Altair® FluxMotor® 2024.1

Release Notes

Updated: 08/20/2024

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Contents

Introduction 1

This chapter covers the following:

1.1 Overview

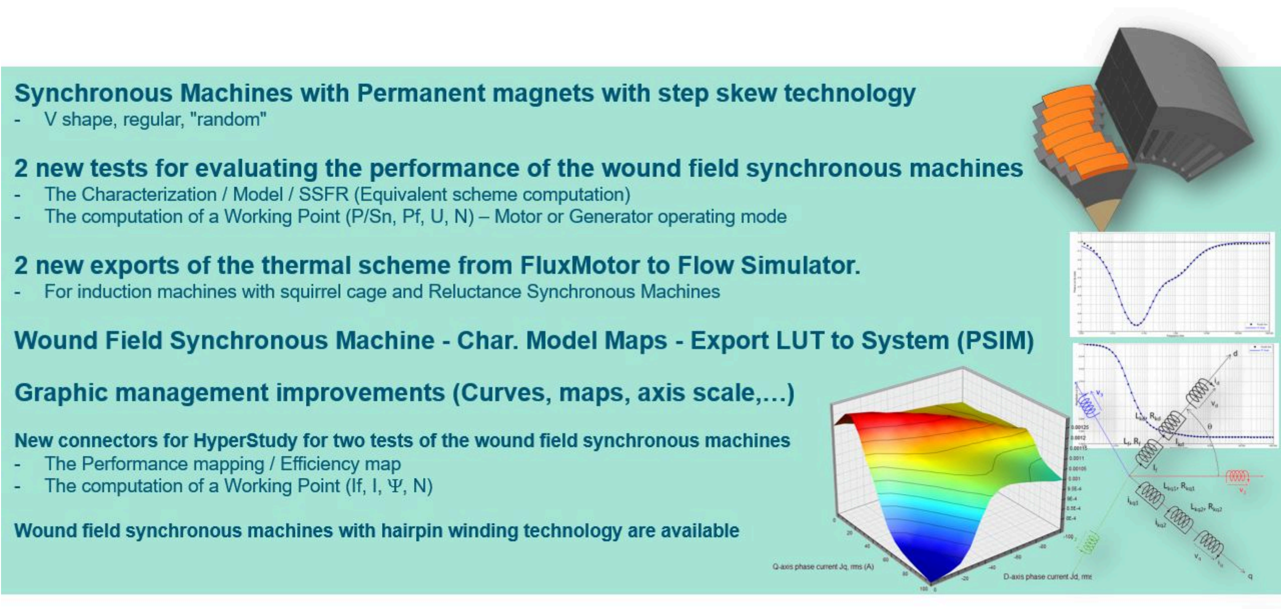
This document gives the major information about Altair® FluxMotor® 2024.1. The main highlights of this new version are described below.

For more detailed information, please refer to the user help guides. The list of documents to read is presented below.

Here are the highlights of the new version:

- Synchronous Machines with Permanent magnets with step skew technology
    - V shape, regular, and "random"
- 2 new tests for evaluating the performance of the wound field synchronous machines
    - The Characterization / Model / SSFR (Equivalent scheme computation)
    - The computation of a Working Point (P/Sn, Pf, U, N) – Motor or Generator operating mode
- 2 new exports of the thermal scheme from FluxMotor to Flow Simulator.
    - For induction machines with squirrel cage and Reluctance Synchronous Machines
- New exports of LUT to System (PSIM)
    - Wound Field Synchronous Machine a Reluctance Synchronous Machine
- Charts features improvements (Curves, maps, axis scale, ...)
- New connectors for HyperStudy for two tests of the wound field synchronous machines
    - The Performance mapping / Efficiency map
    - The computation of a Working Point (If, I, Ψ, N)
- Wound field synchronous machines with hairpin winding technology are available
- Correction of issues

All the added new features are briefly described below, followed by an update on issues and bugs.



FluxMotor 2024.1 – The main highlights

1.2 Documents to read

It is highly recommended to read the user guides given below before using Altair® FluxMotor®. Each user help document can be downloaded from the online user help.

Below is a list of documents that are available.

Installation Guide

- InstallationGuide_Flux_FluxMotor_2024.1.pdf

General user guides for any type of machine - Inner and Outer Rotor

- Supervisor_2024.1.pdf
- MotorCatalog_2024.1.pdf
- PartLibrary_2024.1.pdf
- PartFactory_2024.1.pdf
- Materials_2024.1.pdf
- ScriptFactory_2024.1.pdf
- MotorFactory_2024.1_Introduction.pdf
- MotorFactory_2024.1_Test_BestPractices.pdf
- MotorFactory_2024.1_Windings.pdf

Synchronous Machines with Permanent Magnets (SM PM) - Inner and Outer Rotor

- MotorFactory_2024.1_SMPM_IOR_Design.pdf
- MotorFactory_2024.1_SMPM_IOR_3PH_Test_Introduction.pdf
- MotorFactory_2024.1_SMPM_IOR_3PH_Test_Characterization.pdf
- MotorFactory_2024.1_SMPM_IOR_3PH_Test_WorkingPoint.pdf
- MotorFactory_2024.1_SMPM_IOR_3PH_Test_PerformanceMapping.pdf
- MotorFactory_2024.1_SMPM_IR_3PH_Test_Mechanics.pdf
- MotorFactory_2024.1_SMPM_IOR_Export.pdf

Reluctance Synchronous Machines (SM RSM) - Inner Rotor

- MotorFactory_2024.1_SMRSM_IR_3PH_Design.pdf
- MotorFactory_2024.1_SMRSM_IR_3PH_Test_Introduction.pdf
- MotorFactory_2024.1_SMRSM_IR_3PH_Test_Characterization.pdf
- MotorFactory_2024.1_SMRSM_IR_3PH_Test_WorkingPoint.pdf
- MotorFactory_2024.1_SMRSM_IR_3PH_Test_PerformanceMapping.pdf
- MotorFactory_2024.1_SMRSM_IR_3PH_Test_Mechanics.pdf
- MotorFactory_2024.1_SMRSM_IR_3PH_Export.pdf

Wound Field Synchronous Machines (SM WF) - Inner Salient Poles - Inner Rotor

- MotorFactory_2024.1_SMWF_ISP_IR_3PH_Design.pdf
- MotorFactory_2024.1_SMWF_ISP_IR_3PH_Test_Introduction.pdf
- MotorFactory_2024.1_SMWF_ISP_IR_3PH_Test_Characterization.pdf
- MotorFactory_2024.1_SMWF_ISP_IR_3PH_Test_WorkingPoint.pdf
- MotorFactory_2024.1_SMWF_ISP_IR_3PH_Test_PerformanceMapping.pdf
- MotorFactory_2024.1_SMWF_ISP_IR_3PH_Export.pdf

Induction Machines with Squirrel Cage (IM SQ) - Inner and Outer Rotor

- MotorFactory_2024.1_IMSQ_IOR_3PH_Design.pdf
- MotorFactory_2024.1_IMSQ_IOR_3PH_Test_Introduction.pdf
- MotorFactory_2024.1_IMSQ_IOR_3PH_Test_Characterization.pdf
- MotorFactory_2024.1_IMSQ_IOR_3PH_Test_WorkingPoint.pdf
- MotorFactory_2024.1_IMSQ_IOR_3PH_Test_PerformanceMapping.pdf
- MotorFactory_2024.1_IMSQ_IR_3PH_Test_Mechanics.pdf
- MotorFactory_2024.1_IMSQ_IOR_3PH_Export.pdf

List of new features

2

This chapter covers the following:

2.1 Step skew technology available

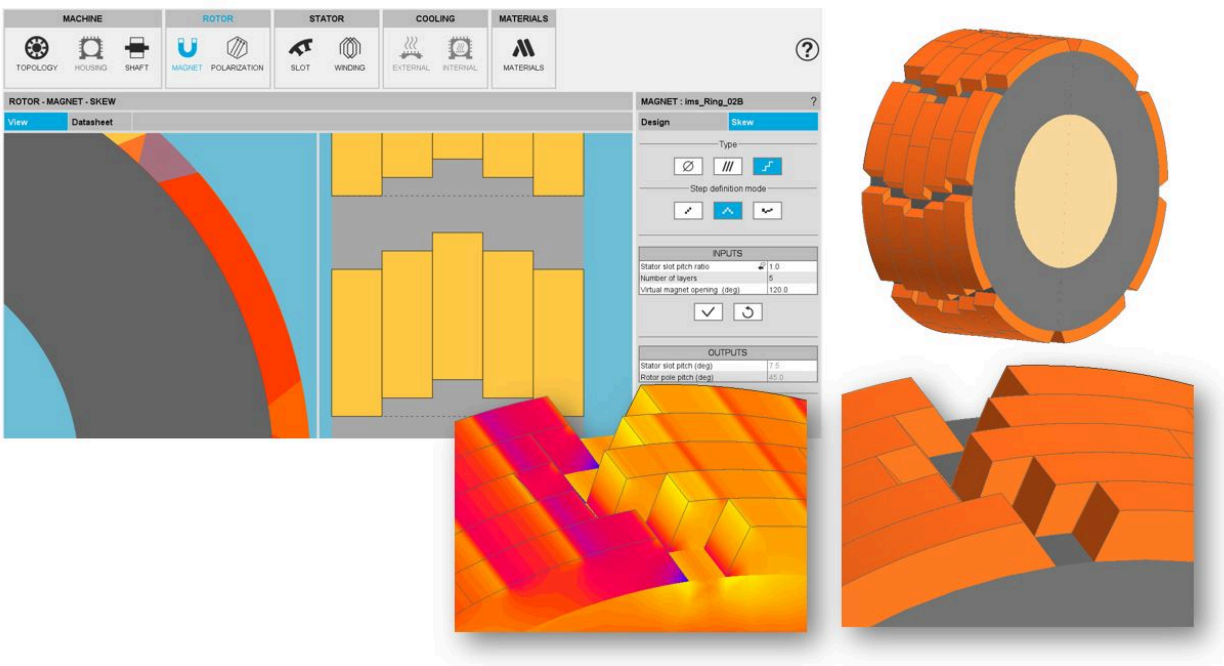
Overview

Step skew technology is available to design the inner rotor of the Synchronous Machines with Permanent magnets.

This completes the existing magnet skew topologies. The first one was the "Continuous skew".

A user-friendly interface allows to define and visualize the topology of the step skew topology to be designed.

Once the machines with step skew topologies are designed, in the back end of Motor Factory, the computations are performed in Flux Skew environment to get a better accuracy of results. It can also be exported to Flux Skew for advanced analysis.



Design the step skewed magnets

Three kinds of step skew topologies are available: “V” shape, Regular, and "random".

> **Note:** The step skew is available for both kind of Synchronous Machines with Permanent magnets with inner and outer rotor.
>
> However, the step skew can be applied only to the magnet.

> **Note:** The user can add a skew angle on the rotor (continuous or step) or on the stator (continuous). If a skew is already defined in the stator when setting a skew on the rotor, the stator skewing will be automatically reset to "None".

Illustrations of all the available topologies are given below.

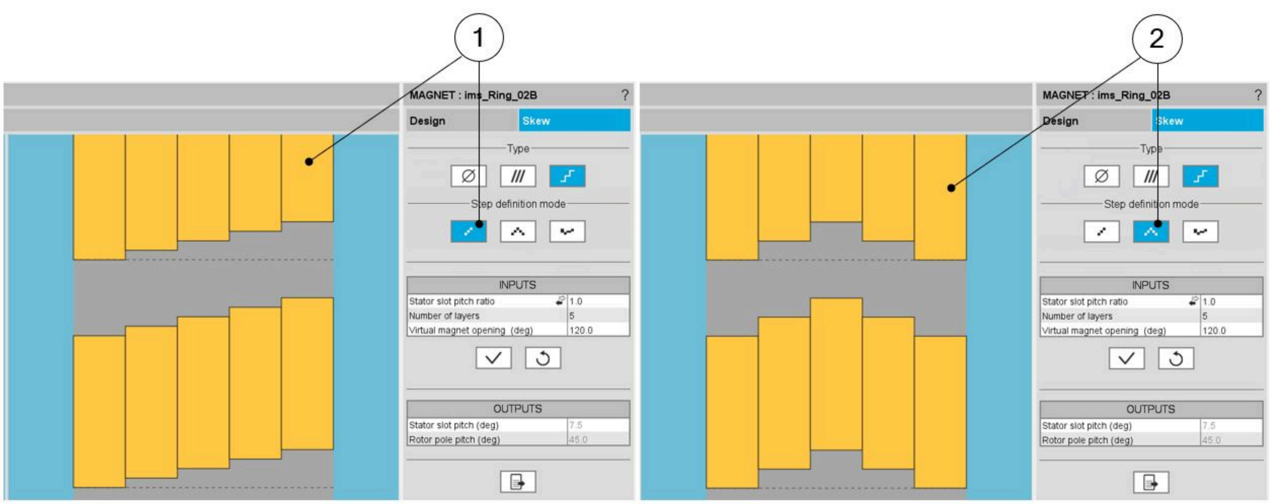
- Regular definition mode

  The magnets are positioned according to a straight line all along the longitudinal direction of the rotor part.
- "V" shape definition mode

  The magnets are positioned according to the "V" shape all along the longitudinal direction of the rotor part.

In both cases, the mode of the skewing can be defined according to the stator slot pitch ratio, the rotor pole pitch ratio or a shift angle.

The number of layers is defined as an input.



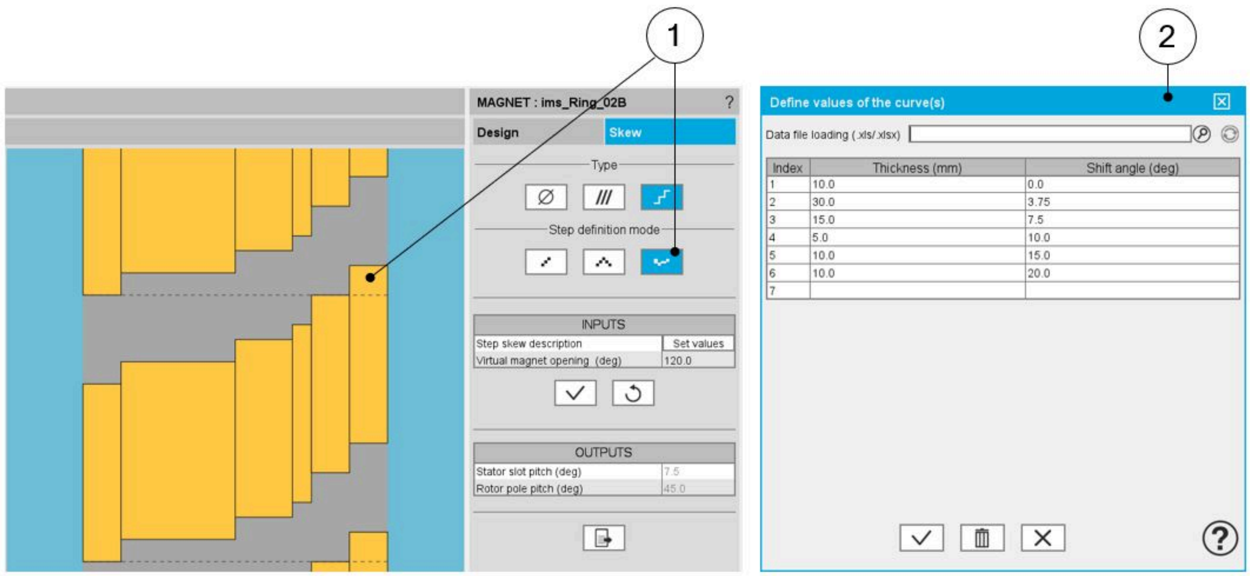
Define a linear step skew with the "Regular" definition mode (1)

Or a V shape step skew with the "V" shape definition mode (2)

- Custom definition mode

  The magnets are defined and positioned according to the values (Thickness and shift angle) written in a table (see illustration below).

> **Note:** The table where thicknesses and shift angle values are written can be imported via an Excel file.



Customization of the step skew topology with the "Custom" definition mode (1)

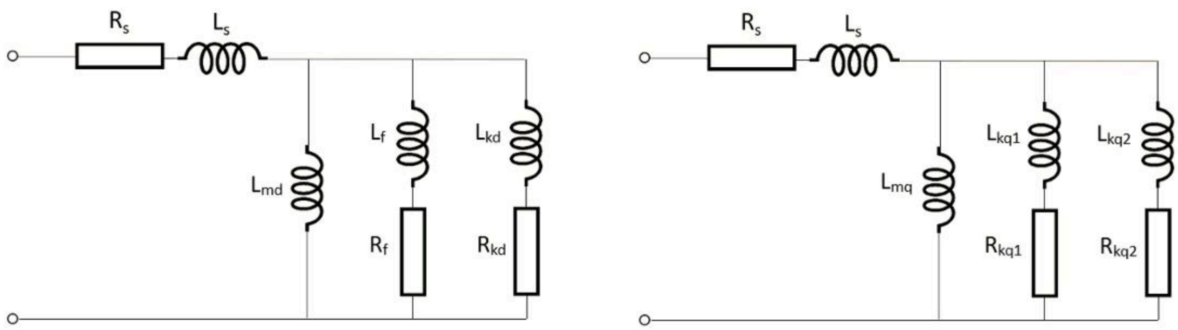
Dialog box to define the thickness and shift angle to build the customized step skew topology (2)

2.2 Wound field synchronous machines - New tests

2.2.1 The Characterization / Model / SSFR

Positioning and objective

The aim of the test “Characterization – Model – Motor – SSFR” dedicated to the wound field synchronous machine is to characterize all the parameters of the D-axis and Q-axis equivalent schemes by performing a frequency analysis.



D-axis parameters of the equivalent circuit

Parameters					
Ls (H)	3.458 E-4	Lsw (H)	2.399 E-3	Lss (H)	1.059 E-4
Rs (Ω)	1.085 E-2	Lmd (H)	1.528 E-2		
Rf (Ω)	2.301 E-3	Lf (H)	1.823 E-3		
Rkd (Ω)	1.931 E-2	Lkd (H)	1.069 E-3		

Q-axis parameters of the equivalent circuit

Parameters					
Ls (H)	3.475 E-4	Lsw (H)	2.399 E-3	Lss (H)	1.076 E-4
Rs (Ω)	1.085 E-2	Lmq (H)	6.989 E-3		
Rkq1 (Ω)	1.762 E-2	Lkq1 (H)	1.029 E-3		
Rkq2 (Ω)	5.182 E-2	Lkq2 (H)	1.168 E-3		

“Characterization – Model – Motor – SSFR” – Characterization of all the equivalent scheme parameters

D-Axis and Q-Axis equivalent scheme data – 2nd order is considered in the example above.

These results are based on the magnitude and the phase of the operational inductance transfer function, which are computed with Finite Element software Flux® 2D.

The resulting reactances and time constants of the machines are also provided. Hence, such data can be used in system modeling tools like Altair® PSIMTM to evaluate the behavior of the machine with its drive and control system.

Reactances

Reactances					
Xd (Ω)	5.892	Xd' (Ω)	7.444 E-1	Xd" (Ω)	3.736 E-1
Xq (Ω)	2.766	Xq' (Ω)	4.692 E-1	Xq" (Ω)	3.223 E-1
Xs (Ω)	1.304 E-1	Xmd (Ω)	5.762	Xmq (Ω)	2.635
Reactances in per-unit system					
Reference impedance (Ω)	2.564				
Xd (%)	229.799	Xd' (%)	29.032	Xd" (%)	14.572
Xq (%)	107.865	Xq' (%)	18.298	Xq" (%)	12.571
Xs (%)	5.084	Xmd (%)	224.715	Xmq (%)	102.756

Time constants

Time constants					
Td' (s)	9.393 E-1	Td" (s)	7.012 E-2	Td0' (s)	7.435
Td0" (s)	1.397 E-1				
Tq' (s)	7.719 E-2	Tq" (s)	2.738 E-2	Tq0' (s)	4.551 E-1
Tq0" (s)	3.986 E-2				

Reactances and time constants of the machine are computed

> **Note:** This feature is available in a "**Beta version**" meaning that it is not entirely qualified, and that the user must be careful when analyzing the results.

Input and output data

User inputs

The main user input parameters are the order of the operational inductance transfer function to be considered for the D-Axis and the Q-Axis of the machine. 1st and 2nd order are considered depending not only on the presence or absence of dampers in the rotor pole shoes, but also on the accuracy of the results obtained with the 1st order model.

Then, the reference frequency and the reference impedance for the per-unit system computation are needed to compute the resulting machine reactances.

In addition, the temperatures of the stator and rotor windings and dampers must be set.

Main outputs and results

The main outputs are all the computed parameters of the equivalent scheme (First or second order).

The quality of results is also illustrated by the superimposition of the magnitude and phase of the operational inductance, which is computed either with Finite Element software Flux® 2D (Steady State AC application) or analytically by considering the resulting operational inductance.

- Tables

  D-Axis and Q-Axis equivalent scheme parameters

  - Operational inductance Laplace function with the corresponding computed parameters
  - Wound field synchronous machine equivalent scheme, D-axis and Q-axis (first and second order) with its associated computed parameters
  - Reactances and time constants
- Curves

  Magnitude of the operational inductance versus frequency – D-Axis and Q-Axis

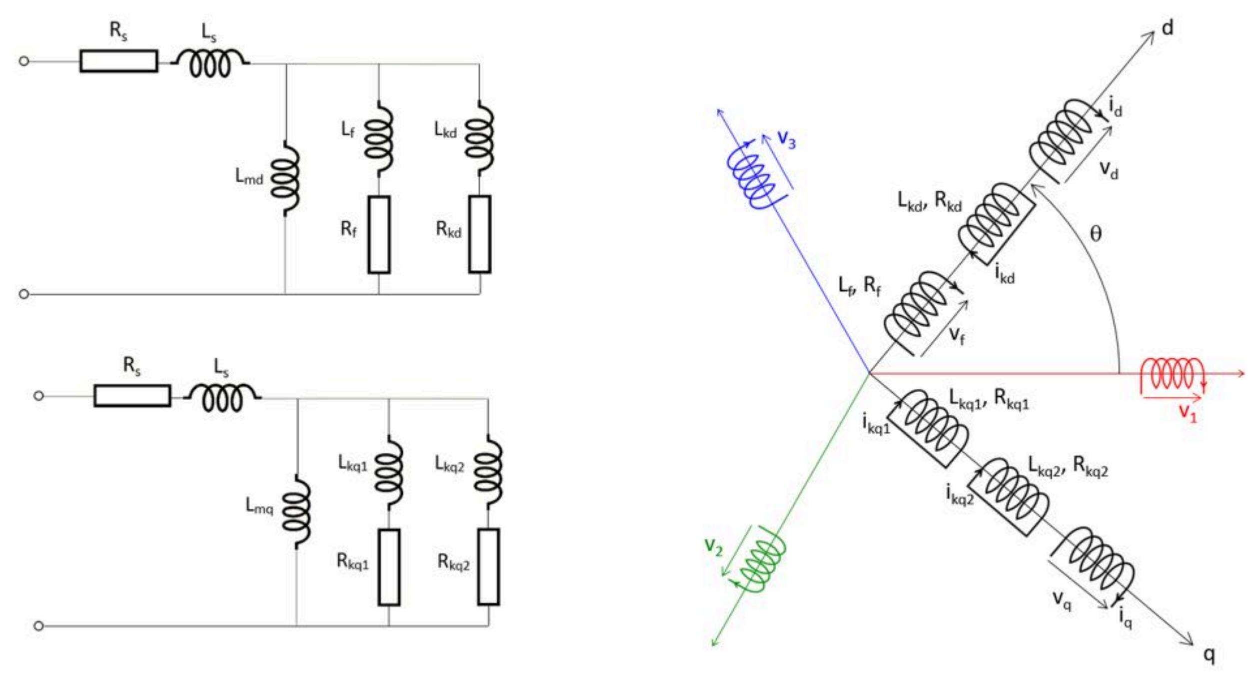
  Phase of the operational inductance versus frequency – D-Axis and Q-Axis

Main principles of computation

Introduction

As said previously, the aim of the test "Characterization – Model – Motor – SSFR" is to identify all the parameters of the electrical equivalent scheme of a 3-Phase wound field synchronous machine by considering either a first order or a second order for the D-Axis and Q-Axis operational inductance transfer function L(p).

Model representation - Second order D-Axis and Q-Axis model



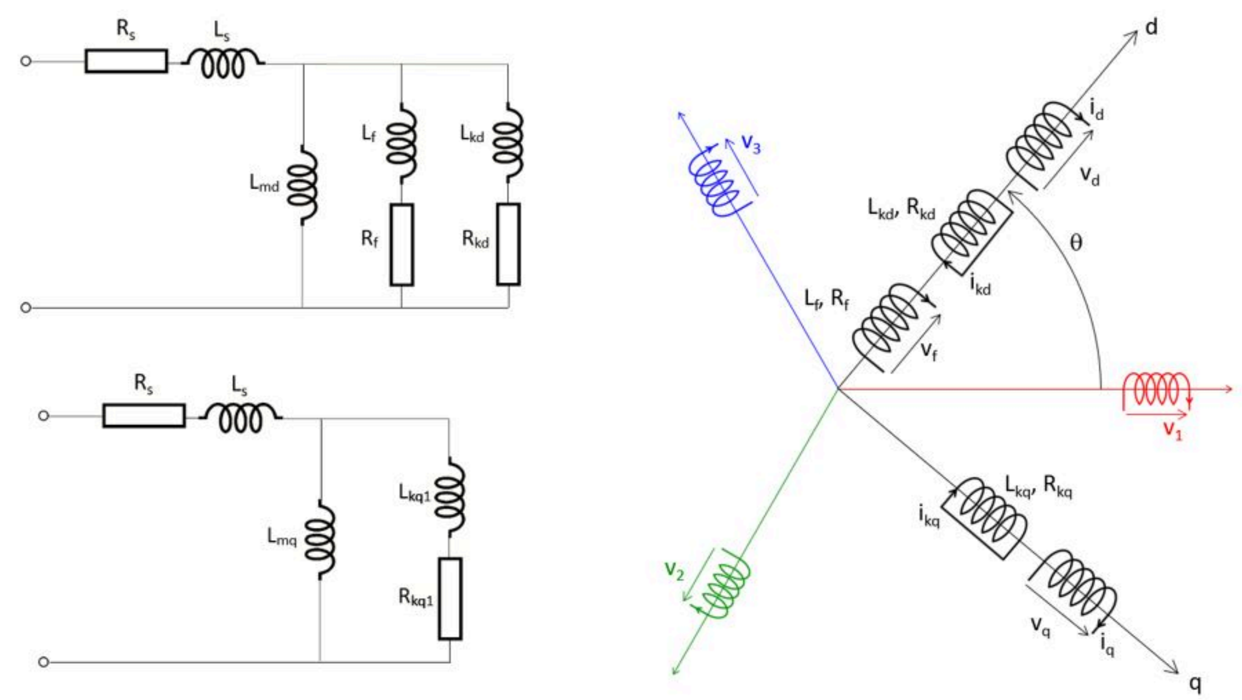
2nd order equivalent scheme of the wound field synchronous machine with dampers

Note:

On the previous graph, # represents the relative position between the first stator winding phase and the d-axis of the machine model.

All the components displayed in the picture correspond to the equivalent scheme parameters. For more information, please refer to the user help guides.

Model representation - Second order D-Axis and first order Q-Axis model



D-Axis 2nd order equivalent scheme and Q-Axis 1st order equivalent scheme

of the wound field synchronous machine with dampers

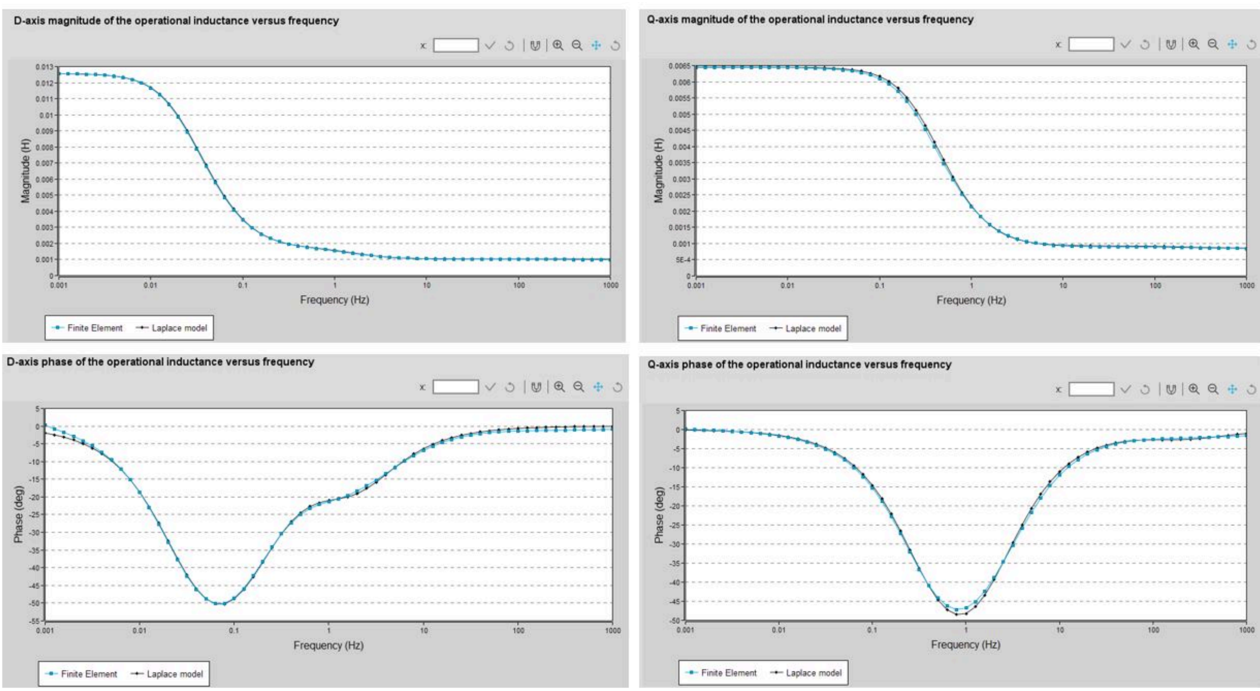
Short description

The rotor of the machine does not rotate. Two positions are considered for the rotor angular position, one to characterize the D-Axis parameters and another one to characterize the Q-Axis parameters.

By considering a 3-Phase wound field synchronous machine, the magnitude and a phase angle of the machine operational inductance L(p) is computed versus the frequency for the D-Axis and the Q-Axis.

As a result, the wound field synchronous machine is characterized on both D-Axis and Q-Axis by its frequency response which is the magnitude and phase angle of the operational inductance transfer function versus the frequency.

Then, an internal optimization process combined with theoretical analytical formulas allow to deduce all the D-Axis and Q-Axis equivalent scheme parameters from operational inductance transfer function coefficients.



Magnitude and a phase of the D-Axis and Q-Axis operational inductance L(p) vs frequency

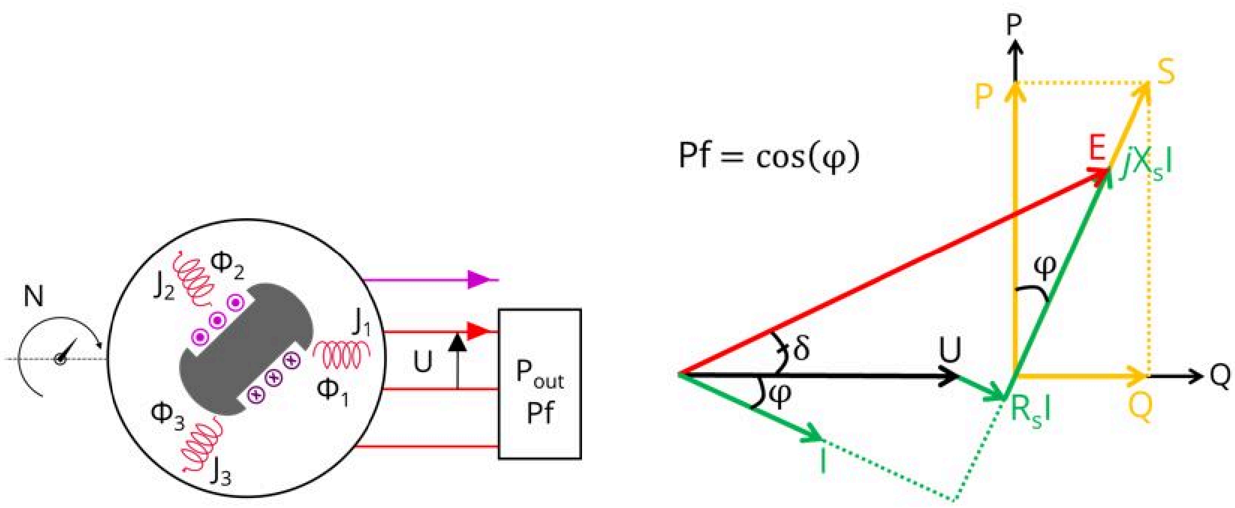
2.2.2 Computation of a Working Point (P/Sn, Pf, U, N)

Positioning and objective

The aim of the test "Working point – Sine wave – Motor & Generator – P, Pf, U, N" is to characterize the behavior of the machine when operating at the working point that is targeted by the user. This point is defined by:

- The output power that can be either the electrical power transmitted to the stator winding if the machine is in generator operation, or the mechanical power exerted on the shaft if the machine is in motor operation. If the generator operation is targeted, the output power can be replaced by the apparent power.
- The power factor,
- The line-line voltage,
- The rotating speed.

Through this test, the user can also verify whether the desired operating point is compatible with the machine. Additionally, the user can identify the appropriate reference values for the field current and the control angle needed to achieve this operating point.



"Working point – Sine wave – Motor – P, Pf, U, N" illustration

The results of this test give an overview of the electromagnetic analysis of the machine, considering its topology.

The general data of the machine, like the machine constant and power balance, are computed and displayed. The user can choose between motor and generator conventions to build the model.

The magnetic flux density is also computed in every region of the machine's magnetic circuit to evaluate the design.

It also gives the capability to make comparisons between the results obtained from the measurements and those obtained with Altair® FluxMotor®.

> **Note:** This feature is available in a "**Beta version**" meaning that it is not entirely qualified, and that the user must be careful when analyzing the results.

> **Note:** The motor convention and motor operating mode are not available yet in the 2024.1 version of FluxMotor.

Input and output data

User inputs

The four main user input parameters are output power / apparent power, power factor lead/lag, speed and line-line voltage. In addition, the temperatures of the windings must be set.

Main outputs and results

Test results are illustrated with data, graphs, and tables.

- Machine performance – Base speed point
    - General data
    - Machine constants
    - Power balance
    - Flux in airgap
    - Flux density in iron
- Ripple mechanical torque
    - Working point

Curves and graphics

- Ripple mechanical torque versus rotor angular position
- Flux density in airgap versus rotor angular position
- Flux density isovalues

Main principles of computation

Introduction

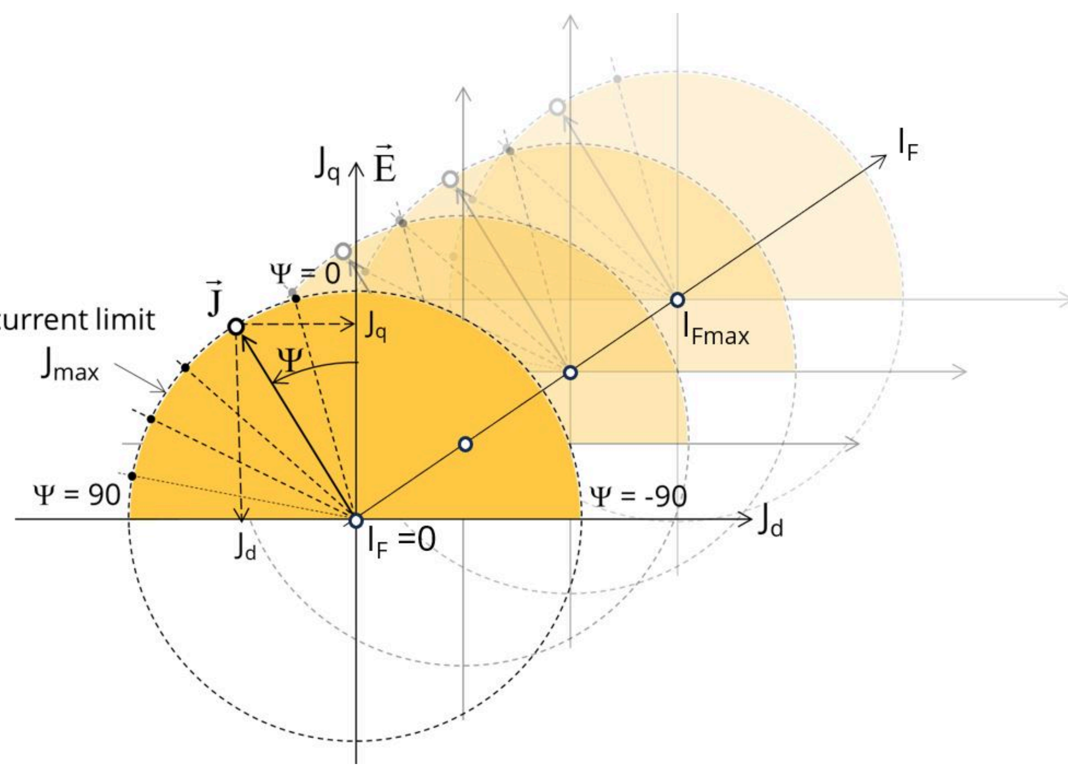
The aim of this test in motor / generator convention is to give a good overview of the electromagnetic potential of the machine by characterizing the working point according to the output power / apparent power, power factor, speed and voltage set by the user.

In addition, ripple torque at the working point is also computed.

To achieve such an objective, in the back end of FluxMotor, an automatic search is performed to identify the line current I, the field current IF and the control angle ψ providing the performance defined by the user.

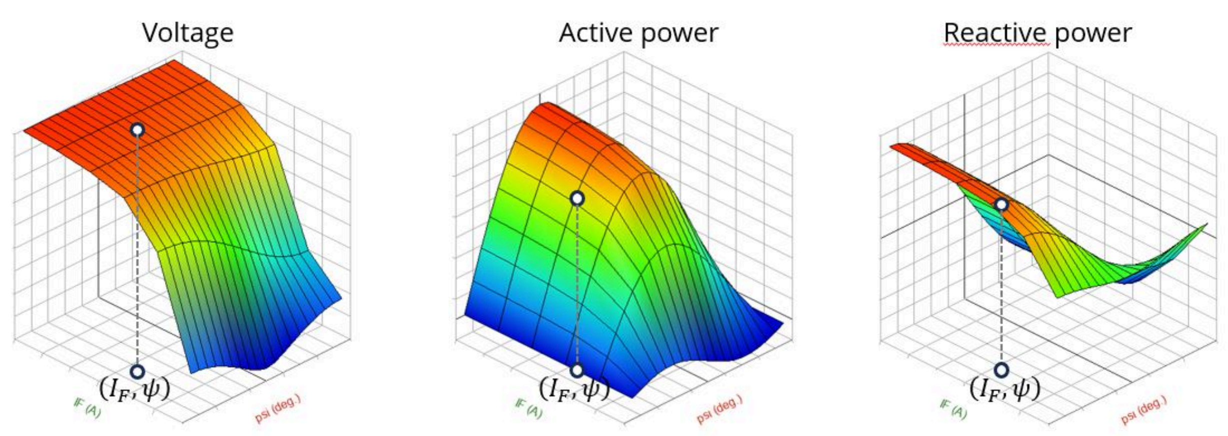
> **Note:** As the motor convention and motor operating mode are not yet available in the 2024.1 version of FluxMotor. From this point on, only the computing principle of the generator convention and generator operating mode are described.

In the generator operating mode, the line current can be deduced directly from the user input (output power / apparent power, power factor and line-line voltage). The research zone comprises thus two dimensions: field current and control angle. It is defined by the maximum field current, the number of computations along the field current axis and the control angle axis, all of which can be adjusted by the user in the inputs of the test.



Research zone of the P-Pf-U-N for the generator operating mode defined by maximum field current and number of computations along the field current axis and control angle axis

Within the research zone, the If-I-Psi-N test will be executed at all points (IF, ψ) to determine the performance response surfaces of the machine. Then an optimizer is used to search for the point (IF, ψ), providing the match with the targeted performance.



Performance of the machine in generator operating mode within the research zone in terms of voltage, active power and reactive power and the point (IF, ψ) providing the targeted performance

For more information, please refer to the user help guides.

2.3 Two new Flow Simulation exports

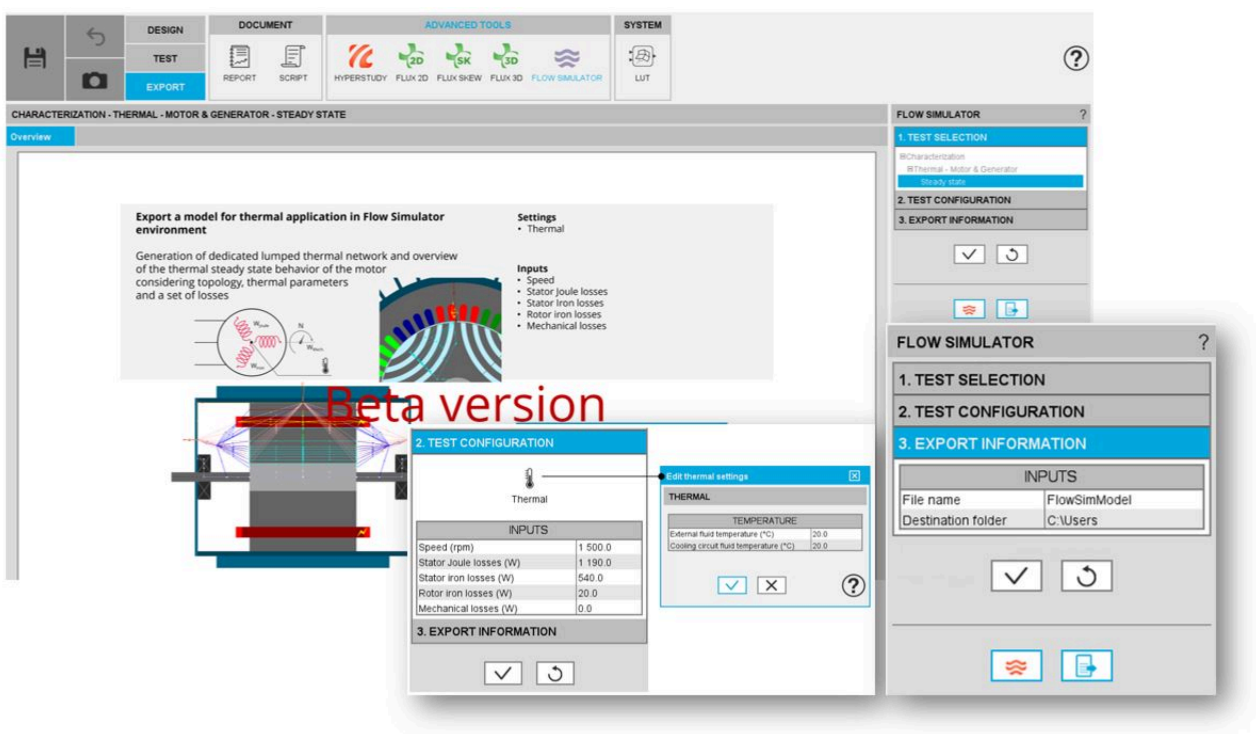
Introduction

The aim of the export "Advanced Tools - Flow Simulator – Steady State" is to represent the thermal behavior of the machine through a customizable lumped thermal parameter model coupled with a flow network when necessary.

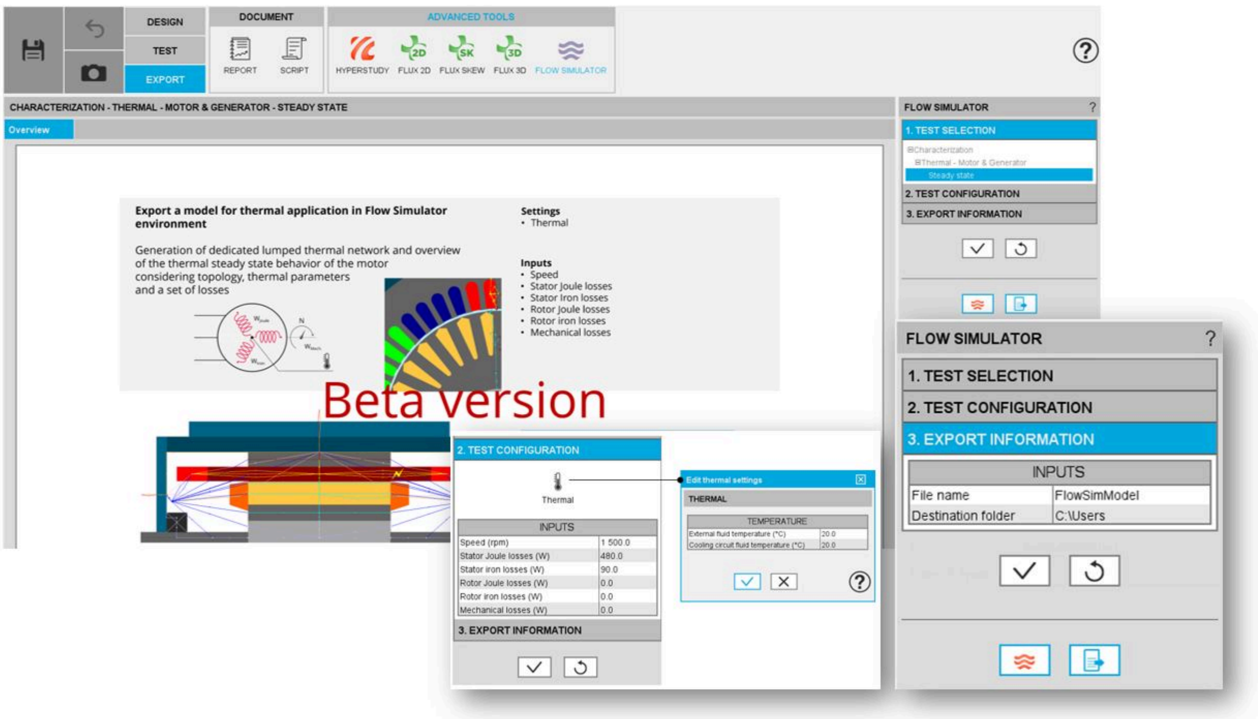
The resulting model is a 3D representation of a steady state thermal circuit built in Altair® Flow SimulatorTM, it corresponds to the thermal model used in Flux Motor® to run both thermal and coupled tests.

With the previous version, it was possible to export the thermal model of a synchronous machine with permanent magnets from FluxMotor to Flow Simulator ready to perform a thermal steady state analysis.

With the new version of FluxMotor, it is now possible to export the thermal model of both reluctance synchronous machine and induction machine with squirrel cage from FluxMotor to Flow Simulator.



Export of the thermal model of the **reluctance synchronous machine** from FluxMotor to Flow Simulator



Export of the thermal model of the **induction machine with squirrel cage** from FluxMotor to Flow Simulator

User inputs and settings

Main inputs of the test

- Speed
- Motor losses
    - Stator Joule losses
    - Stator iron losses
    - Magnet losses
    - Rotor iron losses
    - Mechanical losses

Setting of the test:

- External fluid temperature

Reminders

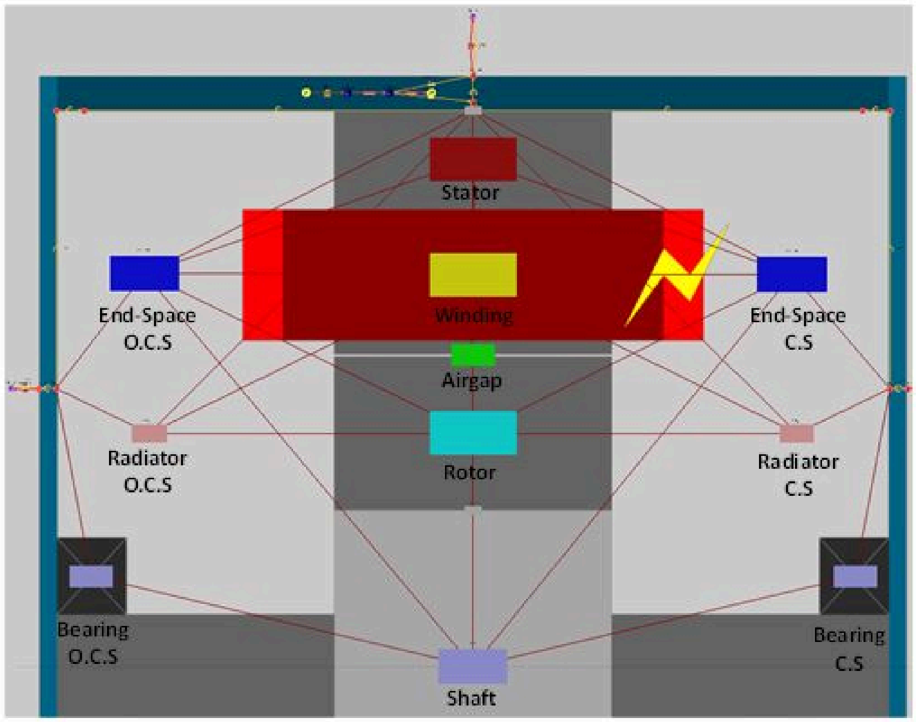
- **Generalized lumped thermal network.**

  The proposed thermal network is based on a general schema where the number of thermal resistances is fixed for some well-known regions in which geometrical changes can be modeled through variable parametrization. These regions are the shaft, the bearings, and the housing (endcaps included).

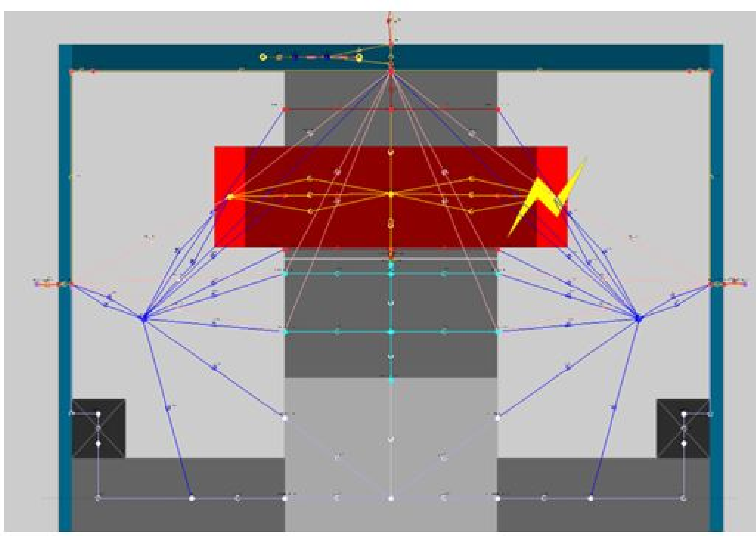
  On the contrary, the local grid of some regions is highly dependent on the chosen topology and should be particularized to achieve the essential goals of maximum customization and versatility during the design stage. These regions are mainly the rotor and the stator (including the winding). Due to their high interaction with these areas, the airgap and the end-spaces also require a customized grid.

  The global network is displayed in a 3D view in Flow Simulator™, and for clarity, the different regions are associated with groups. Resistances can either be hidden inside their groups or expanded, as shown in the images below. This dual view assures, at the same time, the possibility to show a meaningful global view containing the main heat paths or, on the contrary, to have the deepest insight into one or several regions and to study in detail their configuration as explained in section below ("Customizable stator and rotor grids – The constellation method"). Each group can be expanded or collapsed independently.

  Once in Flow Simulator™ the thermal circuit can be solved, and any kind of modification in thermal resistance values or grid connections can be added.



Axial projection of the thermal grid exported to Flux SimulatorTM. Global view



Axial projection of the thermal grid exported to Flux SimulatorTM. Expanded view.

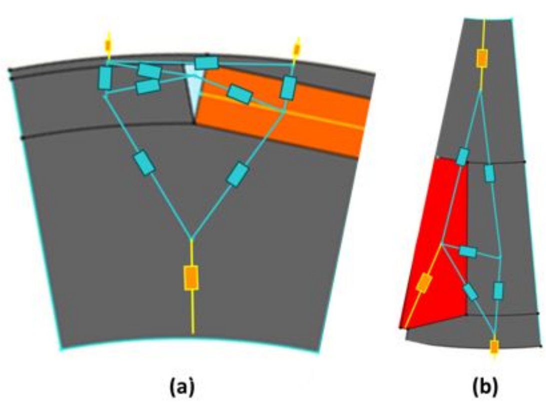
- **Customizable stator and rotor grids – The constellation method**

  Stator and rotor geometries, especially the latter, are subject to big changes during predesign, even for a fixed number of slots or poles. Different shapes and number of magnets per pole, the existence of holes in the active parts and of shoes next to the airgap are usual. These modifications, which have an important impact on the machine's performance, are usually difficult to parametrize.

  The best solution to this challenge is the use of a customizable grid defined using the constellation method, which can be summarized in the next points:

  - Since only radial electric machines are considered, the radial cut of rotor and stator are defined as rotor part and stator part, respectively. These parts are composed of different surfaces, which are represented by its material (generally steel, air, magnets or conductor) and its central point (i.e., its barycenter).
  - Barycenters of neighboring surfaces will be connected by a thermal resistance. These resistances will form the part constellation. Thermal resistances between non-neighboring surfaces are supposed to be infinite.
  - Surfaces in contact with external frontiers will be connected to them by thermal resistances (i.e., in the radial plane, these frontiers are the airgap and the shaft for the rotor part, and the airgap and the frame for the stator part).
  - It is considered that every surface in stator and rotor parts is in contact with both end-spaces; therefore, a thermal resistance must link them to these regions. These resistances are the only ones that are not contained in the considered radial plane.

  The generation of the rotor and stator thermal constellations is developed from their associated parts, as defined in Altair® FluxMotor®



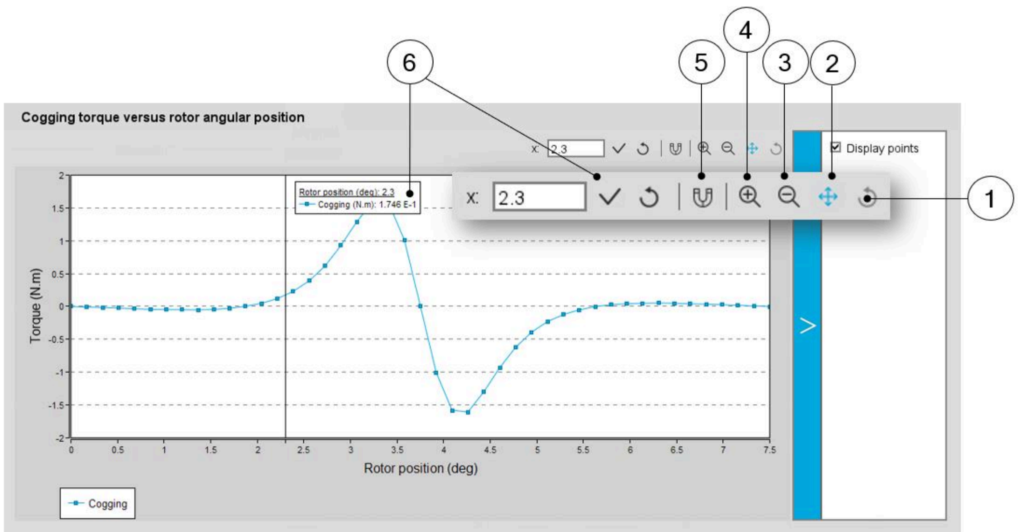
Thermal constellation of a rotor (a) and stator (b) part.
In blue, thermal resistances link internal surfaces.

In yellow, resistances link surfaces with part frontiers.

2.4 Charts features improvements (Curves, maps, axis scale,)

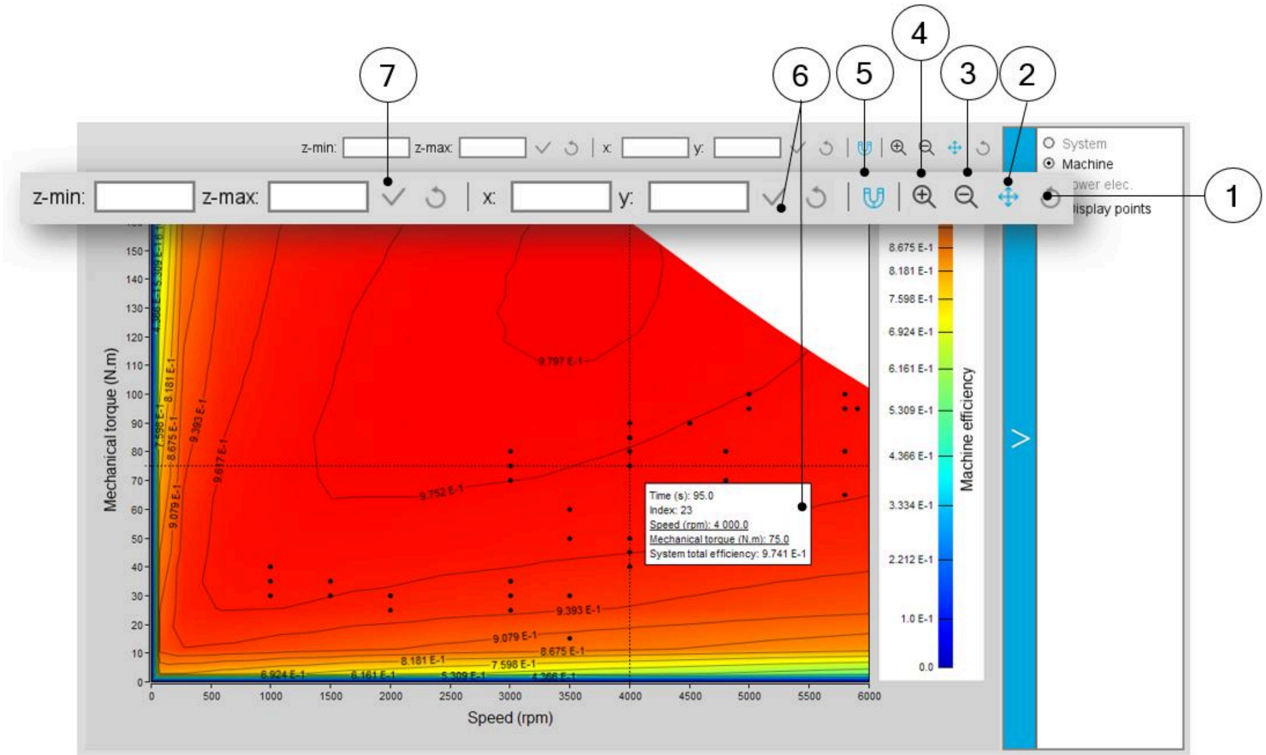
New features - Illustrations

Since 2024.1, essential functionalities have been implemented for almost all charts throughout Motor Factory and Materials. The available features depend on each type of chart. Some functionalities are common to all charts, while others vary slightly depending on the chart type. Below are examples of the most common types of charts, to cover all the features.

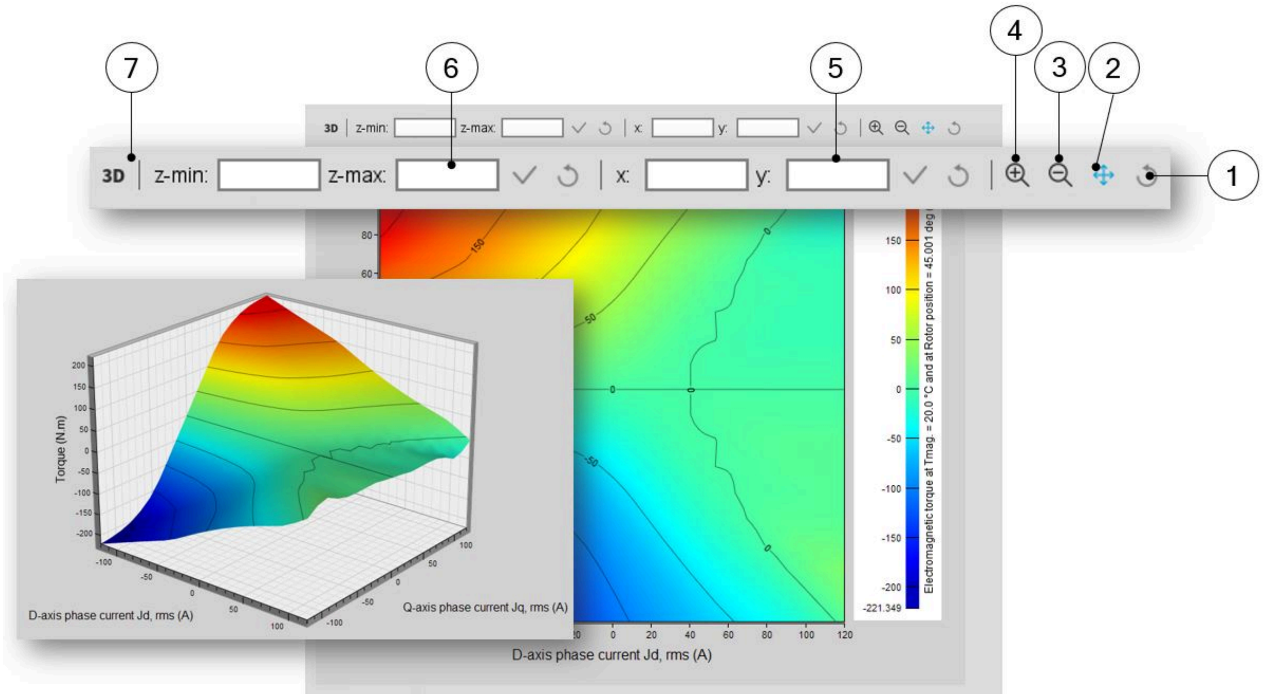


A basic line chart and its features

1	Reset zoom: resets the chart to the initial zoom value (100%).
2	Scroll: the default mouse mode, it allows the user to move around the chart with the left mouse button.
3	Zoom out: this mouse mode allows the user to zoom out the chart by clicking on the chart.
4	Zoom in: this mouse mode allows the user to zoom in the chart, either by clicking or by creating a zoom-in rectangle on the chart.
5	Snap to data points: when activated, the mouse tooltip snaps to the closest data point of the chart.
6	Probe panel: after entering a valid x-value, the user can click on the checkmark button to compute and display the probe on the chart. A movable tooltip will appear alongside a vertical line at the entered x-value. To remove the probe, either click on the reset probe button or the probe line itself.



	An efficiency map and its features
1	Reset zoom: resets the map to the initial zoom value (100%).
2	Scroll: the default mouse mode, it allows the user to move around the map with the left mouse button.
3	Zoom out: this mouse mode allows the user to zoom out the map by clicking on the chart.
4	Zoom in: this mouse mode allows the user to zoom in on the map, either by clicking or by creating a zoom-in rectangle on the chart.
5	Snap to data points: when activated, the mouse tooltip snaps to the closest data point on the map.
6	Probe panel: after entering a valid pair of x and y values, the user can click on the checkmark button to compute and display the probe on the chart. A movable tooltip will appear alongside a cross at the entered coordinate. To remove the probe, either click on the reset probe button, or the probe cross itself.
7	Z-axis bounds panel: after entering valid z-axis bounds, the user can click on the checkmark button to update the z-axis accordingly. This will modify the z-axis color scale and for most maps, the isolines interval.



A model map and its features	
1-6	Same as above example (without snap to data points).
7	3D visualization: toggles the 3D visualization on or off.

2.5 New exports of LUT to System (PSIM)

The area SYSTEM, in the EXPORT environment of Motor Factory, allows exporting data like constants, curves and maps in lookup table (LUT) formats, such as FMU and MAT format files.

Such export is now available for the wound field synchronous machine and for the reluctance synchronous machine.

The test Characterization/Model/Maps can be selected for exporting the data.

Constants, curves and maps" given in Jd-Jq plane for characterizing the 3-Phase synchronous machines with permanent magnets are computed and exported.

These files can be imported directly into environments like Altair® Activate®, Altair® Compose® or Altair® PSIM® as binary variables files (.mat) or inside block functions, ready to be integrated into schemes to represent the model of the corresponding rotating electrical machine.

These functionalities are useful to represent the machine at the system level. Therefore, electrical machine and other system components, such as the drive and the control command, can be represented and simulated altogether into the same area.

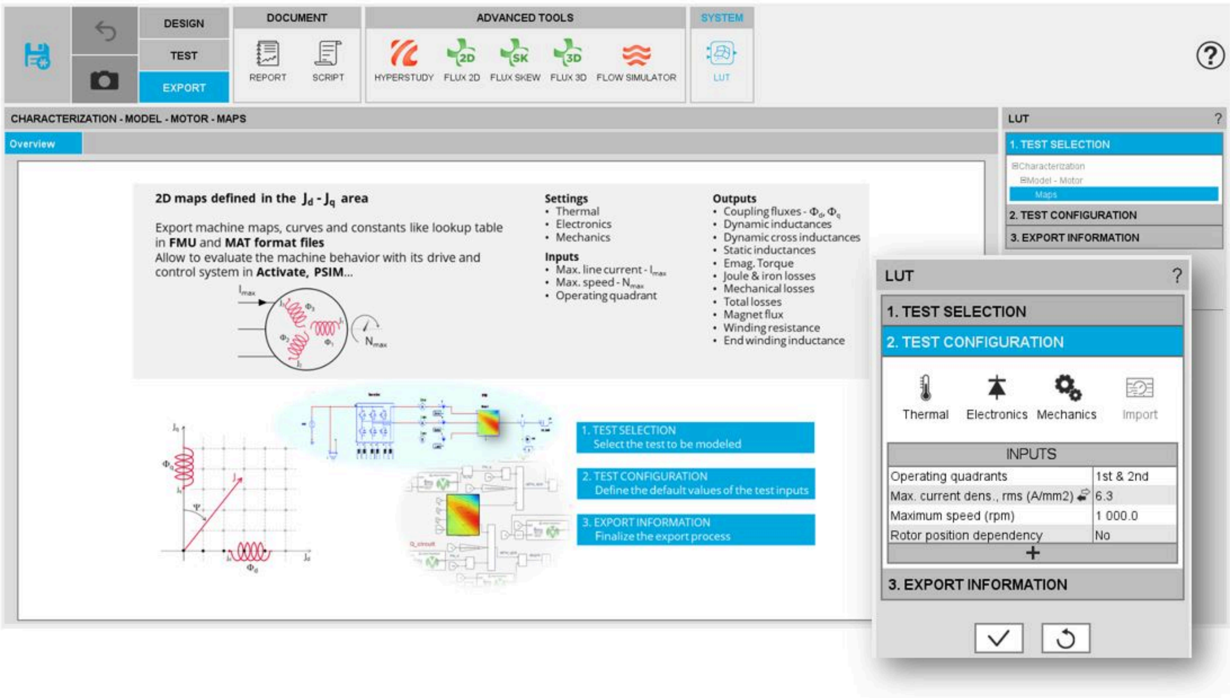
> **Note:** This functionality is not implemented for polyphase machines. It will be addressed in a future version.

In the "Test configuration" Operating quadrants to be considered can be selected. Hence, Export / System LUT (Activate or PSIM) allows exporting data based on 1, 2 or 4 quadrants.

Export / System LUT (Activate or PSIM) allows exporting data with respect to the rotor position dependency.

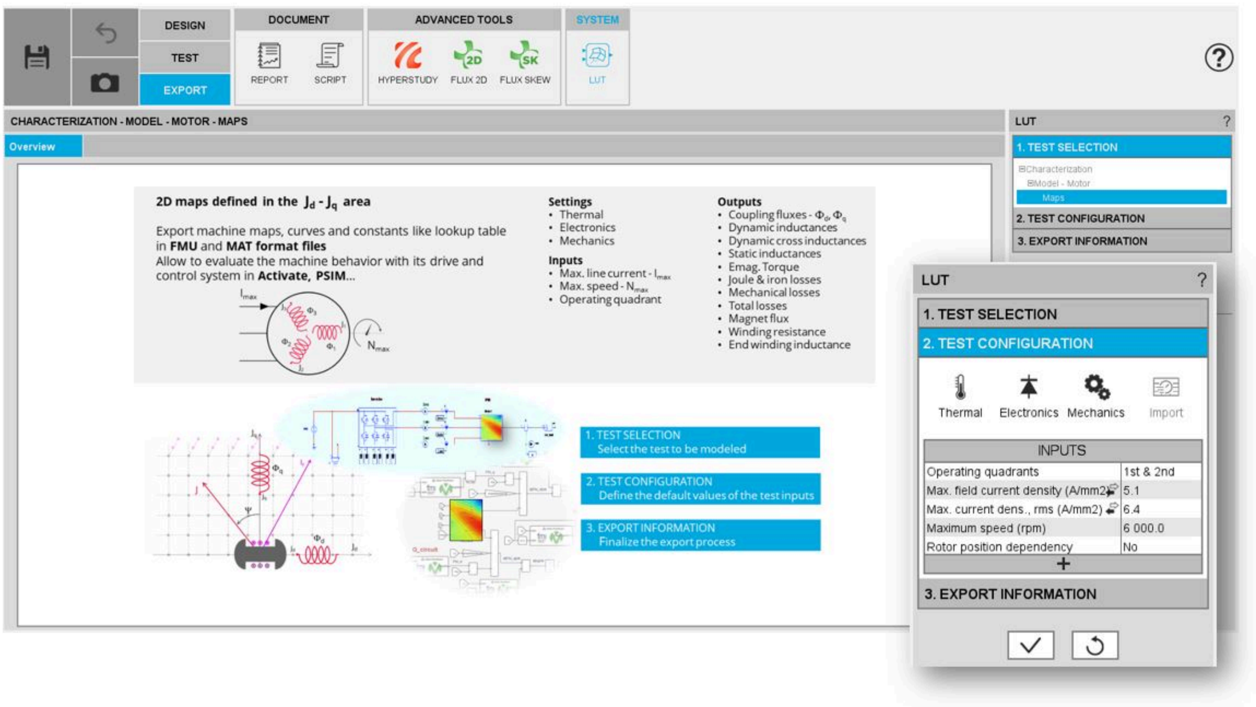
When selected, the rotor position dependency makes the computation done in the Jd - Jq plane with an additional fourth axis corresponding to the rotor position θr.

Area to export LUT dedicated to the reluctance synchronous machines



Motor Factory – EXPORT AREA – Export data in LUT formats available for the reluctance synchronous machines

Area to export LUT dedicated to the wound field synchronous machines



Motor Factory – EXPORT AREA – Export data in LUT formats available for the wound field synchronous machines

> **Warning:** For the Wound Field Synchronous Machines, exporting LUT using FMU format files is not possible with the current version. This issue will be fixed in the next one.

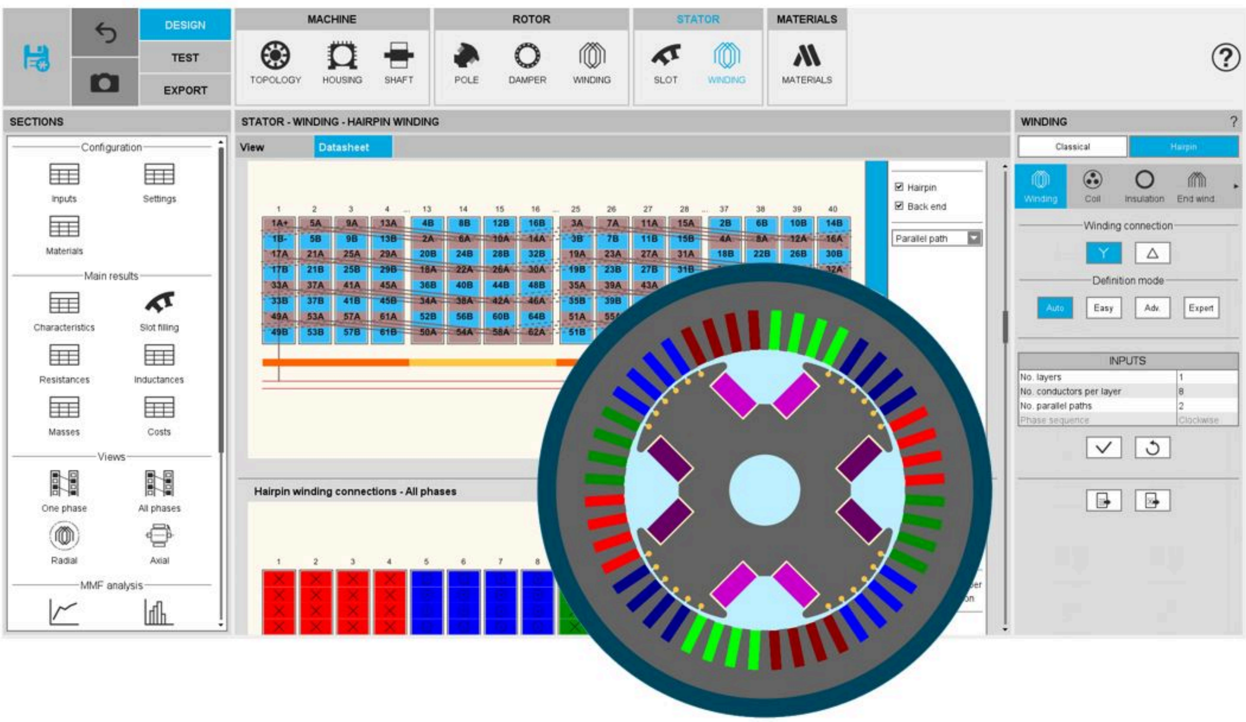
2.6 New connectors for coupling FluxMotor with HyperStudy

New connectors for coupling FluxMotor and HyperStudy have been implemented for the wound field synchronous machine.

Here are the two tests for which a connector to HyperStudy can be generated

- The Performance mapping / Efficiency map
- The computation of a Working Point (If, I, Ψ, N)

2.7 Wound field synchronous machines with hairpin winding technology are available



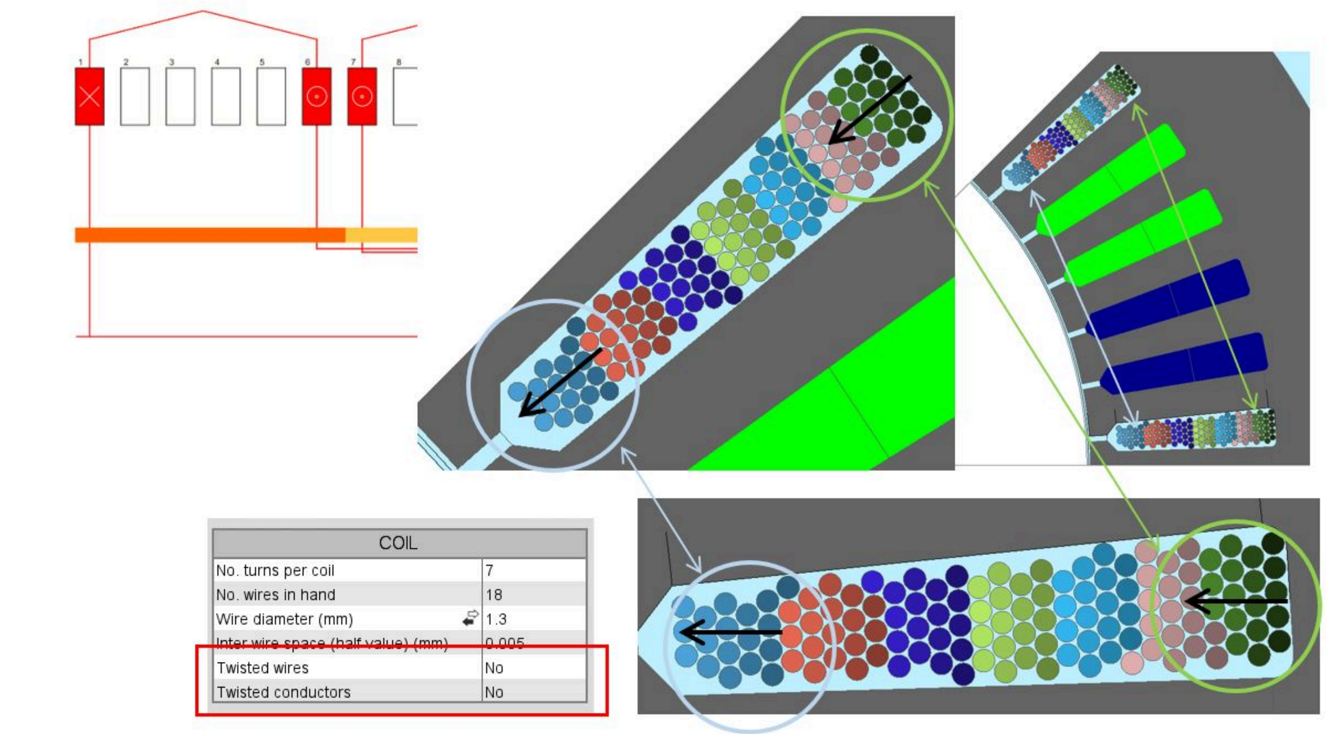
Motor Factory – DESIGN – Winding area – hairpin technology
is available for the wound field synchronous machine

2.8 Twisted conductors and wires

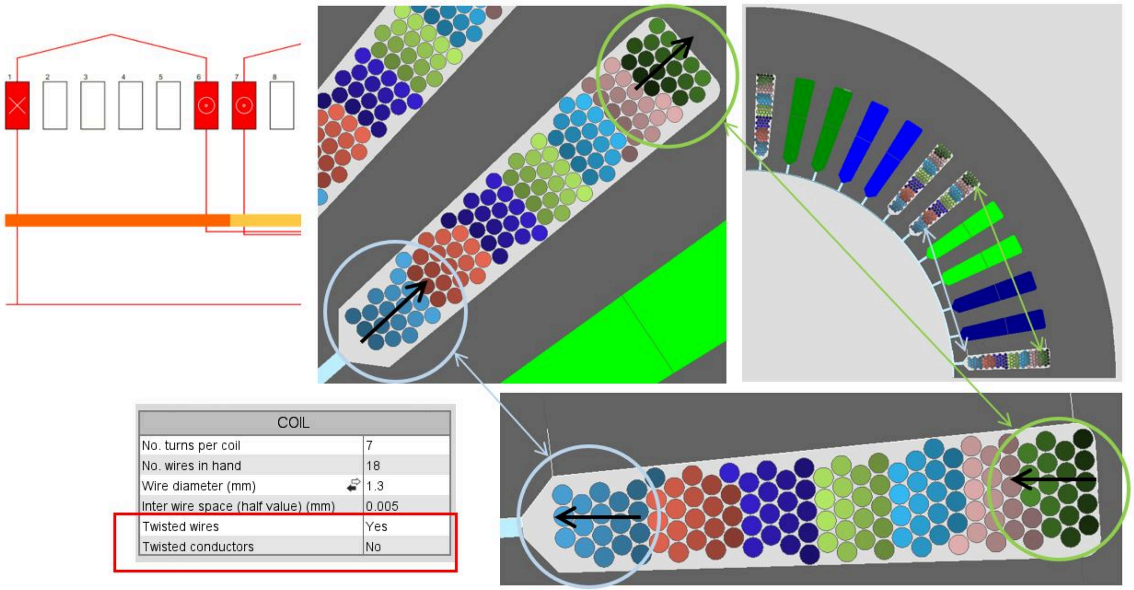
While defining the coil in the design / Winding area, it is possible to twist the wires inside the conductors between the forward and return sections of the coil. It is also possible to twist the conductors between the forward and return sections of the coil.

It is possible to twist both the wires inside the coil and the conductors between the forward and return sections of the coil.

The four illustrations of what it is possible to do are presented below.

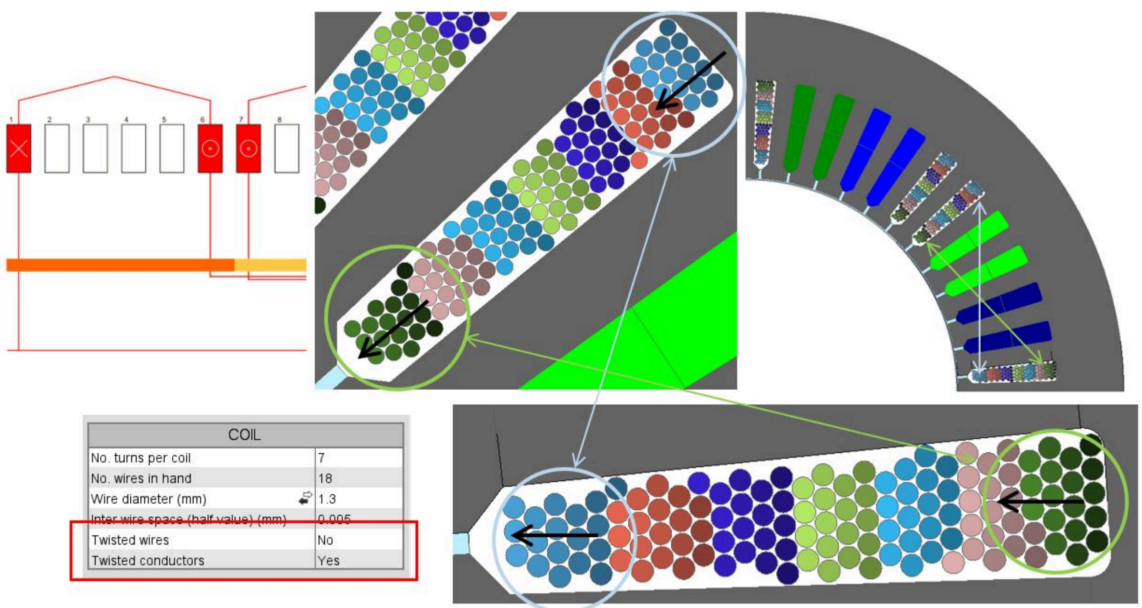


Neither the wires nor the conductors are twisted



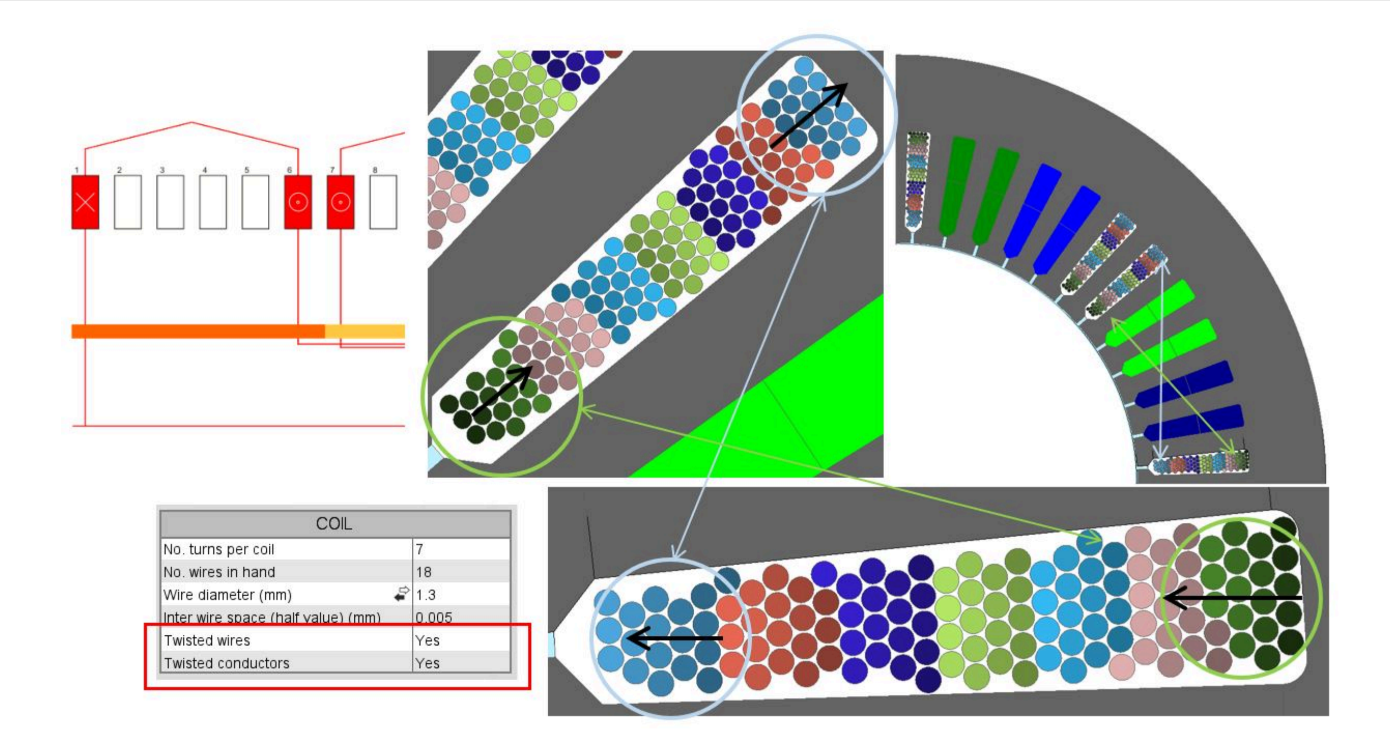
The wires are twisted inside the conductors.

The direction of the gradated conductor color indicates the orientation of the twist.



The conductors are twisted between the forward and return sections of the coil.

The conductor colors indicate the position of conductors



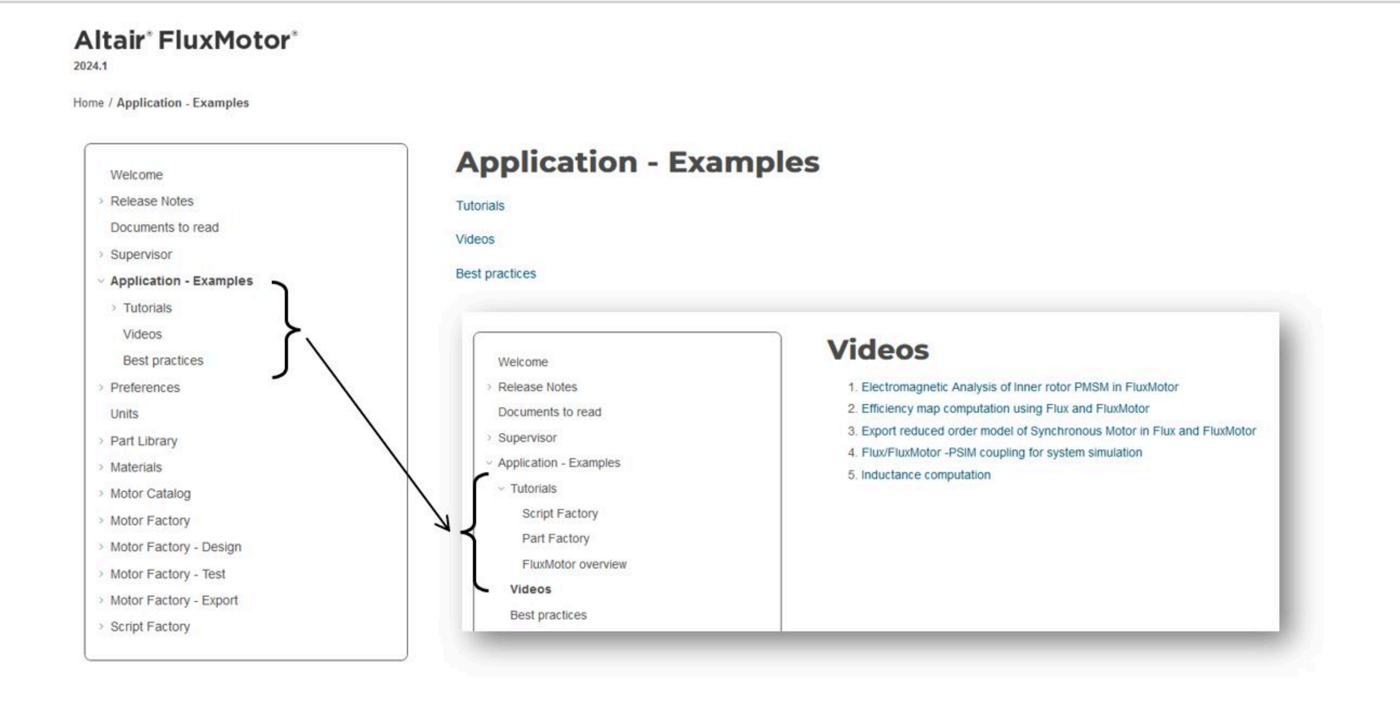
The wires are twisted inside the conductors and

the conductors are twisted between the forward and return sections of the coil.

2.9 Videos, tutorials and best practices

Tutorials, best practices documents and videos are now available on the online user help guide.

Such valuable information allows us to illustrate what is possible to do with FluxMotor and how to exploit the full potential of our solutions.



How to find Tutorials, Videos,and Best pratice documents ?

List of fixed issues and major improvements

3

This chapter covers the following:

3.1 All machines

When creating a Flux skewed project, issue with project

- If you save and close your project, it is impossible to open and solve it.
- If you solve the project, it is impossible to delete results and rerun the project (ref.: FXM-15638).

This issue has been corrected.

The interwire space is not well defined.

The resulting value of the interwire space applied in the finite element model is twice the value set in the user inputs (ref.: FXM-14672).

This issue has been corrected.

3.2 Synchronous machines – Motor Factory – Test environment

SMRSM - Working point – Sine wave – I, Ψ, N – Accurate computation mode with Skew

The computation failed in case of Skewed geometry with the accurate computation mode (ref.: FXM-16581).

This issue has been corrected.

3.3 Materials

Define iron loss parameters from a map

The fitting function for defining the iron loss parameters from a map (Excel file inside in which several iron loss curves as a function of the flux density are available for different values of frequency) doesn't work anymore.

This function worked in the previous version FluxMotor 2023.1.

One workaround consists of using the "Flux Material Identification" tool in Altair® Flux® for defining the parameters.

(ref.: FXM-16789).

This issue has been corrected.

List of warnings

4

This chapter covers the following:

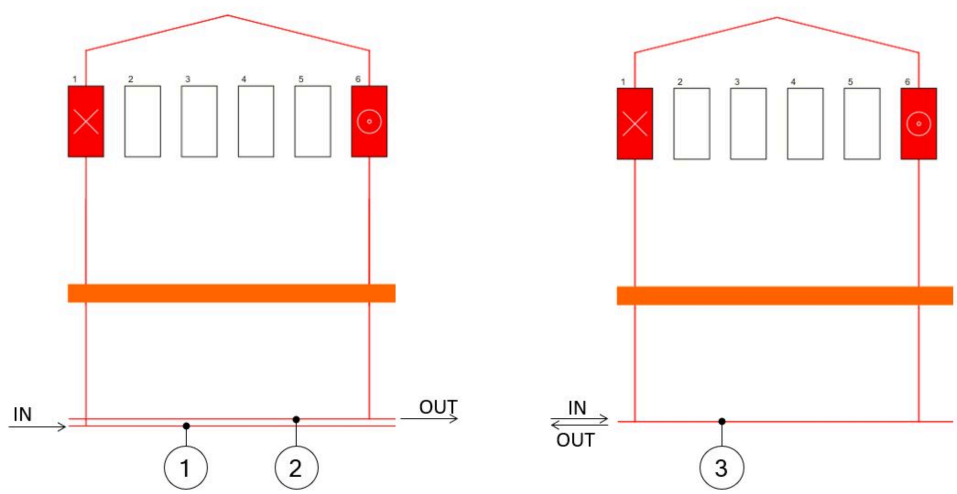
4.1 All machines

Layout of the winding – Winding connections

The representation of connections between coils and phases has been modified.

The lines that collect incoming and outgoing connections are merged into a single line. This has been done to make polyphase winding diagrams easier to read.

The picture below that illustrates the difference between the two representations.



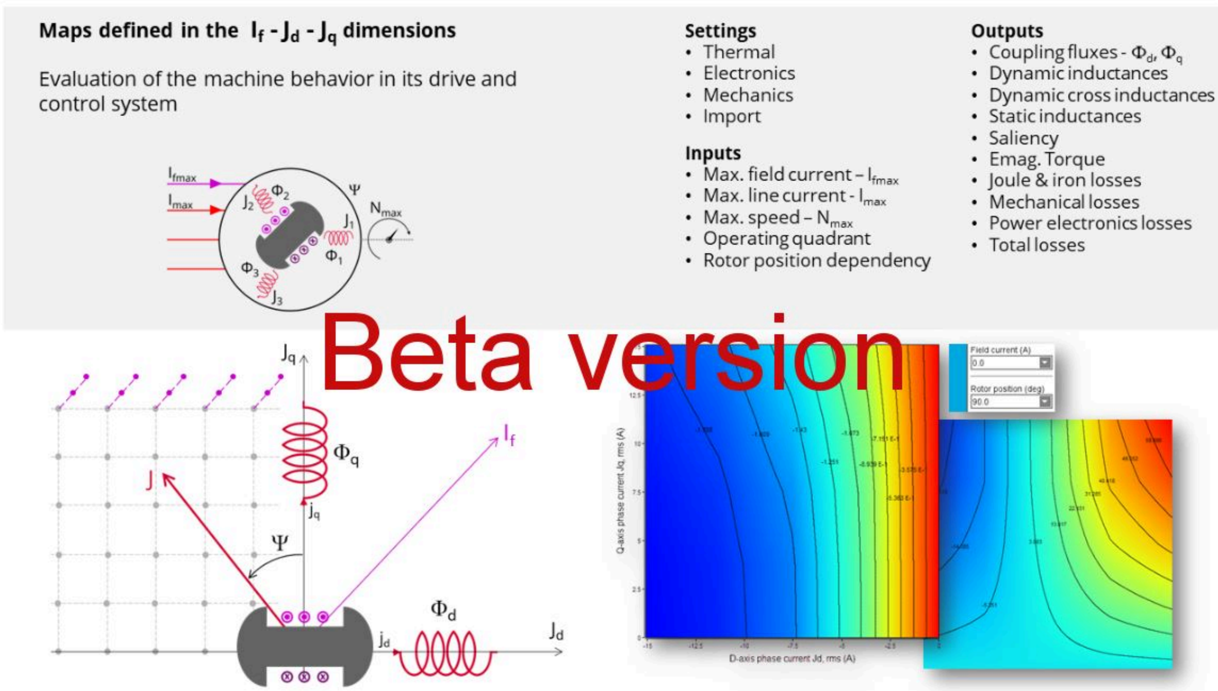
Representation of the winding connections	
1-2	In previous versions, the two lines connection were represented.
3	In new versions, only one line corresponds to both IN and OUT connections

Features available in beta mode.

Sometimes, a new test is provided in beta mode, meaning that it is not entirely qualified. However, we make it available for testing, and we invite the users to give us their feedback and comments for improving this feature even more.

To indicate the "Beta mode" status of the test, "**BETA VERSION**" is written in the overview of the considered test as illustrated below.

Here is an overview of the test, as shown below.



Example of a test provided in beta mode

Distribution of computations cannot be used for computing NVH spectrogram (FXM-15772).

Winding – Expert mode – defining of several circuit per sector.

In Expert mode, several parallel circuits can be defined in a sector and moreover several coils can be built in one circuit.

Such circuits can be connected in parallel according to the user's input No. parallel paths.

In that case, it is mandatory to balance all the parallel paths well while building and connecting the coils inside all the circuits.

Indeed, our internal process of computation doesn't manage the unbalance between parallel paths, i.e., in the case of unbalanced parallel paths, the results of computations are wrong.

> **Note:** For example, unbalance between parallel paths can be due to the number of coils per circuit, which can be different from one circuit to another. It can also be induced by the building of coils (differences in conductor lengths.

Natural convection for end winding

While choosing a model, where the end spaces are cooled with natural convection, the FluxMotor® model uses quite a low rotor tip speed ratio (a value of 5) to describe the fluid velocity far from the rotating components. This may lead to an overestimation of the cooling of the end winding on high-speed machines.

When a tip speed ratio of 5 seems to overestimate the end winding cooling, it is advised to switch to forced convection mode.

This mode allows forcing some higher tip speed ratios for areas far from the rotor, but reduces the efficiency of the cooling on the end winding.

This model will be improved for future versions.

Modification of units

To take the change of units into account in a test, the user must reopen Motor Factory. The modification is not considered instantaneous in applications of Altair FluxMotor® like Motor Factory.

Export a model into Flux® environment with represented elementary wires.

1. Building time of the model in Flux®

   When slots are filled out with a lot of elementary wires, and all the phases need to be represented with solid conductors inside the Flux® 2D model, the resulting python file can be very long. Therefore, the process of building the corresponding model in the Flux® environment can take a longer time.

Browse function

Sometimes, opening a folder from FluxMotor® applications via the browser function requires a longer time (several seconds).

Export environment – HyperStudy®

1. **Compatibility of HyperStudy connectors with respect of FluxMotor solver versions**

   The process that describes how to update the HyperStudy connector is written in the user help guide "MotorFactory_2023.1_Introduction.pdf"

2. New test and connectors for HyperStudy®

   Connectors for coupling FluxMotor® and HyperStudy® are not yet available for the new added tests, like those with transient thermal computations or the tests for induction machine like the "Characterization – Model – Motor – Scalar" and the "Performance mapping – Sine wave – Motor – Efficiency map scalar".

3. Mandatory synchronization between connector and FluxMotor versions

   The connectors used in HyperStudy must be synchronized with the FluxMotor solver version.

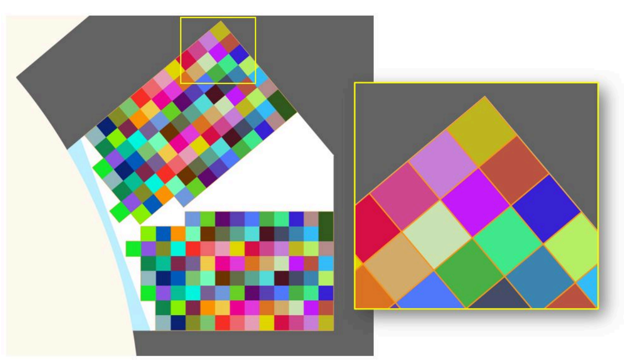
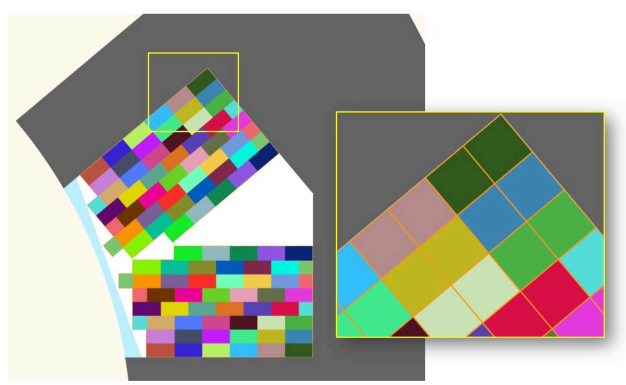
   An error message (inside the log files) is generated while performing HyperStudy studies with a connector provided with a former version of the FluxMotor solver.

Problems with slot filling

1. Slot filling is not yet possible with a non-symmetric parallel slot.
2. When a toothed winding design is considered with rectangular shape wires, the conductor grouping method "horizontal" doesn't work properly, leading to the wrong visualization of conductors. In that case, it is recommended to select the conductor grouping method "vertical".

   All work well with circular shaped wires.

Example with a toothed winding design (i.e., the coil pitch = 1) and with 2 wires in hand.

	
Horizontal filling – wrong visualization, but the total number of wires is right	Vertical filling – good visualization

NVH computations - Advice for use

The modal analysis and the radiation efficiency are based on analytical computation, where the stator of the machine is considered a vibrating cylinder.

The considered cylinder behavior is weighted by the additional masses, like the fins or the winding, and the subtractive masses, like the slots and the cooling circuit holes.

This assumption allows for a faster evaluation of the behavior of machine in connection to NVH. But in no way can this replace mechanical finite element modeling and simulation.

Possible reasons for deviations in results can be the following:

- The limits of the analytical model are reached or exceeded.
- Unusual topology and/or dimensions of the teeth/slots
- Complexity of the stator-frame structure when it is composed of several components, for instance.
- The ratio between the total length of the frame Lframe and the stack length of the machine Lstk. In any case, this ratio must be lower than 1.5:

  L_Frame/L_stk ≤1.5

4.2 Synchronous machines – Motor Factory – Test environment

Working point – Square wave – Forced I – and delta connection.

When running the test "Working point – Square wave – Motor – Forced I" with a delta winding connection, two electrical periods are considered for reaching the steady state behavior of the motor. However, sometimes two periods are not enough to get a good convergence of the process, and therefore, the displayed results may not correctly represent the steady state.

Motors built and tested with previous versions can be loaded with the current version. The existing "current tests" are removed and transformed into "saved tests" with reference to the original version (all the previous versions).

Sometimes, the results of the current tests are removed. The test must be executed again to get the corresponding results.

Delta winding connection

When a delta winding connection is considered, the computation doesn't consider the circulating currents. This can lead to a different result than expected in transient computation for the test "Characterization - Open-circuit - back-emf".

In such a case, it is recommended to perform a transient computation in the Altair® Flux® environment. The application "Export to Flux®" thereby allows exporting this kind of model to the corresponding scenario ready to be solved.

Evaluation of the maximum achievable speed

The aim of this result is to give a rough estimation of the maximum reachable speed, that can be achieved by the machine. This computation is performed by considering the MTPV command mode. However, when the resulting control angle is low (no saliency in the airgap of the machine), the evaluation of the maximum achievable speed may be far away from the maximum speed given by the "Performance mapping – Sine wave – Motor - Efficiency map" test.

Export to FeMT

The export of projects to FEMT is limited to SMPM inner Rotor machines.

Furthermore, when there is more than one parallel path, export to FeMT is blocked because the two electric circuit models are not yet compatible in the electric circuit built by FluxMotor. Here, parallel paths are built to represent the corresponding parallel circuits.

4.3 Induction machines – Motor Factory – Design environment

Computation of inter bar impedance

For induction machines, inter bar impedance (resistance and inductance) is computed by considering characteristics defined in Motor Factory.

However, while exporting the model into Flux® 2D or into Flux® Skew, the inter bar impedance will remain constant, even if a parametric study is performed in the Flux® environment. The topology parameter as well as the temperature variations won't impact the inter bar impedance.

4.4 Induction machines – Motor Factory – Test environment

Computation of tests for induction machines with skewing

When the squirrel cage or the slots are skewed for induction machines, the tests are computed with Altair® Flux® Skew at the back end of the FluxMotor®.

This leads to an increase in computation time.

For the test “Performance Mapping – Sine wave – Motor – T(Slip)” and the test “Characterization – Model – Motor – Linear”, the computation time can be greater than 45 minutes depending on the concerned machine, and is generally lower than 5 minutes when it is without skewing of the squirrel cage or slot.

The computation time for computing a working point is generally close to 8 minutes with the skewing of squirrel cage or slots and lower than 1 minute when it is without skewing.

The required allocated memory is higher when Flux® Skew computations are performed at the back-end of the FluxMotor®.

By default, the maximum allocated memory for Flux® Skew software and Flux® 2D software is set to DYNAMIC (user’s preferences - Advanced tab).

Computation of power density for induction machines

There was an issue in the process of computing or displaying the power density for induction machines.

The result was given in W/m^3 while it is in W/kg for other machines SMPM, RSM.

This issue has been corrected.

However, it won’t be possible to use a connector for HyperStudy®, generated with an older version, for driving the FluxMotor® 2023.

List of the main issues 5

This chapter covers the following:

5.1 All machines

Thermal computation results can be very different between FluxMotor an Flux2D

Thermal computation with FluxMotor can be very different from the one exported to Flux2D with same settings.

Indeed, the second-order temperature interpolation does not manage very well high temperature variations on an element.

That's why, sometime, in Flux2D, the result got for a single thermal node of the mesh can "hide" the real temperature distribution when the temperature map is displayed by default.

As a workaround, we can change manually the temperature scale, to make the results become closer to what is expected (ref.: FXM-16393).

Thermal computations - Problem of convergency

When losses are very high, there is a convergence issue with the Thermal computations (ref.: FXM-15900).

Solving problem during the pre-computation of thermal circuit with negative temperature can occur (ref.: FXM-16948).

Wrong thermal analysis

Zero values are allowed for housing, bearing or shaft dimensions but lead to the wrong thermal analysis (ref.: FXM-14705).

Export to FeMT with too long output path

The Flux script crashes when the output path for FeMT export is too long (ref.: FXM-15471).

Fault in the coupling FluxMotor-HyperStudy

An error in the FluxMotor process doesn't stop the HyperStudy execution (ref.: FXM-15402).

Issue with exported Flux Skew projects

After exporting a Flux Skew project, if the user solves the project, deletes the results, and then solves again, the running of the project fails (ref.: FXM-15075).

The color of wires displayed in the slots is not correct while using Flux Skew export (ref.: FXM-16942).

Null values are not well managed while designing the Frame and shaft.

Null values are allowed for designing the housing, bearing, or shaft dimensions, but this leads to the wrong thermal analysis. It is highly recommended not to use null values for the considered inputs (ref.: FXM-14705).

Error while opening a motor (2020.1) with null shaft extension.

Opening a motor built with version 2020.1 (or older) with a null shaft extension leads to an error. With new versions, a null shaft extension is forbidden (ref.: FXM-14684).

Air material properties are wrong for high temperature.

This issue impacts our internal computation processes during transient thermal solving. Indeed, some iterations involve very high temperature (more than 3000 °K), according to the Newton Raphson non-linear solving method. During the resolution, this can lead to negative conductivity and viscosity, which may make the computation fail (ref.: FXM-14465).

> **Note:** In case of a problem, an “Air material” with the right parameters can be provided.

When an IO cannot be loaded, the test results are not accessible.

When an IO cannot be loaded, the whole process that loads all the test results is stopped. As a result, no test is visible, although the issue may concern one result in a particular test (ref.: FXM-13941).

A wedge and/or inter-coil insulation region leads to a wrong slot equivalent thermal conductivity.

The slot radial thermal conductivity, which is automatically provided by the FluxMotor® in the "Cooling-Internal" context, and used in all thermal tests, is wrong if the slot contains faces "wedge" or "inter-coil insulator" (ref.: FXM-13896).

Power electronics and coupling with HyperStudy®

For tests where the settings "Electronics" is available, data like power electronics stage, maximum efficiency, and its rated power can be selected for generating a connector for HyperStudy®, but it should not be.

In the Export-HyperStudy® area, when the selected test is “Working Point, T-N”, the settings of “Electronics” - "Max efficiency", and "Rated Power" - are exported even if the associated option is not selected (ref.: FXM-13726).

Winding environment – MMF computation

The counter-clockwise sequence (MMF computation) is not considered in the Altair® Flux® model, which one can export. Only the clockwise phase sequence is considered (ref.: FXM-10280).

Using "phase sequence" set to "Counterclockwise" leads to wrong results in tests (ref.: FXM-13358).

Flux density isovalues

When a skewed topology is considered (synchronous machines or induction machines), the flux density isovalues, the vector potential isolines, and the rotor bars current density isovalues are not displayed (ref.: FXM-12564).

Japanese language and Flux software exports

When we export a Flux project (Flux2D, FluxSkew and Flux3D) some chracters are written in Japanese which makes the file crash during the execution. A work-around consist in delete all the Japanese characters and then execute the python file (ref.: FXM-16590).

5.2 Synchronous machines – Motor Factory – Test environment

In accurate mode the sign of the reactive power, and the phase angle is not right.

The sign conventions are not respected for defining the reactive power and phase angle (ref.: FXM-16143 & FXM-16542).

Working point – Square wave – Forced I – Average computation of quantities.

The computation of average quantities like iron losses, the Joule losses in magnets, and torque is not executed over a full electrical period. That can lead to wrong results (ref.: FXM-14091).

Maximum speed computation

The estimation of the maximum speed is wrong for the tests "Working point - Sine wave – Motor - U-I" and "Working point - Sine wave – Motor - T-N" when the control mode MTPA is selected (ref.: FXM-10916). The computation is always performed by considering the MTPV command mode.

5.3 Induction machines – Motor Factory – Test environment

The computation of power balance for IMSQ in "accurate mode" is not well balanced.

In the test "working point – sine wave – motor – U, f, N", while computing the power balance with the accurate mode (i.e., with the transient application) the results are not well balanced. Indeed, the difference between the electrical power and the power on the shaft is not exactly equal to the total amount of losses.

Depending on the considered slip the difference can be about a few percent (ref.: FXM-16121 & FXM-16561).

> **Note:** The number of computation points per electrical period and the number of considered electrical periods (user's inputs) have an impact on the accuracy of the results.

> **Note:** The displayed value (in FluxMotor) of the mechanical torque is based on the Finite Element computations and considers the iron losses and the mechanical losses.

> **Note:** The rotor Joule losses (squirrel cage) result from the Finite Element computations.

The computation of the efficiency map (U, I) with mechanical losses can fail.

This issue raises a null-pointer exception (ref.: FXM-16157).

The flux density is not displayed in accurate mode computation.

While computing a working point (U, f, N) for an induction machine with a skewed squirrel cage and outer rotor the flux density inside the airgap is not displayed. (ref.: FXM-16154).

Possible negative AC Joule losses

While computing a working point in accurate mode, the AC Joule losses can be negative if they are computed on a half electrical period with a low number of computations per electrical period (ref.: FXM-16919).

Error when exporting and solving a project in Flux Skew – Transient application.

This issue occurs when the user input "Represented coil conductors" is set to All phases (ref.: FXM-15877).

Scalar Maps or Efficiency map (U,f) tests fails with hairpin winding technology

Sometimes, the tests Scalar Maps and Efficiency map (U,f) are not correctly solved with a hairpin winding configuration, like for the Motor M1 of the reference catalog (ref.: FXM-15843).

Power balance of No-load working point

Sometimes, computation of the no-load working point (slip=0.1%) leads to a NaN (Not a Number) result. The computed amount of iron losses is not consistent with the power balance (ref.: FXM-12600).

Torque slip curve

Test results are not continuously consistent over a torque slip curve. This occurs with the test Performance mapping T(Slip) - induction machines with a skewed squirrel cage. When the user targets a working point as an added value to be computed with the whole Torque-slip curve, sometimes this additional working point doesn't belong to the curve.

(ref.: FXM-12599).

5.4 Wound field synchronous machines – Motor Factory – Export environment

Exporting LUT using FMU format files

For the Wound Field Synchronous Machines, exporting LUT using FMU format files is not possible with the current version.

This issue will be fixed in the next one.

5.5 Part Factory

Wrong management of part borders

An inner part with an air region on the bottom border is not allowed (ref.: FXM-13445).

5.6 Script Factory

Scripts cannot be executed.

If the path to the batch file or the working directory in ScriptFactory contains spaces, the script cannot be executed (ref.: FXM-16120).

Script Factory does not stop correctly.

Script Factory does not stop correctly if FluxMotor has been killed. This occurs if the FluxMotor process has been killed externally. Then, Script Factory is not able to get back to a valid state, neither automatically nor after a kill of the process (ref.: FXM-15140).

Sometimes the store button status is bad.

The store button is not enabled when a file is opened without modification (ref.: FXM-15136).

Script Factory freezes temporarily when running a script.

When running a script, the Script Factory gives the impression of freezing (while still running in the background). The editing window of the script becomes unresponsive until the script is done executing (ref.: FXM-13138).

Testing and exporting projects should be prohibited for certain use cases.

For example, testing and exporting of projects with script should be prohibited when slot filling is bad, or when the End-windings X-Factor leads to negative end-windings resistance (ref.: FXM-16455).

The new files are not visible in the tree if the folder is empty

When we open an empty directory, the workspace tree is empty. Using the 'New file' button does not make visible the created files (ref.: FXM-16901).

Name of the motor catalogue (or Part Library) is not case sensitive

When name of catalogues (or Libraries) are written with the same letters but with a mismatch in the name due to the usage of uppercase and lowercase discrepancy, this leads to issues like user cannot access the motor catalogue with name and this prevents us from opening or deleting it (ref.: FXM-16888).

5.7 Supervisor – Preferences

Reboot after changing language fails

While changing the language in Chinese, then in Japanese the automatic reboot of FluxMotor fails (ref.: FXM-15088).