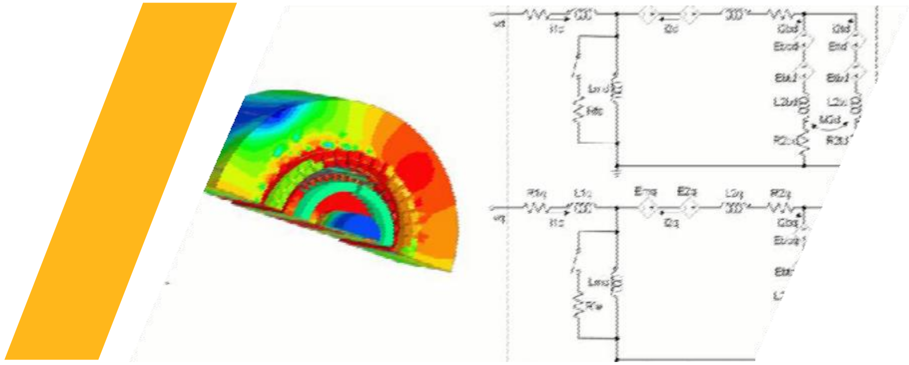
ANSYS Maxwell 2022R2 新功能介绍

新科益系统与咨询（上海）有限公司

CAD-IT
CONSULTANTS

Agenda



Maxwell Highlights

- ✓ Magnetic Latching Coupling Workflow with Structural Dynamics
- ✓ Skew Modeling to a New Paradigm
- ✓ Core-loss Dependent ROM for Induction Machine

Motor-CAD Highlights

- ✓ High fidelity synchronous machine lab model
- ✓ NVH Enhancements
- ✓ RPC automation for Motor-CAD

2022 R2 What's New
Low Frequency

CONSULTANTS

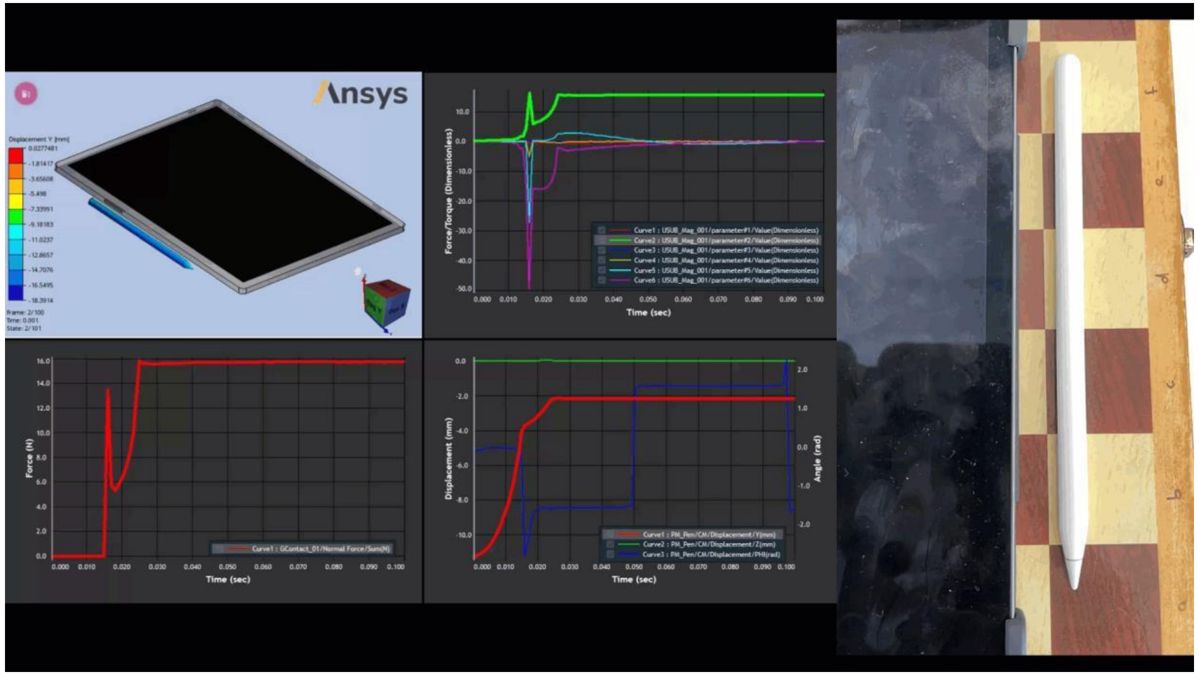
What’s New – Magnetic Latching Coupling Workflow with Structural Dynamics

What’s New

- New best-in-class Multiphysics magnetic latching coupling workflow from Ansys Maxwell and Motion.

User Benefit

- Electromagnetic coupling with Kinematics ensures full degree-of-freedom control of permanent magnets motion.
- Tackle complex engineering challenges like creating enough force for a strong hold without the risk of magnets destroying adjacent metal or plastic materials.



End User and Applicable Industries

✓ Benefits electrical and mechanical engineers designing magnetic latching devices and mechanisms

✓ High-tech industry for portable devices. e.g., detachable keyboards, pencil that attaches to tablets, wireless charging pads, latching wall-mount security camera, smart screen covers for phones, etc.

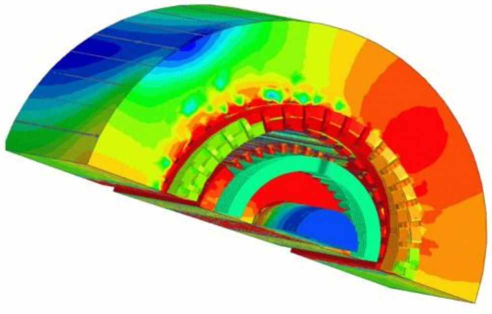
What’s New – Core-loss Dependent ROM for Induction Machine

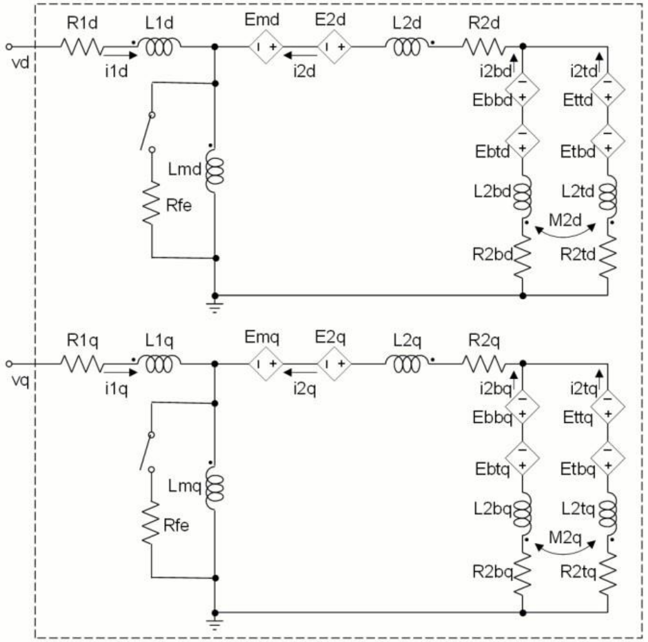
What’s New

- Ability to generate the most accurate ROM model for induction machine to be leveraged into Twin Builder for larger drive system simulation.

User Benefit

- Increase induction machine ROM accuracy at the system integration level by incorporating loss dependency
- Time-domain circuit realization made easy based on frequency dependent core-loss parameters identified in the frequency domain





End User and Applicable Industries

✓ Hugely benefits the electrical machine designers and system designers who are evaluating the impact of component design into the entire drive system.

✓ Electrification through its electrified power train systems topologies (traction applications) is the main industry segment where ROM for induction machine can be used.

What’s New – Skew Modeling to a New Paradigm

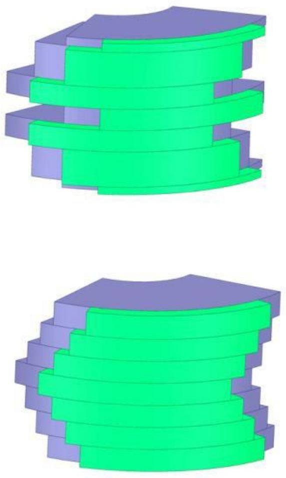
What’s New

- Skew Modelling in Maxwell – Touching a New Paradigm

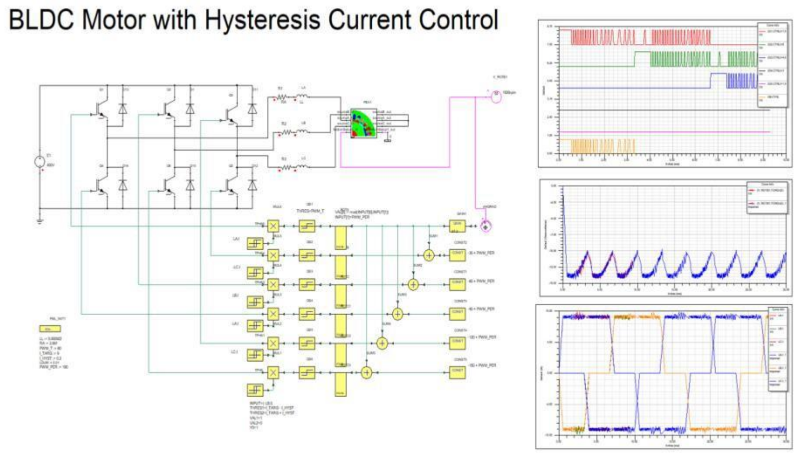
User Benefit

- The new ROM technique can be leveraged to extract an equivalent circuit of a 2D skew design benefitting the system engineer.
- HPC enables parallelization of the existing multi-slice technology increasing the speed of entire 2D FEA simulation including circuit coupling.

ROM of a 2D Skew Design



HPC Skew Modeling with External Circuit

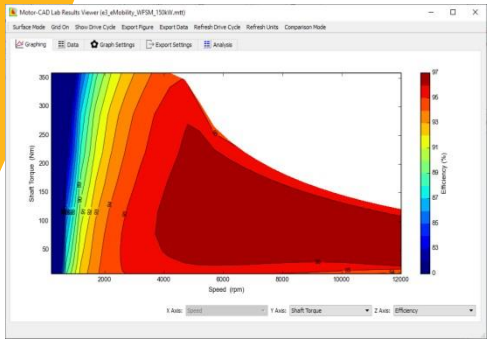


End User and Applicable Industries

✓ Benefits both the system engineers and electric motor designers.

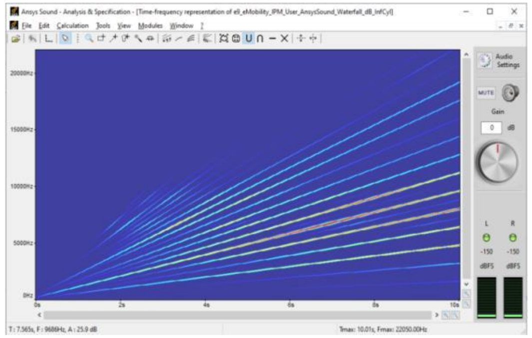
✓ Electrification through its electrified power train systems topologies (traction applications) is the main industry segment where skewed electric motor configurations are used.

Ansys Motor-CAD 2022 R2



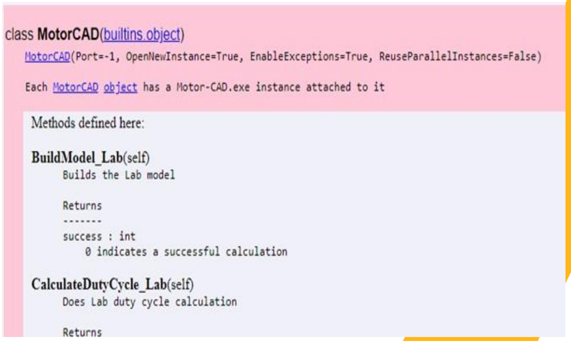
High fidelity synchronous machine lab model

- ✓ The resolution of the synchronous machine lab model available in Motor-CAD can now be customized and defined by the user enabling high fidelity efficiency map, torque/speed curve and drive cycle calculations.
- ✓ This enhances features which are unique to Motor-CAD
- ✓ Benefits the engineers working on synchronous wound field machines in the automotive and electrification industries.



NVH Enhancements

- ✓ New advances in the NVH solution include the infinite cylinder acoustic model, A weighting options and export to Ansys sound enabling improved accuracy and calibration capability to the NVH analysis.
- ✓ Helps in the design of Brushless permanent magnet and reluctance machines
- ✓ Hugely benefits electric machine engineers who want to simulate the NVH behavior of electric machines concepts at the design stage.
- ✓ Only solution on the market which offers complete electromagnetic, thermal, mechanical stress, drive cycle analysis and NVH simulation of electric machines.
- ✓ Applies to Electrification and automotive industry



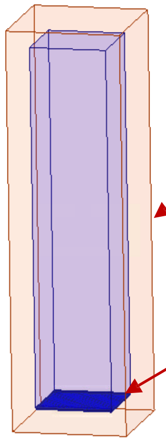
RPC automation for Motor-CAD

- ✓ Enhances the class leading automation capabilities of Motor-CAD is the introduction of RPC automation through Python
- ✓ Enables more control over automated Ansys Motor-CAD instances and allows instances to be distributed and controlled on remote machines and provides improved error handling when scripting.
- ✓ Applies to any engineer using automation with Motor-CAD and all design types.

Core Technology/Solvers

Translation Motion with Moving Part Touching Stationary Part

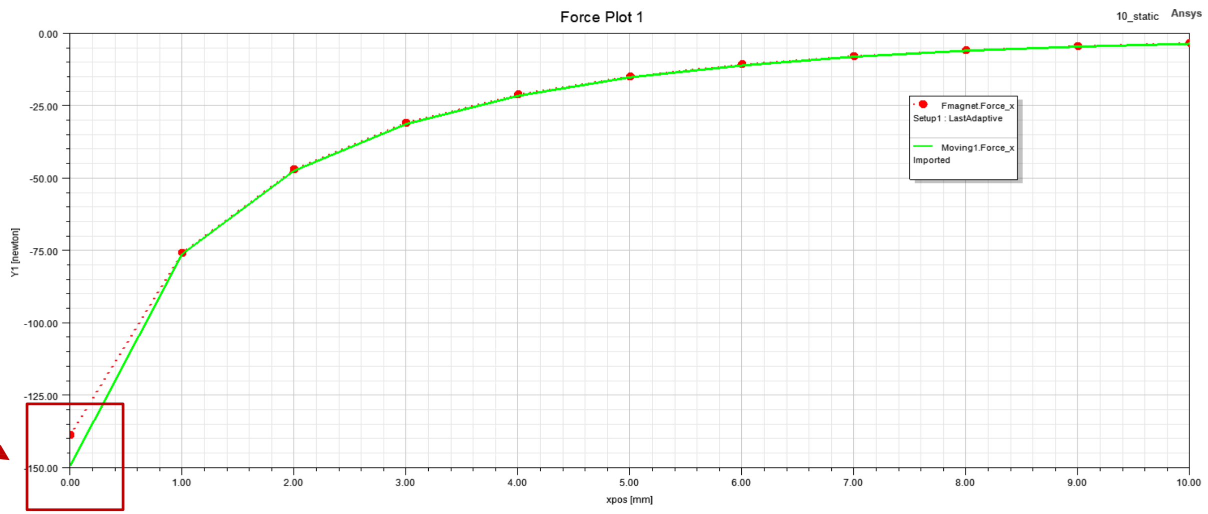
- In simulation with non-periodic translational motion, the moving part can touch the stationary part
- Requirements of the touching boundary setup:
  - The touching boundary should be defined on the surface of the moving part.
  - At any time step, each touching boundary must either fully touches the stationary part or completely separated from the stationary part. The touching boundary can not partially touch the stationary part at any time.
  - The touching boundary can not touch the boundary of the computational region.



Band

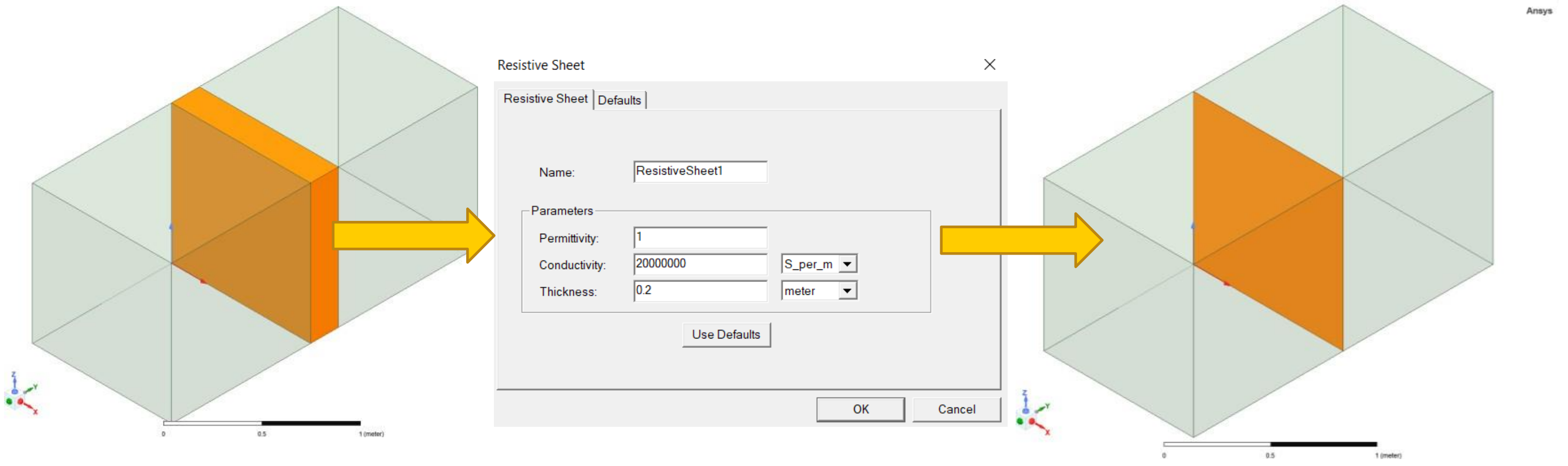
Touching boundary

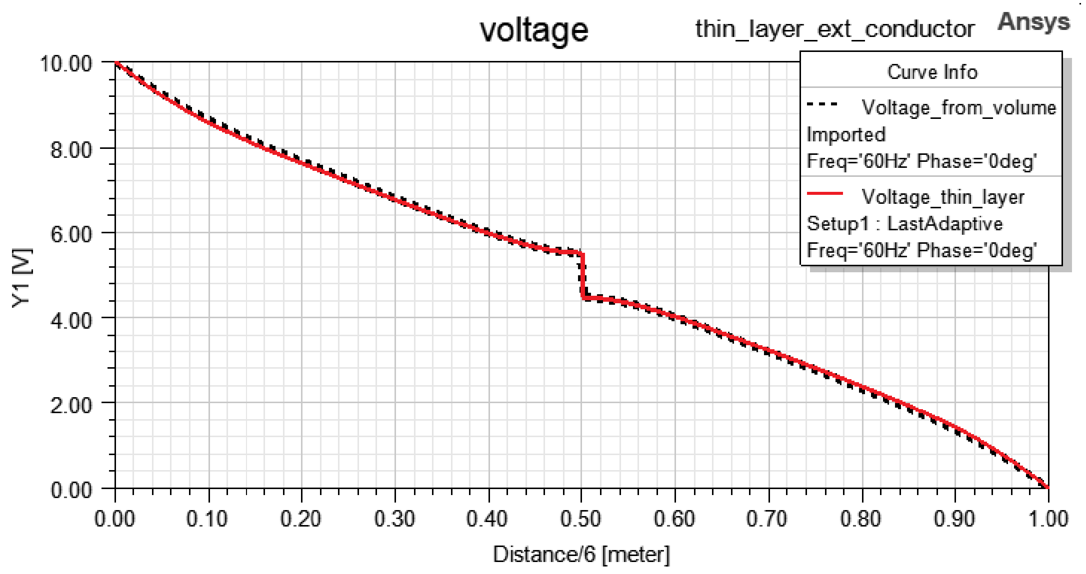
Touching case

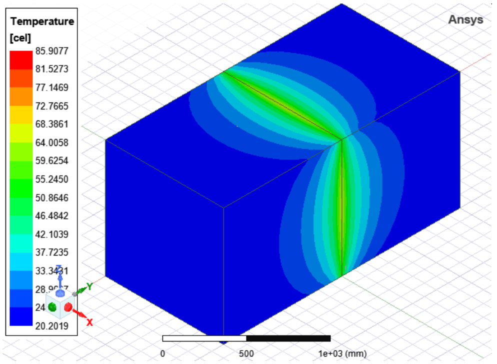


Thin Layer and Insulation Boundary for 3D AC Conduction Design

- Insulating BC
- Thin layer BC
  - Can be used to model:
    - Contact resistance: $\sigma > 0, \varepsilon_r = 1$
    - Insulation capacitive effect: $\sigma = 0, \varepsilon_r > 1$
    - Thin lossy material: $\sigma > 0, \varepsilon_r > 1$
  - Supports thermal coupling







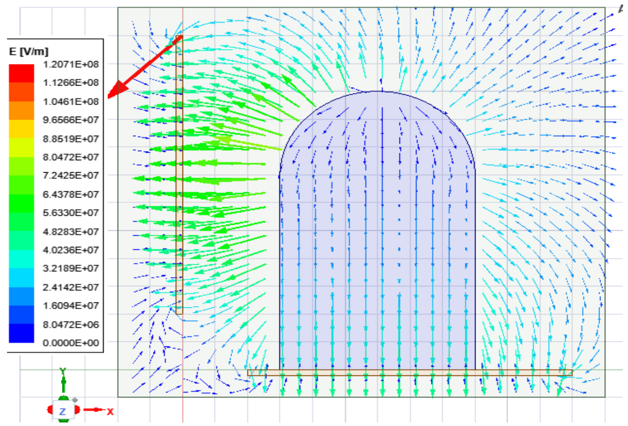
Improvements of Force Calculation in Electrostatic Solver

Surface/Volumetric force density on dielectric materials, conductors and charged objects

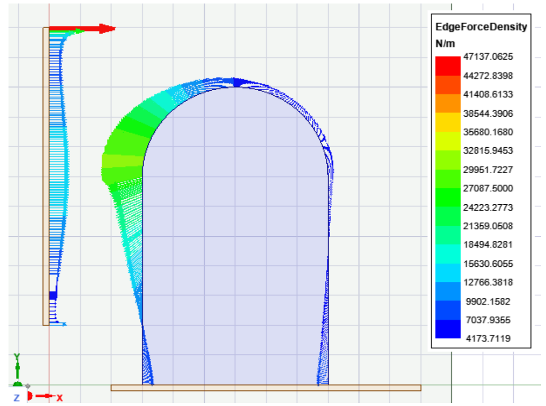
- Field display of surface/volumetric force density

One-way force coupling in WB/AEDT

- Support one-way Maxwell-Mechanical force coupling: surface force density and volumetric force density



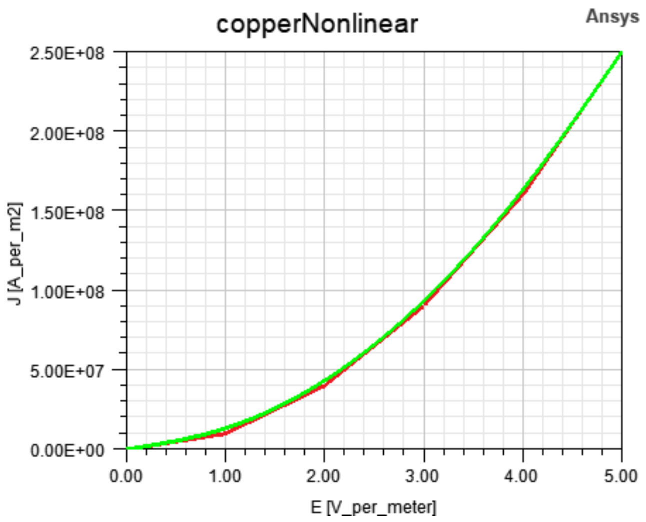
E field

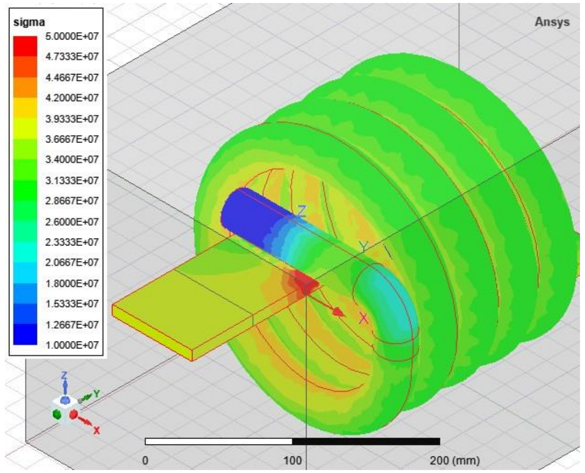


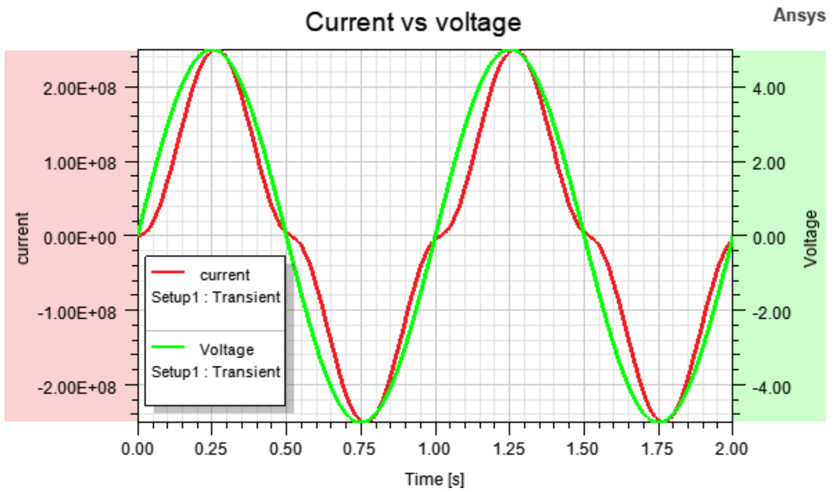
Surface force density distribution

Nonlinear Material for the Electric Transient Solution

- Motivation
  - Semi-conductor and high-voltage industries
- Proposed method
  - The non-linear model was included in the Rosenbrock time-integration scheme
  - Non-linear iterations are not necessary
  - Keep the time interpolation capability for the fields
  - Supports only σ non-linear







CAD-IT CONSULTANTS

Element-Based Harmonic Force Export in .CSV File

Element-Based volumetric harmonic force density export in CSV file with 3D transient

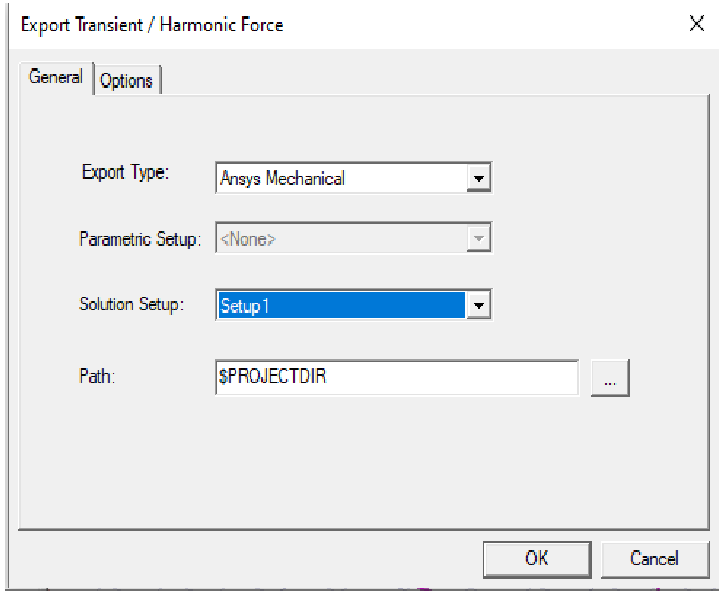
- Export file in post processing: one solving, multiple exports
- Flexible frequency range
- Support variable time step
- Support TDM, Partial model
- One line for one element, multiple frequencies

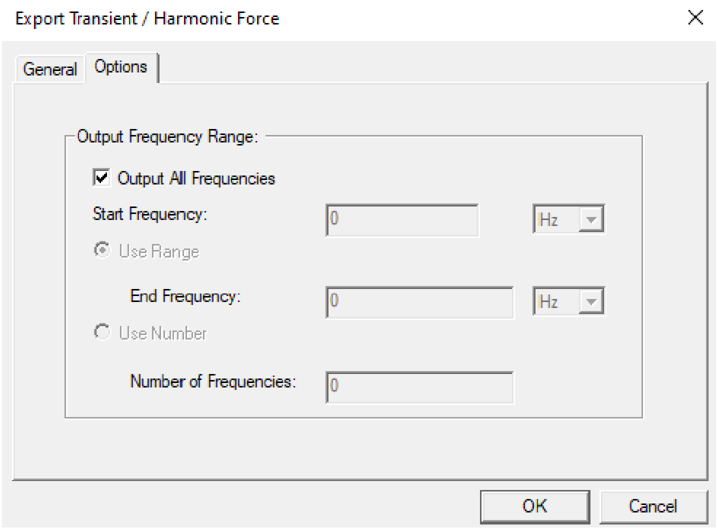
Mapping is done by Mechanical

- Better mapping solution in PCB applications
- Import as external loads in Mechanical

Limitations:

- Only available for 3D transient, element-based volumetric harmonic force





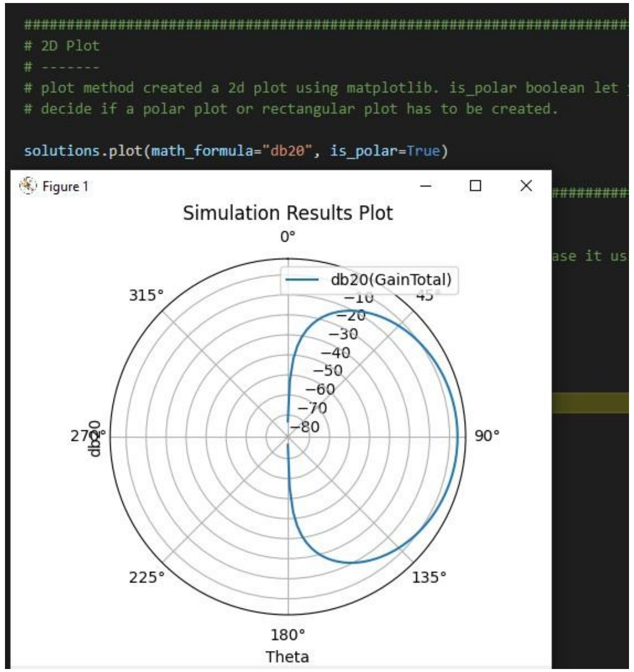
AEDT Desktop and Core

Core Framework

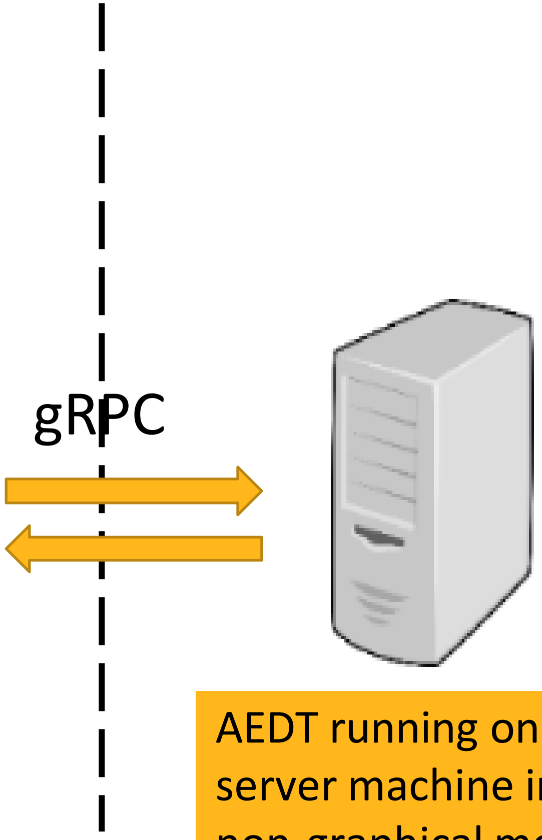
Pervasive Insights

- AEDT script execution from CPython
  - Beta feature in 2022 R2
  - Python script support on Windows in 2022 R2
  - Remote execution of AEDT on Windows or Linux through gRPC
  - All existing IronPython APIs available from CPython
  - Student version supported

- Query and Edit plot properties in non-graphical mode



Python script from client machine connects to AEDT on a remote machine

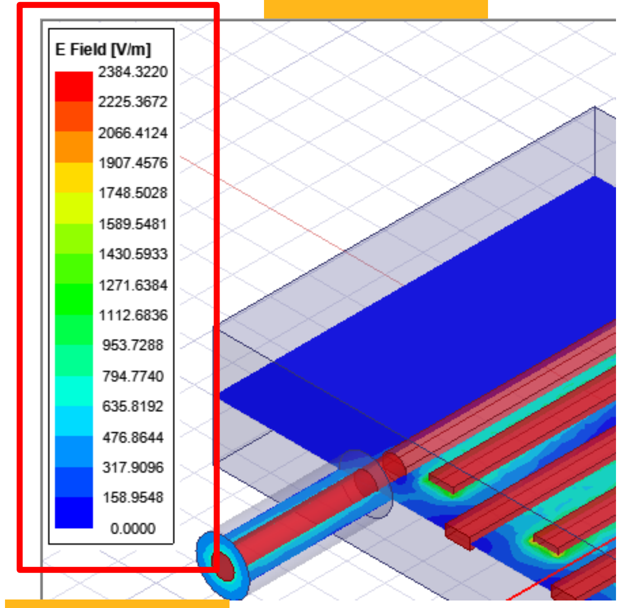


AEDT running on server machine in non-graphical mode

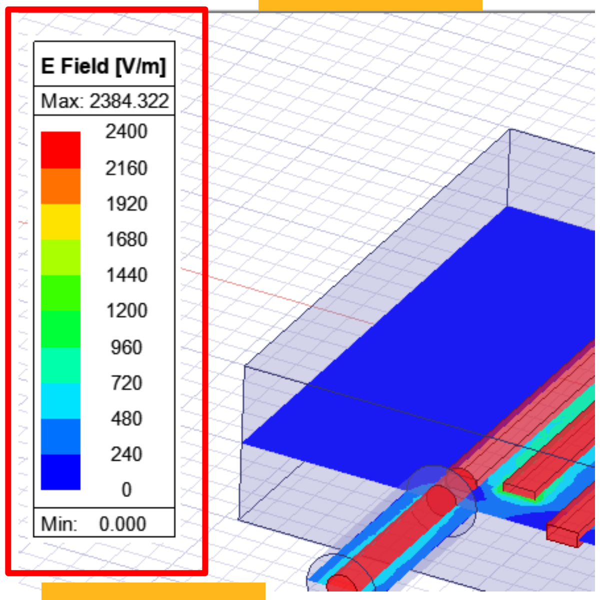
Post processing display improvements

- Rounded numbers in field plot color scale
- Redundant trailing zeros from report axes removed
- Fonts are automatically scaled based upon screen resolution
- Redundant report legend title removed

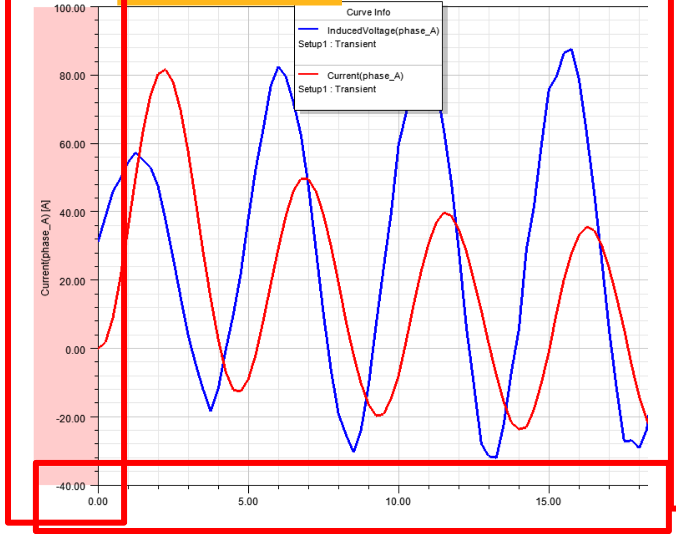
2022 R1



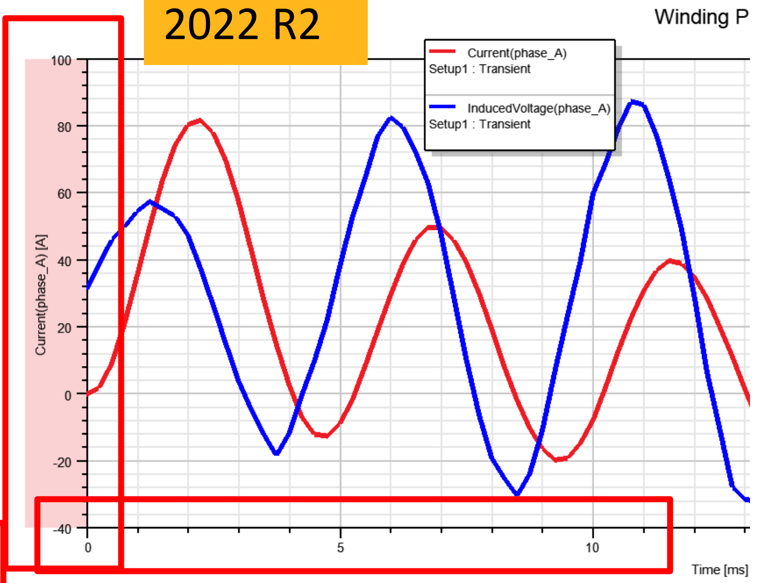
2022 R2



2022 R1

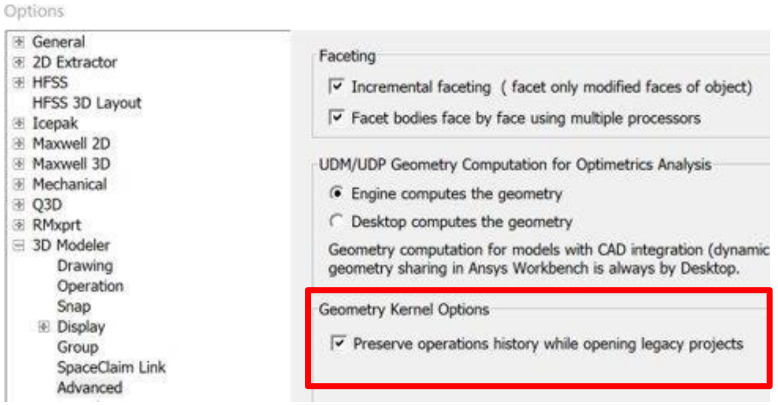


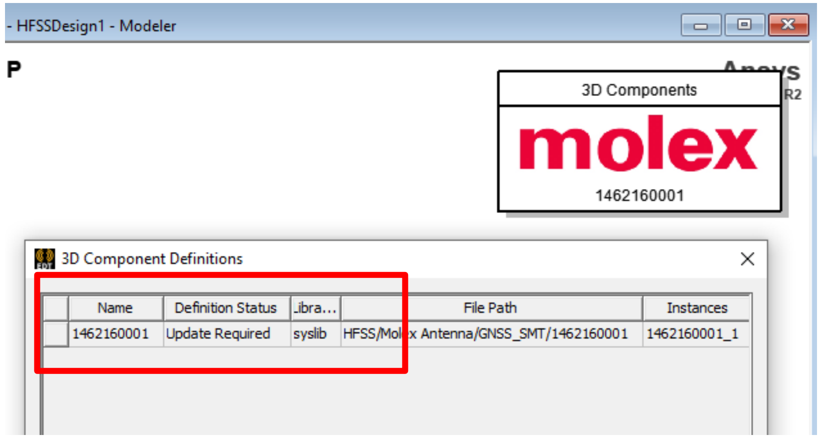
2022 R2



Parasolid kernel for 3D Modeler

- Beta option in 2022 R2
- All 3D Modeler functionality available
  - Except Wrap Sheet. To be supported later
- Option to migrate without model history when history migration fails
  - Geometry parametrization is lost
- Encrypted 3D components embedded in legacy projects are not translated to Parasolid
  - Marked for user to update to Parasolid version
  - Project cannot be solved until such 3D components are updated
- Non encrypted 3D components embedded in legacy projects are automatically translated to Parasolid

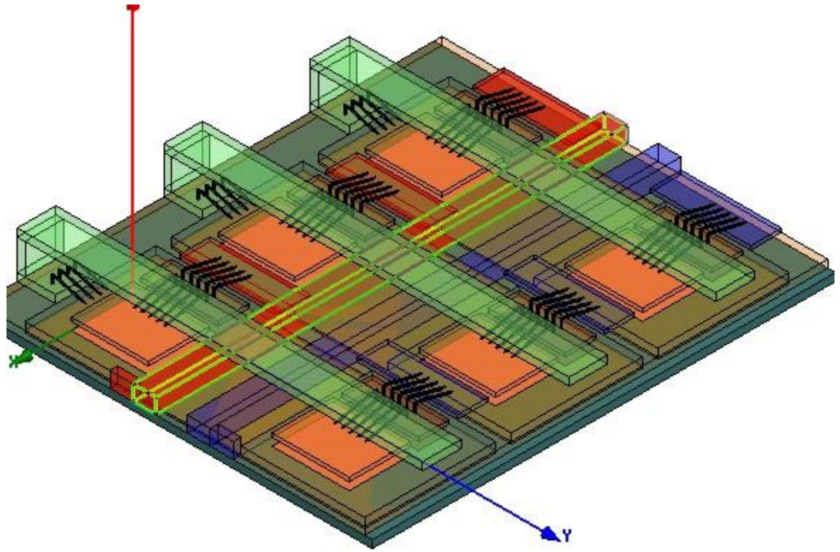


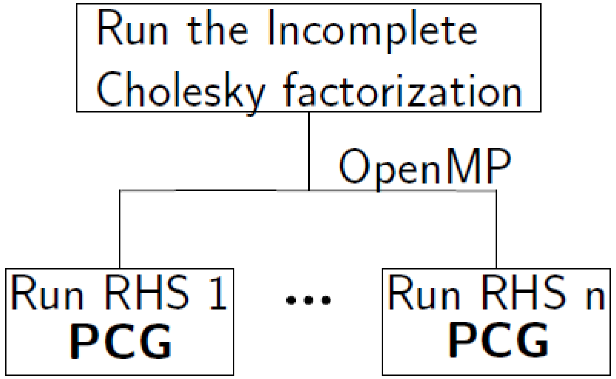


High Performance Computing

3D Electrostatic - Capacitance Matrix Extraction

- Shared Memory Parallel Iterative solver to speed-up capacitance matrix extraction
- Motivation:
  - Need to speed-up capacitance matrix extraction for large matrices
  - Several right-hand-side (RHS's):
    Solve the linear system "RHS" times
  - Large number of DoFs
  - Computation time and memory improvements
- Proposed method:
  - The preconditioner only needs to run once
  - Memory proportional to the number of parallel threads
  - Trade-off between computation time and memory
  - Uses the general Preconditioned Conjugate Gradient (PCG) algorithm in parallel



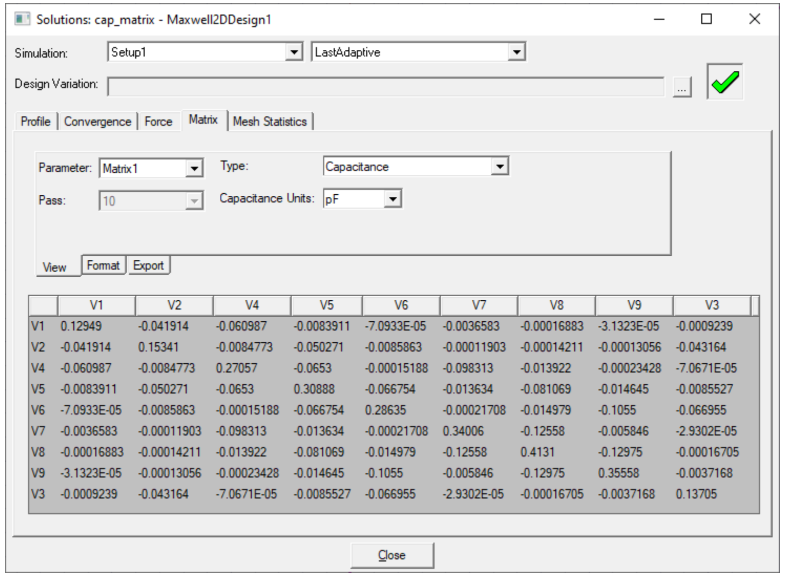


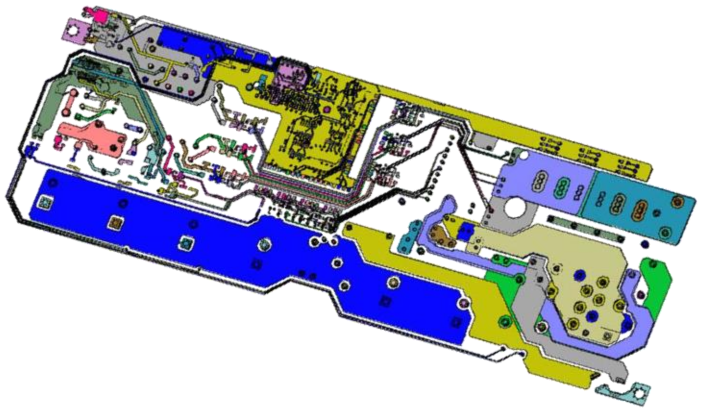
3D Electrostatic - Capacitance Matrix Extraction

- Benchmark Results > 10x speed up for some cases

	Case A-1		Case A-2		Case A-3		Case A-4		Case B	
NZ	4.6E+07		1.5E+07		4.6E+07		1.5E+07		4.7E+07	
DoF	3.3E+06		1.1E+06		3.3E+06		1.1E+06		3.5E+06	
RHS	108		108		108		108		4	
Cores	8		8		32		32		32	
Method	Time	Mem.	Time	Mem.	Time	Mem.	Time	Mem.	Time	Mem.
PCG Serial	106	1.91	30	0.6	107	1.91	30	0.6	10	2
Direct Serial	14	31.9	3	10.5	14	37	3	10.5	4	18
BLPCG	210	23.3	49	7.6	74	21.3	18	7.6	7	2.9
PCG Parallel	9	5.7	2	1.86	5	9.24	1	3	3	2.7

Times are in minutes and memory in GB.

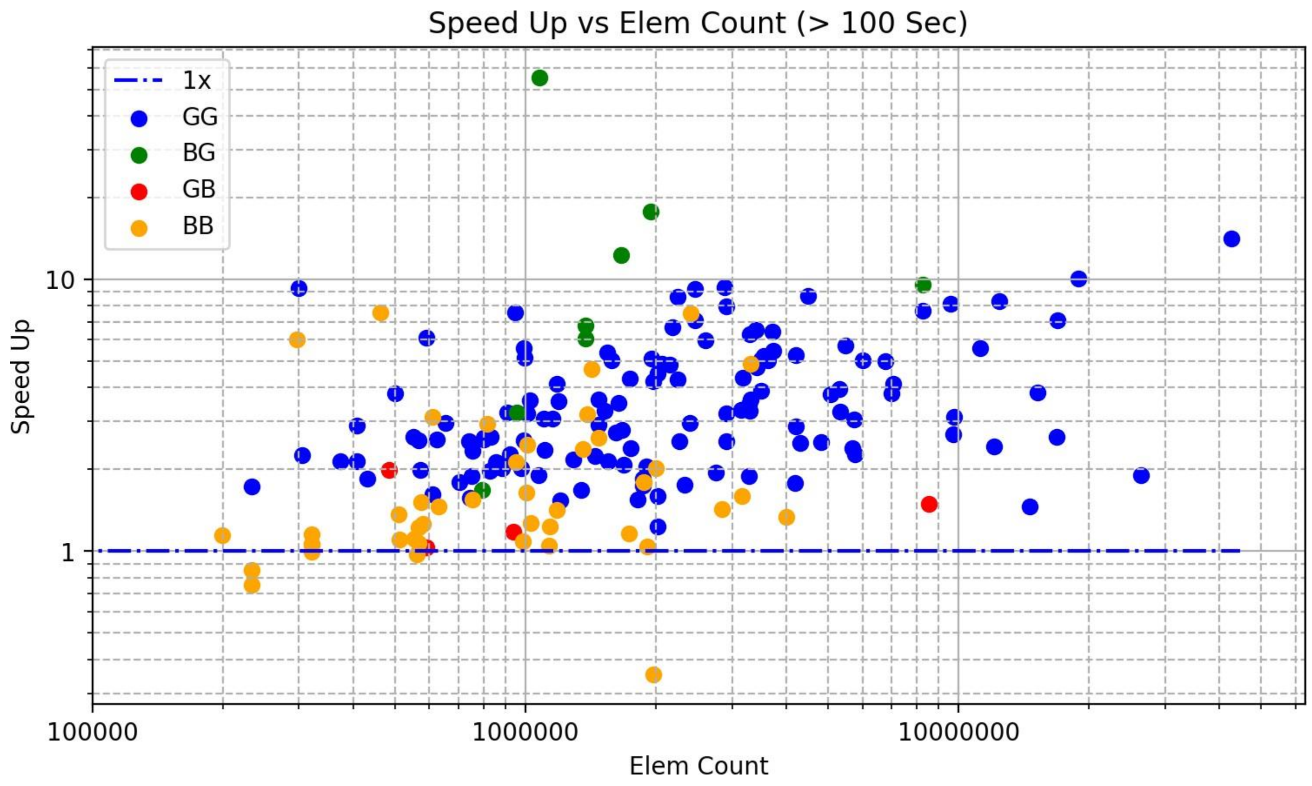


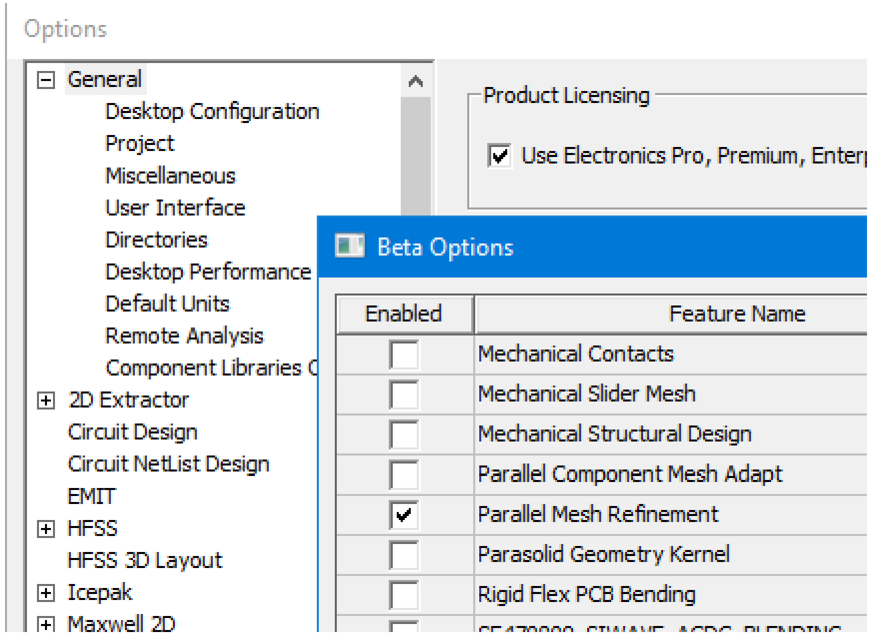


Meshing

2022R2 EBU Meshing features

- Parallel Meshing Refinement PMR [BETA]
  - Load predictor and decomposition (up-to specified # of threads)
  - PMR not supported for Q3D

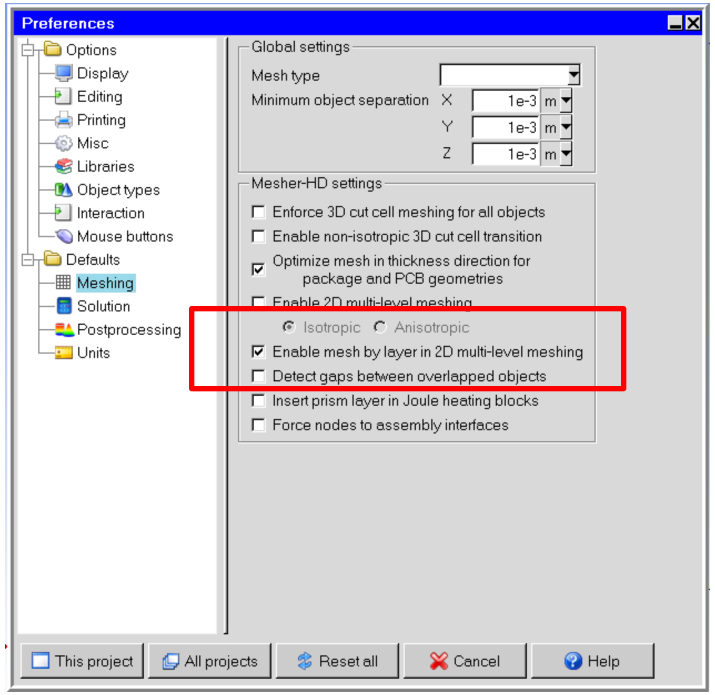


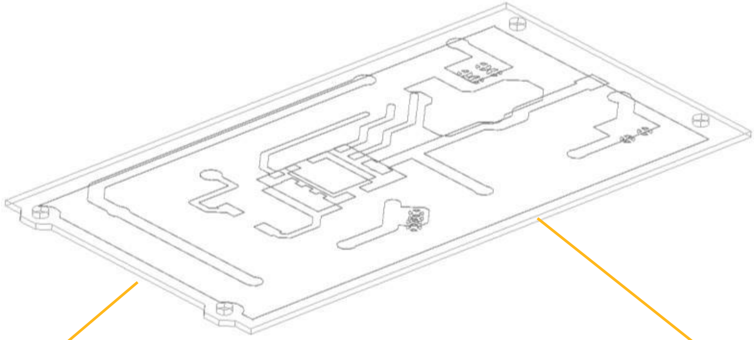


Check box in Beta Options

2022R2 EBU Meshing features (Cont'd)

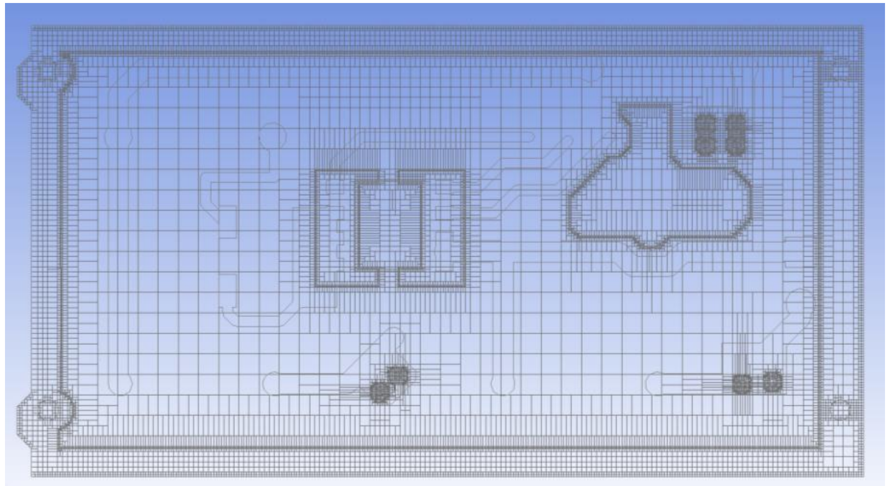
- Layer-by-layer meshing in 2D MLM
  - Auto decomposition in "thickness" direction
  - ANSYSEM_FEATURE_S425570_Icepak_Hdm_Cart2d_Blocking_ENABLE (for AEDT Icepak)

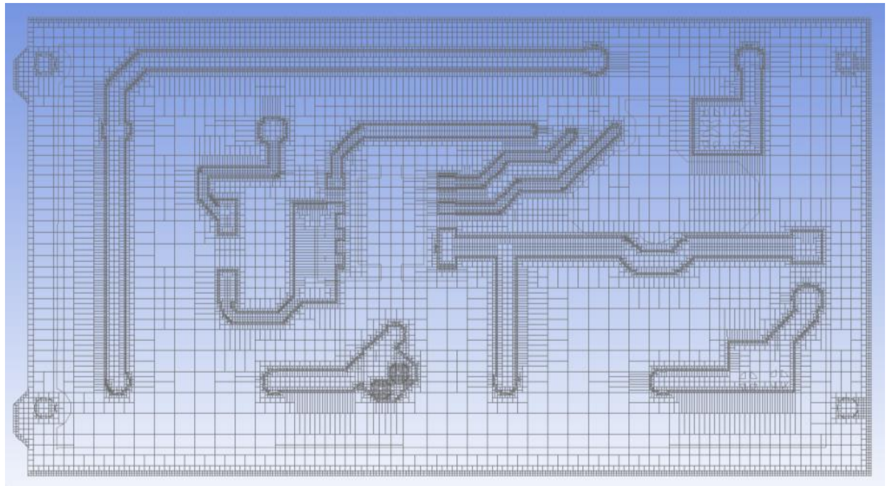




Bottom layer

Top layer

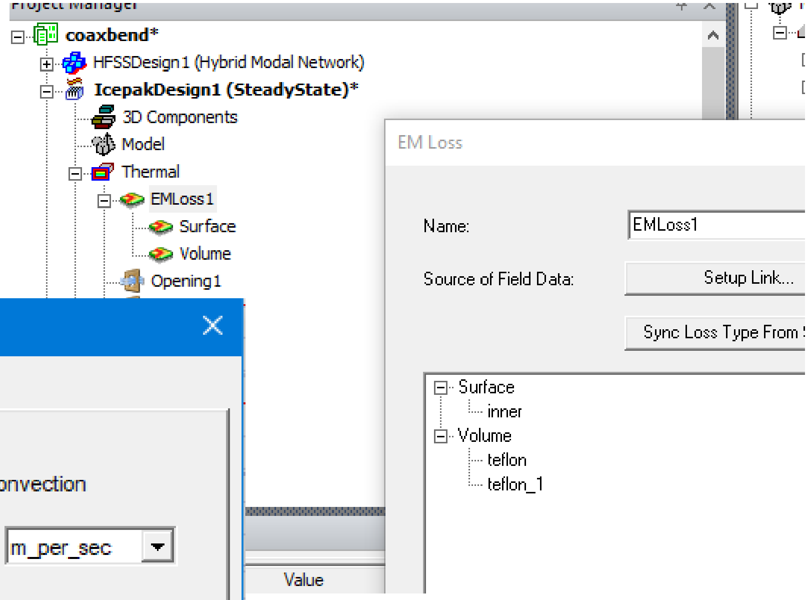


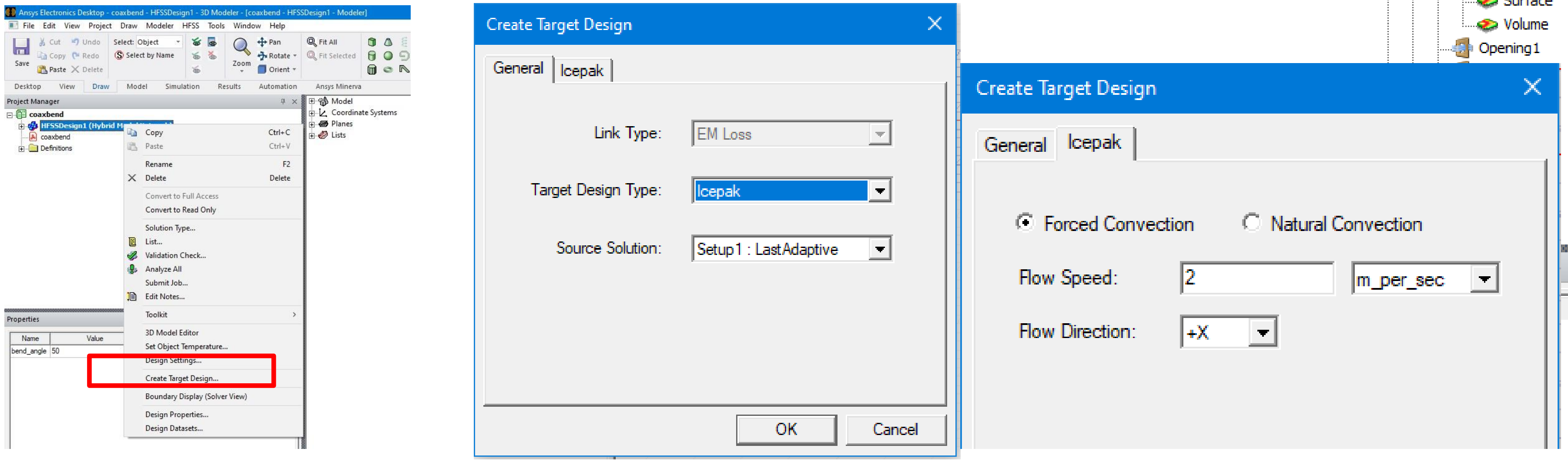


Thermal

Thermal Design Creation from HFSS/Maxwell/Q3D (Beta)

- Automated creation of linked thermal design from a source EM design
  - Icepak/Mechanical target designs created
  - Source can be HFSS/Maxwell/Q3D
  - 3D components supported
- Boundary conditions and excitations created automatically
  - Forced convection & Natural convection domains (Icepak)
  - Conduction setup (Mechanical)
  - Solution setup created in ready-to-run design



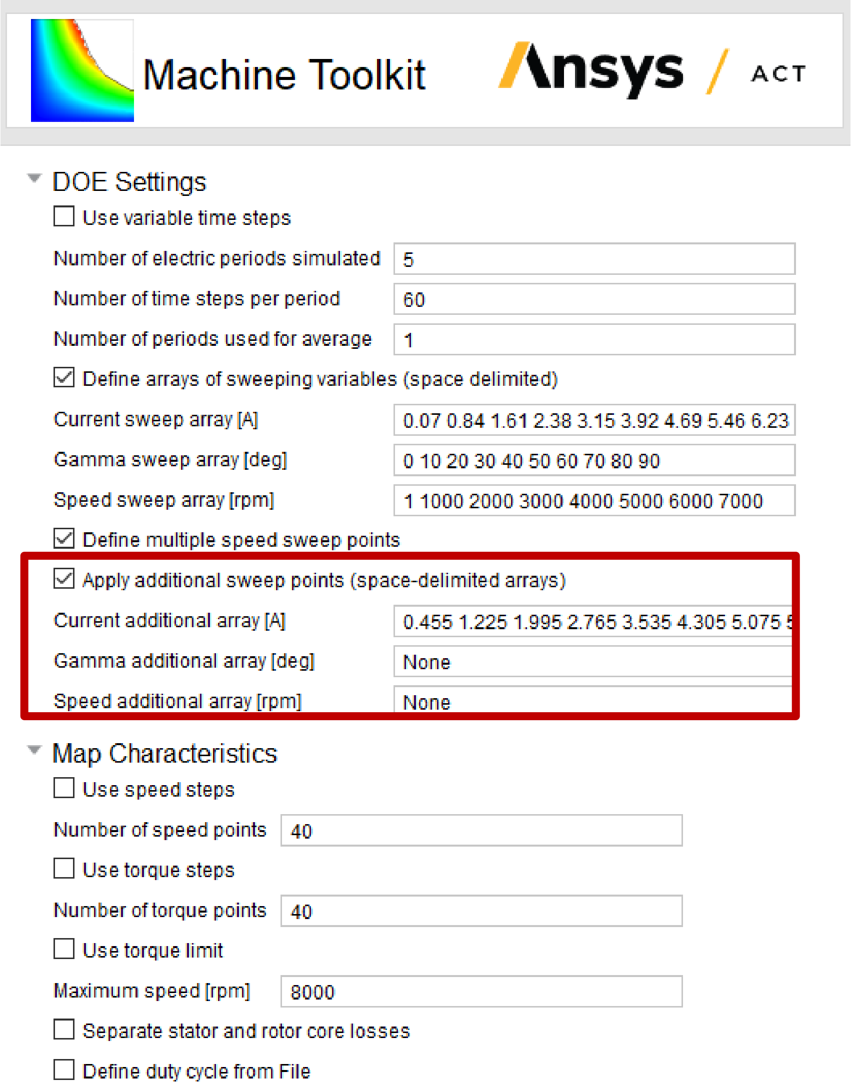


Electrical Machine Enhancements

Continue Prior Analyses with Additional Sweep Points

- **Feature Description**
  - This feature allows the user to input an additional sweeping array for each variable, then Machine toolkit continues the previously solved parametric analysis by only simulating these added sweep points.
  - **Advantages**: flexible and time-efficient; all machine types supported; Large-scale DSO supported.

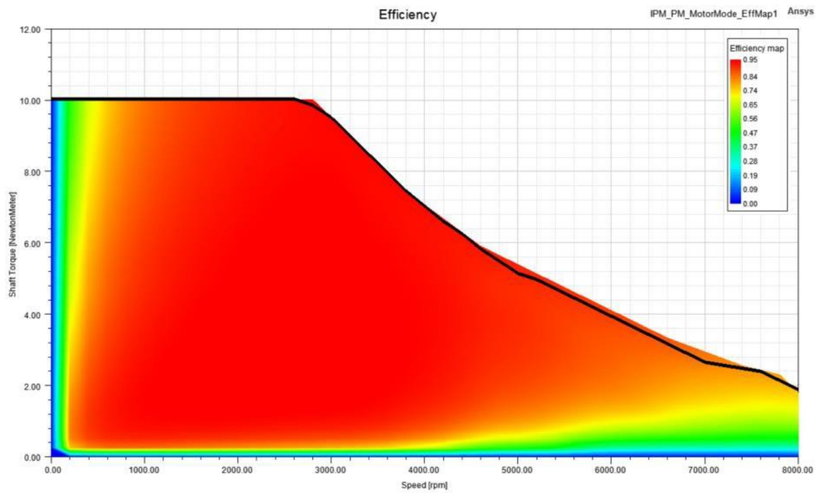
- **Additional UI options**
  - Add an option “Apply additional sweep points (space-delimited arrays)”
  - If the above option is selected, the user needs to input arrays of additional sweep points for each sweeping variable;
  - Each value in the arrays is separated from adjacent values by a space;
  - Mark “None” to the variables if no sweep points are added;
  - For PM synchronous and synchronous reluctance machines, if “Define multiple speed sweep points” is disabled, then the speed sweep array is hidden in the UI.



CAD-IT CONSULTANTS

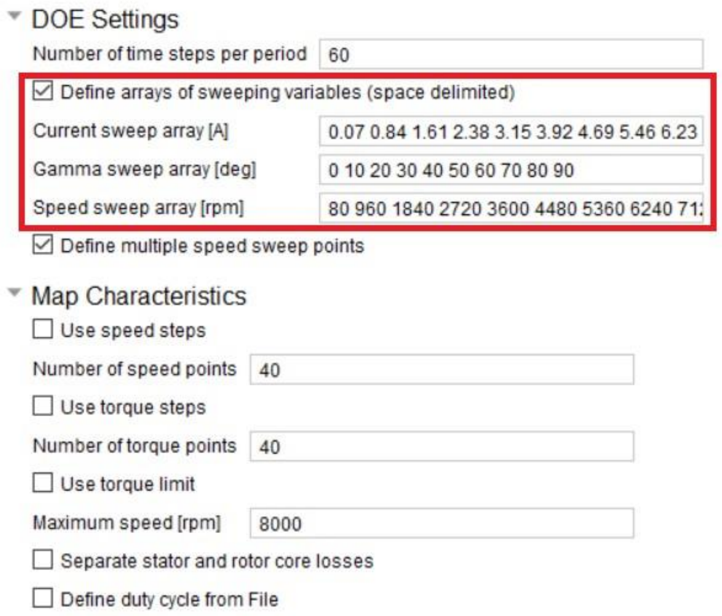
Generalize Sweep Points for Efficiency Map Generation

- **Feature Description**
  - In previous versions of Machine Toolkit, the sweep points are uniformly distributed between the minimum and maximum values of each independent variable.
  - This feature supports defining flexible and general arrays of sweep points for the independent variables in the parametric analysis.
  - **Advantages**: Higher flexibility in parametric sweep; all machine types and simulation scenarios supported; higher accuracy in the critical region by defining dense sweep points; simulation time reduced by lowering sweep resolution in less important regions.



Machine Toolkit Ansys / ACT

- **Additional UI options**
  - Add an option “Define arrays of sweeping variables (space delimited)”;
  - If the above option is selected, all the other DoE parameters are hidden, and the user needs to input arrays for each sweeping variable;
  - Each value in the arrays is separated from adjacent values by a space;
  - For PM synchronous and synchronous reluctance machines, if “Define multiple speed sweep points” is disabled, then the speed sweep array is hidden in the UI.

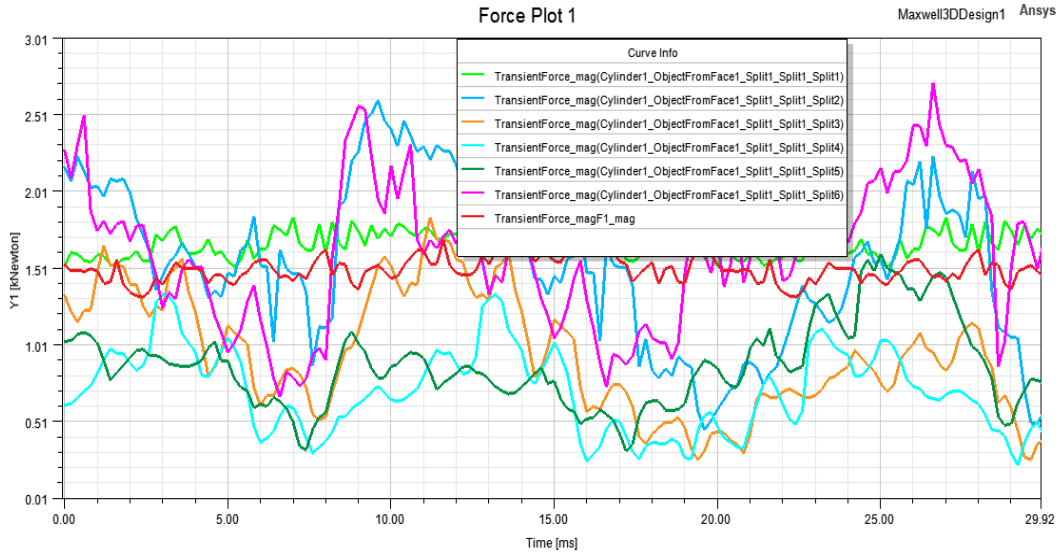


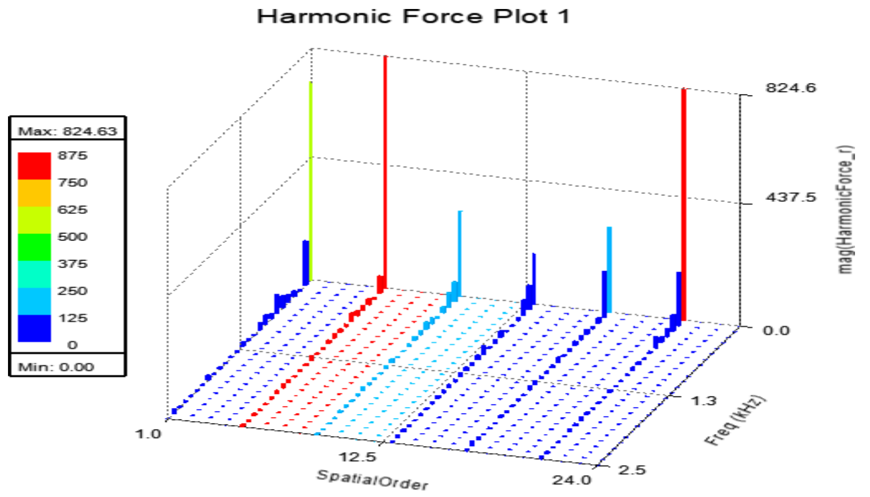
CONSULTANTS

Spatial and Temporal DFT Creation in 2D and 3D Transient

3D rectangular bar plot for harmonic force component
- Based on 2D discrete Fourier transformation
- Display index of wave number in spatial and frequencies in temporal
- Display options: Mag, Re, Imag, Phase

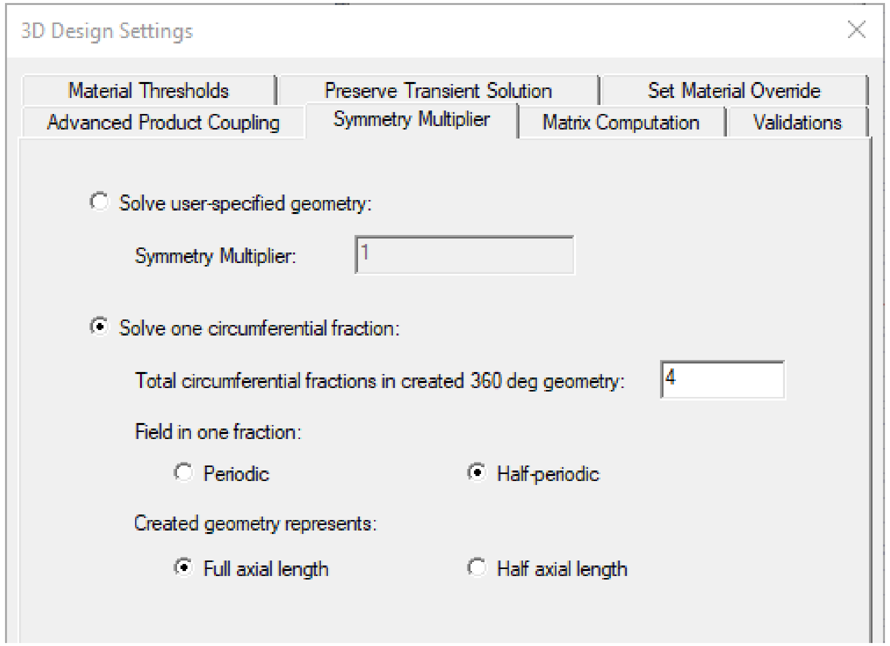
Benefits:
- Identify major frequencies to monitor the vibrations in spatial and temporal
- Force interpolation (by Inverse DFT)

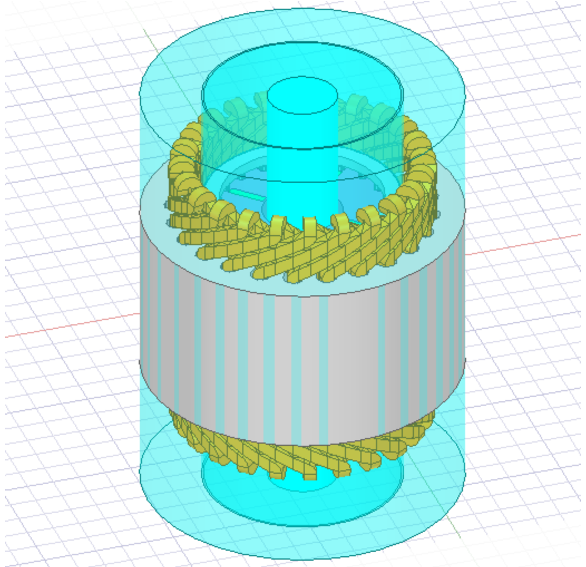




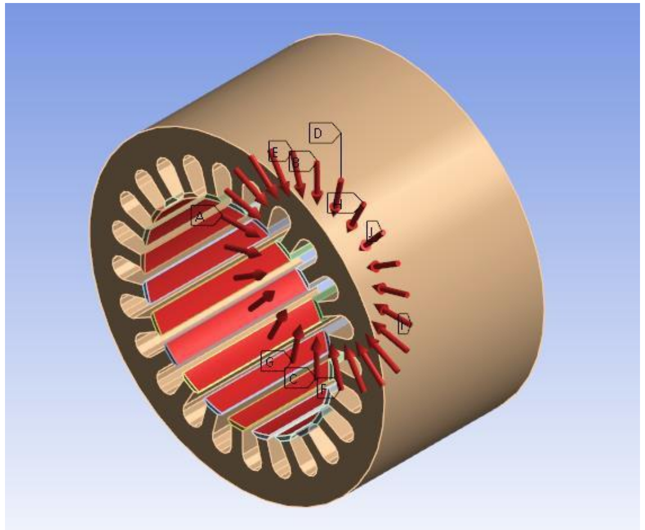
Harmonic Force Calculation in Partial Simulation of Full model

- Enable user to calculate object-based harmonic force when using partial simulation for full model
- ALL teeth tips need to be selected





Partial simulation of full model



Remote load (force) for full model

Ansys Motor-CAD 2022 R2 Release Highlights

What’s new in Ansys Motor-CAD?

- NVH Enhancements
- Machine type modelling improvements
- New RPC automation with Python
- Motor-CAD to Maxwell export updates
- Motor-CAD to OptiSLang export updates

What’s new in Ansys Motor-CAD?

- NVH Enhancements
- Machine type modelling improvements
- New RPC automation with Python
- Motor-CAD to Maxwell export updates
- Motor-CAD to OptiSLang export updates

Infinite cylinder and Acoustic Weighting model (new!)

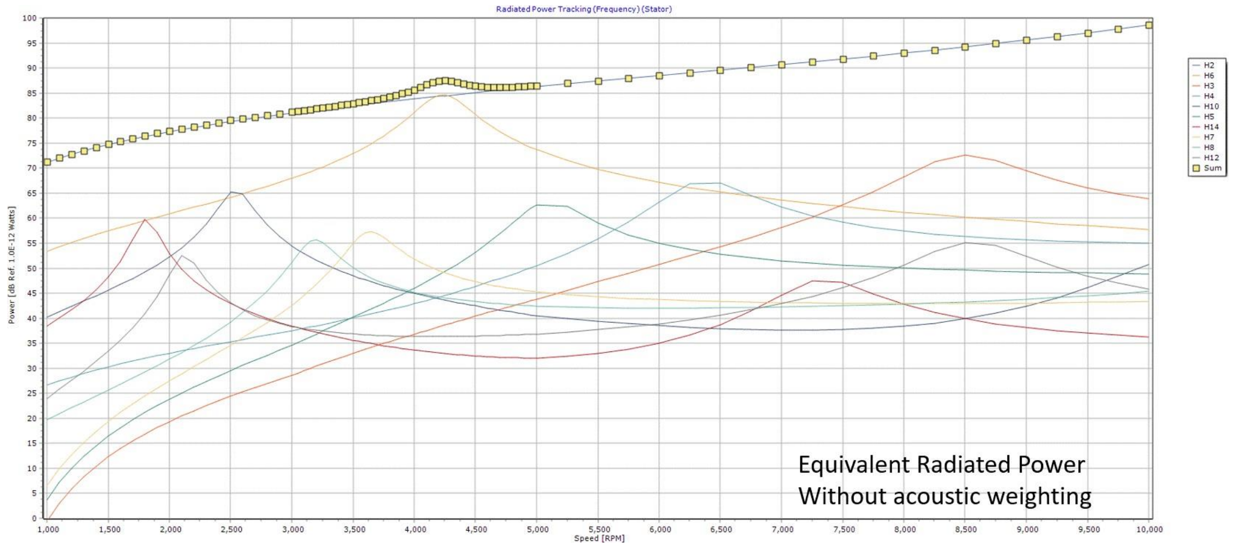
Acoustic model:

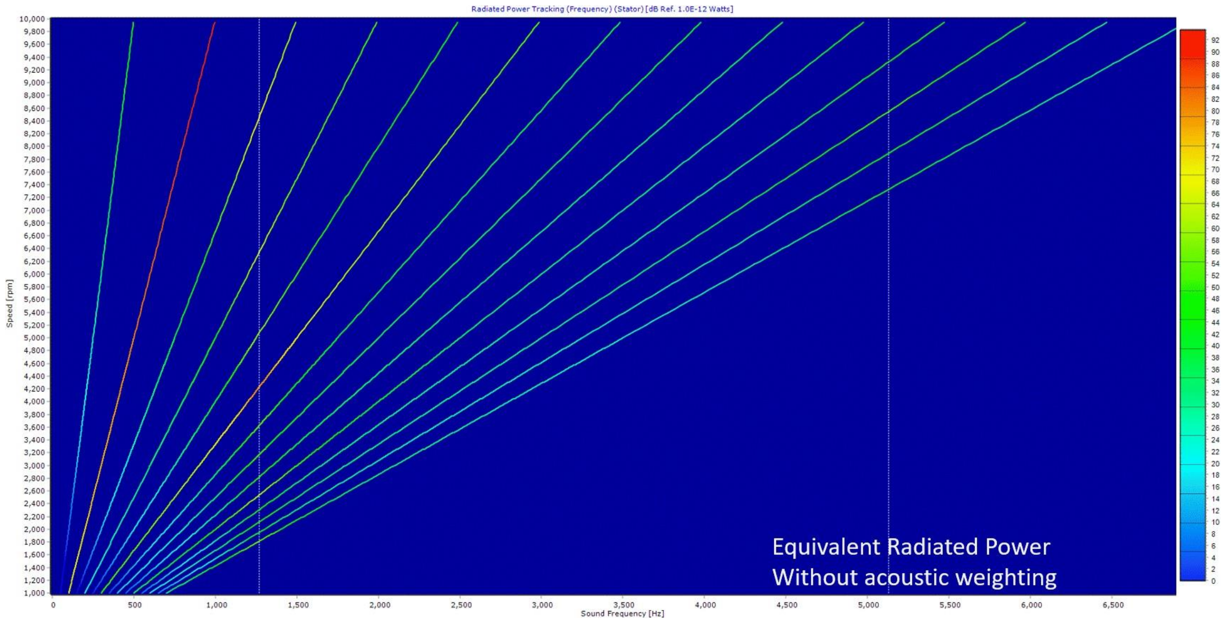
- Infinite cylinder acoustic model added, giving better prediction of low frequency sound radiation
  - This takes into account how efficiently stator vibration is converted into sound radiating away from the motor.

- Equivalent Radiated Power (ERP) is a good value for comparison between motors, but can substantially overestimate noise at low frequencies, where the wavelength of the sound is much larger than the size of the motor.

Weighting:

- A weighting can be applied to acoustic results, to give a closer match to human perception of noise level

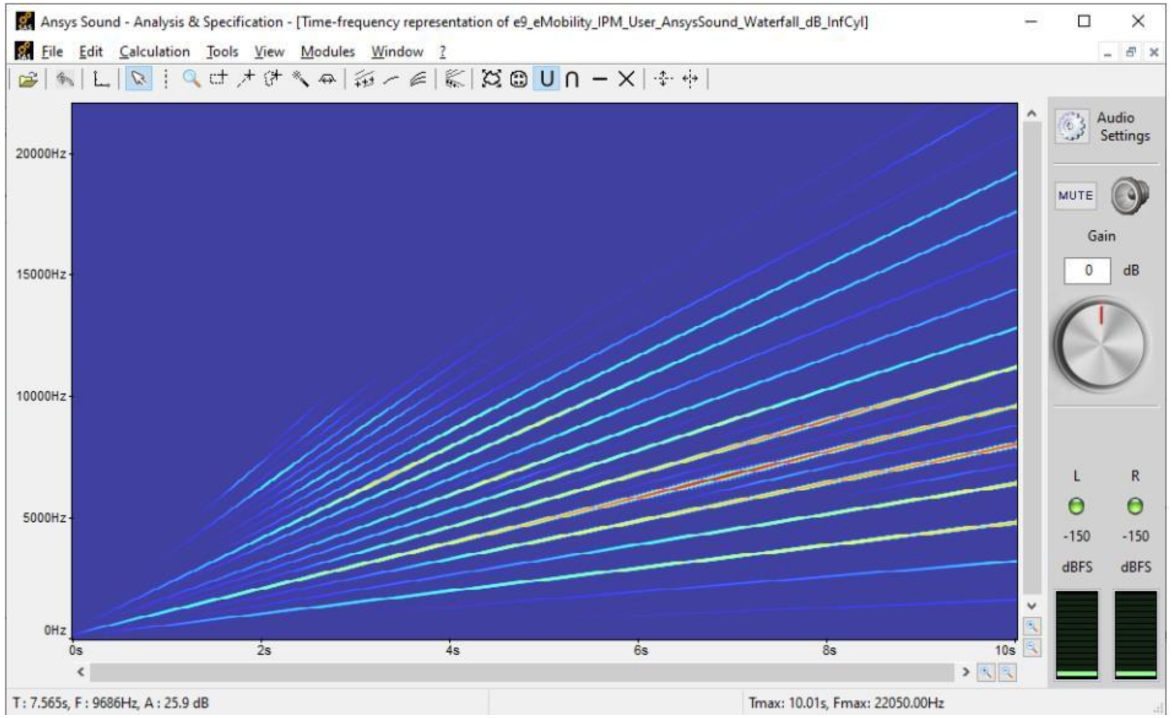




NVH: Export to Ansys Sound (new!)

Ansys Sound export:

- Motor-CAD noise predictions can be exported to Ansys Sound (SAS) in order to
  - Replay noise
  - Calculate psychoacoustic measures
  - Use Sound Composer to hear the predicted motor noise in a full acoustic environment including measured masking noise from wind and tyres



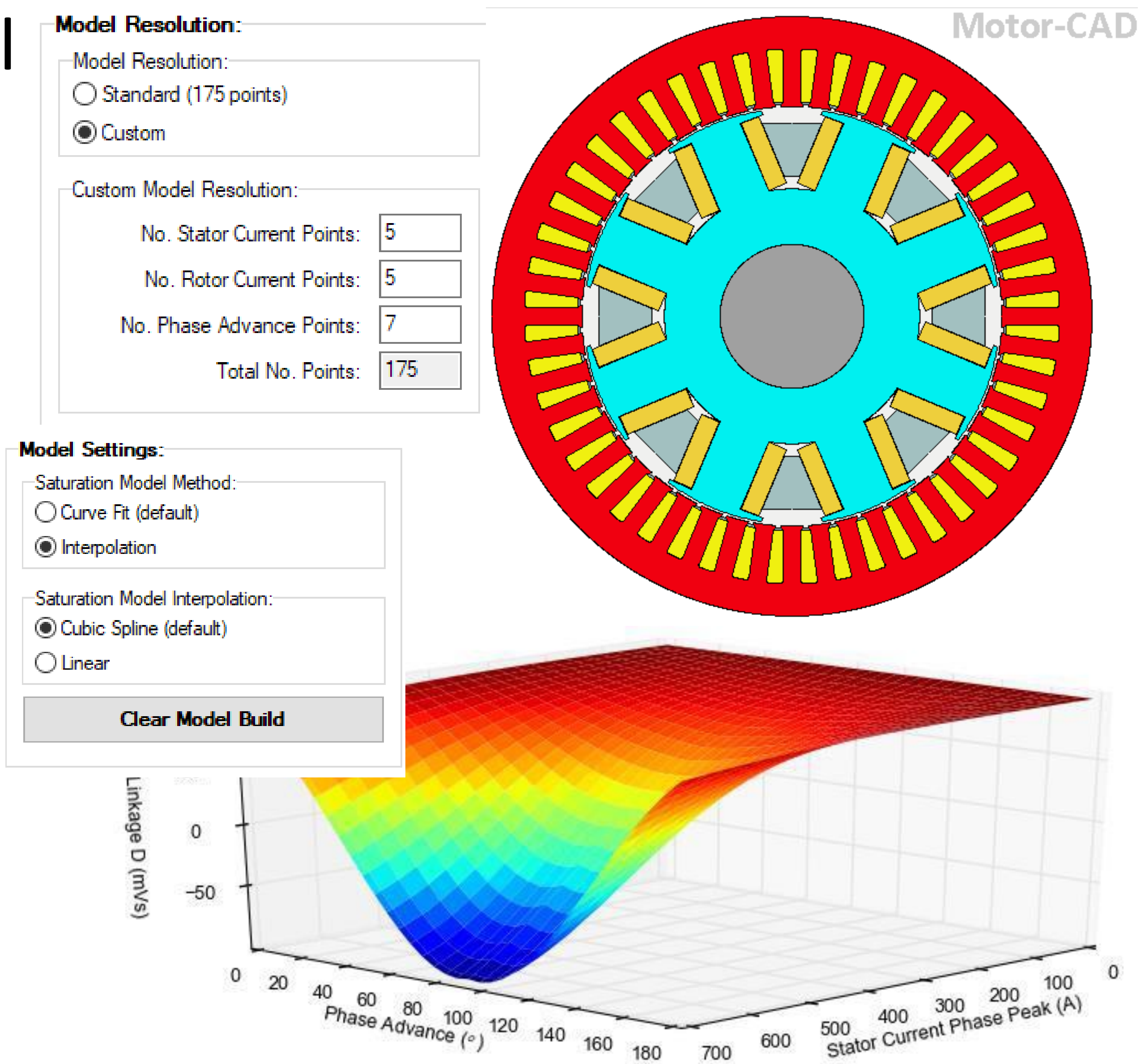
What’s new in Ansys Motor-CAD?

- NVH Enhancements
- Machine type modelling improvements
- New RPC automation with Python
- Motor-CAD to Maxwell export updates
- Motor-CAD to OptiSLang export updates

Synchronous machine lab model

- Model build resolution can now be specified
  - Enabling high fidelity efficiency map and drive cycle analysis
  - Interpolation methods may also be varied

- Rotor/stator loss bias ratio added
  - Enables tuning of the control strategy to shift joule losses between the rotor or the stator
  - Useful for ensuring continuous thermal e maximised



What’s new in Ansys Motor-CAD?

- NVH Enhancements
- Machine type modelling improvements
- New RPC automation with Python
- Motor-CAD to Maxwell export updates
- Motor-CAD to OptiSLang export updates

New Communication Method – JSON-RPC

- Replaces ActiveX for Python/MATLAB
- Motor-CAD starts an RPC server
- We can connect to this using a new Python module
- New *MotorCAD_Methods Module* for Python – installed with latest release
  - *MotorCAD* object attaches to Motor-CAD instance
  - Old Method:

```python
import win32com.client
mc = win32com.client.Dispatch("MotorCAD.AppAutomation")
```

  - New Method:

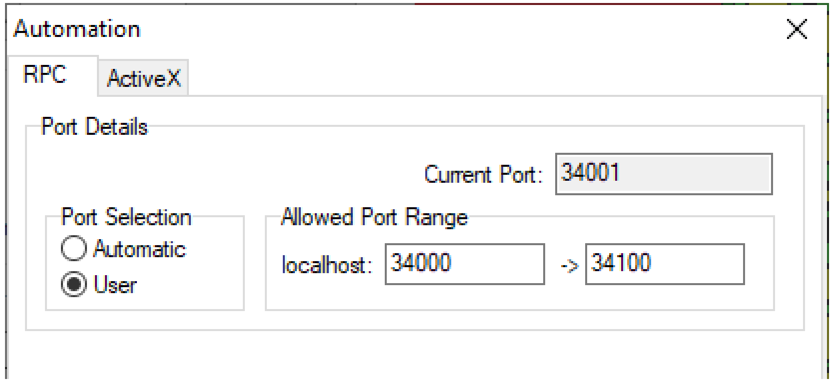
```python
from MotorCAD_Methods import MotorCAD
mc = MotorCAD()
```

- Syntax/behaviour can be kept identical to ActiveX

CAD-IT CONSULTANTS

Current State of Work

- All ActiveX functions in 2022 R2
- RPC is hidden in 2022 R2
  - Enable in Defaults.INI *(RPC_Enabled)*
  - Settings in *Defaults -> Automation*



- Works with Python/MATLAB
- Docstring/error messages for most common functions

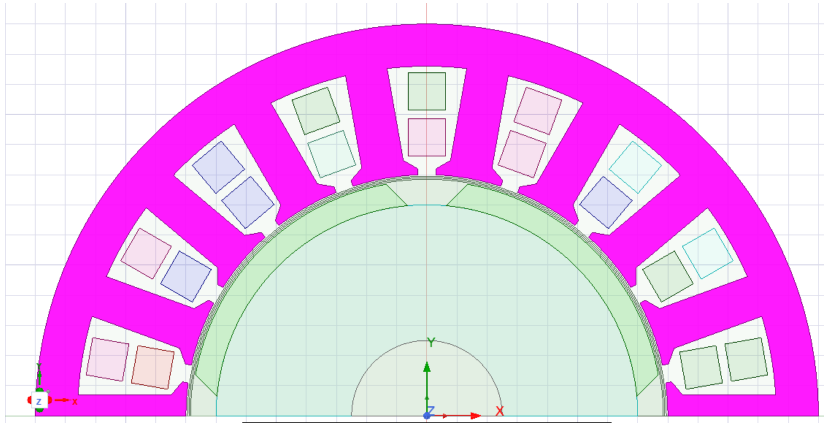
```
// Variables
function GetVariable(const variableName: string) : TJsonResult;
function GetArrayVariable(const arrayName: string; const arrayIndex: integer) : TJsonResult;
function SetVariable(const variableName :string; const variableValue : TJsonObject) : TJsonResult;
function SetArrayVariable(const arrayName: string; const arrayIndex: integer; const variableValue : TJsonObject) : TJsonResult;

// UI
function ShowMessage(const aMessage: string) : TJsonResult;
function Quit : TJsonResult;
function ShowMagneticContext : TJsonResult;
function ShowMechanicalContext : TJsonResult;
function ShowThermalContext : TJsonResult;
function DisplayScreen(const screenName : string) : TJsonResult;
function SaveScreenToFile(const screenName, fileName: string) : TJsonResult;

// Calculations
function DoMagneticCalculation : TJsonResult;
function DoSteadyStateAnalysis : TJsonResult;
function DoTransientAnalysis : TJsonResult;
function DoWeightCalculation : TJsonResult;
function DoMechanicalCalculation : TJsonResult;

// Lab
function ClearModelBuild_Lab: TJsonResult;
function SetMotorLABContext: TJsonResult;
function BuildModel_Lab: TJsonResult;
function CalculateOperatingPoint_Lab: TJsonResult;
function CalculateMagnetic_Lab: TJsonResult;
function CalculateThermal_Lab: TJsonResult;
function CalculateDutyCycle_Lab: TJsonResult;

// Geometry
function CheckIfGeometryIsValid(const editGeometry: integer): TJsonResult;

// Files
function LoadFromFile(const motFile : string) : TJsonResult;
function SaveToFile(const motFile : string) : TJsonResult;

// Internal Scripting
function LoadScript(const scriptFile : string) : TJsonResult;
function RunScript : TJsonResult;

// Graphs
function GetMagneticGraphPoint(const graphID : TJsonObject; const pointNumber : integer): TJsonResult;

// FEA
function GetPointValue(const parameter: TJsonObject; const x, y: Double): TJsonResult;

// Thermal
function GetNodeTemperature(const nodeNumber: integer): TJsonResult;
```

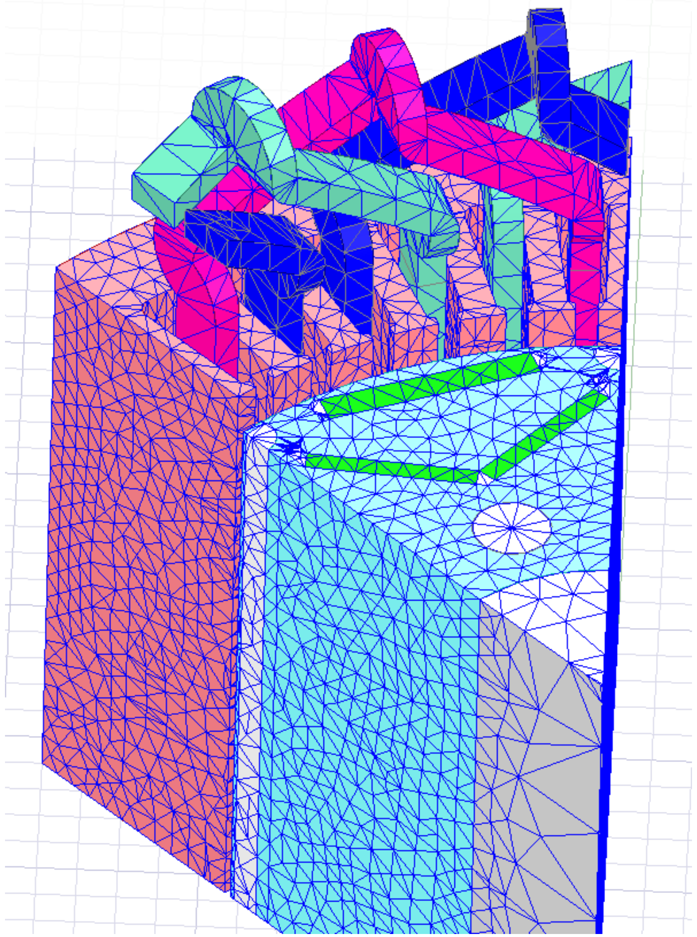
What's new in Ansys Motor-CAD?

- NVH Enhancements
- Machine type modelling improvements
- New RPC automation with Python
- Motor-CAD to Maxwell export updates
- Motor-CAD to OptiSLang export updates

UDP’s

- Added new UDP’s :
  - BPM - Surface Radial and Surface Parallel (rotor/magnets)
  - Stator Parallel Tooth and Parallel Tooth Square Base
  - SRM – Added stator pole taper angle into existing UDP

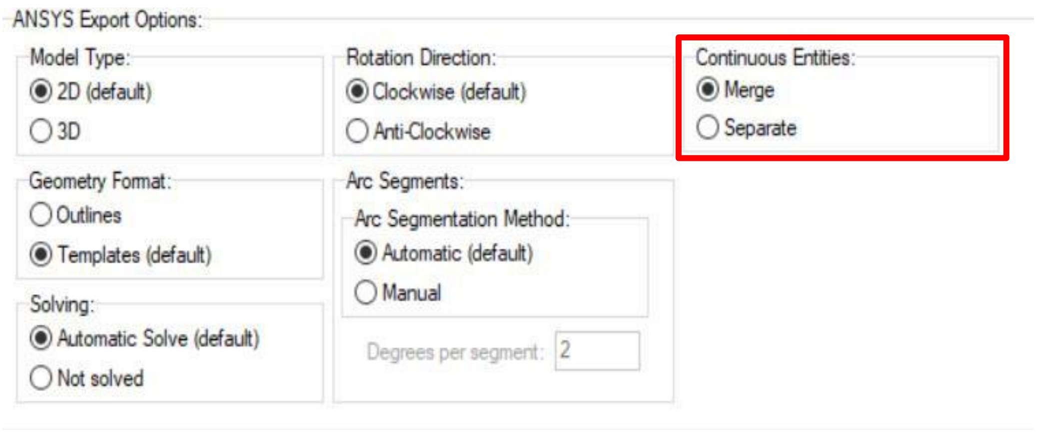


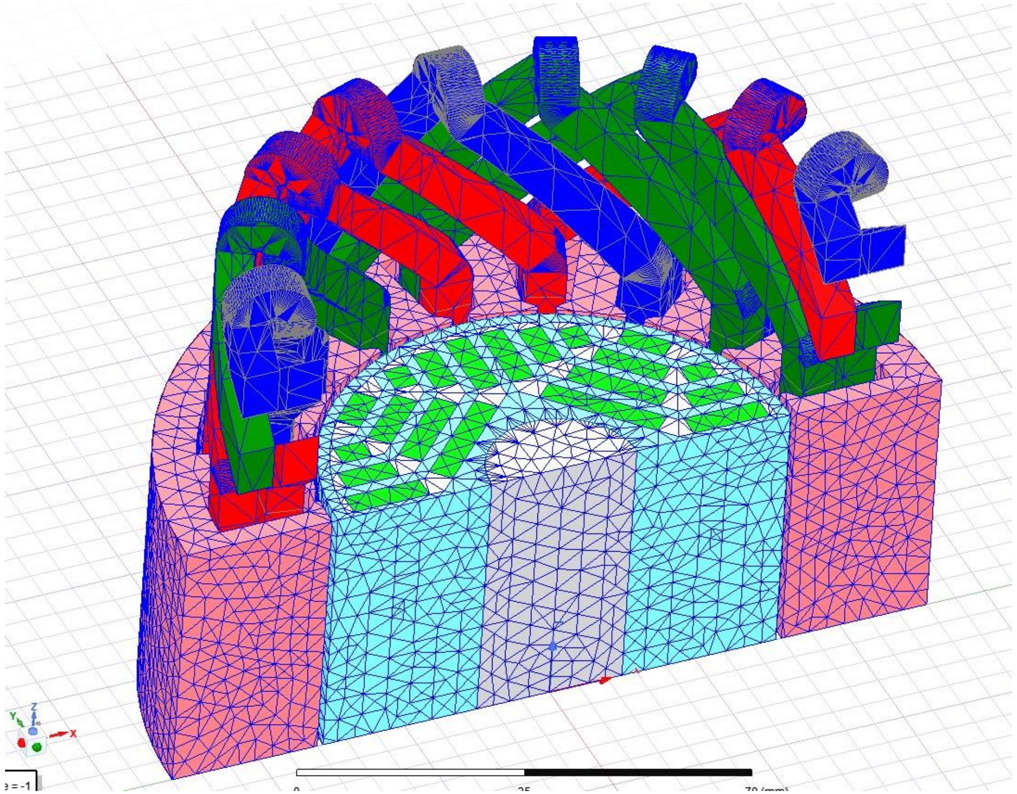


CAD-IT CONSULTANTS

New Functionality

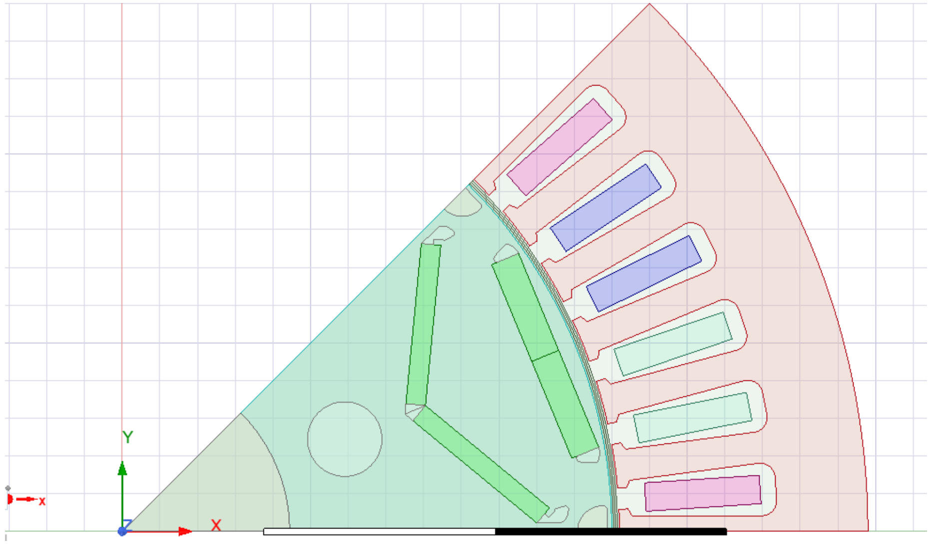
- Ability to enable or disable “Continuous Entities”, which merges continuous entities (arc or line) within the polyline region.





Improved Functionality

- Improvements to polyline detection and creation when using imported DXF’s.
- Ability to replace arc entities within DXF geometries which are not valid within Maxwell, e.g. small arc entities replaced using a line entity.



Overall benefits

- Higher UDP coverage provides faster meshing times with the ability to use parameterised geometries within Maxwell.
- Decreased exported model generation times when using continuous entity merging and/or UDP's.
- Improved polyline detection and creation for DXF based models allows for accurate transfer of customised geometries into Maxwell.
- Ability to export and solve 3D models to accurately determine end effects etc using Finite Element solvers.
- Ability to use Maxwell Clone Meshing (User must select this option within Maxwell)

What’s new in Ansys Motor-CAD?

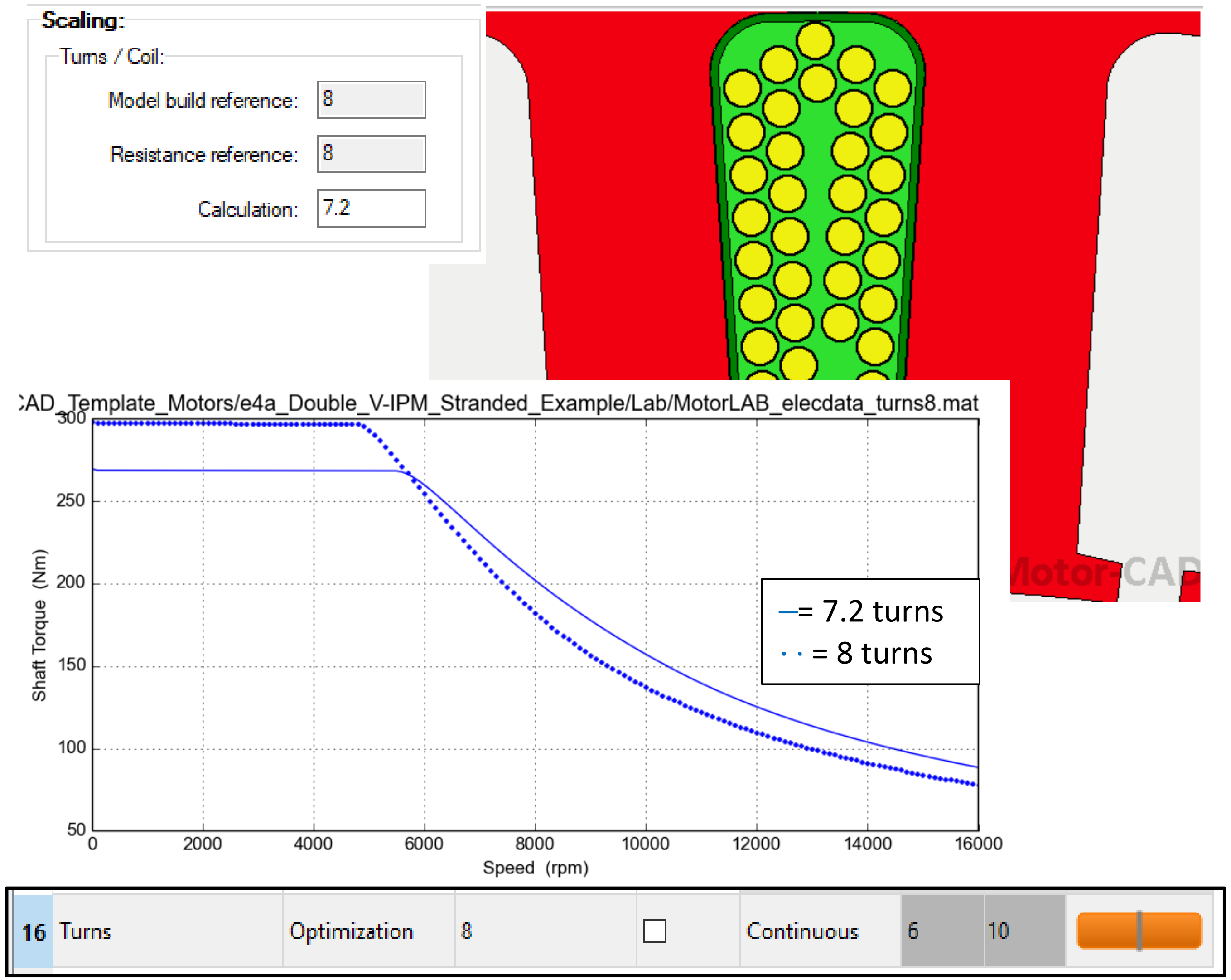
- NVH Enhancements
- Machine type modelling improvements
- New RPC automation with Python
- Motor-CAD to Maxwell export updates
- Motor-CAD to OptiSLang export updates

Motor-CAD - optiSLang Export – Winding turns as input

- User can include the number of turns per slot as an input for optimisations using stranded winding.

- The Lab module turns scaling feature, allows non integer values to be calculated.

- This turns scaling enables a continuous range to be used at the sensitivity analysis stage, easing MOP generation and improving accuracy.

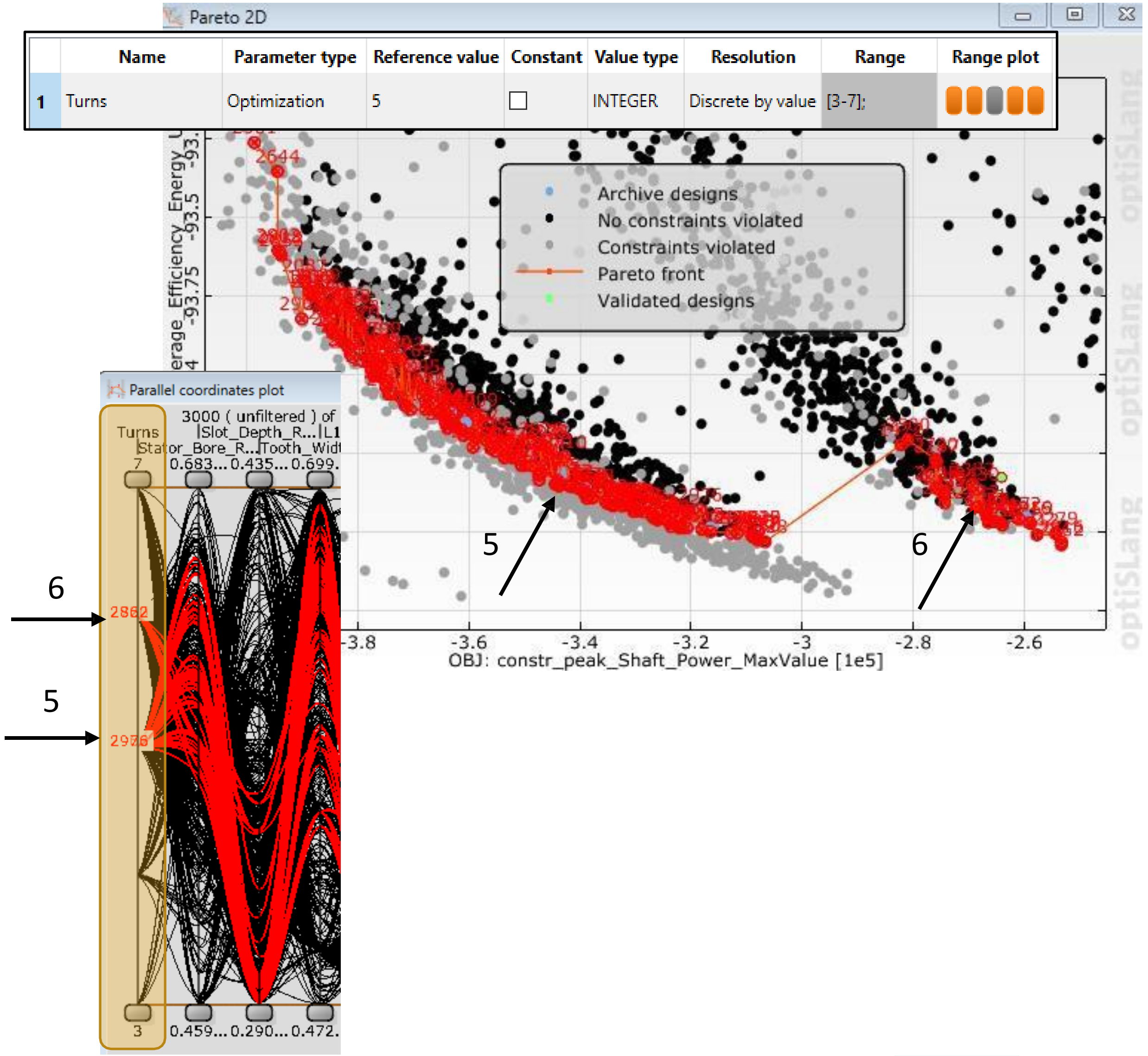


Motor-CAD - optiSLang Export – Winding turns as input

- At the optimisation stage, a discrete, integer range may be set to ensure only feasible windings are used.

- Here two distinct pareto fronts are present at two different values of winding turns.

- Available for stranded BPM motor types. It's a key parameter to be included, improving functionality for many users.



CAD-IT CONSULTANTS

Motor-CAD - optiSLang Export – Updated tutorial

- A new section has been added to the end of the Motor-CAD to optiSLang integrated export tutorial.

- It provides guidance and examples on how to customise the script, to alter inputs, outputs or do analysis, not currently included within the integrated export.

- This allows complete freedom to users, allowing them to combine the benefits of exported script with the ability to fully customise the optimisation.

Motor-CAD Software Tutorial:

Advanced Multiphysics optimisation of electric machines with Motor-CAD and optiSLang software tools

Application to an IPM traction motor

The script is shown below with the three new lines added (lines 193,194):

```
187    ### Handle housing scaling if applicable
188    success, statorDiameter = mcApp.GetVariable('Stator_Lam_Dia')
189    success, housingDiameter = mcApp.GetVariable('Housing_Dia')
190    housingThickness = housingDiameter - statorDiameter
191
192    ### Set number of magnet segments dependent on Active Length
193    Single_Mag_Length = 25
194    Mag_Segments = int(i_Active_Length/Single_Mag_Length)
195
196    ### Set parameters (do not change this comment)
197    mcApp.SetVariable('Ratio_Bore', i_Stator_Bore_Ratio)
198    mcApp.SetArrayVariable('RatioArray_PoleArc', 0, i_L1_Pole_Arc_Ratio)
199    mcApp.SetArrayVariable('MagnetThickness_Array', 0, i_L1_Magnet_Thickness)
200    mcApp.SetArrayVariable('PoleVAngle_Array', 0, i_L1_Pole_V_Angle)
201    mcApp.SetVariable('Ratio_SlotDepth_ParallelSlot', i_Slot_Depth_Ratio)
202    mcApp.SetVariable('Ratio_SlotWidth', i_Slot_Width_Ratio)
203    mcApp.SetVariable("Stator_Lam_Length", i_Active_Length)
204    mcApp.SetVariable("Rotor_Lam_Length", i_Active_Length)
205    mcApp.SetVariable("Motor_Length", i_Active_Length + motorExtension)
206    mcApp.SetVariable("Magnet_Length", i_Active_Length)
```

CAD-IT CONSULTANTS

新科益工程仿真中心

咨询邮箱：ansyssupport@cadit.com.cn

公司网址：http://www.cadit.com.cn