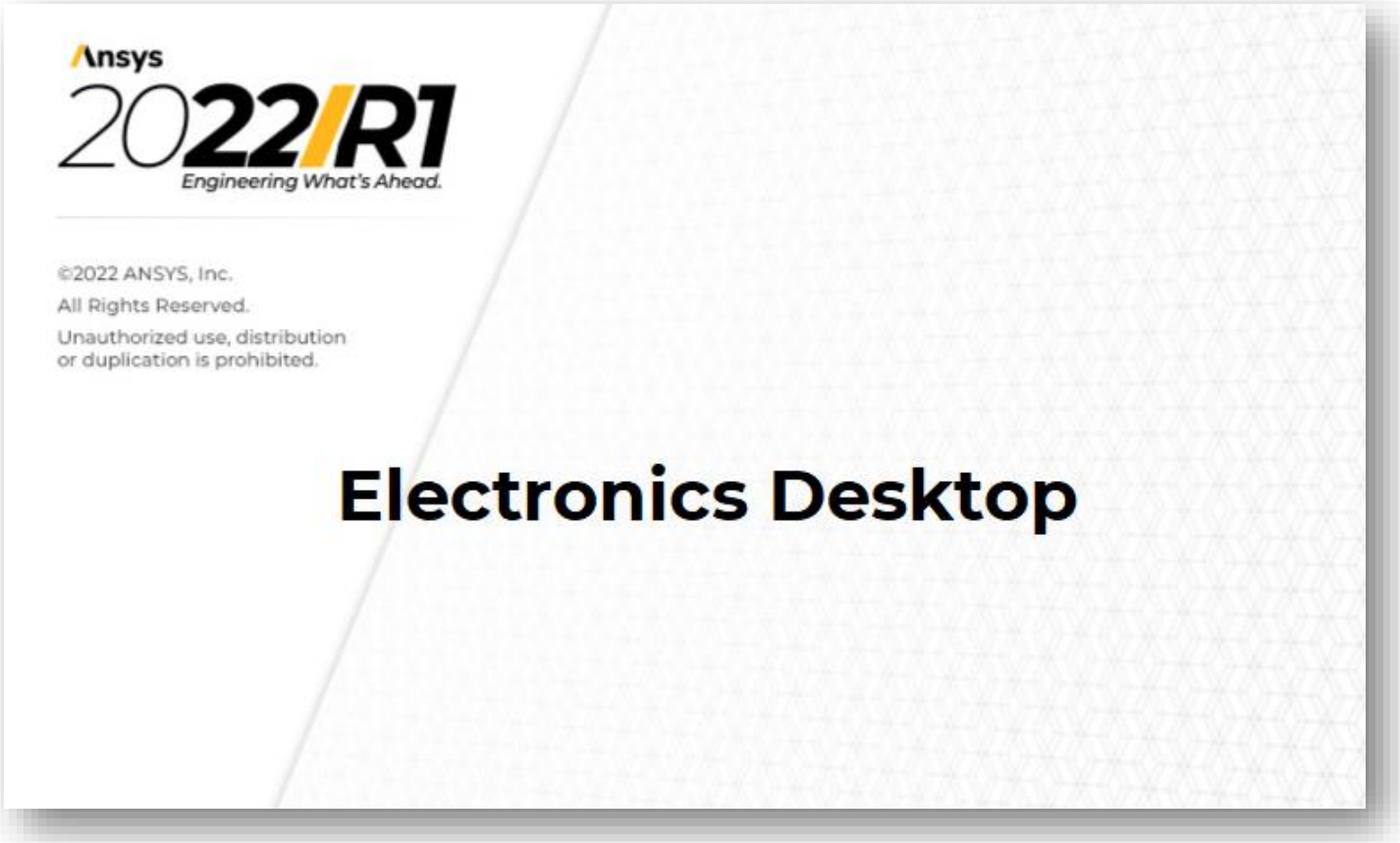
Release 2022 R1 Highlights
Ansys Maxwell

Outline

- Solver Technology
- HPC
- Usability (UX)
- Electrical Machine Performance
- Multiphysics

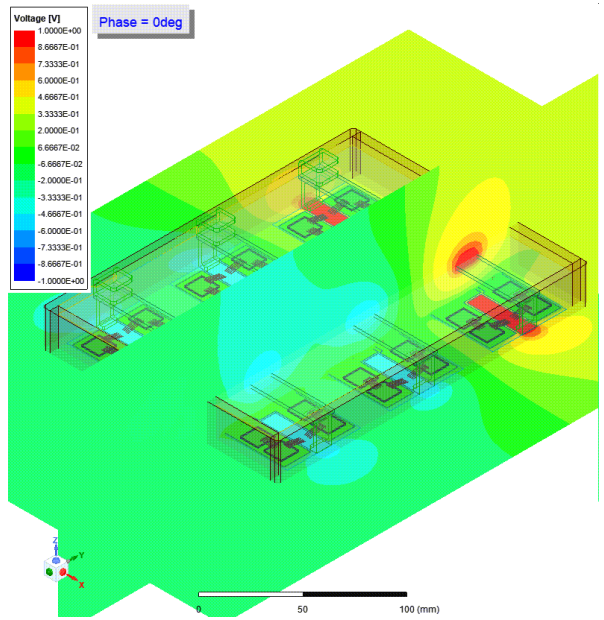


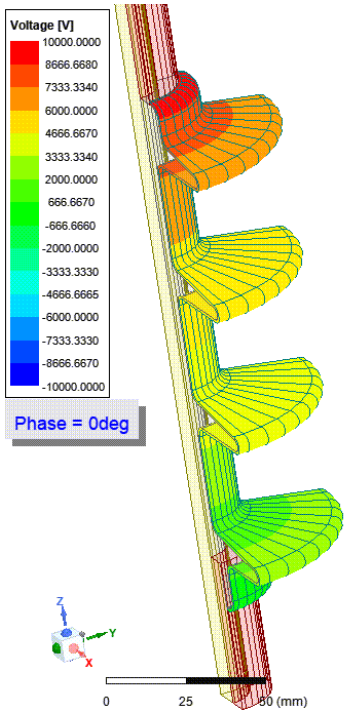
Solver Technology

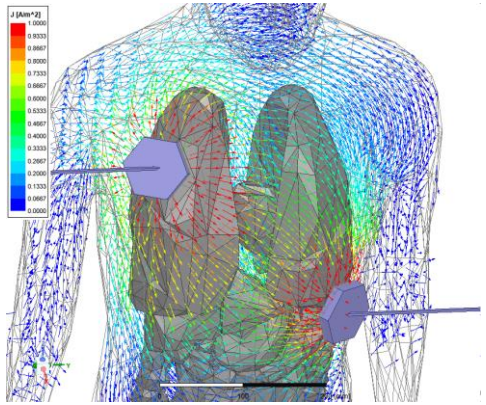
Maxwell 3D AC Conduction Solver

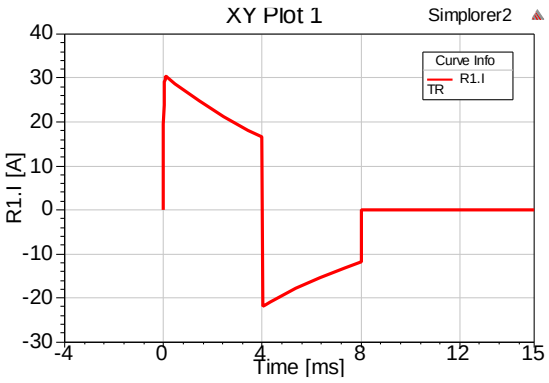
- 3D electric frequency domain solution
  - Temperature dependent material
  - Non-linear materials
  - Two-way coupling with thermal solver
  - Insulating BC
  - Field results
  - Field quantities (Energy and Qsurf)

- Key applications
  - PCB analysis
  - Parameter's extraction
  - High-voltage equipment
  - Health care
  - Sensors









3D A-Phi Transient Solver Enhancements

- A-Phi solver good for open multi-terminal busbars
- Capacitance Matrix enhancement (DC + Static)
- Voltage/Current outputs at Terminals
- Object and element-based (surface and volumetric) harmonic force calculation including 3rd party Links
- Time Averaged Fields (loss density) for Multiphysics simulations
- Nonlinear Permanent Magnets, Core loss effect on field, Hysteresis, Magnetization/Demagnetization

2021 R2

Parameter: Matrix1 Type: Capacitance

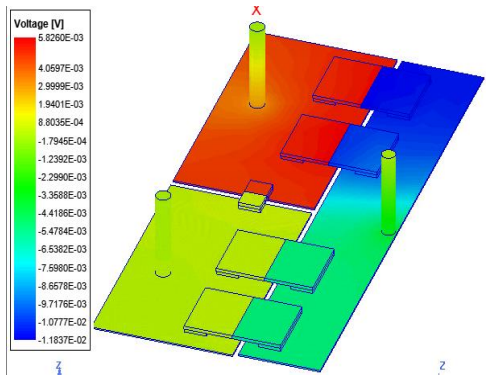
Time: 39us Capacitance Units: pF

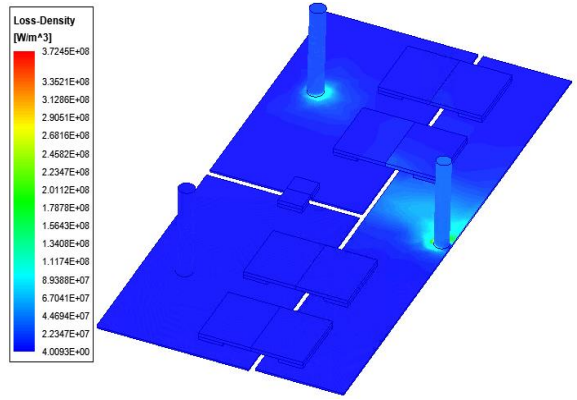
View | Format | Export

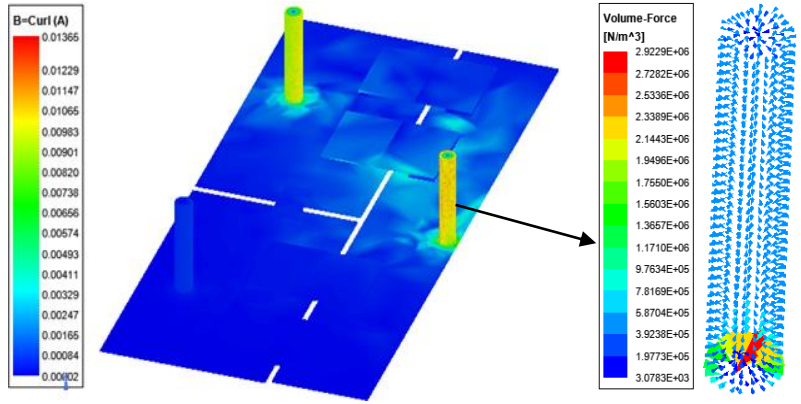
	Current1	Current2	Current3	Current4	Current5
	0.7291	-0.00011818	5.4672E-05	3.8858E-05	9.7629E-05
	-0.00011818	0.68447	6.1799E-05	4.5925E-05	0.00010298
Current3	5.4672E-05	6.1799E-05	0.6767	-9.7157E-05	-0.00014074
Current4	3.8858E-05	4.5925E-05	-9.7157E-05	0.58137	-0.00011279
Current5	9.7629E-05	0.00010298	-0.00014074	-0.00011279	0.22494

2022 R1

TerminalCurrent(Current1) [mA] Setup1 : Transient	TerminalCurrent(Current2) [mA] Setup1 : Transient	TerminalCurrent(Current3) [mA] Setup1 : Transient
.978630	1.978630	16481.877200

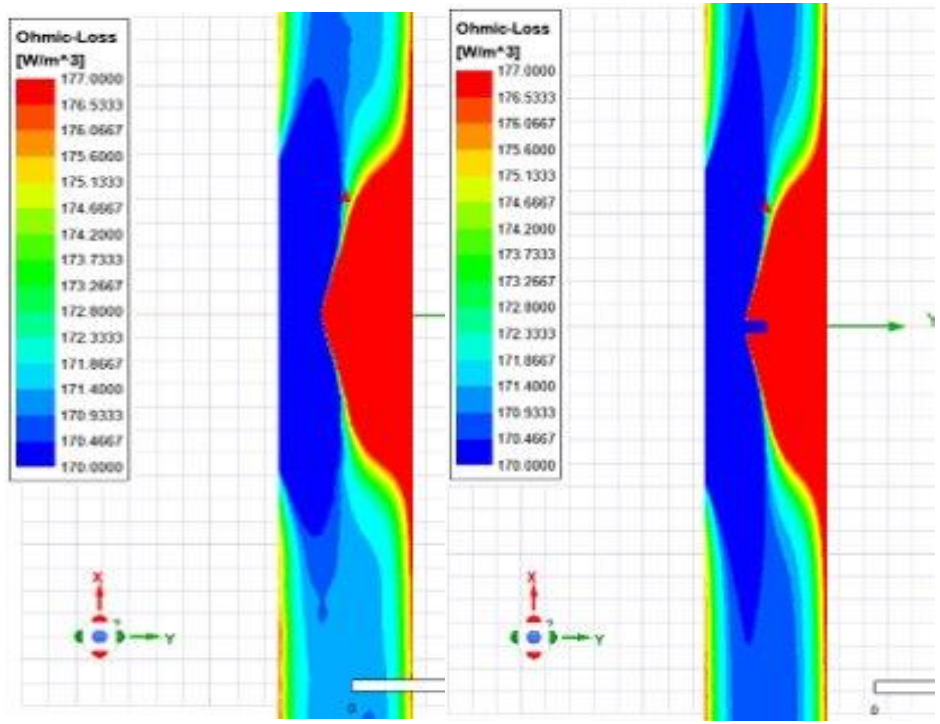






Resistive Sheet Support in Eddy-Current Simulation

- Expand resistive sheet support from transient simulation to eddy current simulation
- The resistive sheet can be defined in the conductor when the conductor is
  - Solid source conductor
  - Solid winding with any winding type
  - Conductor with eddy effect turned on
- The current is assumed to be perpendicular to the resistive sheet
- DDM simulation is supported
- Surface loss density can be plotted on the surface

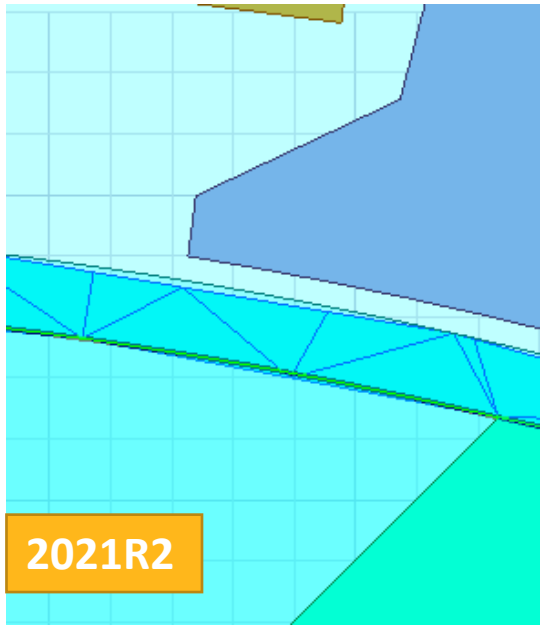


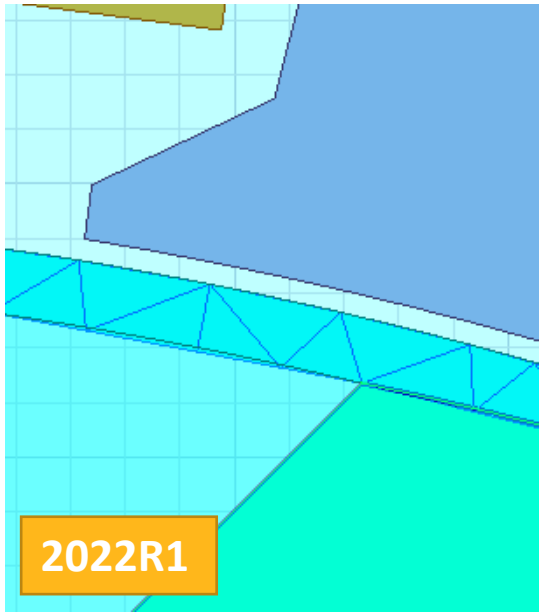
Resistive Sheet

Thin Box

Support Tau Mesh in 2D Band Region

- Cylindrical gap mesh operation now supporting Maxwell 2D transient models
- How to assign cylindrical gap mesh operation?
  - Same as 3D setup
- Tau mesh will take cylindrical gap mesh operation and ensure band mesh
  - Instead of Tau mesh band detection, user provide band info
  - Tau mesh makes remesh on band. Ensure band mesh exactly located on band curve
  - If cylindrical gap mesh operation is not assigned, Tau still try to do band detection





HPC

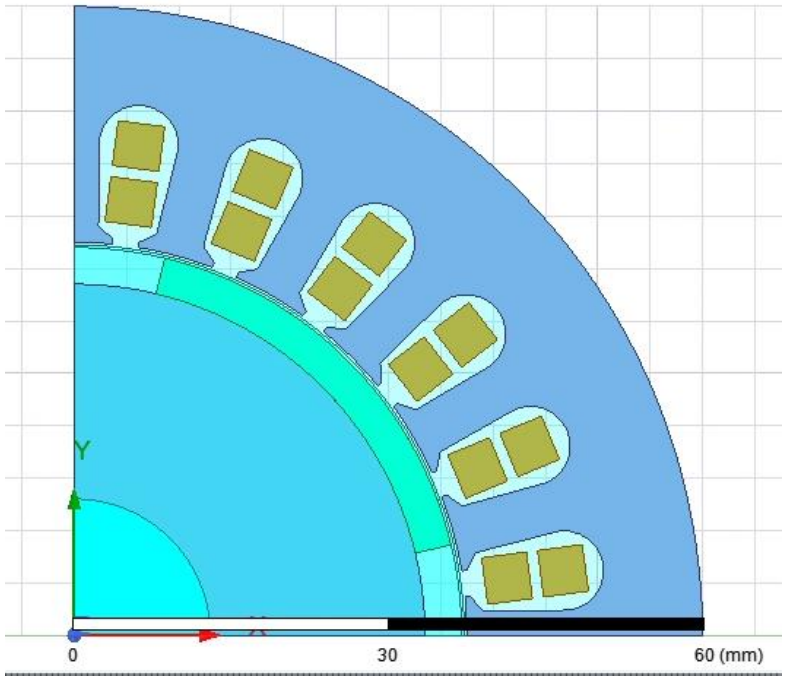
Expression Cache Performance Speed-Up

- Significant expression cache efficiency improvements

5x Speed-Up

Example:

- 2D Non-skewed model
- Compare 2021R2 and 2022R2 for Parametric Run on project with **14 expression cache items** saved every time step
- Parametric run with 6 parallel tasks, 12 cores and 10 variations to solve, no MPI



2021R2 – 23:42 minutes

Result | Profile

Maxwell 2D version 2021.2.0 started on CDCVDT4EXTG024 at 08-30-20

Variation	Le1	R1	conds	delta	fractions	Start	Stop	Elapsed	Analysis Machine
1	0.0...	1....	26	0deg	4	18:29:...	18:42:...	00:13:11:519	localhost
2	0.0...	1....	26	10d...	4	18:29:...	18:43:...	00:13:28:141	localhost
3	0.0...	1....	26	20d...	4	18:29:...	18:43:...	00:13:53:985	localhost
4	0.0...	1....	26	30d...	4	18:29:...	18:43:...	00:13:58:233	localhost
5	0.0...	1....	26	40d...	4	18:29:...	18:43:...	00:14:00:472	localhost
6	0.0...	1....	26	50d...	4	18:30:...	18:44:...	00:14:05:312	localhost
7	0.0...	1....	26	60d...	4	18:42:...	18:52:...	00:10:09:132	localhost
8	0.0...	1....	26	70d...	4	18:43:...	18:53:...	00:10:04:516	localhost
9	0.0...	1....	26	80d...	4	18:43:...	18:53:...	00:09:43:161	localhost
10	0.0...	1....	26	90d...	4	18:43:...	18:53:...	00:09:32:743	localhost

2022R1 – 4:27 minutes

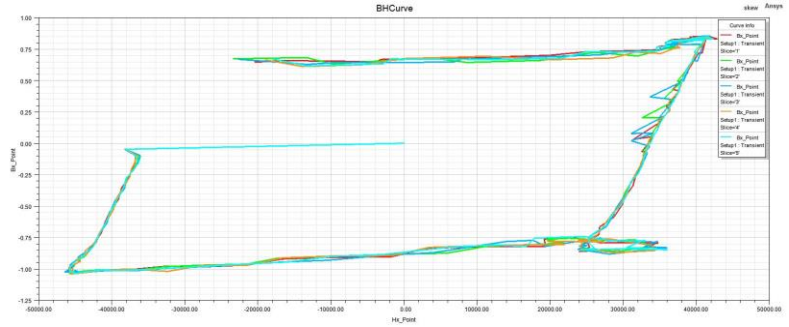
Result | Profile

Maxwell 2D version 2022.1.0 started on CDCVDT4EXTG024 at 08-30-202

Variation	Le1	R1	conds	delta	fractions	Start	Stop	Elapsed	Analysis Machine
1	0.0...	1....	26	0deg	4	17:29:...	17:32:...	00:02:28:163	localhost
2	0.0...	1....	26	10d...	4	17:29:...	17:32:...	00:02:26:117	localhost
3	0.0...	1....	26	20d...	4	17:29:...	17:32:...	00:02:25:671	localhost
4	0.0...	1....	26	30d...	4	17:29:...	17:32:...	00:02:23:815	localhost
5	0.0...	1....	26	40d...	4	17:29:...	17:32:...	00:02:25:652	localhost
6	0.0...	1....	26	50d...	4	17:29:...	17:32:...	00:02:23:548	localhost
7	0.0...	1....	26	60d...	4	17:32:...	17:34:...	00:01:55:893	localhost
8	0.0...	1....	26	70d...	4	17:32:...	17:34:...	00:01:56:787	localhost
9	0.0...	1....	26	80d...	4	17:32:...	17:34:...	00:01:57:407	localhost
10	0.0...	1....	26	90d...	4	17:32:...	17:34:...	00:01:57:124	localhost

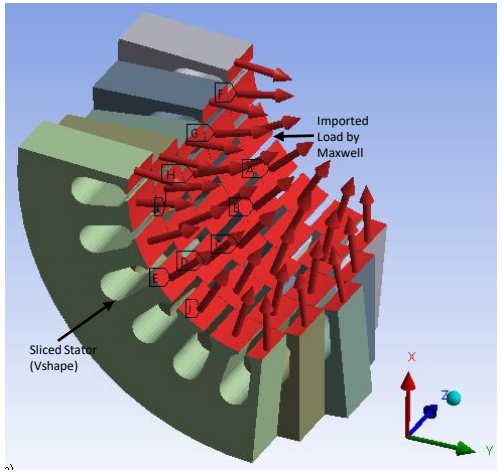
MPI support for Skew Model

- Support hysteresis effects



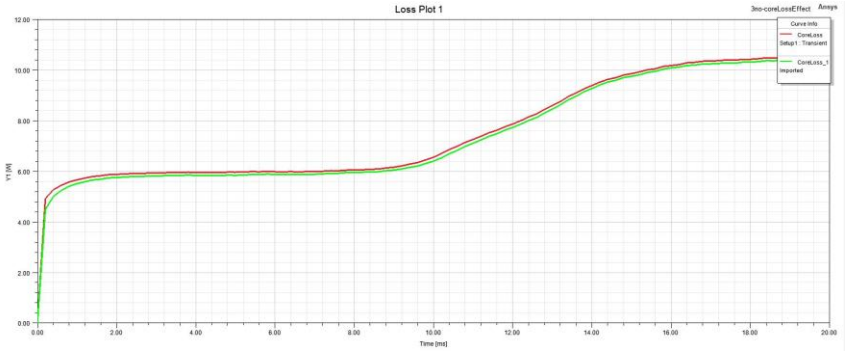
Hx Bx curve in hysteresis material

- Support harmonic force (object-based)



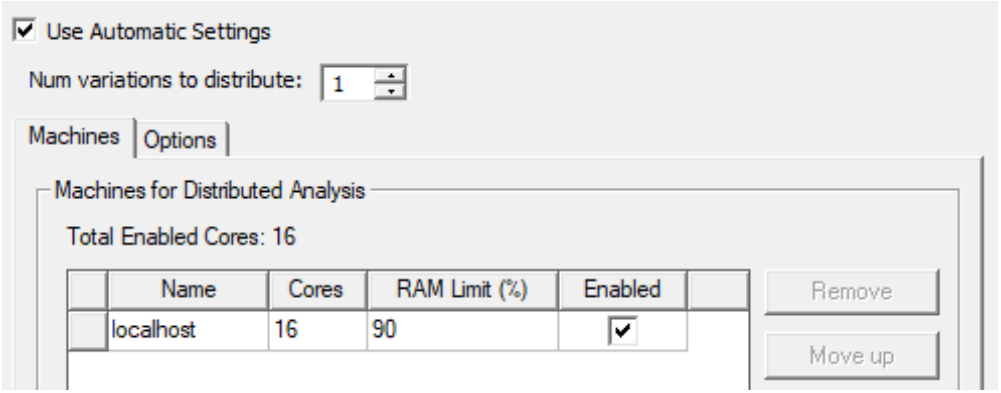
- Support stop-continue analysis

- Support core-loss effects



Core-loss: with core-loss effect VS. without core-loss effect

- Support auto-HPC

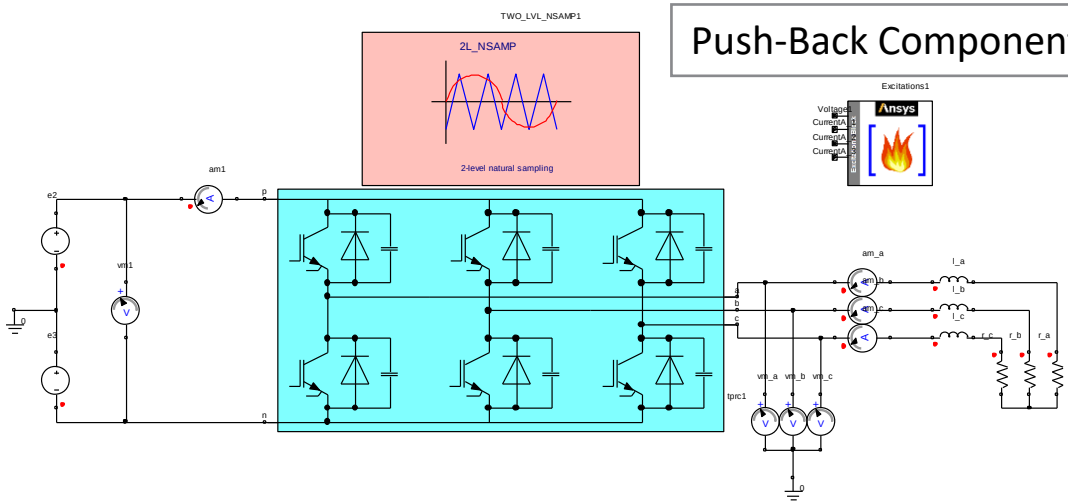


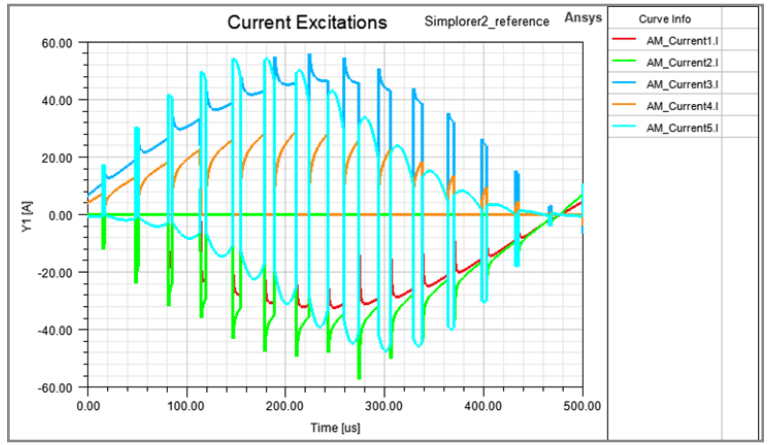
Usability (UX)

System Push-Back Excitation for 2D/3D Magnetic Transient

- Automated open loop FEA power design with decoupled circuit/system input
- Push excitation component in Simplorer/TB now provides automated assignment of the excitation values in Maxwell transient solvers
- User simply links the Maxwell design and maps the Maxwell excitations to the corresponding circuit components in Simplorer/TB

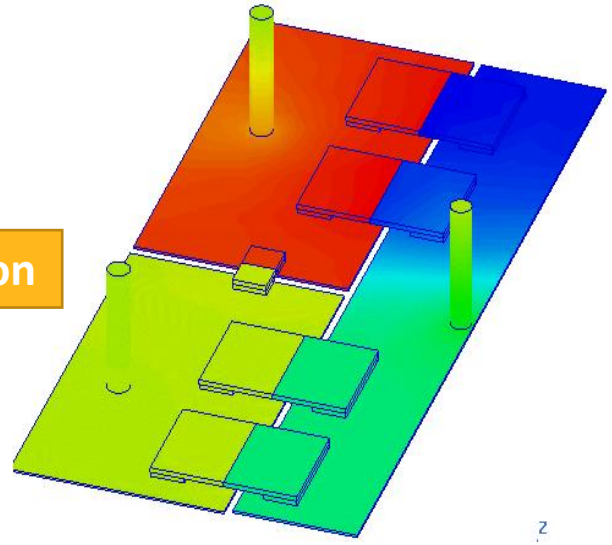
Push-Back Component





Push-Back Excitation Circuit Schematic

Inverter Package - Voltage Distribution



Performance Improvement of Harmonic Force Calculation

- **Improvements of Harmonic Force Calculation**

  Data reconstruction for non-constant time step Data set before DFT to eliminate the occurrence of frequency shift and nonphysical force components

- **Improvements of UI and Transient Force Export**

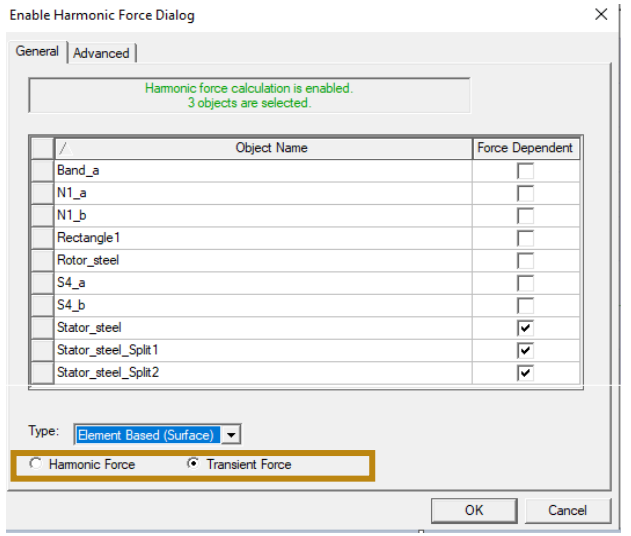
  All options of Transient force export are consolidated into one single Dialog panel at design level

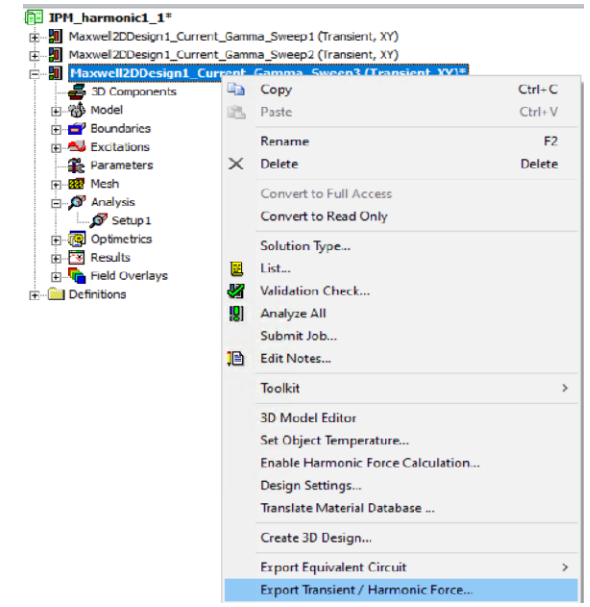
  Allow user to switch export type, to update time window without re-solving the design

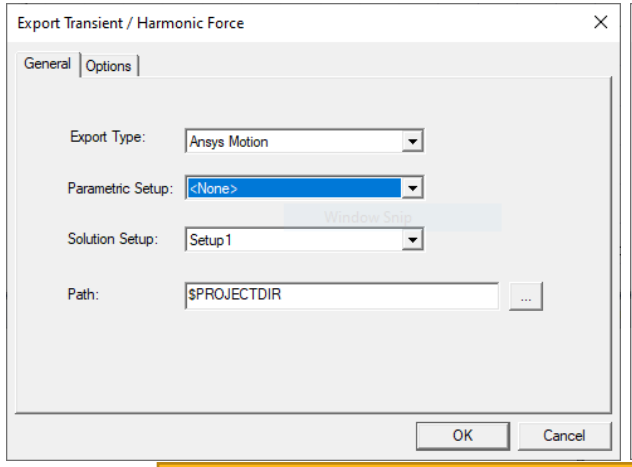
  Supports multiple RPM (parametric sweep)

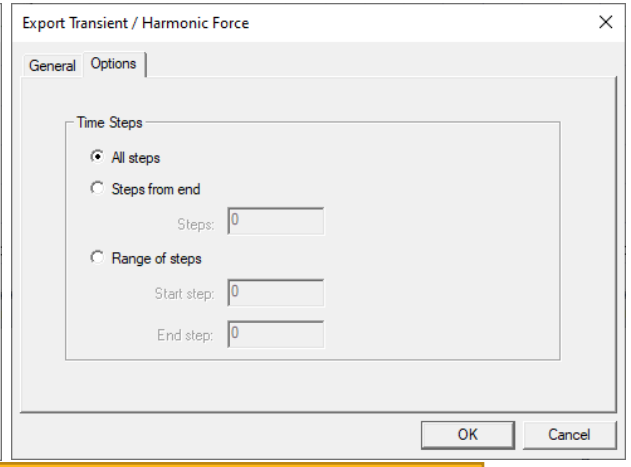
- **New General File Format of Transient Force Data**

  To support the development of NVH modeling in Mechanical without WB or with any third party





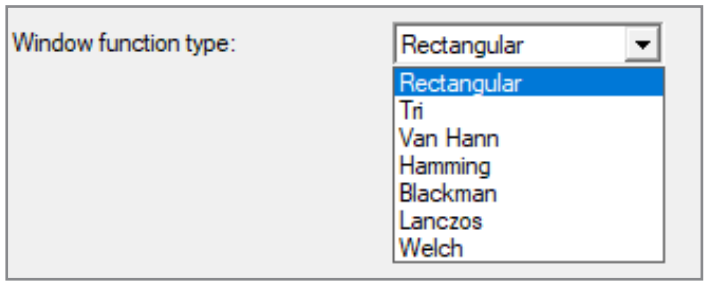


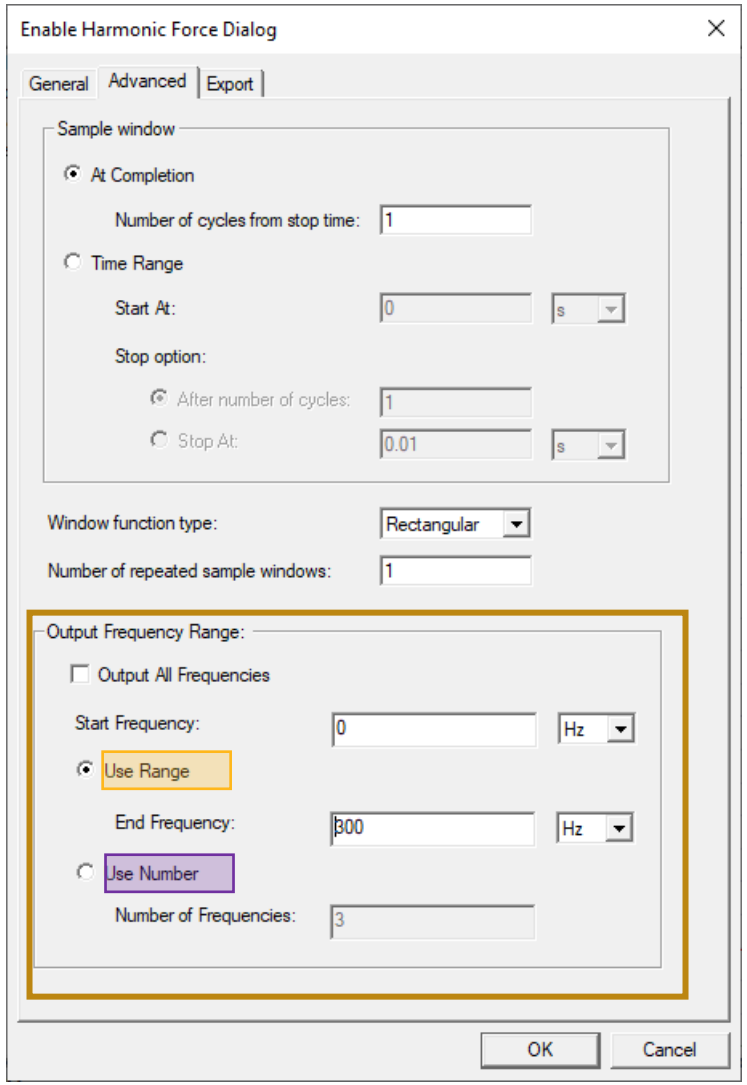


Export Type and Range selection after Solving

Option to Set Frequency Range of Harmonic Force Calculation

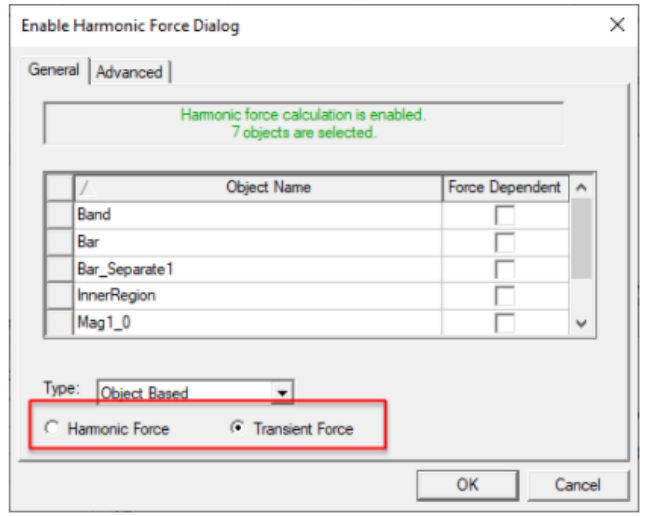
- Enable user to define the output frequency range of harmonic force to filter uninterested frequency components that have little contribution to NVH analysis
- Improve mapping efficiency and reduce solving load on Mechanical side
- Range option: Start and end frequency
- Number option: Start frequency and number of frequencies
- FFT Window Function type:

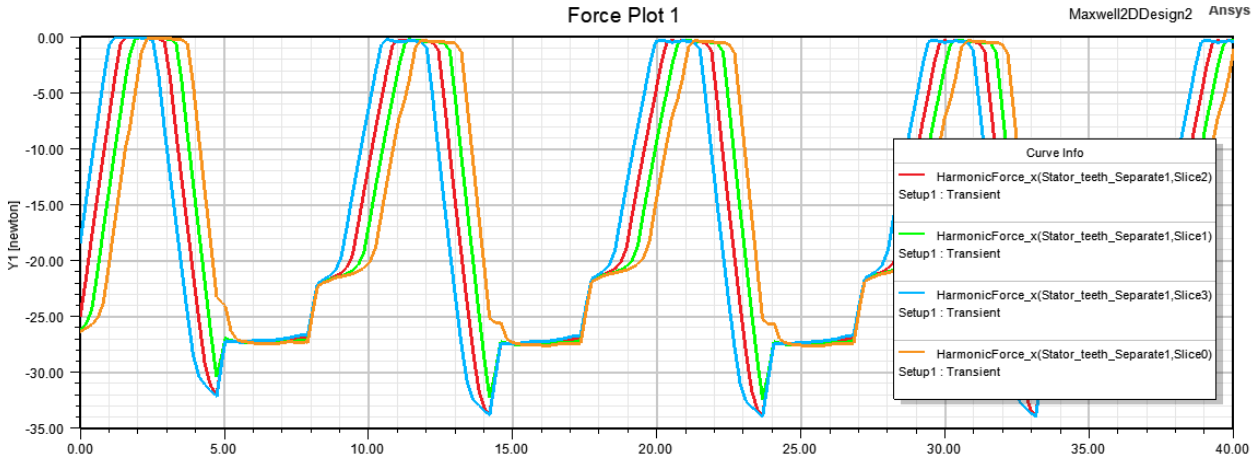




Original object-based force data plot in “Create Transient Result”

- **Allows for transient force plot for any objects which are included in FFT calculation**
- **Transient force data on preselected object-based harmonic-force objects**
  - Force data range: 0 ~ tend, all time steps
  - Force components: mag, Fx, Fy, Fz
  - 2D/3D transient solvers
  - Supports skew models (2D slice model)
  - Supports TDM HPC
- **Transient Report plot**
  - Force components vs time
  - Update on the fly
  - Stackable plots (multicuves)
  - Transient data export
  - FFT on curve available



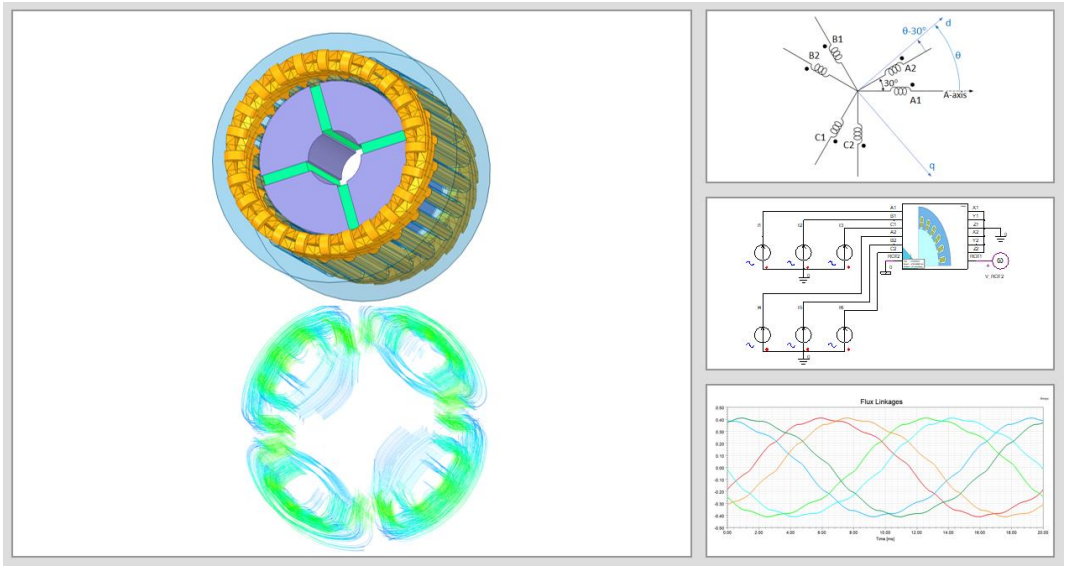


Fx of stator tooth on different slice

Electrical Machine Performance

New Poly-Phase Electrical Machine ROM

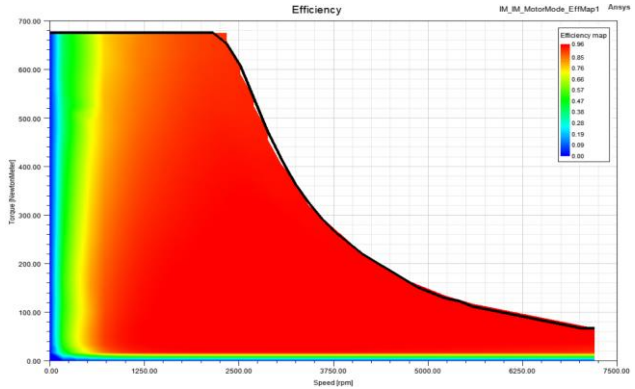
- 6-phase (Dual Three-phase) Machines
  - Advantages: high power density, low torque ripple, high reliability
  - Applications: wind turbines, electric vehicles, locomotive traction, marine propulsion
- ECE Model of 6-phase Windings
  - Flexible: this model can be combined with other ECE models to create ROM of various 6-phase machines
  - Accurate: saturation effects are considered based on fundamental equivalence; harmonic components are included in dq0 flux linkages
  - Computationally efficient: sweep only one set dq currents; save 50% sweeps compared with ECE 3-phase model
  - Convenient: dual three-phase models are automatically connected



6-Phase IPM – ROM extracted from FEA

Change Sweep Variable from Frequency to Speed for IMs

- Approach
  - Fundamental sweep variables: mechanical speed (instead of frequency), slip, and stator terminal voltage
  - Advantages: the upper bound of speed in the efficiency map matches the user-defined maximum speed for both motor & generator modes; smoothness of the torque-speed curve and the efficiency map; rigorous solution in the high-speed region
- Additional UI options
  - For induction machines, the user can define 2 slip sweep intervals, which facilitates high slip limit in the parametric analysis to fill the efficiency map in the low-speed region
  - The user can define the torque limit in the efficiency map, and the samples with a torque exceeding this limit will be excluded from the map, which results in a flat torque-speed curve in the low-speed region



DOE Settings

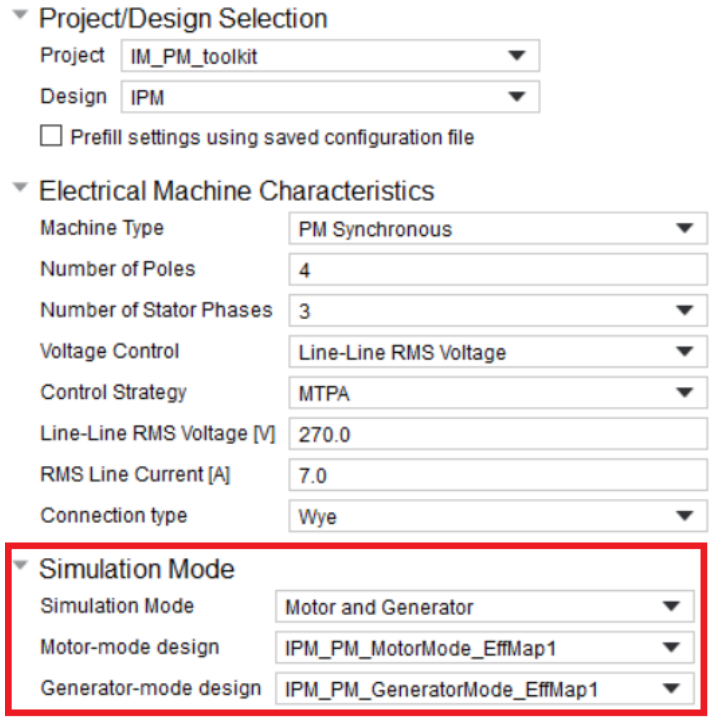
Number of time steps per period	20
Number of voltage sweep points	10
☑ Define 2 slip sweep intervals	
Number of slip sweep points in 1st interval	10
Number of slip sweep points in 2nd interval	10
Number of speed sweep points	12

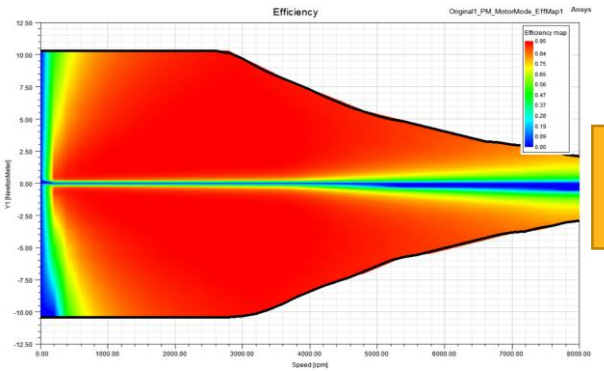
Map Characteristics

☐ Use speed steps	
Number of speed points	40
☐ Use torque steps	
Number of torque points	40
☑ Use torque limit	
Torque limit [Nm]	675
Maximum speed [rpm]	7200
Minimum slip	0.001
Maximum slip of 1st interval	0.2
Maximum slip of 2nd interval	0.8
☐ Separate stator and rotor core losses	
☐ Define duty cycle from File	

Combine Efficiency Map of Motor Mode and Generator Mode

- Feature description
  - Machine Toolkit combines the results of the motor-mode design and generator-mode design of the electric machine, and produces the maps of all required performance indices in a new motor & generator mode design
  - **Advantages**: the specifications of the motor and generator modes can be different; arbitrary path to obtain performance maps, e.g., LS-DSO, periodic TDM, fast DOE; supports all types of machines in Machine Toolkit; no need for repetitive parametric analysis.
- Additional UI options
  - Add an option “Motor and Generator” for “Simulation Mode”
  - Add UI options “Motor-mode design” and “Generator-mode design” that appear when “Motor and Generator” is selected



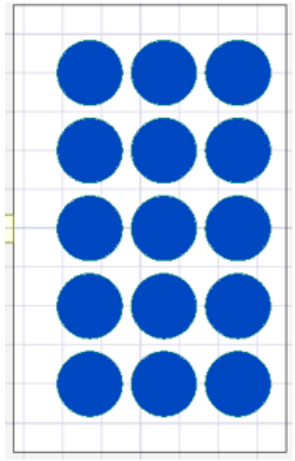


1st, 4th quadrant

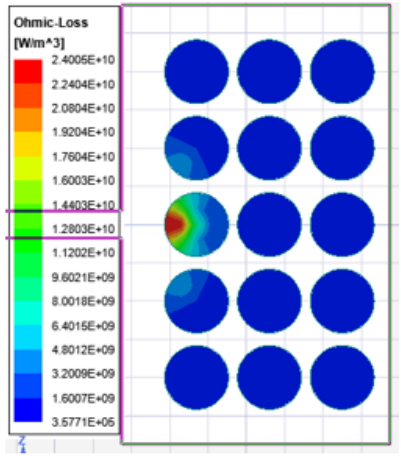
Multiphysics

Litz Wire Loss Two-Way Thermal Coupling

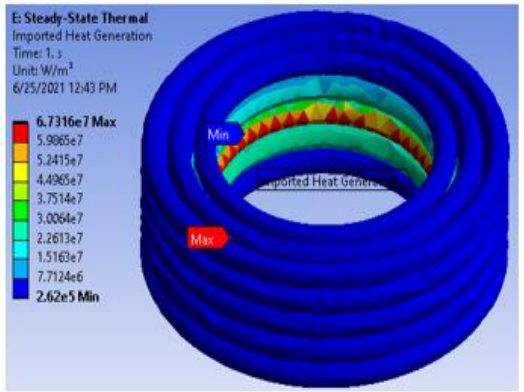
- **Sum of Litz wire losses (DC loss and AC loss) is assigned as Emloss for thermal coupling for stranded winding**
  - Emloss field display (Litz wire loss of stranded winding)
  - Integrated Litz wire loss in transient solver
  - .lss file in 3D eddy-current solver for Litz loss output
  - Available 2D/3D eddy/transient solvers
- **Two-way thermal coupling in WB/AEDT**
  - Thermal modifier can be applied to material conductivity to include temperature dependent Litz wire loss model
  - Temperature feedback from two-way thermal coupling in WB/AEDT



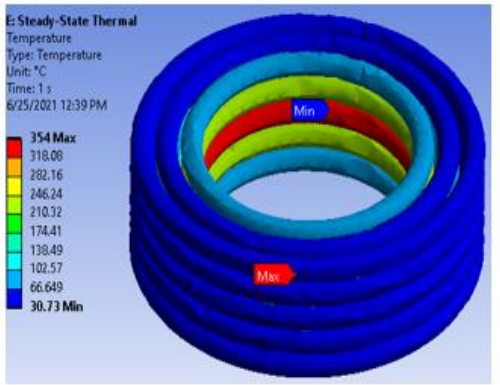
EM Loss – No Litz Wire



EM Loss – Litz Wire



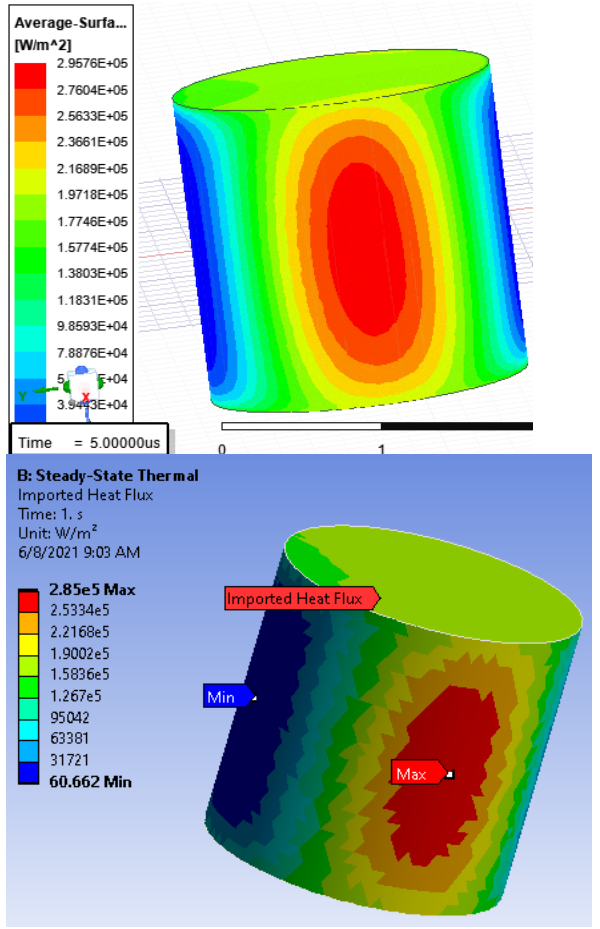
Imported Heat Generation Distribution



Temperature Field Distribution

3D Transient Impedance Boundary with 2-way Thermal Coupling

- **Impedance Boundary available in time-domain** 2021 R2
- **Time integrated surface loss density**
  - Flexible to calculate averaged loss density between user specified time interval
  - Time-averaged surface loss density can be displayed on impedance BC
- **Two-way thermal coupling in WB/AEDT**
  - Thermal modifier can be applied to material conductivity and permeability on impedance BC
  - Temperature feedback from two-way thermal coupling in WB/AEDT
  - Surface temperature can be displayed when it is updated from two-way coupling



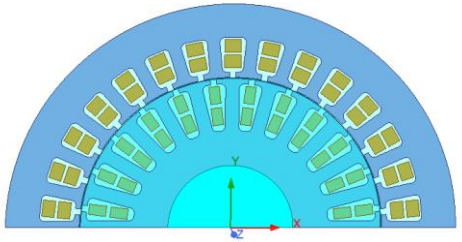
Calculated loss density distribution vs mapped loss density distribution

Multiphysics on AEDT

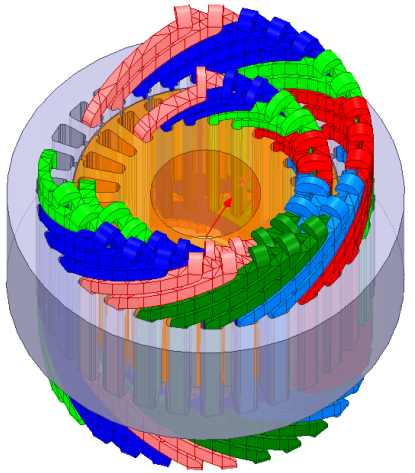
Icepak Coupling

Support EM Loss Import from Maxwell 2D

- Extruded geometries of 2D representations



Maxwell 2D Geometry



Thermal 3D Geometry

Mechanical Coupling

Support EM Loss Import from Maxwell 2D

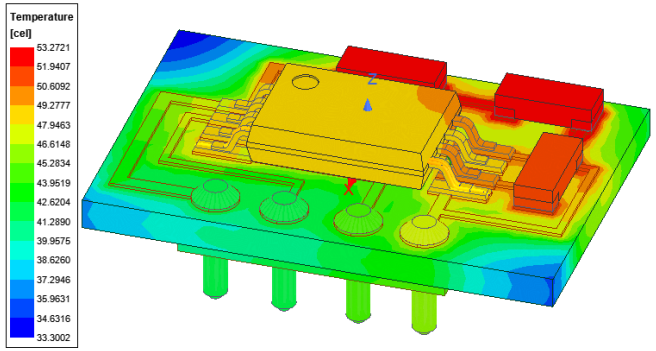
- Extruded geometries of 2D representations

Coupled Thermal Stress Analysis

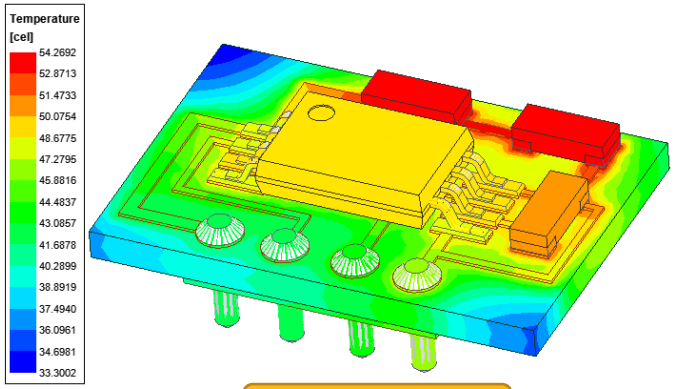
- Linked to Thermal design
  - System Coupling mapper used

Coupled EM Force – Structural Analysis

- Linked to Maxwell 3D and HFSS
  - 1-way coupling support



Thermal



Structural

Conclusions

- Ansys Low Frequency in 2022 R1
  - **Accuracy**
  - **Workflow/UX**
  - **Scale**
  - **Speed**
- **Accuracy:** AC Loss on complex winding configurations
- **Workflow:** System push-back excitation
- **Scale:** Extends Ansys leadership on ROM complex system integrations for electrical machines
- **Speed:** Expression cache performance


Ansys