 2: Bending of a braided catheter

ev264-mi210s.dat





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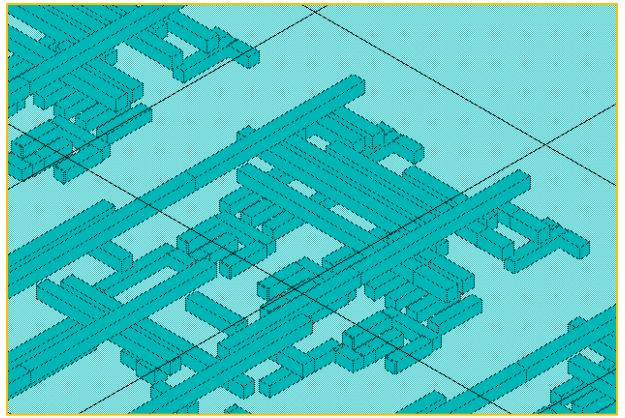
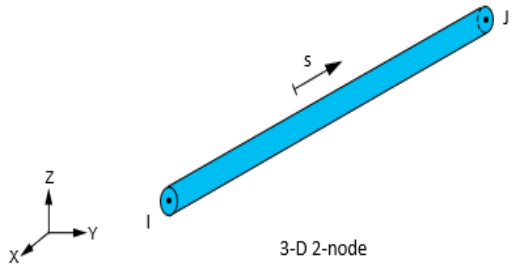
Coupled-Field Link Element (LINK228)

- Motivation
  - Element embedding method already adopted in electronic reliability study
  - Many PCB/Chip components can be simulated with line elements
  - Need for coupled-field line elements to properly capture the physics



- Overview
  - LINK228 : 3D 2-Node Coupled-Field Link
  - Supported coupling types
    - Structural-Thermal , Thermal-Electric, Structural-Thermal-Electric coupling
  - Supported analyses
    - Static, Transient, Harmonic
  - Max. DOFs : UX, UY, UZ, TEMP, VOLT



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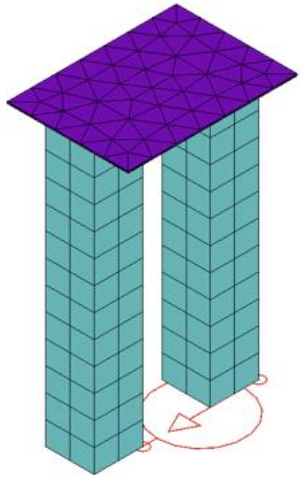
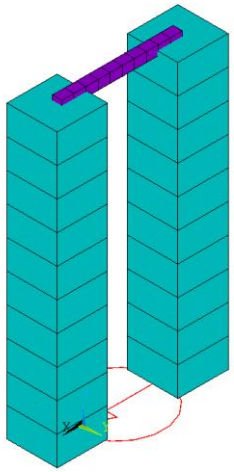
Case 1: Thermo-Electric coupling : Peltier Cooler

- Comparison between SOLID225 and LINK228
- Accurate results with smaller models

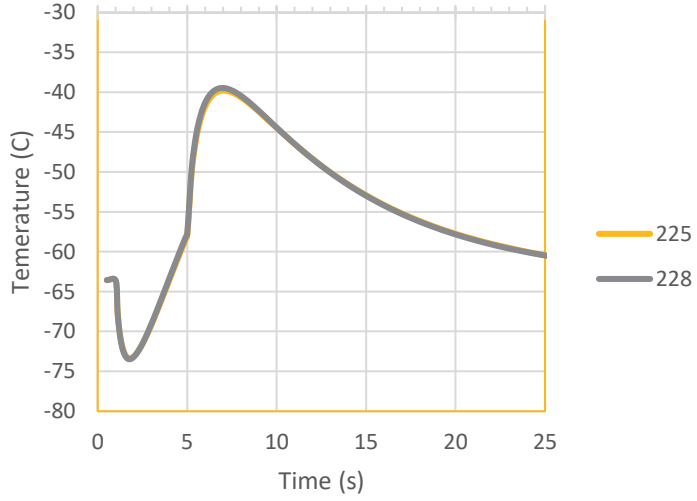
SOLID225

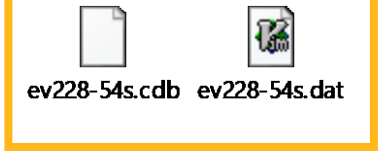


LINK228



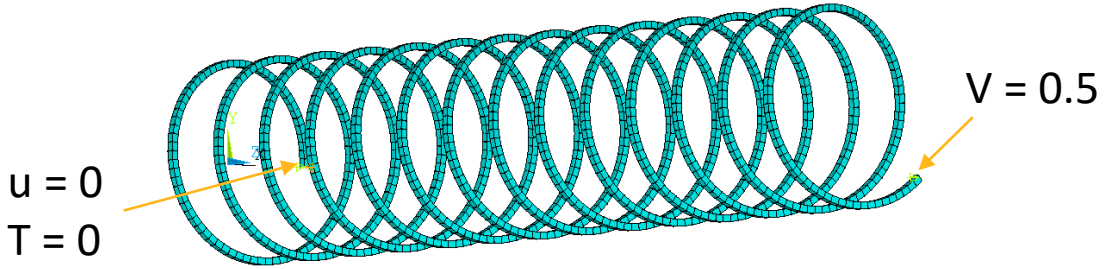
Cold Junction Temperature

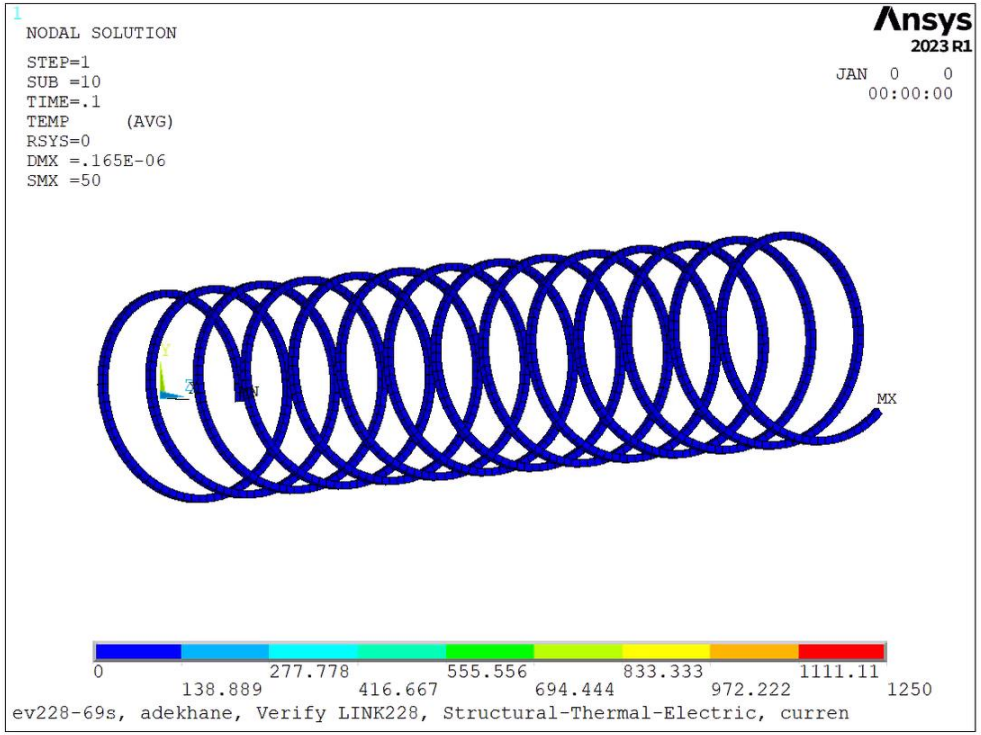




Case 2: Structural - Thermo-Electric Coupling

- Electric field induced deformation





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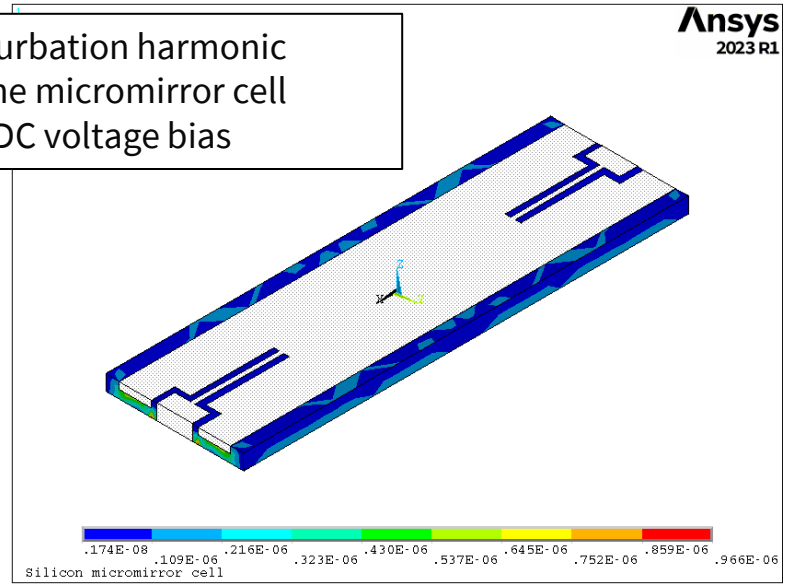
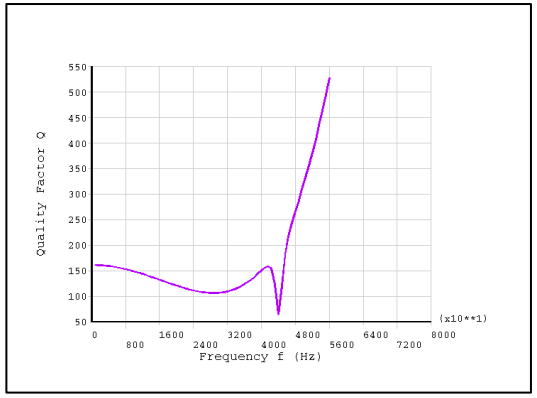
Electrostatic-Structural Analysis Enhancements

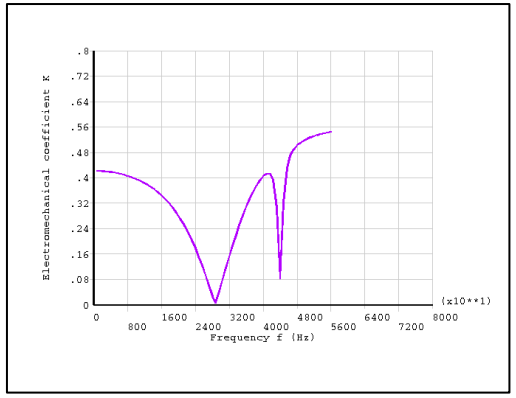
- The electrostatic-structural analysis (KEYOPT(1)=1001) of elements PLANE222, PLANE223, SOLID225, SOLID226, and SOLID227 has
  - A new keyoption (KEYOPT(4) = 4) to turn off the default electric force coupling
  - New element output quantities available with the electric force coupling to make result post-processing consistent with the piezoelectric coupling:
    - electric current density (JS),
    - energies (Ue, Ud, Um, SENE, KENE, DAMP)
    - Joule heat (JHEAT)

A linear perturbation harmonic analysis of the micromirror cell subject to a DC voltage bias



demo_mirror.dat





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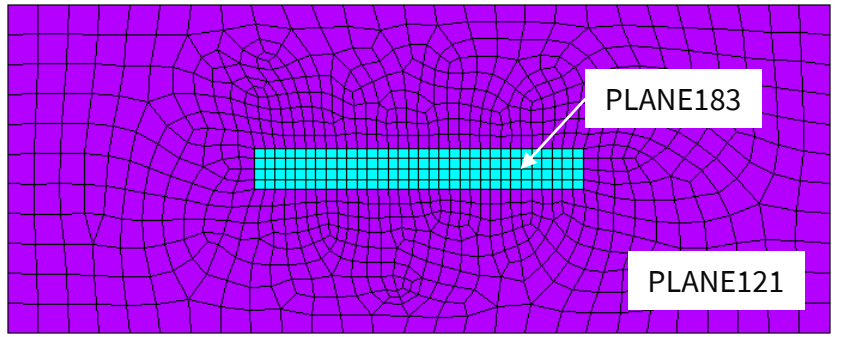
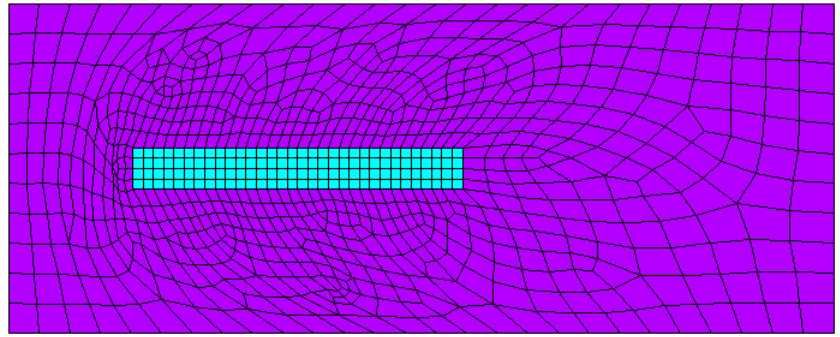
MORPH Command Enhancement

- The MORPH command with the option that allows structural elements in the model (StrOpt = YES) now supports the morphing of the following meshes:
  - Electrostatic
  - Electric
  - Thermal
  - Diffusion
  - Electromagnetic
  - Coupled-field with no structural degrees of freedom

Undeformed electrostatic mesh
Capacitance C0 = 62.4pF



Morphed electrostatic mesh following the displacement of a structural mesh to the left
Capacitance C1 = 64 pF



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