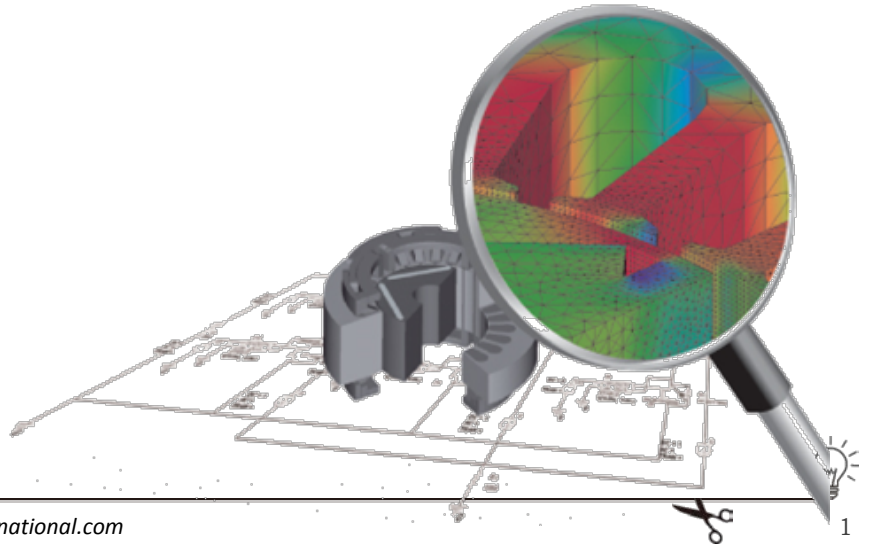
JMAG V18.0 Review of new functions

January 2019

JMAG Division

JSOL Corporation



Why JMAG V18.0?

- Get a proper vision of your geometry
- Enhancement of simulations capability
- Improve your HIL, SIL and MIL models
- Improve your loss calculations
- Better parameter handling and enhanced optimisation capability
- Think your JMAG circuit differently
- Efficiency maps directly in JMAG-Designer

Get a proper vision of your geometry

To start a good simulation, it is always better to have a good vision and easy customization of the parts you want to simulate. JMAG V18.0 will help you with that

Complex shape in your geometry

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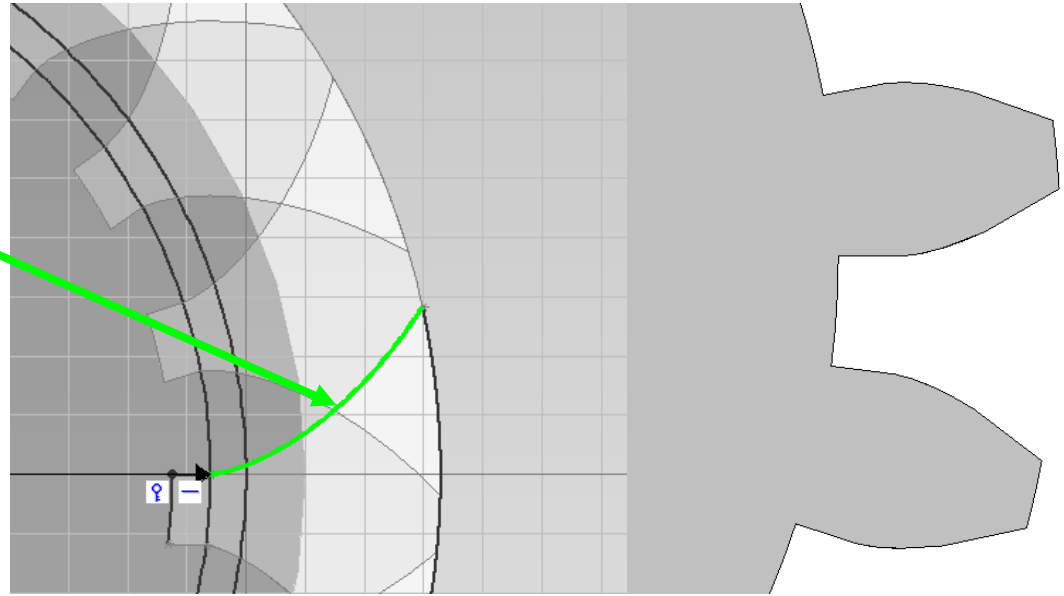
Geometry Editor

- Function based line drawing allows complex outlines.

$$X = cos\big(t - atan(t)\big) \cdot R \cdot \sqrt{t^2 + 1}$$
$$Y = sin\big(t - atan(t)\big) \cdot R \cdot \sqrt{t^2 + 1}$$



Involute gear sketch made possible with the new function.

Shapes created with user defined program

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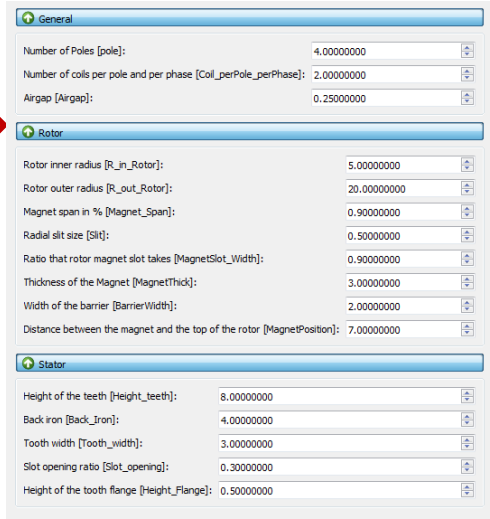
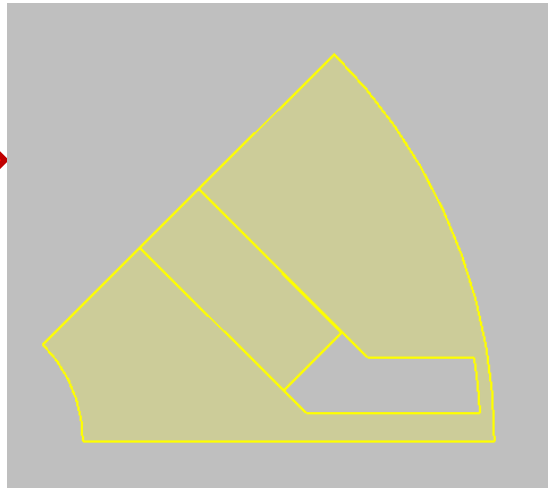
Geometry Editor

- Geometry templates by modeling API functions (Python) parametrize the region shape without the burden of constraints.

You can set a Python code that will define your geometry.



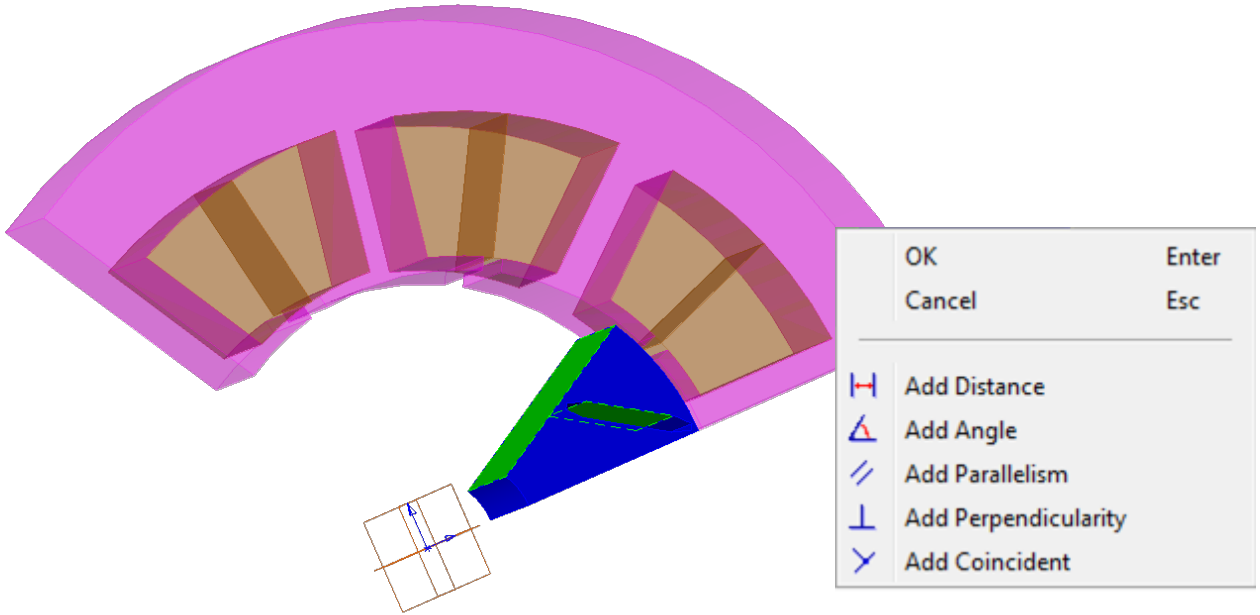


You can easily parametrize your model.

Easy access to direct modelling

Geometry Editor

- Context based menu for the direct modelling gives the same usability as the geometric constraints.



Easy to access the direct modelling functionality .

Better visualization of your geometry

New performance improving functions	
Better UI to visualize large models	JMAG Designer
Select the number of visible digits on constraints	Geometry Editor
Add labels to your geometry constraints	Geometry Editor
Add measurements annotation on the geometry	Geometry Editor

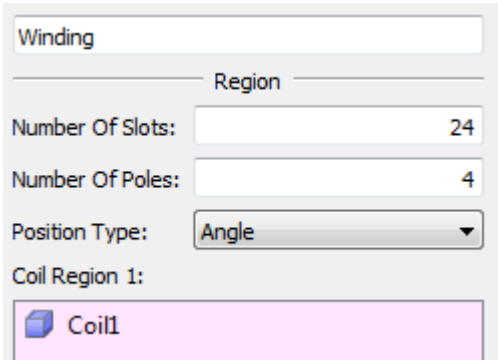
Enhancement of simulations capability

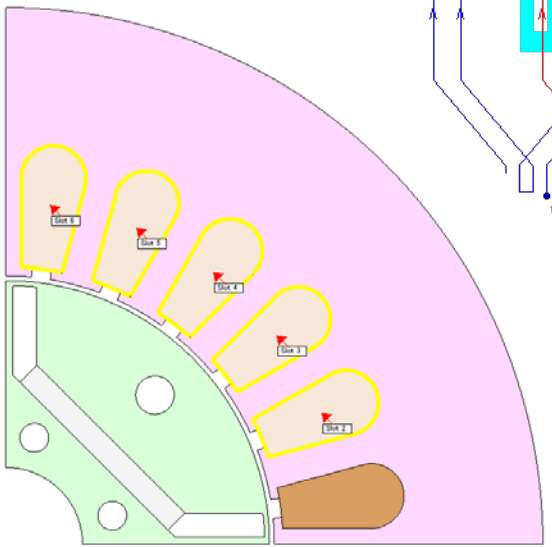
Get a new study type. Reduce your calculation time, reduce your memory usage allow yourself a better handling of large scale models and calculation

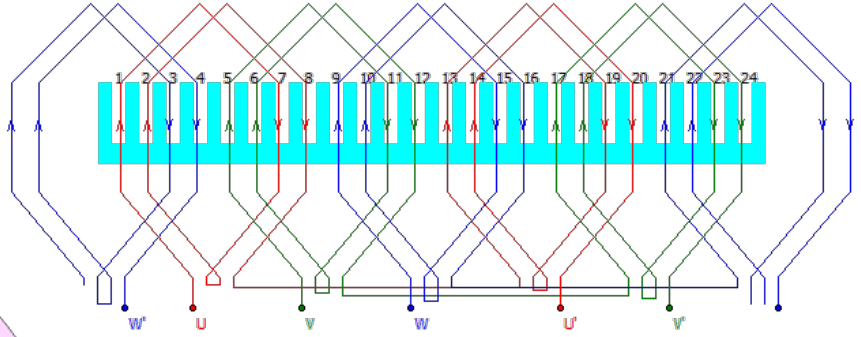
Simplify your winding setting

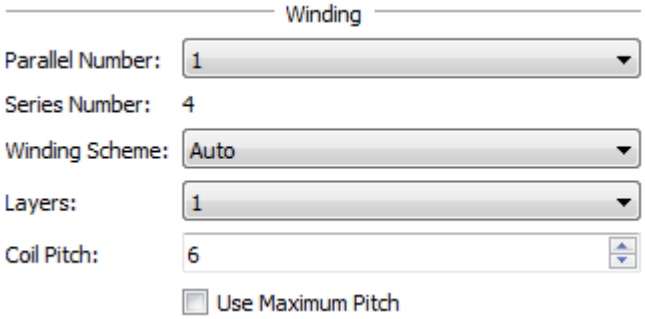
Study

- Parametrized for the winding setting like JMAG-Express.







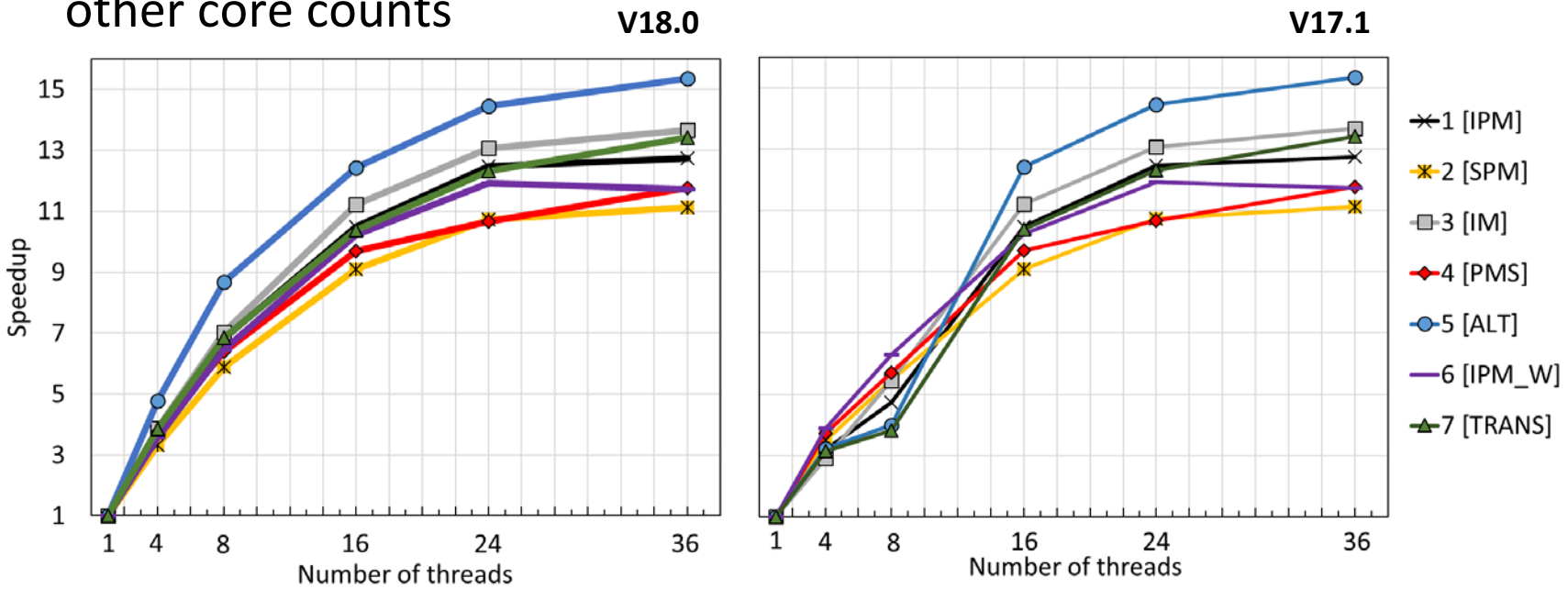


Select your winding region, and its parameter to get a winding chart you can customize.

Faster SMP

Study

- The use of SMP at 4 and 8 cores result low speed-up compared to other core counts

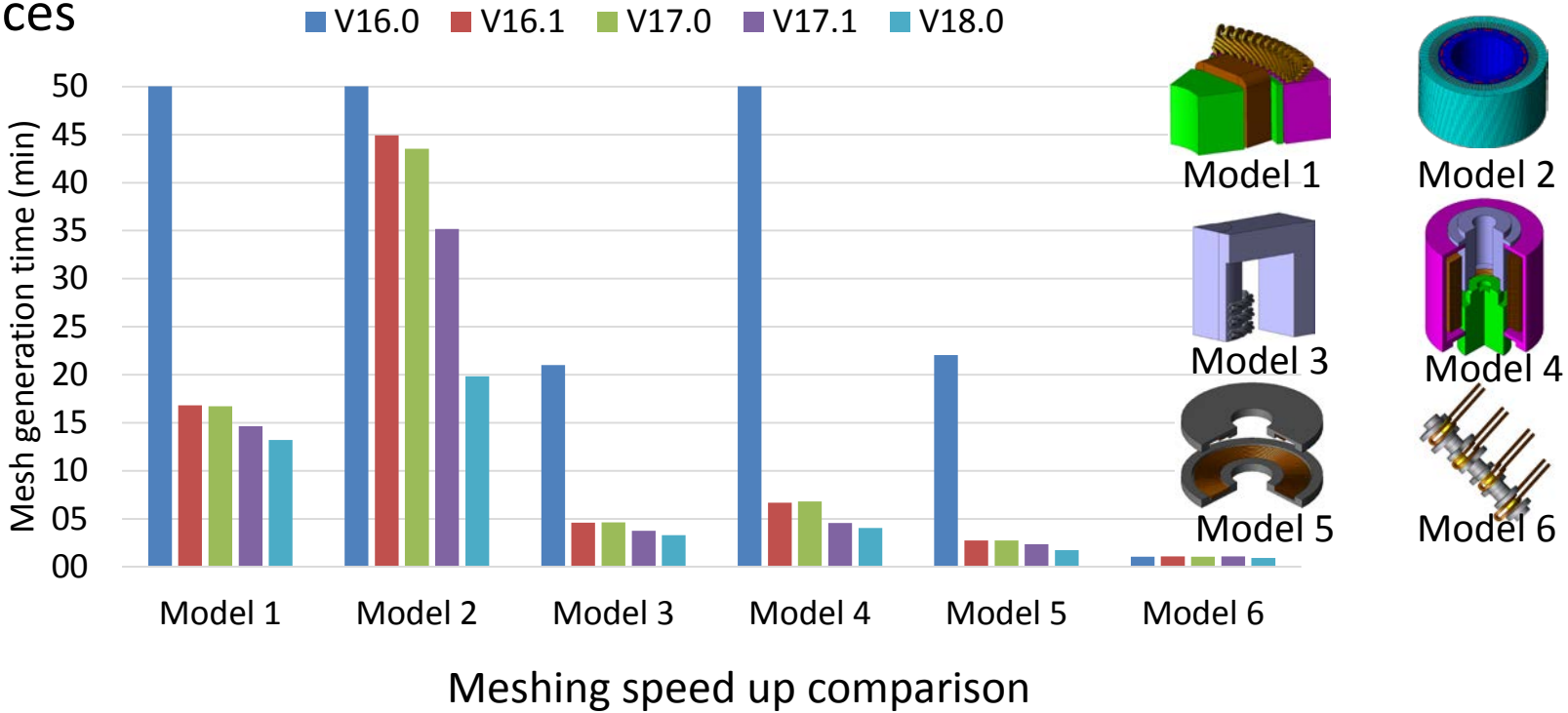


Get a speed increase when using SMP 4 and 8 cores

Speed up your meshing

Mesh

- Improve the meshing for large scale models with large number of faces



Speed-up for models with extended slide mesh

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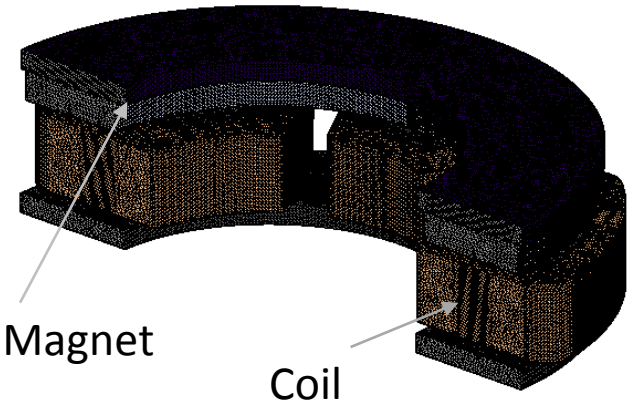
Mesh

- Remove the need of re-meshing by generating inconsistent mesh



Method	Number of elements	Calc. time (hour)
Conventional	3,675,614～3,682,413	12.11
New	3,676,656	9.49

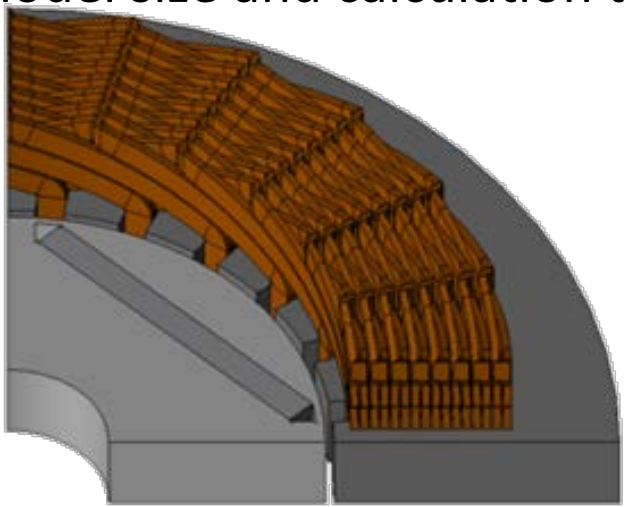
Inconsistent meshing to axial gap motors

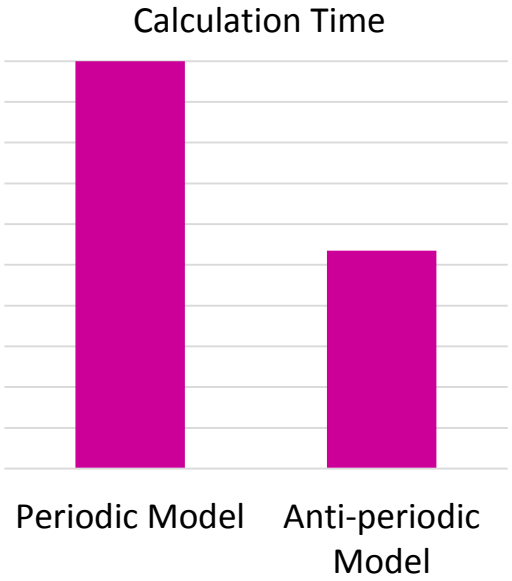
By introducing the inconsistent meshing, it can save the time of re-meshing of the extended slide meshing.

Speed-up your model with FEM conductor

Boundary

- The support of Ant-periodic boundary condition allow for reductions in model size and calculation time





Square wire model using FEM coils

When the periodic boundary condition is used the number of elements is 1,094,932. However it is reduced to 608,006 with the anti-periodic condition.

A new solver to help for convergence

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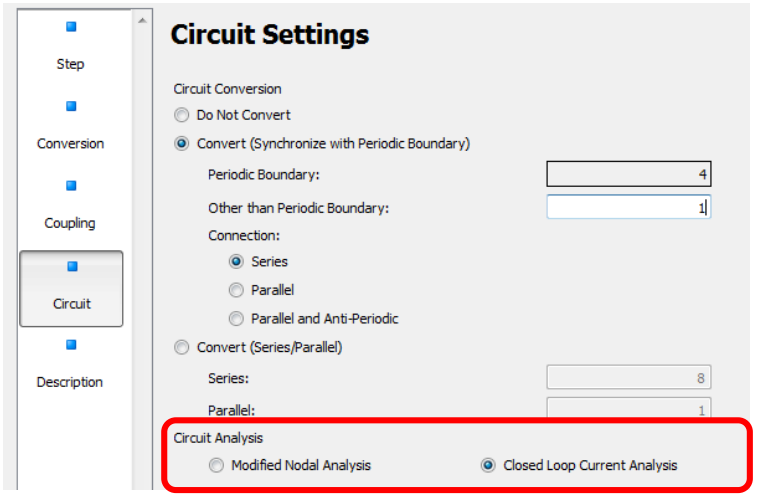
Study

- Some case can have difficulties to converge or take time to converge



Correlation with the Coil type

Type of Coils	Test case number	Cases improved by the Closed Loop Current Analysis
FEM coils	22	9 (41%)
FEM conductors	9	6 (67%)

Correlation with the circuit elements number

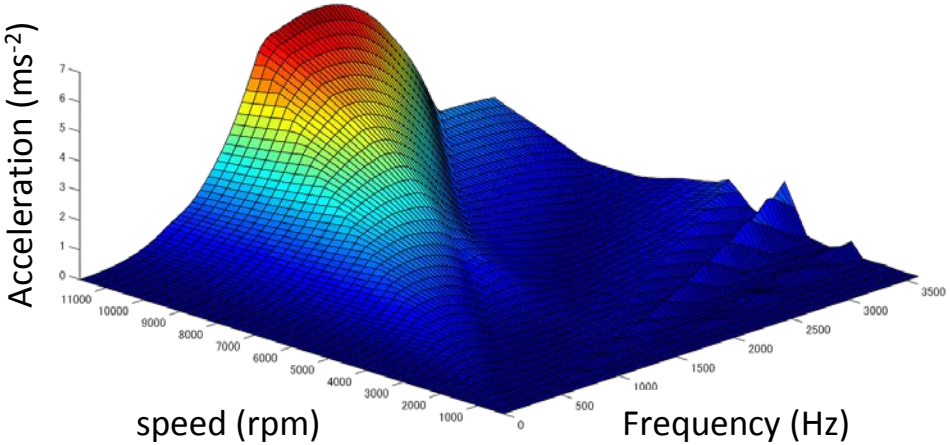
Number of circuit components	Test case number	Cases improved by the Closed Loop Current Analysis
Less than 10	21	9 (43%)
More than 10	6	4 (67%)

For case with FEM conductors and high number of circuit elements the convergence will be likely improved using the circuit analysis via Closed Loop Current Analysis.

Scale calculated force for different frequencies

Force

- Get the forces for different frequency input without the need for redoing the magnetic field calculation



NVH evaluation of a motor via parametric structural analysis

Conventionally, it was necessary to repeat the transient magnetic field analysis, but using a parametric analysis in which the rotation speed is changed by frequency scaling, it is only required once.

Introduction to transient structural analysis

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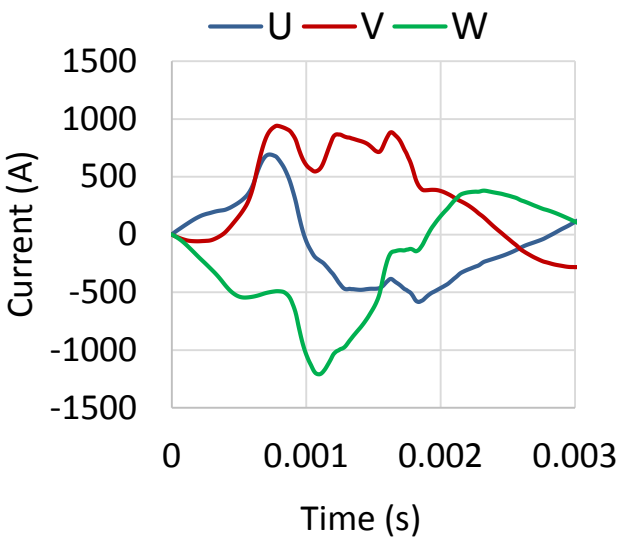
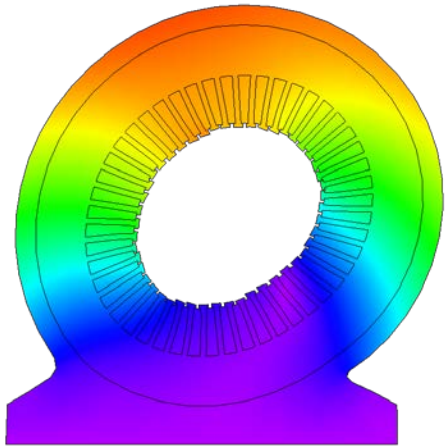
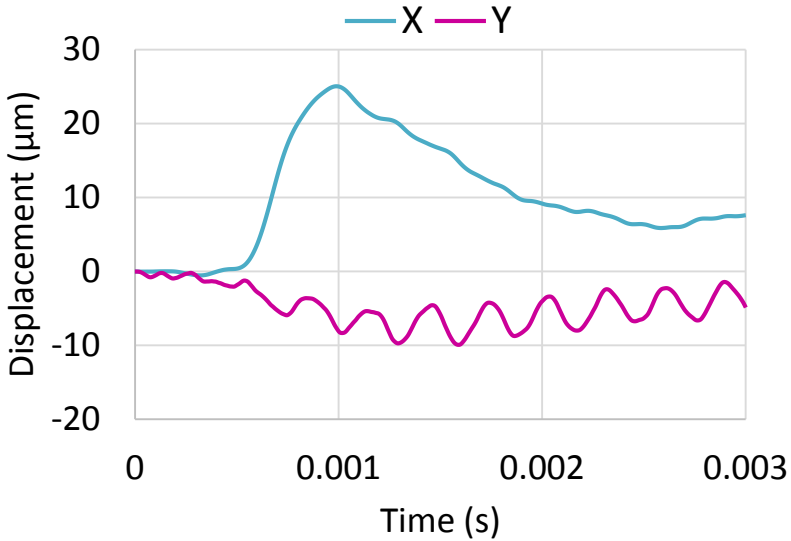
Study

- Evaluate the transient structural deformation due to the starting of a PMSM







The transient currents created by the starting of the machine generate forces on the machine structure that deforms it. When can evaluate this deformation changing with time.

Other performance improvement

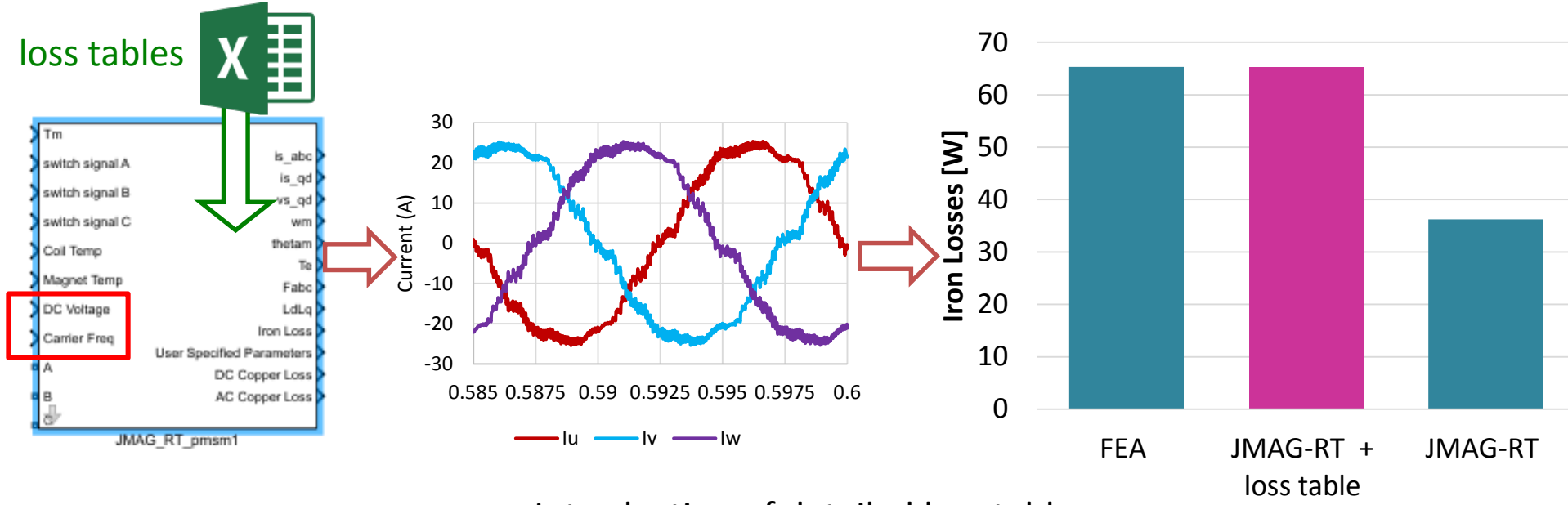
New performance improving functions	
A new solver to help for convergence	Study
Mesh robustness improvement	Mesh
Restarting adaptive mesh	Mesh
Change the priority of execution of cases in the scheduler	JMAG-Scheduler
Iron loss calculation available up 90 millions elements	Loss
Force mapping in preview for each frequency	Force mapping

Improvement of JMAG-RT models

For faster model generation as well as an increase in the accuracy of the loss in your JMAG-RT models

Enhancement of loss accuracy

- Consider of harmonic losses in PMSM and IM

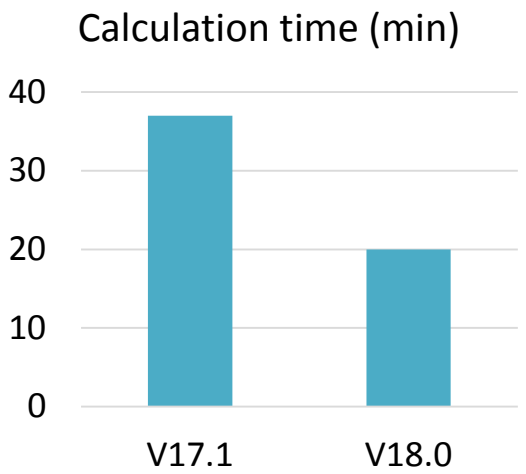


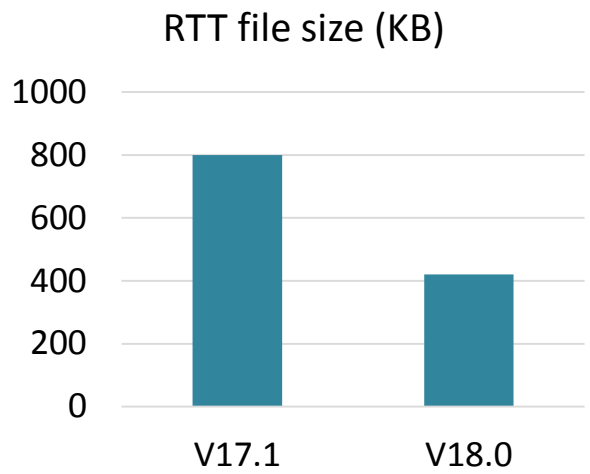
Introduction of detailed loss table:

A detailed loss table is obtained via FEA and added to JMAG-RT as a CSV file. 2 new inputs can be set besides the speed and voltages; carrier frequency and DC voltage.

Shorter JMAG-RT file generation time

- Reduce the number of calculation cases using current phase symmetry
  - PMSM, wounding field synchronous motor, linear machines motor





JMAG-RT developments

New JMAG-RT functions
Wound field synchronous motor
Get a status report on the progress of your JMAG-RT file creation while using SSH
Iron losses on the generic models
Stability improvement of the induction machine simulation

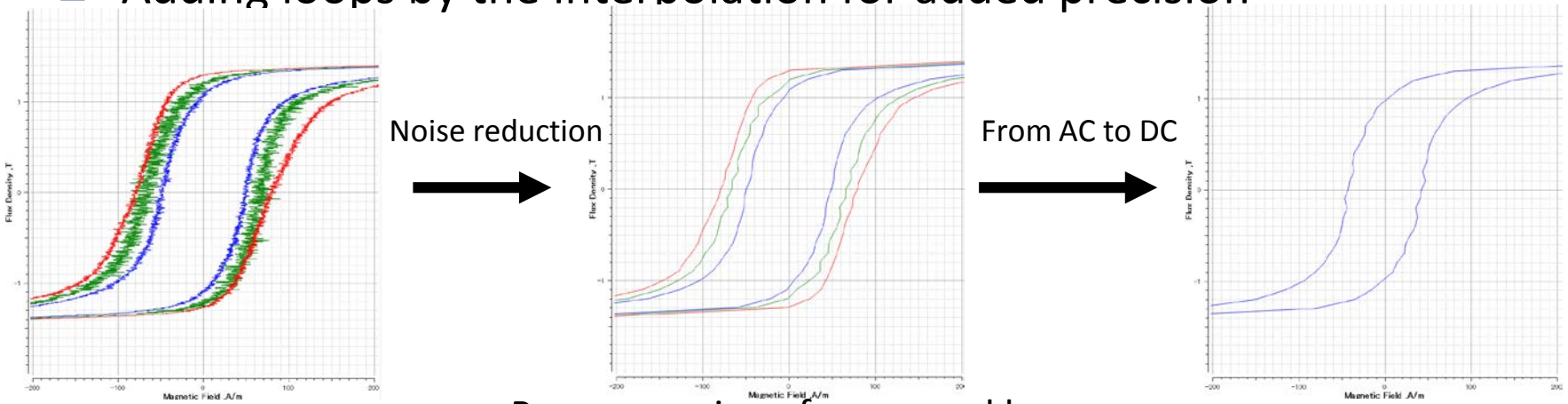
Improve your loss calculations

Better accuracy in you simulation comes with better calculations of your losses

Tool to create your own data for play model losses

Loss

- Reduces the noise of the measured symmetric loops
- Estimates the DC symmetric loops from multiple AC loops
- Adding loops by the interpolation for added precision



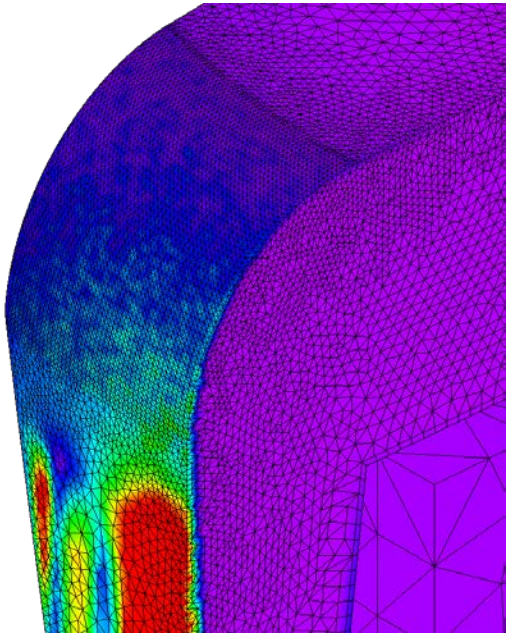
Pre-processing of measured loops

Major loops at 2T are measured at 50,100, and 200Hz. The tool reduces the noise and generate a loop at DC.

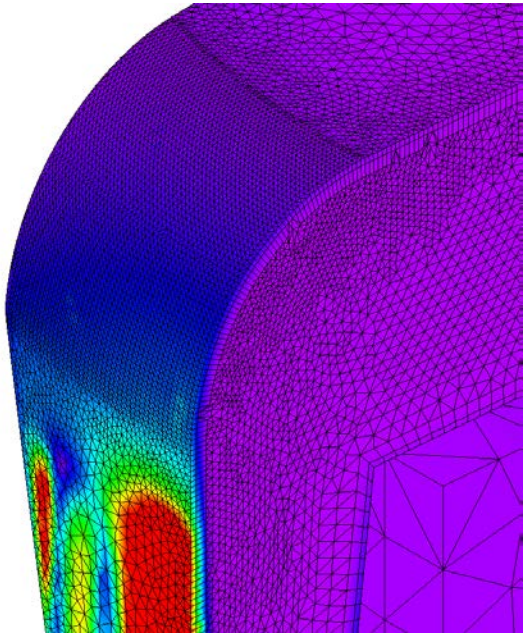
Eddy currents with skin depth mesh in 3D

Mesh

- Improvement of generation of skin depth mesh under curved faces



Inconsistent mesh around the skin mesh creates a patchy eddy current density

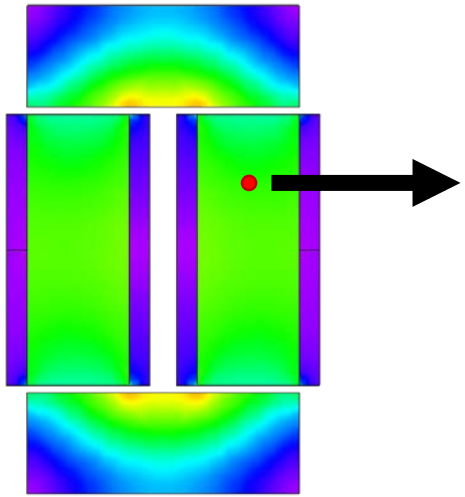


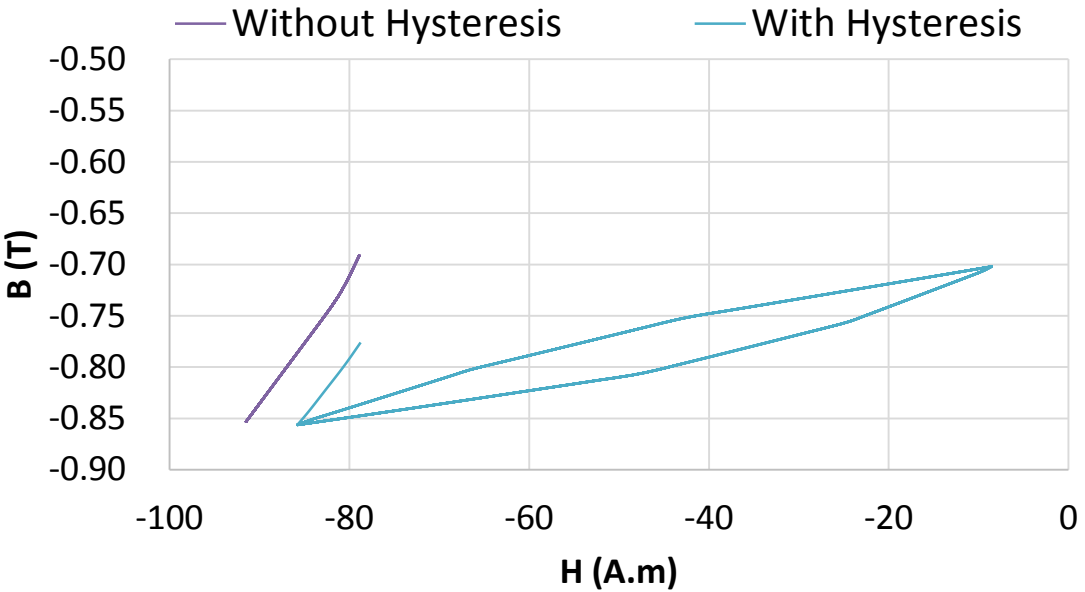
Smoother eddy current loss density due to proper skin depth mesh generation (V18.0)

Hysteresis losses on 3D models

Loss

- The use of play models for accurate hysteresis losses





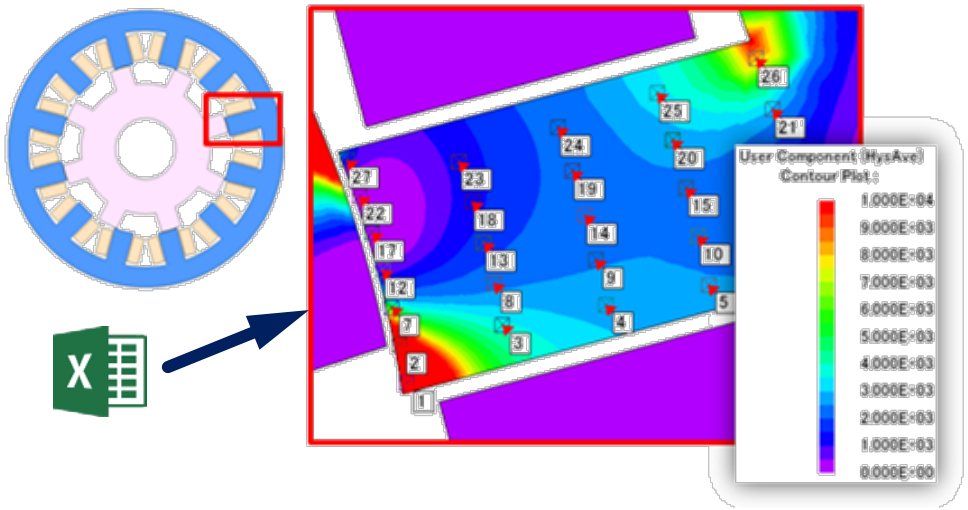
You can now have access to take in account the effect of the hysteresis losses during the calculation and not only just during the post-processing.

Better parameter handling and enhanced optimisation capability

Get more flexibility with your outputs and parameters. Have a better vision and efficiency of your optimisation. Get a whole new way to do optimisation in JMAG

Split the CSV output

- To confirm the loop in the teeth of a machine would require a large amount of probes. Set them manually would be time consuming

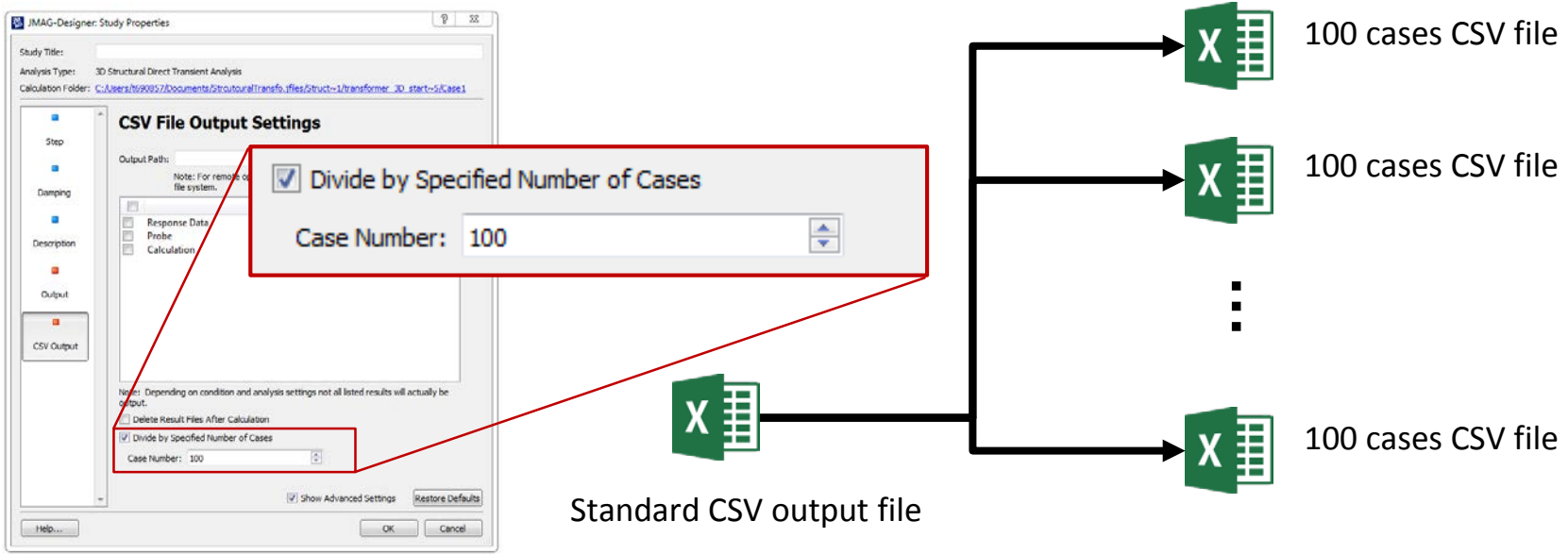


Set of probes via a CSV file to observe the hysteresis loops at different position in the teeth.

Separation of CSV Outputs

CSV Output

- The CSV output of large scale calculation can be difficult to post process



You can separate the csv output files by a certain amount of case.

Response Data for parametric optimisation

New Response Data
Outputs set in any coordinates system you need
Output the area or volume of parts of your geometry
Output of complex number can be set in polar form
Line to Line voltage can now be exported as response data into CSV files
Output the average temperature of grouped parts

Improvement of optimisation efficiency

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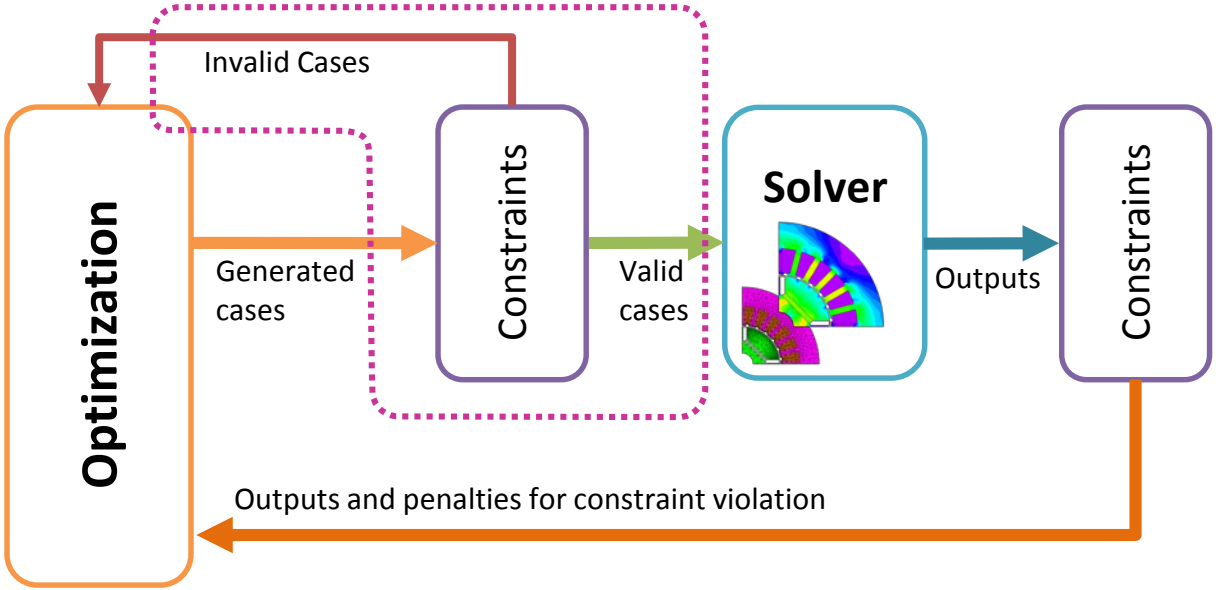
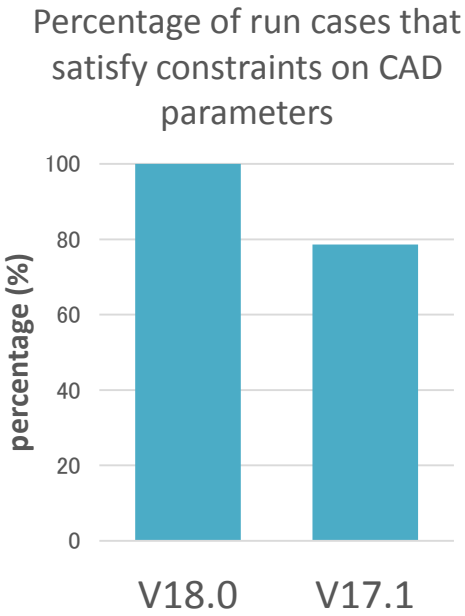
Case Control

- Skip calculation of cases that do not satisfy constraints

New Step in the Optimisation process





Reduction of unnecessary calculation time and improvement of the optimisation's efficiency.

Keep an eye on your submitted optimisation

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Case Control

- You can now export Objectives functions with the response Data
- The timing of the update of the CSV files can changed according to the needs

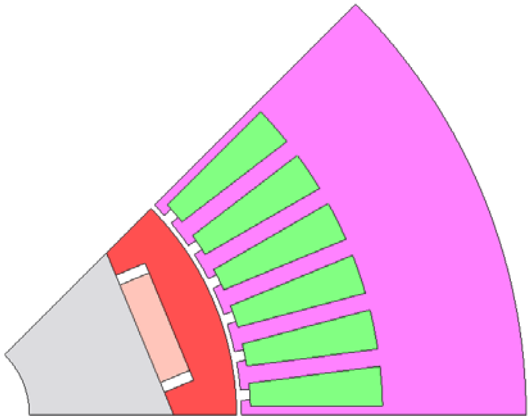
	A	B	C	D	E	F	G	H	I	J	K
1	Case	Obj A	Obj b	Obj c	T	Loss	Other	a	b	c	d
2	1	-	-	-	-	-	-	-	-	-	-
3	2	0.4807	0.380836	0.131147	0.015743	0.976434	0.393066	0.041552	0.367983	0.428894	0.080029
4	3	0.431391	0.093614	0.147422	0.771917	0.698966	0.760017	0.048498	0.085674	0.982002	0.699409
5	4	0.224167	0.459357	0.810402	0.505816	0.45491	0.892577	0.992754	0.827355	0.932694	0.806687
6	5	0.226894	0.713508	0.317899	0.284757	0.741043	0.202487	0.534892	0.178022	0.912759	0.362971
7	6	0.43841	0.294803	0.495594	0.753284	0.718092	0.39654	0.292836	0.646776	0.346416	0.571331
8	7	0.562329	0.739856	0.224752	0.034783	0.4821	0.221852	0.555415	0.090495	0.574607	0.342626
9	8	0.511993	0.433951	0.871429	0.448752	0.504835	0.974373	0.217461	0.043341	0.307987	0.138944
10	9	0.652035	0.571528	0.487579	0.338235	0.627718	0.067897	0.913924	0.321168	0.608989	0.461366
11			Objectives		Response Values			Parameters			
12											

Example of output file given by the optimisation

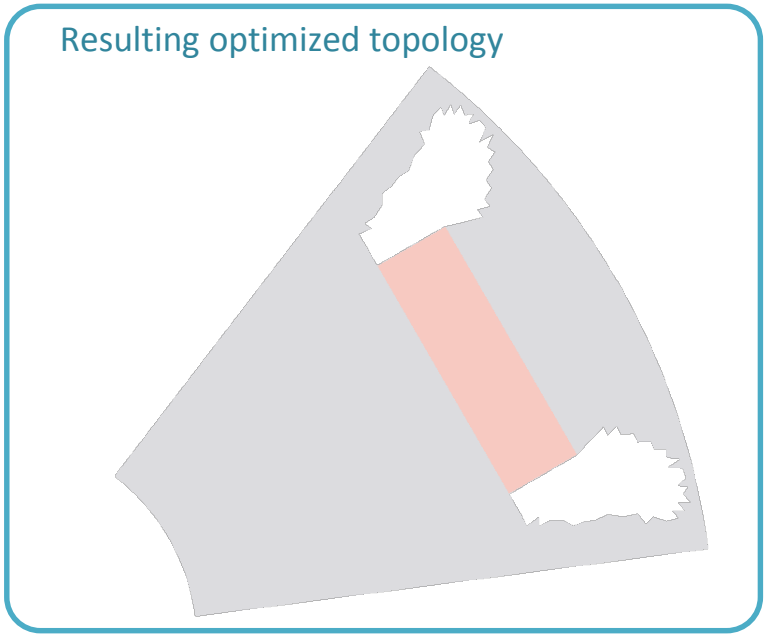
Topology optimisation available in JMAG

Function

- Use an ON/OFF method to optimise shapes



Selected design space



Rotor shape optimisation. The material of each element of design zone is changed by the optimisation to maximize the torque.

Think your JMAG circuit differently

Your JMAG circuit is now much more!

Welcome Control in JMAG

Use control circuits without external software

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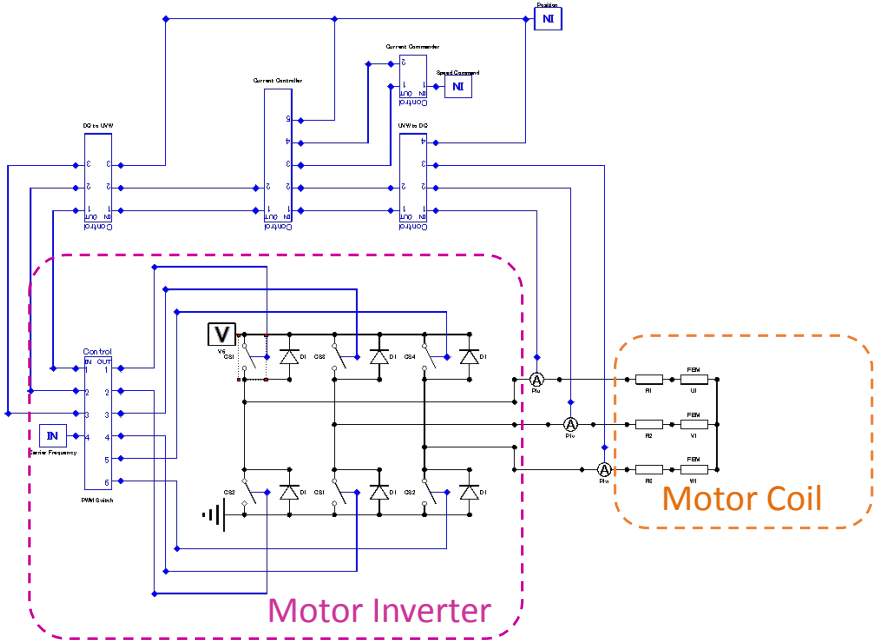
Circuit

- Introduce control circuit in its JMAG circuit:

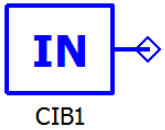
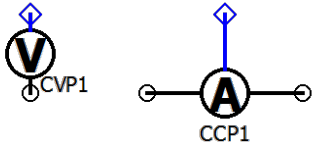
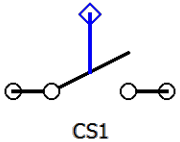
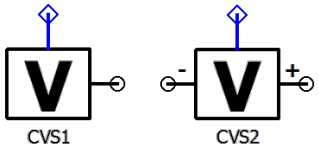
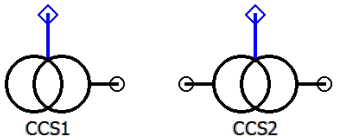
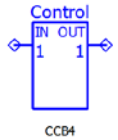


Motor drive system

The black lines represent the power circuit. The blues ones the control signals.

Control Components list

Circuit

Name	Component	Name	Component
Control Input		Control voltage and current probe	
Control Output		Controlled switch	
Controlled voltage source		Control signal probe	
Controlled current source		User defined macro via python files	

Control pre-defined components (1/2)

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Functions	
Abs	Diff
Add	Divide
Atan	Gain
Cos	Product
Sin	Sqrt
Transfer Mechanical angle to electrical angle	Branch
1D Look-up table	2D Look-up table

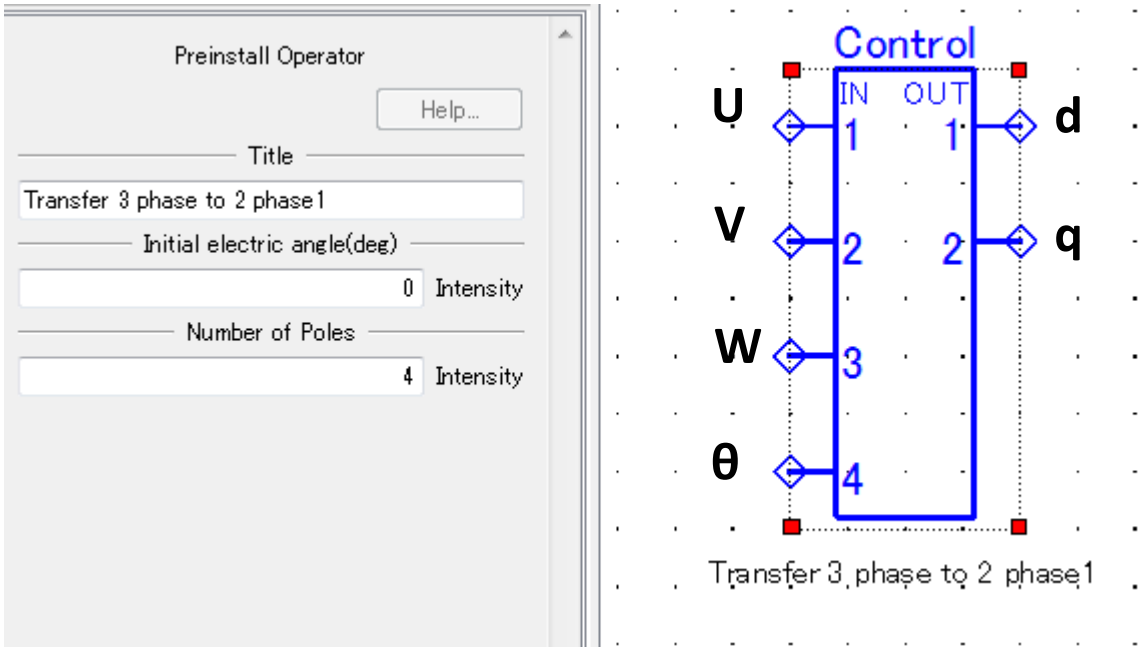
Control pre-defined components (2/2)

Functions	
Sine wave	Step
Ramp	Triangle wave
Sawtooth wave	Comparator
Saturation	Zero Order hold
Dead time	PWM

DQ transformation as predefined component

Circuit

- The use of 3 phase signals can sometimes be laborious



JMAG circuit has a dq (Park) component to convert the signals

Use your JMAG-RT models in JMAG-Designer

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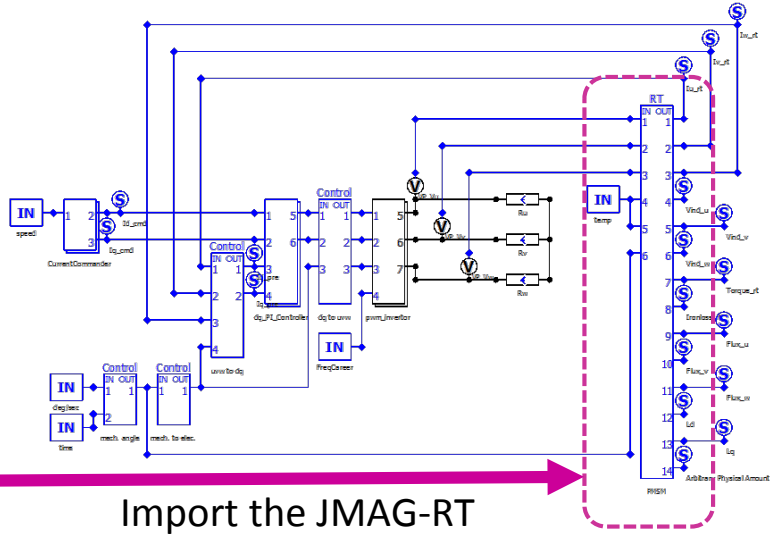
Simulation Technology for Electromechanical Design

Circuit

- Use control systems with your JMAG-RT models and combine them with FEA calculations



RT JMAG-RT

Create an JMAG-RT model of your model

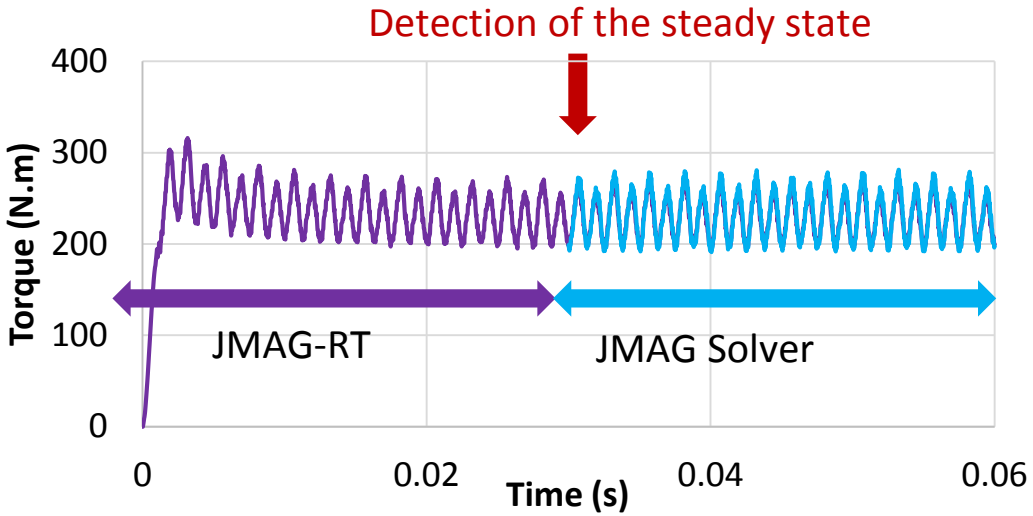
Import the JMAG-RT model into a circuit

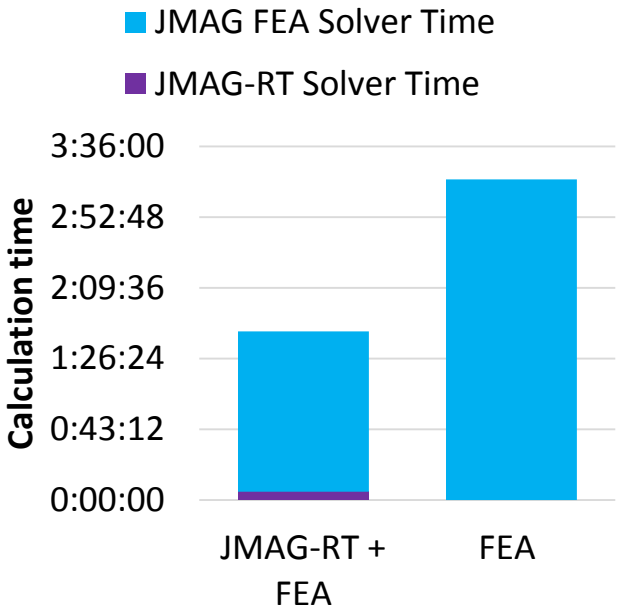
You can use your JMAG-RT file in your JMAG circuit.

Steady state detection tool

Circuit

- Reduce the calculation of your control system FEA calculations





You can use the JMAG-RT model of your design to reach the steady state of a selected operating point. Then only run the FEA study on the steady state.

Efficiency maps directly in JMAG-Designer

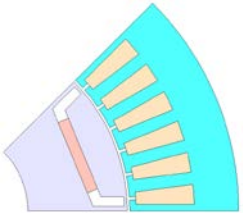
Evaluate your machine’s performance a not only on one operating point but on its full operation area

Efficiency map evaluation function

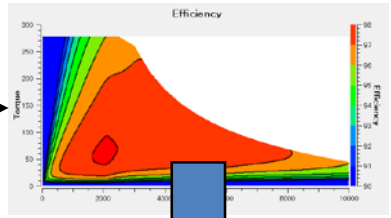
Efficiency map

- Speed priority (parametric mode)
- Precision priority (high accuracy mode)

Speed priority

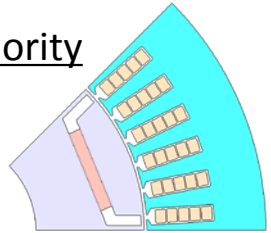


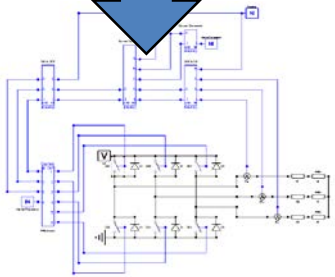
Response Table
(Motor characteristic mapping)

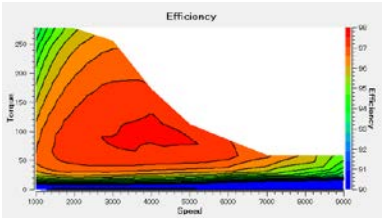


Current vector for each operating point

Precision priority



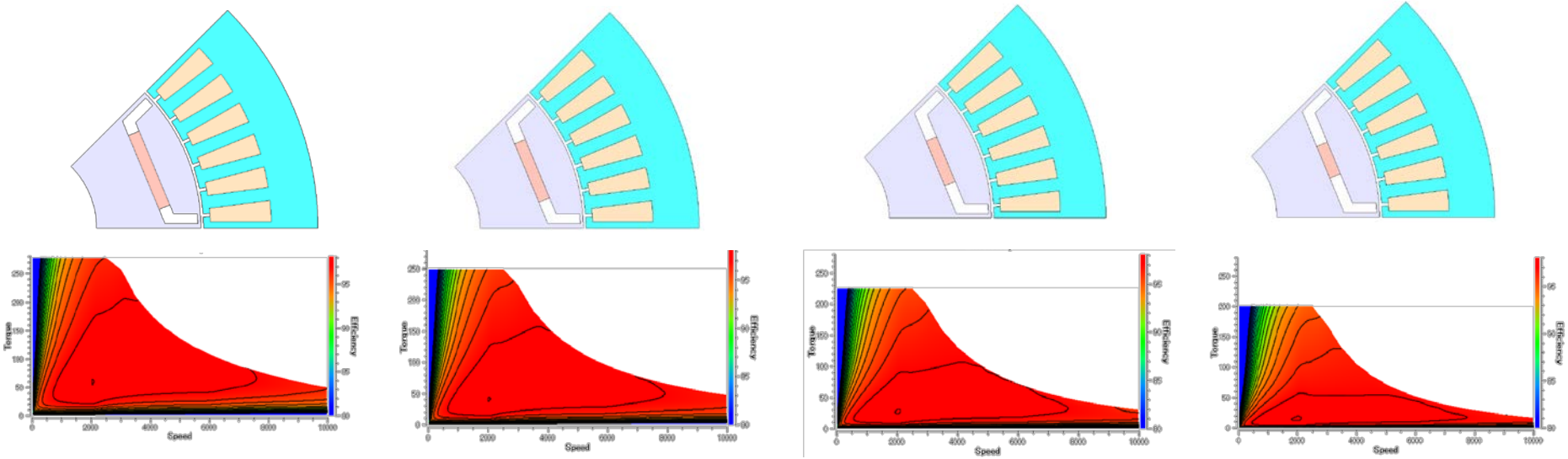




Speed priority (parametric mode)

Efficiency map

- Fast generation of efficiency maps for each shapes of potential designs

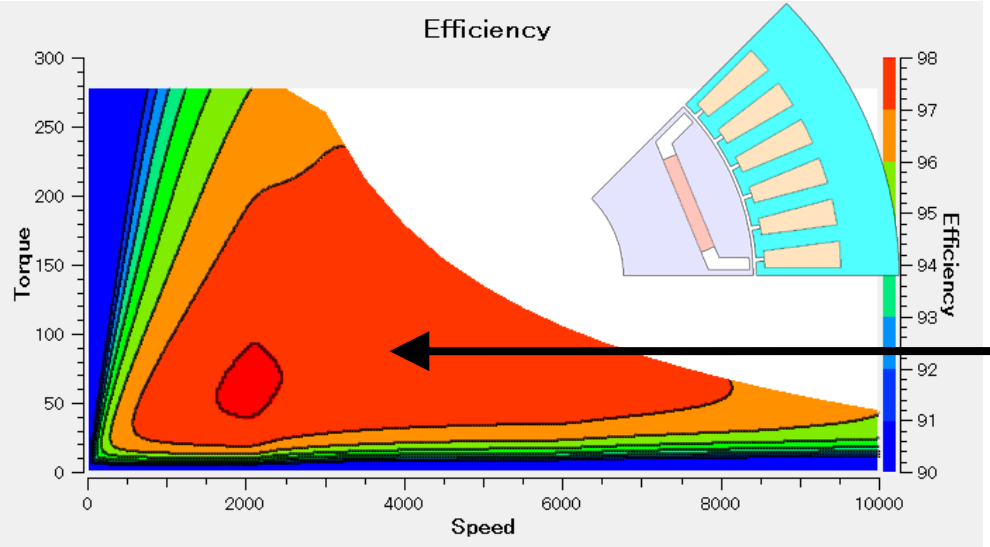


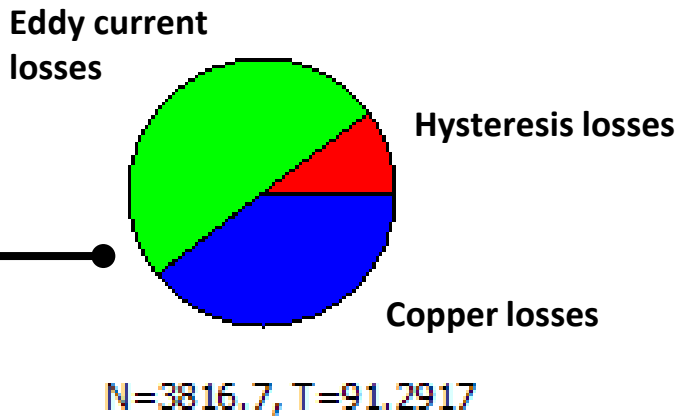
Parametric analysis of efficiency maps with changing magnet width

Efficiency map directly with JMAG Designer

Efficiency map

- Breakdown of the losses for each operating point can be displayed in one click



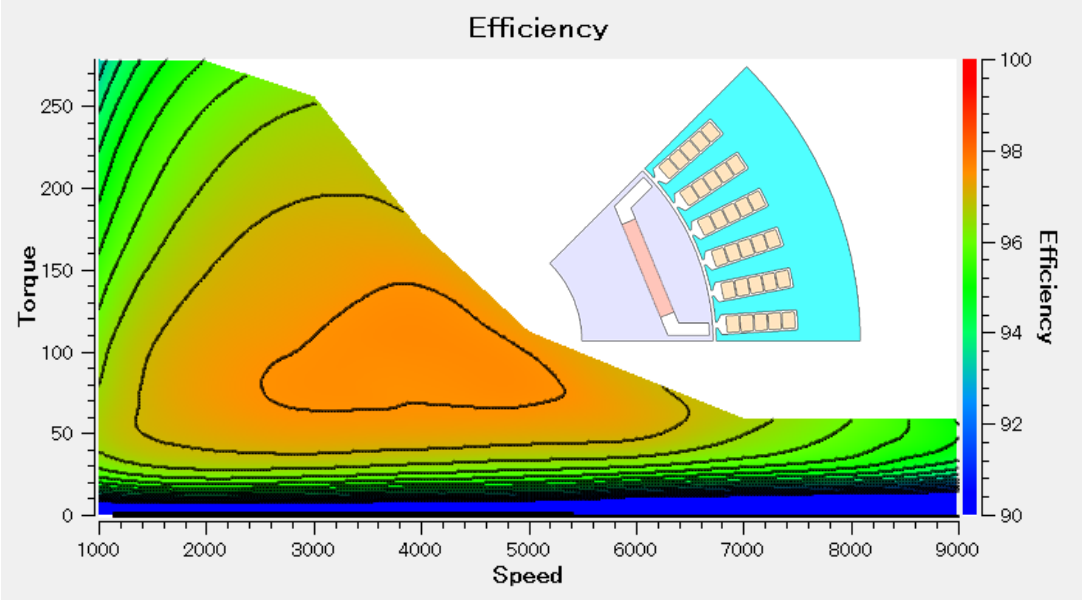


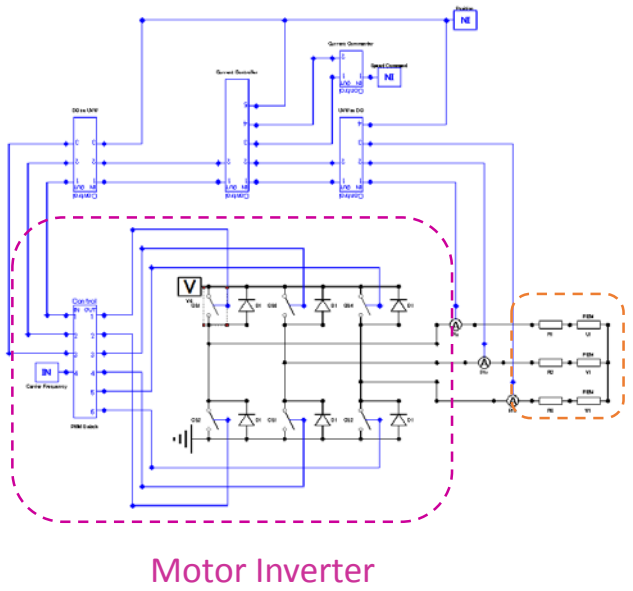
Example of efficiency map and the losses breakdown for one operating point

High accuracy efficiency map

Efficiency map

- The efficiency map can be improved by adding the effect of the control system



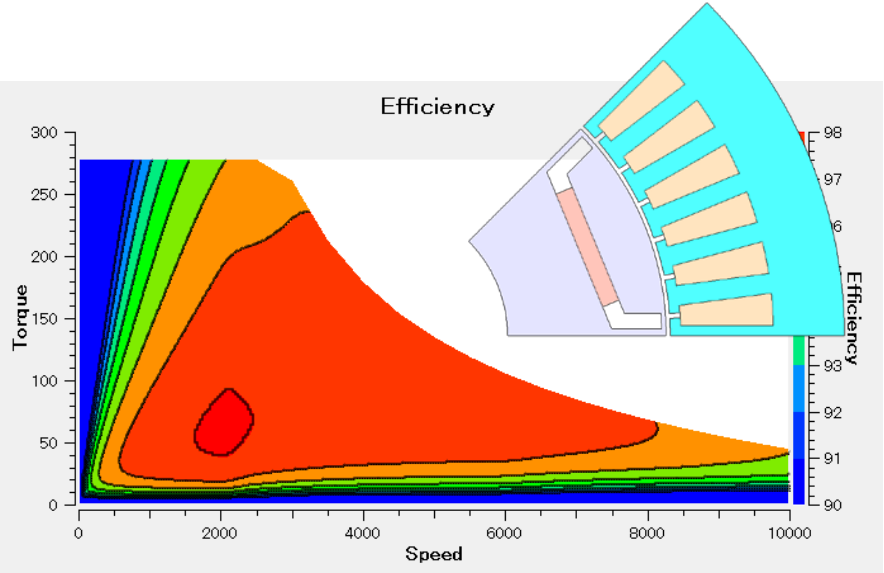


Get high accuracy efficiency maps can be obtained

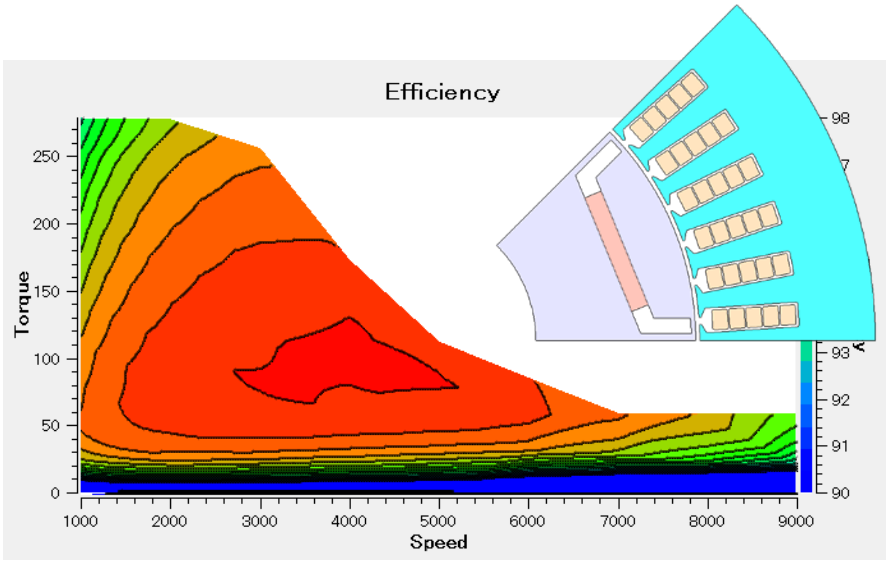
Precision priority (high accuracy mode)

Efficiency map

- Efficiency map including harmonics and AC losses with PWM



AC losses ignored and sinusoidal waveform



AC losses included and PWM waveform

Comparison of efficiency maps for models with different degrees of precisions

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