



ALTAIR

ONLY FORWARD

Altair[®] FluxMotor[®] 2024

Release Notes

Updated: 04/19/2024

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Altair support portals are available 24x7 and our global support engineers are available during normal Altair business hours in your region.

When contacting Altair support, specify the product and version number you are using along with a detailed description of the problem. It is beneficial for the support engineer to know what type of workstation, operating system, RAM, and graphics board you have, so include that in your communication.

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See www.altair.com for complete information on Altair, our team, and our products.

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- [1.1 Overview](#) (p. 13)
- [1.2 Documents to read](#) (p. 14)

1.1 Overview

This document gives the major information about Altair® FluxMotor® 2024. 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:

- Three new tests for evaluating the performance of the wound field synchronous machines:
 - The Characterization / Model / Maps
 - The Performance mapping / Efficiency map
 - The computation of a Working Point (I_f , I , Ψ , N)
- Short circuit export for the wound field synchronous machines
- Export of the thermal scheme from FluxMotor to Altair® Flow Simulator™ software
- A major improvement for computing the efficiency maps for synchronous machines
- A new efficient way for importing / exporting Motors in Motor Catalog, and Parts in Part Factory
- A more effective way of considering the magnets in electrical circuit (SMPM machines)
- Correction of issues

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

Architecture and provided functions

Supervisor

Motor Factory

- DESIGN SMPM 3Ph
- TEST SMPM (18)
- DESIGN SMPM nPh
- DESIGN SM RSM
- TEST SM RSM (11)
- DESIGN SM WF ISP
- TEST SM WF ISP (3)
- DESIGN IMSQ
- TEST IMSQ (13)

Motor Factory

- EXPORT
- Report, Script
- HyperStudy
- Flux 2D / 3D / Skew
- FMU (Activate)
- MAT (PSIM-Activate)

Motor Catalog – (With a comparator)

Part Library

Part Factory

Material database

Script Factory

Unit manager

Three new tests for evaluating the performance of the wound field synchronous machines

- The Characterization / Model / Maps
- The Performance mapping / Efficiency map
- The computation of a Working Point (I_f , I , Ψ , N)

Short circuit export for the wound field synchronous machines

- 3-Phase, 2-Phase, and 1-Phase

A major improvement for computing the efficiency maps for Synchronous machines.

Export of the thermal scheme from FluxMotor to Flow Simulator.

A new efficient way for importing / exporting the Motors, and the Parts.

A more effective way for considering the magnets in electrical circuit (SMPM machines).

FluxMotor 2024 – 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.pdf

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

- Supervisor_2024.pdf
- MotorCatalog_2024.pdf
- PartLibrary_2024.pdf
- PartFactory_2024.pdf
- Materials_2024.pdf
- ScriptFactory_2024.pdf
- MotorFactory_2024_Introduction.pdf
- MotorFactory_2024_Test_BestPractices.pdf
- MotorFactory_2024_Windings.pdf

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

- MotorFactory_2024_SMPM_IOR_Design.pdf
- MotorFactory_2024_SMPM_IOR_3PH_Test_Introduction
- MotorFactory_2024_SMPM_IOR_3PH_Test_Characterization.pdf
- MotorFactory_2024_SMPM_IOR_3PH_Test_WorkingPoint.pdf
- MotorFactory_2024_SMPM_IOR_3PH_Test_PerformanceMapping.pdf
- MotorFactory_2024_SMPM_IR_3PH_Test_Mechanics.pdf
- MotorFactory_2024_SMPM_IOR_Export.pdf

Reluctance Synchronous Machines (SM RSM) - Inner Rotor

- MotorFactory_2024_SMRSM_IR_3PH_Design.pdf
- MotorFactory_2024_SMRSM_IR_3PH_Test_Introduction.pdf
- MotorFactory_2024_SMRSM_IR_3PH_Test_Characterization.pdf
- MotorFactory_2024_SMRSM_IR_3PH_Test_WorkingPoint.pdf
- MotorFactory_2024_SMRSM_IR_3PH_Test_PerformanceMapping.pdf
- MotorFactory_2024_SMRSM_IR_3PH_Test_Mechanics.pdf
- MotorFactory_2024_SMRSM_IR_3PH_Export.pdf

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

- MotorFactory_2024_SMWF_ISP_IR_3PH_Design.pdf
- MotorFactory_2024_SMWF_ISP_IR_3PH_Test_Introduction.pdf
- MotorFactory_2024_SMWF_ISP_IR_3PH_Test_Characterization.pdf
- MotorFactory_2024_SMWF_ISP_IR_3PH_Test_WorkingPoint.pdf
- MotorFactory_2024_SMWF_ISP_IR_3PH_Test_PerformanceMapping.pdf
- MotorFactory_2024_SMWF_ISP_IR_3PH_Export.pdf

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

- MotorFactory_2024_IMSQ_IOR_3PH_Design.pdf
- MotorFactory_2024_IMSQ_IOR_3PH_Test_Introduction
- MotorFactory_2024_IMSQ_IOR_3PH_Test_Characterization.pdf
- MotorFactory_2024_IMSQ_IOR_3PH_Test_WorkingPoint.pdf
- MotorFactory_2024_IMSQ_IOR_3PH_Test_PerformanceMapping.pdf
- MotorFactory_2024_IMSQ_IR_3PH_Test_Mechanics.pdf
- MotorFactory_2024_IMSQ_IOR_3PH_Export.pdf

This chapter covers the following:

- [2.1 Wound field synchronous machines - New tests](#) (p. 17)
- [2.2 Wound field synchronous machines - New export](#) (p. 36)
- [2.3 Thermal scheme - Export to Flow Simulator](#) (p. 38)
- [2.4 Efficiency maps - A major improvement](#) (p. 41)
- [2.5 Importing / Exporting Motors and Parts](#) (p. 42)
- [2.6 Magnets in electrical circuit](#) (p. 46)

2.1 Wound field synchronous machines - New tests

2.1.1 The Characterization / Model / Maps

The Characterization / Model / Maps for characterizing the wound field synchronous machines.

Positioning and objective

The aim of the test “Characterization - Model - Motor - Maps” is to give maps along the three dimensions, I_f - J_d - J_q , for characterizing the 3-Phase synchronous machines with wound field.

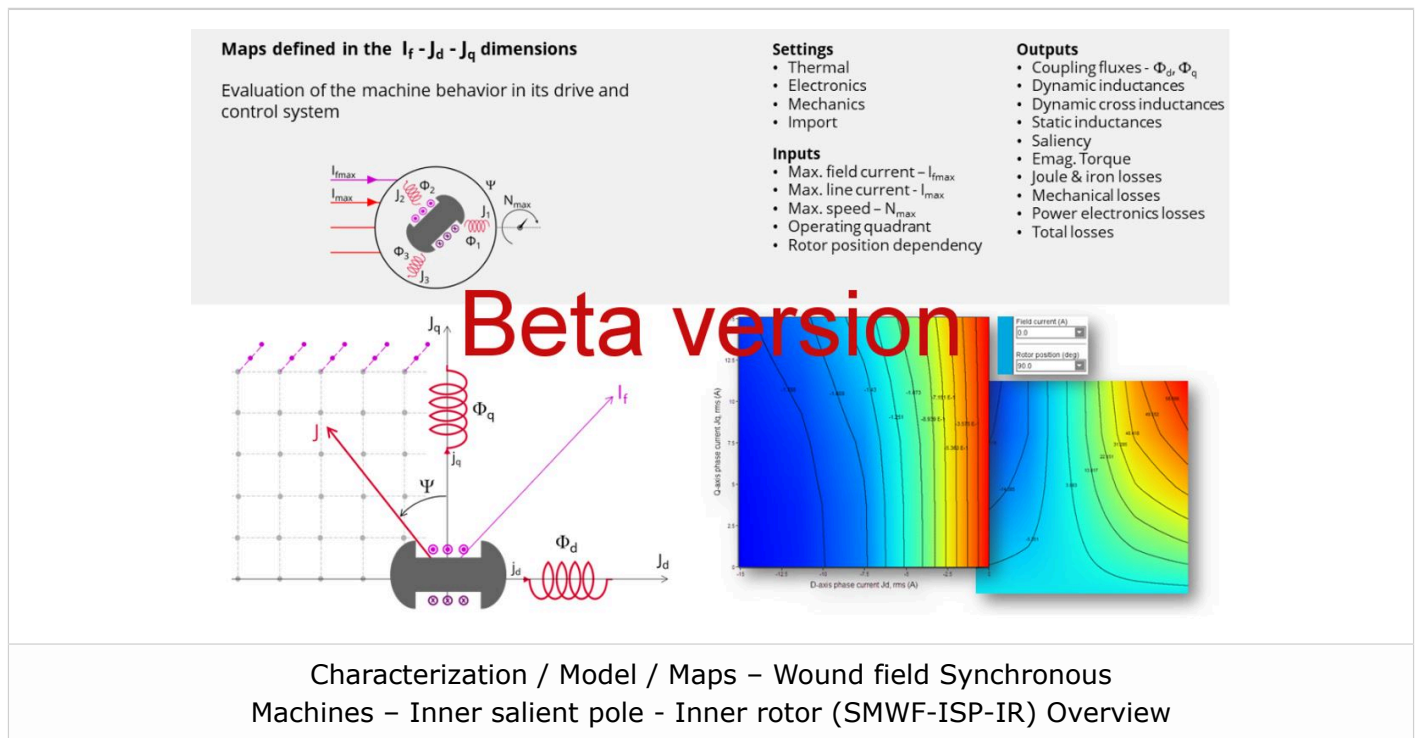
These maps allow for predicting the behavior of the electrical rotating machine at a system level.

In this test, engineers will find a system integrator and / or control-command tool adapted to their needs and able to provide accurate maps ready to be used in system simulation software like Activate.

The performance of the machine in steady state can be deduced from the results obtained in this test in association with the drive and control mode to be considered.

! **Important:** This 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.

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



User inputs

Maps are mainly function of the following user inputs: the maximum value of the field current, the maximum value of the line current, the speed, the number of quadrants to be considered, and the rotor position dependency.

Among the standard inputs, the operating quadrants can be selected. Options allow computing and displaying 1, 2, or 4 quadrants.

This allows defining the quadrants in the $J_d - J_q$ plane where the test will be carried out.

By default, the considered quadrants are "1st and 2nd" (i.e., the grid is defined for both negative and positive values of the current in the d axis and positive ones in the q axis). This option is chosen as the default because the Synchronous Machine with wound field heritages the characteristics of both Synchronous Machine with Permanent Magnets and Reluctance Synchronous Machines which work respectively in the second and first quadrant in the motor operating mode.

The other possible values for this input are "2nd", "2nd and 3rd", and "all".

! **Important:** The set of inputs and Flux data can be imported from a test that has already been performed in Motor Factory test environment – Performance Mapping – Efficiency maps.

Please see additional information in the section below (the import button allowing sharing the data simulated in Flux between model map and efficiency tests).

Main outputs

Different kinds of outputs are displayed like data, maps, and curves.

Here is a list of results that can be provided and displayed within the framework of this test.

Maps in the three dimensions $I_f - J_d - J_q$

- Flux linkage
 - D-axis flux-linkage Φ_d
 - Q-axis flux-linkage Φ_q
 - Flux linkage derivative (only when the rotor position dependency is considered)
 - D-axis flux-linkage derivative with respect to the rotor position $d\Phi_d/d\theta_r$
 - Q-axis flux-linkage derivative with respect to the rotor position $d\Phi_q/d\theta_r$
- Inductance
 - D-axis inductance (dynamic, cross dynamic and static)
 - Q-axis inductance (dynamic, cross dynamic and static)
- Saliency
- Electromagnetic torque T_{em}
- Losses
 - Stator iron losses $W_{ironStator}$ versus speed
 - Rotor iron losses $W_{ironRotor}$ versus speed (only when the rotor position dependency is considered)
- Total losses W_{total} versus speed

Maps in the two dimensions Jd - Jq

- Losses
 - Joule losses WCus in stator winding
 - Power electronics losses

Curves

- Field current flux and cross effect flux curve versus Jq
- Joule losses WCur in rotor winding versus field current
- Mechanical losses versus speed versus speed

Characterization / Model / Maps – Wound field Synchronous Machines – Inner salient pole - Inner rotor (SMWF-ISP-IR)

Inputs / Outputs in the test area - Illustration

Main principles of computation

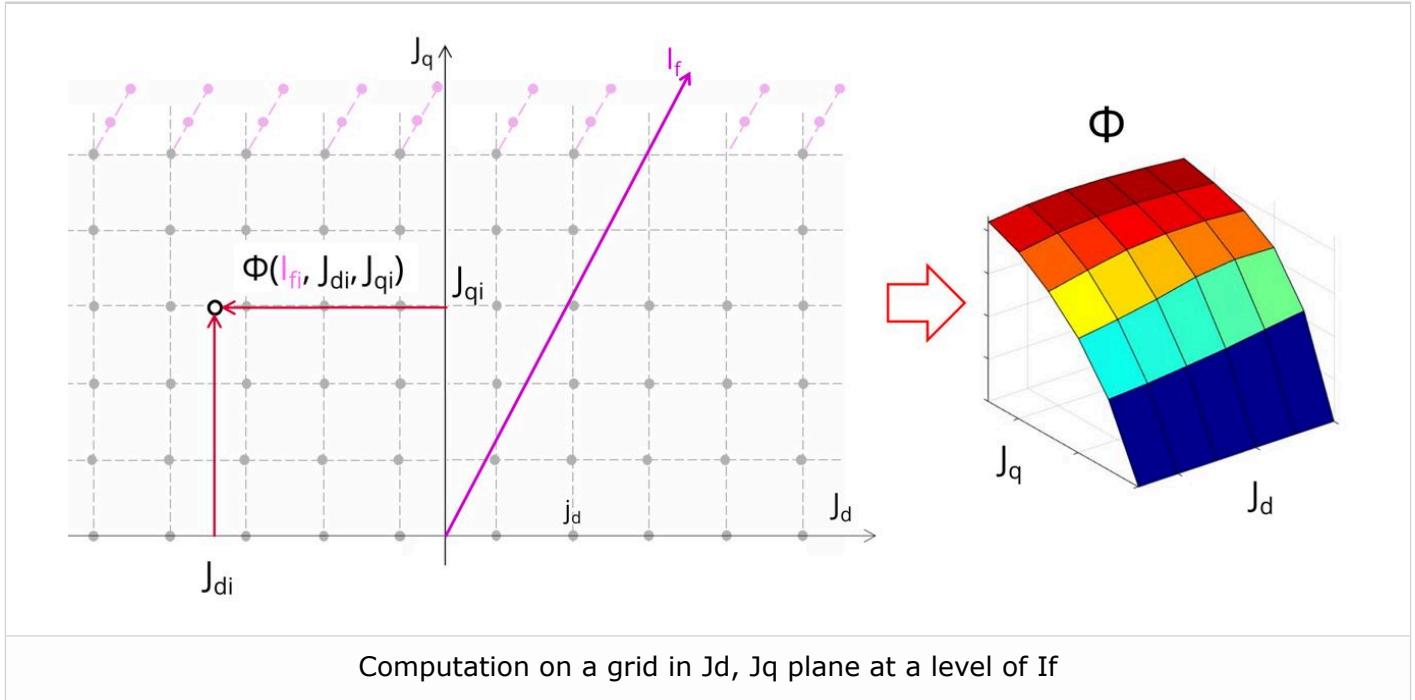
One of the goals is to compute the D-axis and Q-axis flux linkage in the Jd, Jq planes at different levels of If between zero and the maximum value of If.

At each level of If, a grid of values (Jd, Jq) is considered. Finite Element modeling (Flux® software – Magnetostatic application) is then performed at every node of the grid. The corresponding flux linkage through each phase is extracted (#a, #b, #c) through the corresponding phases (a, b, c).

D-axis flux-linkage component - #d and Q-axis flux-linkage component - #q are deduced according to Park's transformation.

Next, the other outputs listed in the previous section are derived from analytical formulars.

For more details, refer to MotorFactory_2024_SMWF_ISP_IR_3PH_Test_Characterization.pdf.




Note: In the examples shown in the images, negative value of J_d and positive value of J_q are considered as the 2nd quadrant is chosen as example. However, the considered quadrants can be chosen through dedicated input (e.g., user can choose all quadrants or only the 2nd, the 2nd and 3rd ones, etc.), allowing the characterization of the machine behavior for other control conditions.


Note: In case the rotor position dependency is set to "Yes", the computation is done in the three dimensions $I_f - J_d - J_q$ with an additional fourth axis corresponding to the rotor position θ_r . As has been stated for other types of machines, the rotor position dependency mode provides more accurate results than without rotor position dependency.

2.1.2 Half electrical period computation for the Characterization / Model / Maps test of synchronous machines

The user input "No. computed elec. periods" (Number of computed electrical periods only required with rotor position dependency set to "Yes") influences the computation time of the results. A new option for this input has been added allowing the computation in a half electrical period and hence reducing the computation time by a half while maintaining the identical accuracy.

The default value of "No. computed elec. periods" is equal to 0.5. The maximum allowed value is always 1, according to the fact that computation is done to characterize steady state behavior based on magnetostatic finite element computation.

 **Note:** The outcomes obtained at 0.5 or 1 electrical period are identical across all presented outputs, except for slight variations in rotor iron losses arising from the symmetrical assumption regarding the magnetic flux waveform on the rotor.

 **Note:** This improvement concerns Synchronous Machines with Permanent Magnets (SMPM), Reluctance Synchronous Machine (RSM), and Synchronous Machines with wound field – Inner salient pole - Inner rotor (SMWF-ISP-IR) as well

Illustrations of results depending on the user's inputs dealing with "No. computed elec. periods" ("0.5" or "1").

The image displays two electromagnetic torque plots in the Jd-Jq area, comparing the results of a half electrical period and one electrical period simulation. The top plot shows the torque distribution for a half electrical period, with a maximum rotor angular position of 89.999 degrees. The bottom plot shows the torque distribution for one electrical period, with a maximum rotor angular position of 134.999 degrees. The input parameters for both simulations are shown in the 'Map' window, with the 'No. computed elec. periods' parameter highlighted in red and set to 1/2 for the top simulation and 1 for the bottom simulation.

Half electrical period from initial position

Map	
Thermal Electronics Mechanics	
INPUTS	
Operating quadrants	2nd
Max. current dens., rms (A/mm ²)	6.0
Maximum speed (rpm)	6 000.0
Rotor position dependency	Yes
No. computed elec. periods	1/2
No. comp. / elec. period	1/2
No. comp. for Jd, Jq	1
No. comp. for speed	10
Rotor initial position (deg)	Auto
Mesh order	2nd
Airgap mesh coefficient	1.5

One electrical period from initial position

Map	
Thermal Electronics Mechanics	
INPUTS	
Operating quadrants	2nd
Max. current dens., rms (A/mm ²)	6.0
Maximum speed (rpm)	6 000.0
Rotor position dependency	Yes
No. computed elec. periods	1
No. comp. / elec. period	40
No. comp. for Jd, Jq	6
No. comp. for speed	10
Rotor initial position (deg)	Auto
Mesh order	2nd
Airgap mesh coefficient	1.5

Electromagnetic torque in Jd - Jq area

Maximum rotor angular position with half electrical period option (1) in the drop-down menu, and maximum rotor angular position with one electrical period option (2) in the drop-down menu

2.1.3 The Performance mapping / Efficiency map

The Performance mapping / Efficiency map for evaluating the performance of the wound field synchronous machines.

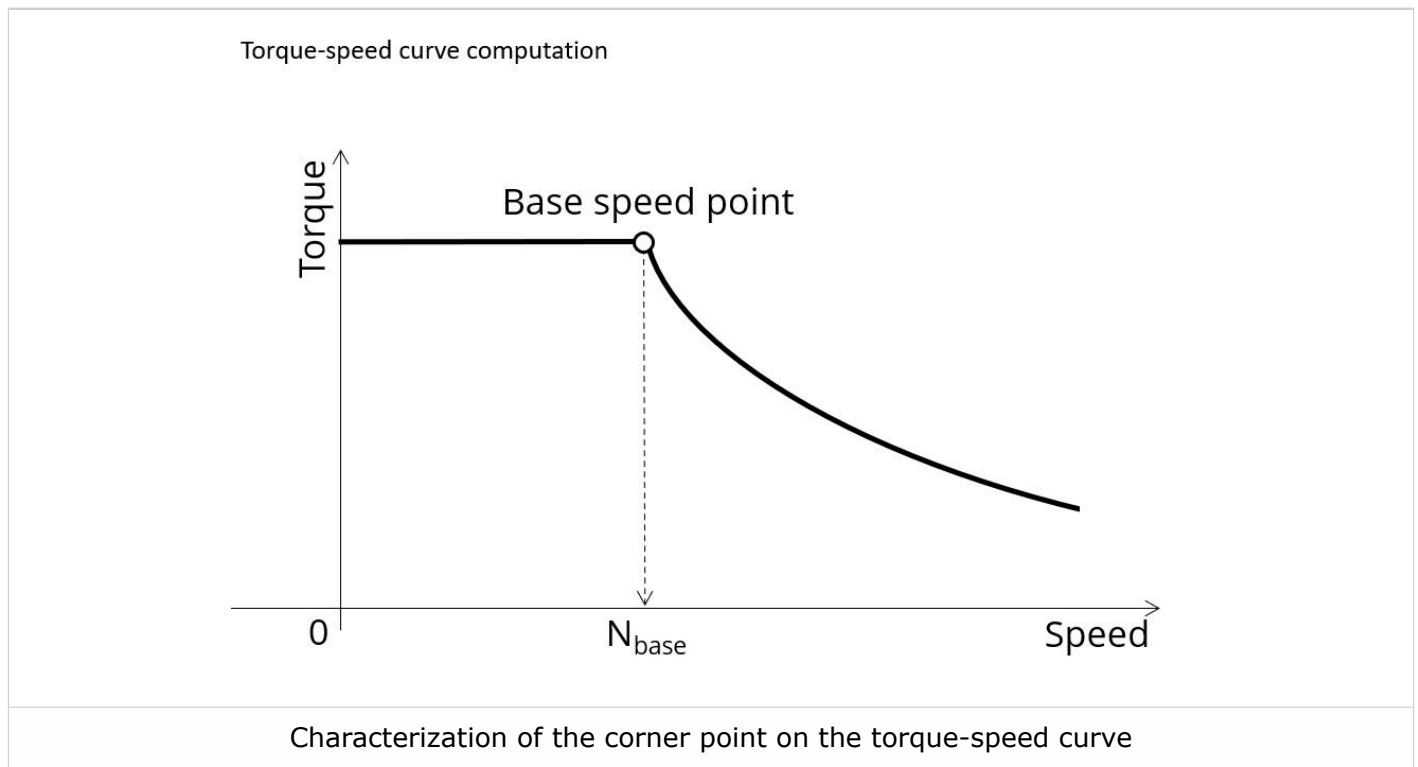
Positioning and objective

The aim of the test "Performance mapping – Sine wave – Motor – Efficiency map" is to characterize the behavior of the machine in the "Torque-Speed" area.

Input parameters like the maximum "Field current", the maximum "Line current", maximum "Line-Line voltage", and the desired "Maximum speed" of the machine are considered.

Only the Maximum Torque Per Volt command mode (MTPV) is available in this version. The Maximum Torque Per Amps command mode (MTPA) will be provided in the next releases.

Input parameters define the torque-speed area in which the evaluation of the machine's behavior is performed.



! **Important:** This 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.

Here is an overview of the test, given below.

Machine behavior in the torque-speed area

Overview of the electromagnetic behavior of the motor according to its speed

Settings

- Thermal
- Electronics
- Mechanics

Inputs

- Max. field current - I_{fmax}
- Max. line current - I_{lmax}
- Max. Line-Line voltage - U_{max}
- Command mode
- Max. speed - N_{max}
- Rotor position dependency
- User working points

Outputs

- Base speed data
- Max. speed data
- User working point data
- Torque vs speed
- Efficiency map
- Current
- Voltage
- Control angle
- Power
- Power factor
- Losses

Beta version

Performance mapping / Efficiency map – Synchronous Machines with wound field – Inner salient pole - Inner rotor (SMWF-ISP-IR) - Overview

User inputs

The main user input parameters needed to perform this test are the maximum allowed supplied, field current, line current, line-line voltage, the targeted maximum speed, and the command mode. Winding temperatures must also be set.

When required, the location of the working points (single point or duty cycle) to be evaluated must be defined as inputs.

Warning: The default values of advanced inputs have been set to get the best compromise between accuracy and computation time.

Four advanced user input parameters allow adjusting the compromise between accuracy and computation time: the number of computations for J_d - J_q , the number of computations for I_f , for speed, and for torque.

Important: The set of inputs can be imported from a test that has already been performed in Motor Factory test environment – Characterization – Model - Maps.

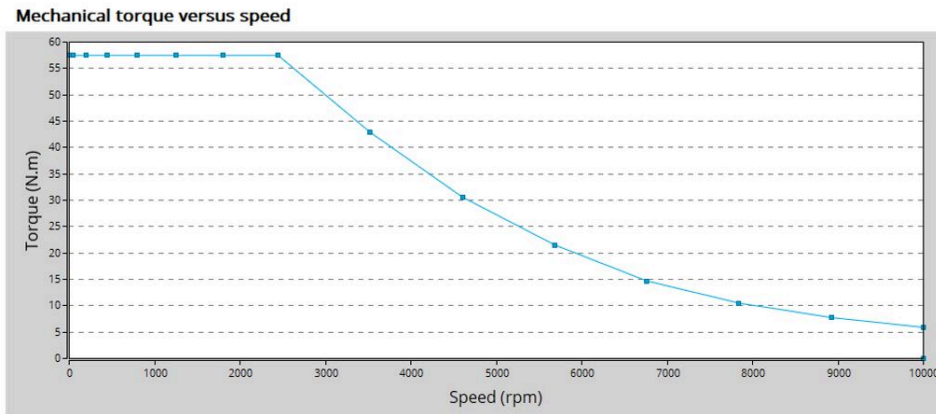
Please see additional information in the section below (the import button allows sharing the data simulated in Flux between model map and efficiency tests).

Main outputs

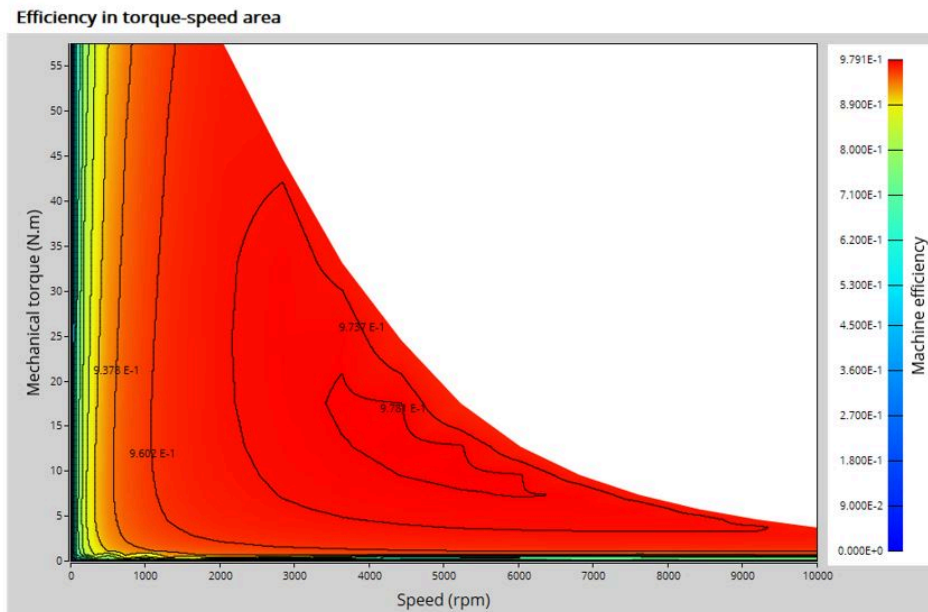
Different kinds of outputs are displayed, like data, curves, maps, and tables.

In the results, the performance of the machine at the base point (the base speed point) and for the maximum speed set by the user are presented. A set of curves (like Torque-Speed curve) and maps (like Efficiency map) are computed and displayed.

Here are below illustrations of some results that can be provided in the test.



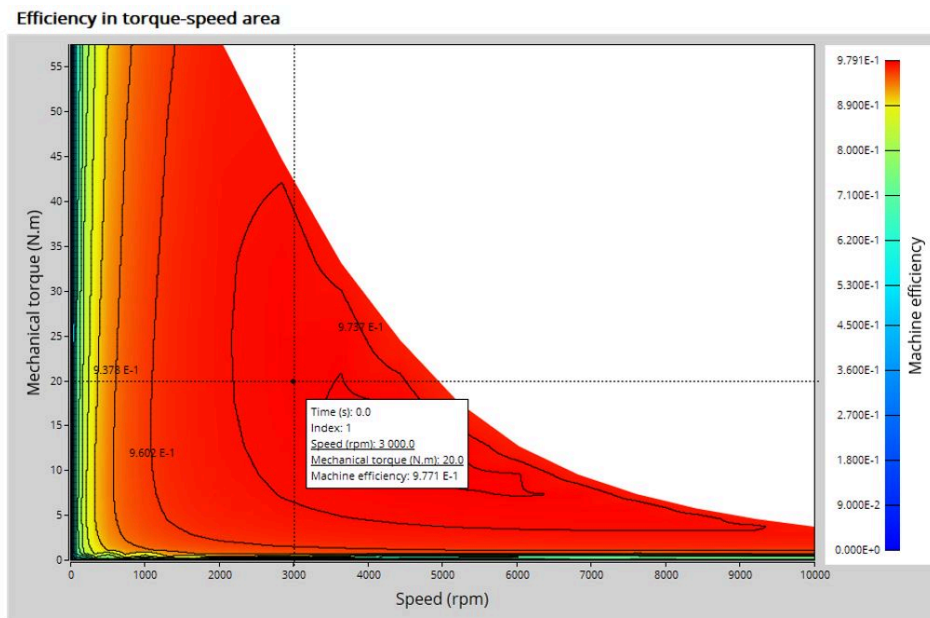
Mechanical torque versus speed - Example



Efficiency in torque-speed area - Example

Two additional features are available in this test. The first one allows extracting one torque-speed point from the efficiency map to get the machine performance, for this specific working point (general data + power balance).

Note: The considered working point is then displayed on all the maps available. The working point can be selected to visualize the corresponding main information.

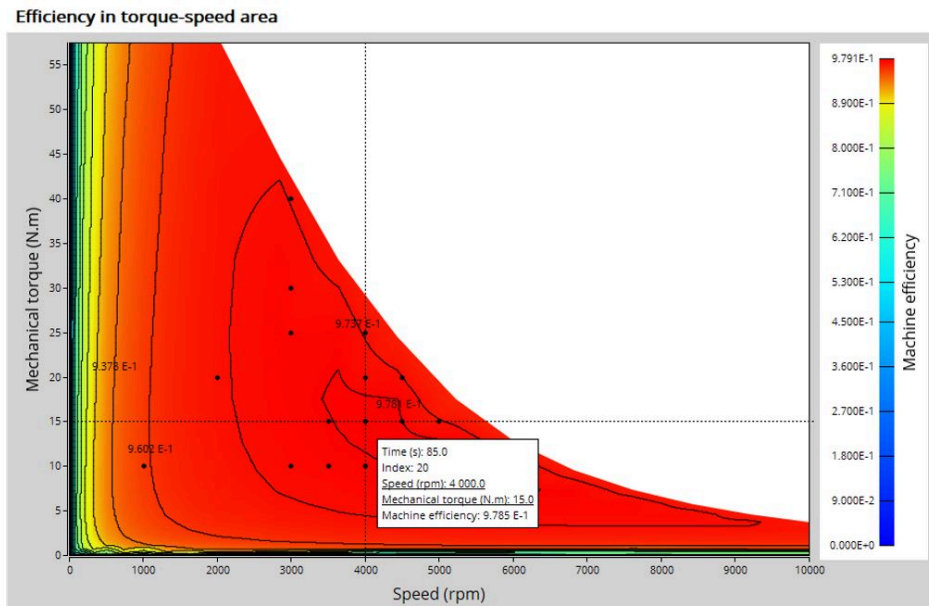


A "single" working point displayed on the efficiency map - Example

The second feature allows the user to define a duty cycle by giving a list of working points (speed, torque) versus time. The displayed results illustrate the machine performance over the considered duty cycle (mean, min, and max values).

The time variation of the main quantities is also displayed (mechanical torque, speed, control angle, current, voltage, power, efficiency, and losses).


All the corresponding points are displayed on the different map provided. Each working point can be selected to visualize the corresponding main information.



A "Duty cycle" displayed on the efficiency map - Example

Other main test results

- Machine performance - Base speed point
- Machine performance - Maximum speed
- Machine performance - User working point (when requested)
- Machine performance - Duty cycle analysis (when requested)
- Power electronics (when requested by the user)
- Torque-speed curves and maps
- Efficiency in torque-speed area
 - Current (I_f , J , J_d , J_q) in torque-speed area
 - Voltage (V_f , V , V_d , V_q) in torque-speed area
 - Control angle in torque-speed area
 - Power in the torque-speed area (machine electrical power, stator electrical power, excitation power, mechanical power, system electrical power) in the torque-speed plane
 - Power factor in torque-speed area
 - Losses in the torque-speed area (total, Joule, iron, mechanical, power electronics, and additional) in the torque-speed plane
- Duty cycle curves (when requested)

 **Note:** When a user working point has been targeted or if a duty cycle is considered, the corresponding working points are displayed on all the maps described above.

In the results, the performance of the machine at the base point (base speed point) and for the maximum speed set by the user are presented.

A set of curves (like Torque-Speed curve) and maps (like Efficiency map) are computed and displayed.

Main principles of computation

The process to get the torque-speed curves and maps (For example - efficiency map) is separated into the two following parts:

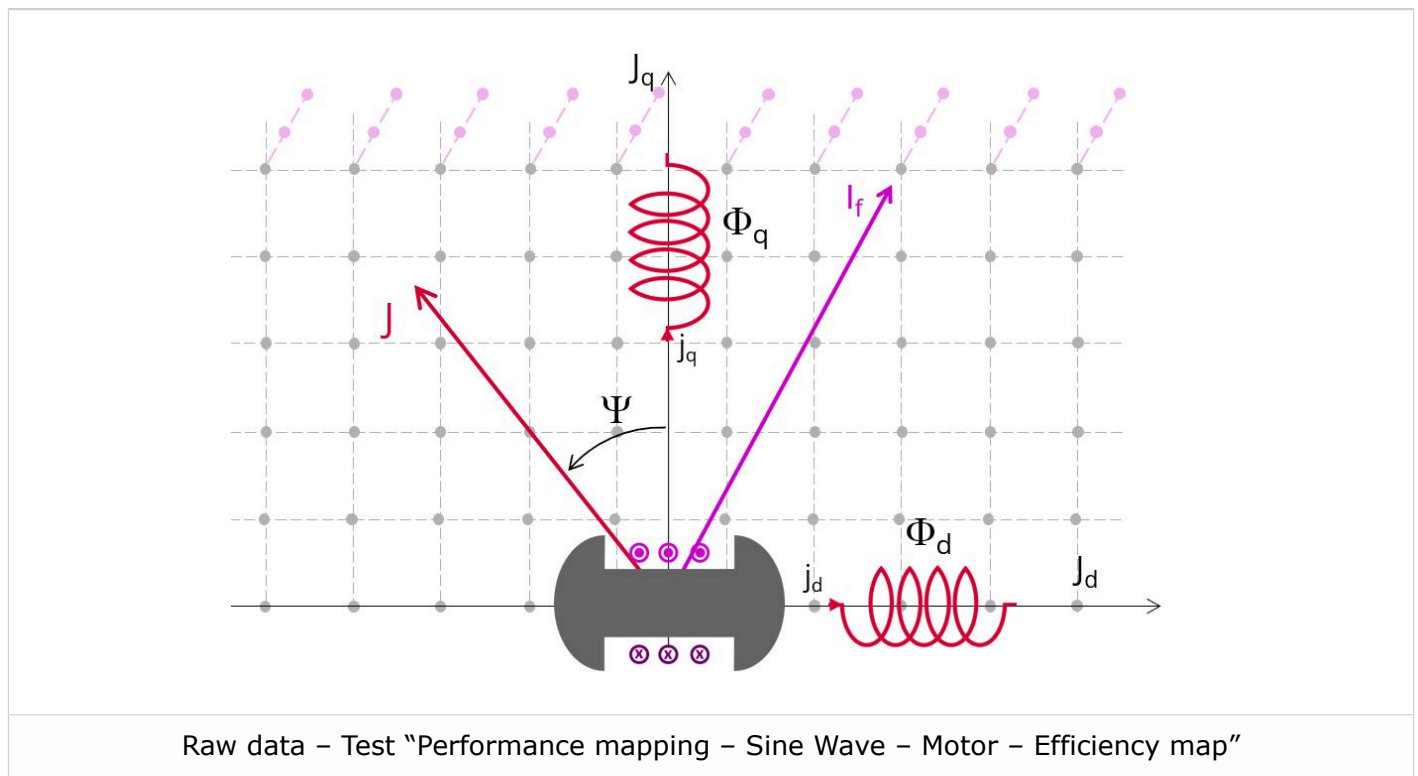
- Raw data and Park's model
- Identification of the torque-speed curves and maps

Raw data and Park's model

The first step consists of computing the raw data that characterizes the machine in the three dimensions I_f - J_d - J_q . This is done using Finite Element modelling (Flux® – Magnetostatic application).

To do that, a grid of values (J_d , J_q) is considered for all levels of I_f .

For each node of this grid, the corresponding flux linkage through each phase is extracted (#a, #b, #c). Flux density in regions (teeth and yoke of the machine) is also extracted.



The second step consists of using the raw data with Park's model.

D-axis flux-linkage component (#d) and Q-axis flux-linkage component (#q) are computed according to the Park's transformation.

The Electromagnetic torque T_{em} is computed in different ways as a function of the input rotor position dependency value.

If rotor position dependency is set to "No", the flux linkage maps, and the following formula are used:

$$T_{em} = \frac{m}{2} \times p \times (\Phi_d \times J_q - \Phi_q \times J_d)$$

Where m is the number of phases (3) and p is the number of pole pairs. J_d and J_q are the d and q axis peak current.

If rotor position dependency is set to "Yes", the Electromagnetic torque T_{em} is computed thanks to finite element computation and the virtual work method to get the best evaluation of the ripple torque.

Note: In case the rotor position dependency is set to "Yes", Electromagnetic torque T_{em} average value computed with Park's equation or with virtual works is equal.

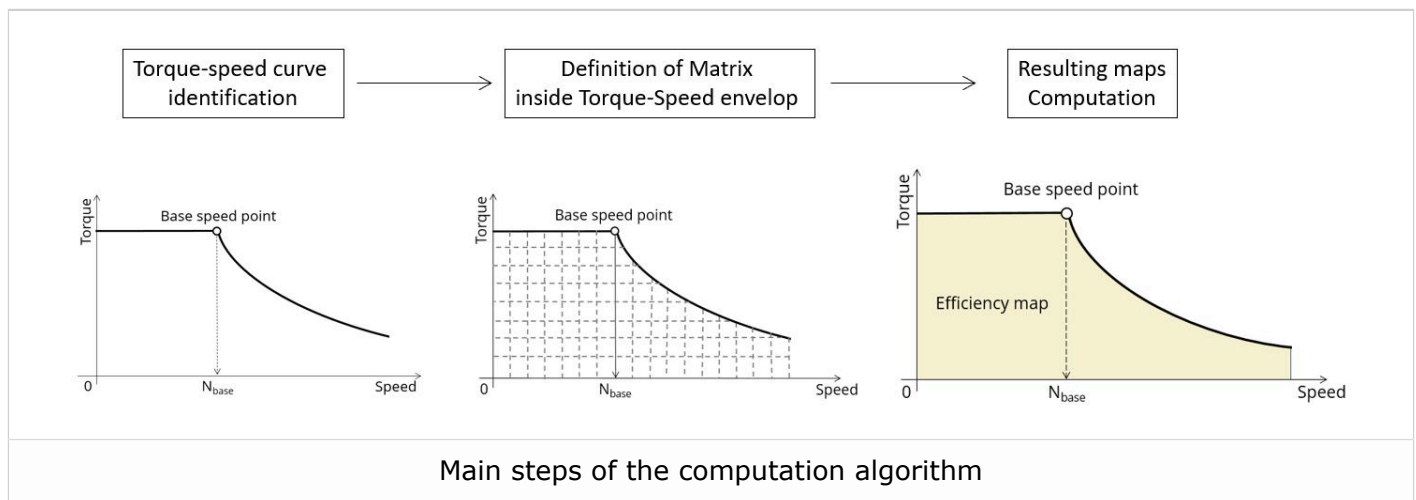
Note: The computations are the same as those performed in the test "Characterization - Model - Motor - Maps" with or without rotor position dependency.

Identification process for the torque-speed curves and maps

Below are the three main steps involved in building the efficiency map and other associated results.

These steps are performed by using the computed raw data (see previous section) with optimization processes.

- Building of the torque-speed curve and other associated results
- Define the grid in the area under the torque-speed curve
- Building of the efficiency map and other associated results




For more information, refer to MotorFactory_2024_SMWF_ISP_IR_3PH_Test_PerformanceMapping.pdf

2.1.4 The import button allows sharing the data simulated in Flux between model map and efficiency tests

By implementing the rotor position dependency option for the model map test and efficiency map test of synchronous machines, this update facilitates the seamless transfer of settings, inputs, and crucially, simulated data in Flux between the two tests. As they use the same Flux data in most cases and significant computation time is required to obtain it, users can now accelerate the test resolution and optimize their workflow.


To streamline this process, an import button has been introduced in both the model map and efficiency map tests of the following machines:


- Reluctance Synchronous Machines - Inner rotor
- Synchronous Machines with wound field – Inner Salient Pole - Inner rotor


 **Note:** The import button will be added to the tests of Synchronous machines – Permanent magnets - Inner & Outer rotor in the next version.


Upon completing a model map test, users can activate the import button in the efficiency map test GUI. This enables them to effortlessly import the settings and corresponding Flux data from the previous test, eliminating the need to rerun Flux for identical data, a step that typically consumes a substantial portion of computation time during efficiency mapping.

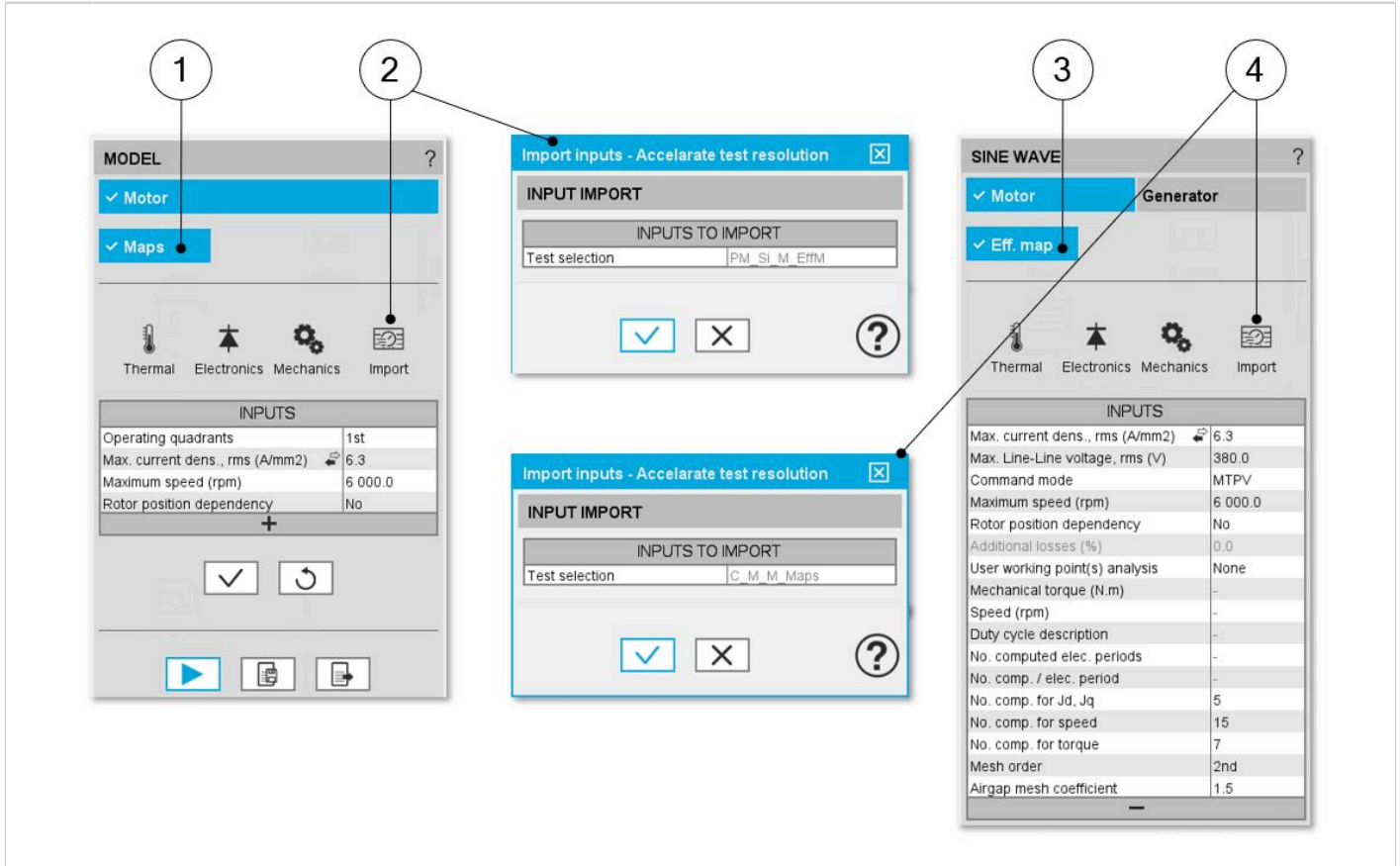
Conversely, upon concluding an efficiency map test, users can use the import button in the efficiency map test GUI to import settings and Flux data from the efficiency map test, further enhancing workflow efficiency.

 **Note:** Only the most recent test results can be imported, saved test results are not yet able to be imported.

 **Note:** While there are shared settings and inputs between the tests, each test may have its own unique settings and inputs. In such cases, the default settings and inputs of the second test are automatically applied.

 **Note:** When importing from the efficiency map test to the model map test, the quadrant setting defaults to the value specified in the model map test. For certain machine types (SMWF: 1st and 2nd quadrants, SM-RSM: 1st quadrant), specific quadrant selections are applied.

 **Note:** In instances where quadrant inputs lead to incompatibility between the model map test and the efficiency map test, only settings and inputs are imported. A warning is issued, and Flux simulation is initiated to rectify the discrepancy.



Import function in Model Map test and Efficiency Map test to accelerate test resolution

1	Open model map test environment when an efficiency map test is available for import
2	Click the import button and import the settings, inputs, and Flux data of the latest efficiency map test
3	Open efficiency map test environment when a model map test is available for import
4	Click the import button and import the settings, inputs, and Flux data of the latest model map test

2.1.5 The computation of a Working Point

The computation of a Working Point (If, I, Ψ , N) for evaluating the performance of the wound field synchronous machines

Positioning and objective

The aim of the test “Working point – Sine wave – Motor – If, I, Ψ , N” is to characterize the behavior of the machine when operating at the targeted input values If, I, #, N (magnitude of field current, magnitude of current, control angle, speed).

These three inputs are enough to impose a precise working point.

For instance, a working point can be chosen on the efficiency map by identifying the field current, current, the control angle, and the speed with different curves or maps displayed in the “Performance mapping / Sine wave / Motor / Efficiency map” test. Then, the “Working point – Sine wave – Motor – If, I, Ψ , N” test allows to compute the performance for this working point.

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 motor convention is used to build the model.

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

Two computation modes are available:

- “Fast computation mode” is perfectly suited for the pre-design step (Hybrid model based on Magneto-Static Finite Element computations and Park transformation theory)
- “Accurate computation mode” is perfectly suited for the final design step (Pure Finite Element modeling based on transient computations)

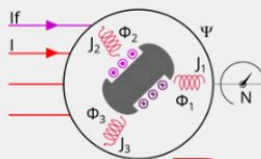
It also gives the capability to make comparisons between the results obtained from the measurements and those obtained with Altair® FluxMotor®.

 **Important:** This 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.

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

Identifying a working point defined by targeted field current I_f , current I , control angle Ψ and speed N

Overview of the resulting electromagnetic behavior of the motor



Settings

- Thermal
- Electronics
- Mechanics

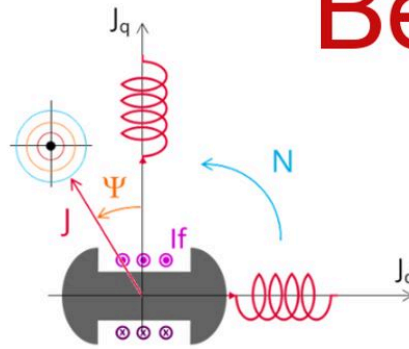
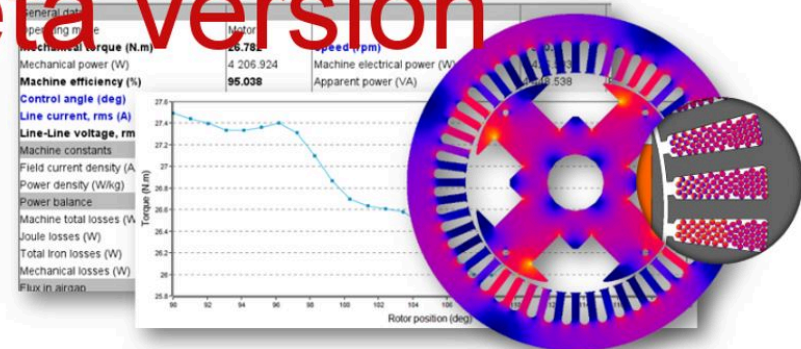
Inputs

- Field current - I_f
- Line current - I
- Control angle - Ψ
- Speed - N

Outputs

- General data
- Machine constants
- Power balance
- Flux in airgap
- Flux density in iron
- Ripple torque
- Flux density isovalues
- AC losses
- Iron losses (stator, rotor)

Beta version

Working point – Sine wave – Motor – I_f , I , Ψ , N – Synchronous Machines with wound field – Inner salient pole - Inner rotor (SMWF-ISP-IR) - Overview

User inputs

The four main user input parameters are the field current, supply line current, control angle, speed, and computation mode. In addition, the temperatures of the windings must be set.

Main outputs

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

Main results

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

Curves – in the “Fast computation modes”

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

Curves – in the “Accurate computation modes”

- Mechanical torque versus rotor angular position
- Mechanical torque harmonic analysis
- Flux density in airgap versus rotor angular position
- Flux density in airgap harmonic analysis
- Field voltage versus rotor angular position
- Field current versus rotor angular position
- Phase voltage versus rotor angular position
- Phase voltage harmonic analysis
- Phase current versus rotor angular position
- Phase current harmonic analysis

Graphics

- Isovalues

Main principles of computation

The aim of this test in motor convention is to give a good overview of the electromagnetic potential of the machine by characterizing the working point according to the field current, line current, control angle, and speed set by the user.

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

Two computation modes are available:

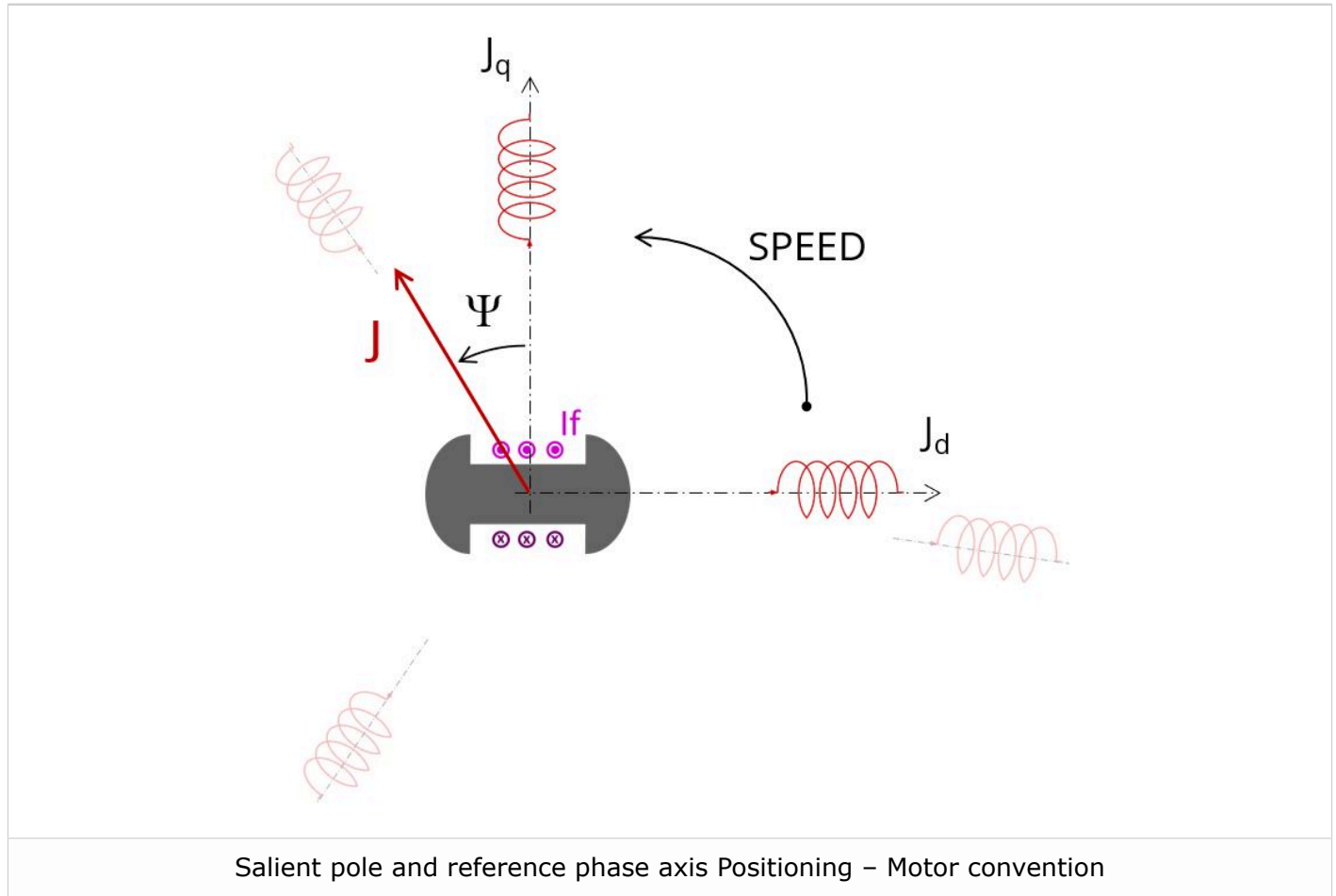
- “Fast computation mode” is perfectly suited for the pre-design step to explore the space of solutions quickly and easily (Hybrid model based on magnetostatic FE computations and Park transformation).
- “Accurate computation mode” is perfectly suited for the final design step because it allows for getting more accurate results and to compute additional quantities like the AC losses in winding and rotor iron losses (Pure FE model based on transient computations).

Fast computation mode

To compute the working point, the principle consists of positioning the salient pole towards the reference phase axis by considering the targeted control angle.

At the same time, the targeted field current, line current, and speed are imposed.

Then, the resulting behavior of the machine can be simulated, and all the main electromagnetic characteristics of the machine can be deduced by using Park’s transformation and associated electric equations.



The method used for the computation of electromagnetic behavior depends on whether ripple torque analysis is set to “Yes” or “No”:

- “Yes” is selected: The analysis of the electromagnetic behavior is done over one ripple torque period.
- “No” is selected: The analysis of the electromagnetic behavior is done through a dedicated static computation (1 rotor position to be considered) for the computed working point (with field current, line current, control angle, and speed obtained for the working point).

For more information, refer to [MotorFactory_2024_SMWF_ISP_IR_3PH_Test_WorkingPoint.pdf](#).

Accurate computation mode

Working point computation is based on a transient magnetic finite element simulation over a half, one, or several electrical periods for a given set of inputs: field current, line current, control angle, and speed, defined as for the Fast computation mode.

Thus, all the main electromagnetic characteristics of the machine can be deduced accurately.

All the main quantities are directly computed from the Flux® software in the framework of a transient magnetic finite element simulation.

For more information, refer to [MotorFactory_2024_SMWF_ISP_IR_3PH_Test_WorkingPoint.pdf](#).

2.2 Wound field synchronous machines - New export

Short circuit export for the wound field synchronous machines

The aim of the export "Characterization - Short circuit - Motor & Generator - Three / Two / Single Phase" is to characterize the behavior of the machine, when considering a short circuit happening between three phases, two phases or a single phase.

The resulting model is fully parameterized, and it is built in the Flux® 2D / Skew environment, transient application.

The type of short circuit can be chosen from a list of choice:

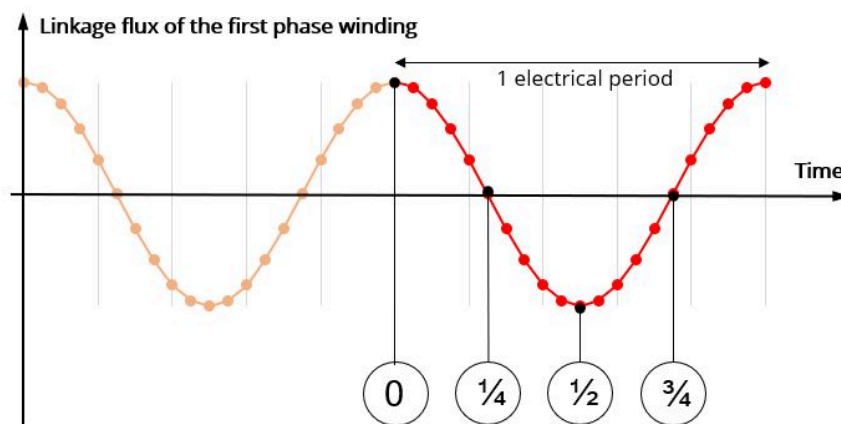
- Three-phase: the three phases of the stator windings are short circuited.
- Two-phase: the first phase and second phase of the stator windings are short circuited.
- Single-phase: the first phase of the stator windings is short circuited.

In the Flux project, the field winding is supplied by a voltage source to fully simulate the transient behavior of the machine.

And the scenario is piloted in time instead of rotor position. The scenario can be tuned via the number of points per electrical period, the number of electrical periods in the open circuit state, in the short circuit state and the short circuit instant.

The short circuit instant is the most important factor causing the different behavior of the short circuit transient curve. It can be chosen from a list of choice:

- Instant 0: the linkage flux of the first phase winding is supposed to be maximum.
- Instant $1/4$: the linkage flux of the first phase winding is supposed to be zero.
- Instant $1/2$: the linkage flux of the first phase winding is supposed to be minus maximum.
- Instant $3/4$: the linkage flux of the first phase winding is supposed to be zero.



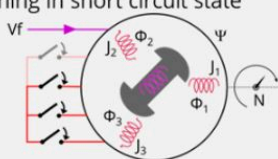
Short circuit instant illustration

Here below is an overview of the export “Characterization - Short circuit – Motor & Generator – Three / Two / Single Phase”.

Export a model for transient magnetic application in Flux2D environment

Solving scenario for the test:
Characterization / Short circuit / Motor & Generator / Three / Two / Single phase

Machine behavior when running in short circuit state

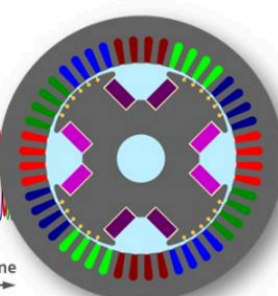
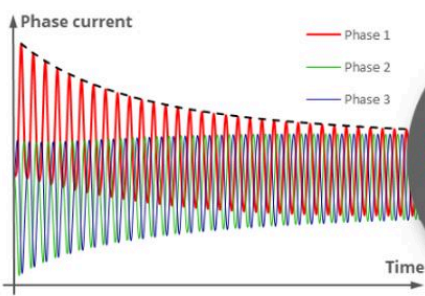


Settings

- Thermal

Inputs

- Type of short circuit
 - Three phase
 - Two phase
 - Single phase
- Field voltage – Vf
- Speed – N
- Short circuit instant



- 1. TEST SELECTION
Select the test to be modeled
- 2. TEST CONFIGURATION
Define the default values of the test inputs
- 3. EXPORT INFORMATION
Finalize the export process

Export – Characterization – Short circuit – Motor & Generator – Three / Two / Single Phase – Synchronous Machines with wound field – Inner salient pole - Inner rotor (SMWF-ISP-IR) - Overview

2.3 Thermal scheme - Export to Flow Simulator

Flow Simulation export for Inner Rotor Permanent Magnet Synchronous Machines

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 Flow Simulator™, it corresponds to the thermal model used in Flux Motor® to run both thermal and coupled tests.

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.

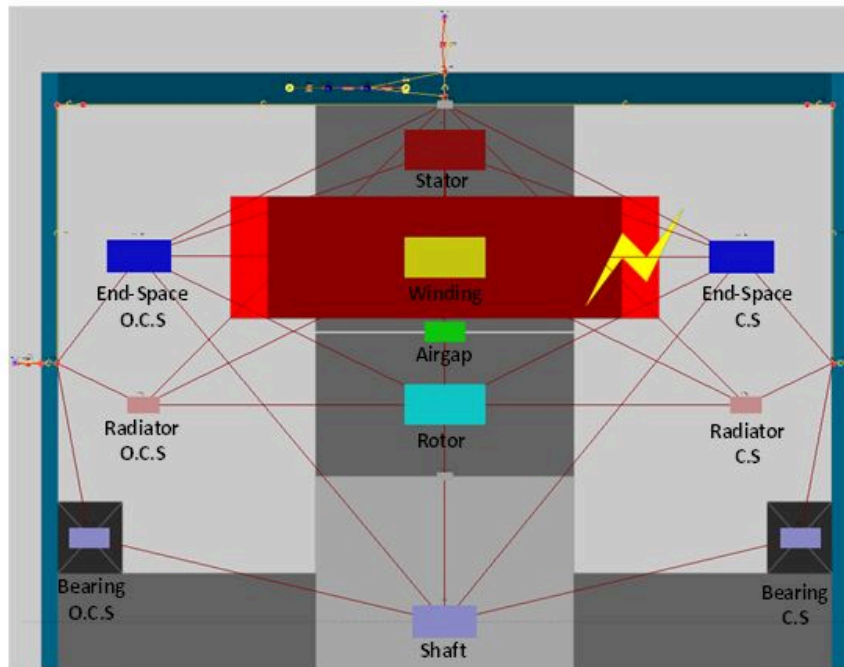
Generalized lumped thermal network.

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 modelled through variable parametrization. These regions are the shaft, the bearings, and the housing (endcaps included).

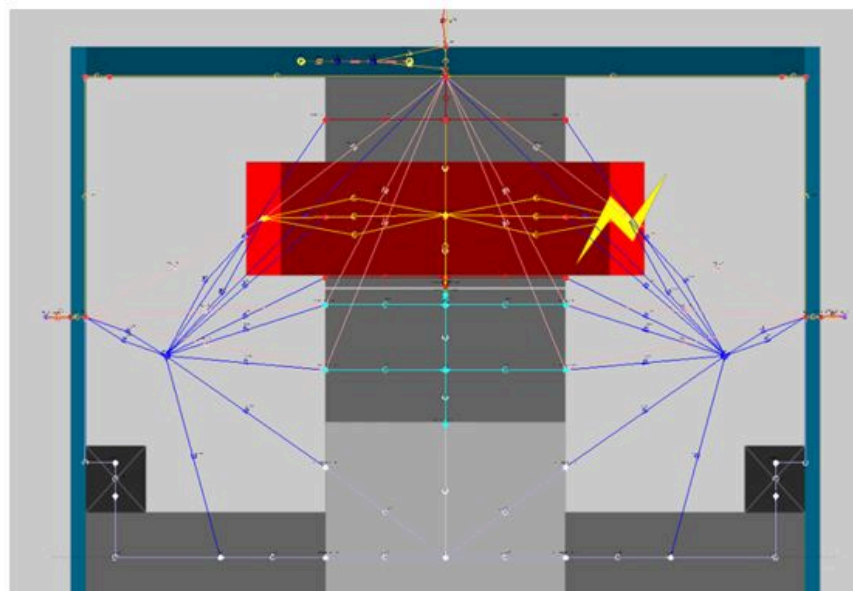
On the contrary, the local grid of some regions is highly dependent on the chosen topology and should be particularized to achieve the essential goals of maximum customization and versatility during the design stage. These regions are mainly the rotor and the stator (including the winding). Due to their 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 Flux 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 dedicated to the “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 Simulator™. Global view



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

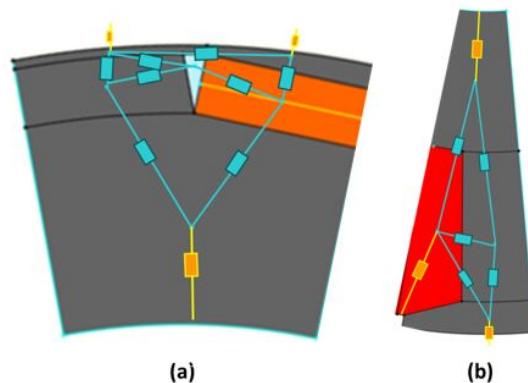
Customizable stator and rotor grids – The constellation method

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 Efficiency maps - A major improvement

A major improvement for computing the efficiency maps of synchronous machines.

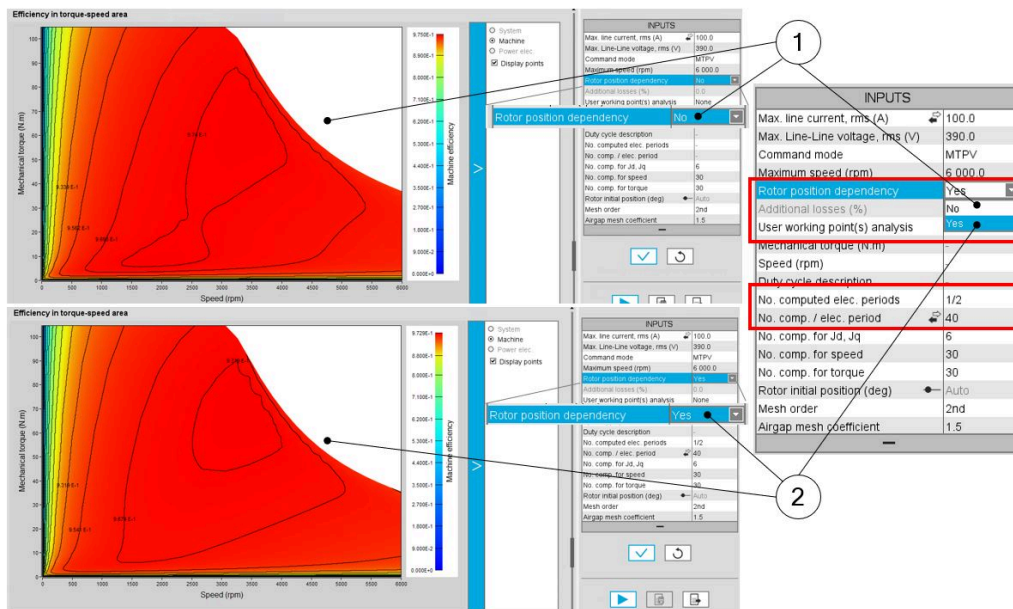
An enhanced efficiency mapping model is introduced, integrating rotor position dependency into the analysis of all synchronous machines, including Synchronous Machines with Permanent Magnets (SMPM), Reluctance Synchronous Machine (RSM), and Synchronous Machines with wound field – Inner salient pole - Inner rotor (SMWF-ISP-IR).

This upgraded process delivers a more accurate efficiency map by precisely estimating electromagnetic torque and stator iron losses while also considering previously neglected rotor iron losses.

Users now have the option to select and fine tune the rotor position dependency mode, offering greater flexibility and control.

Note: All inputs related to the rotor position dependency mode are commonly shared between the model map test and the efficiency map test. Therefore, the latest half electrical period option for “No. computed elec. periods” is also available for the efficiency map test.

Note: For a detailed comparison between the classic approach and the new model in terms of accuracy and computation time, refer to the "Best practices" section of the User Help Guide.



Efficiency map without (1) and with (2) rotor position dependency of a Synchronous Machines with Permanent Magnets (SMPM)

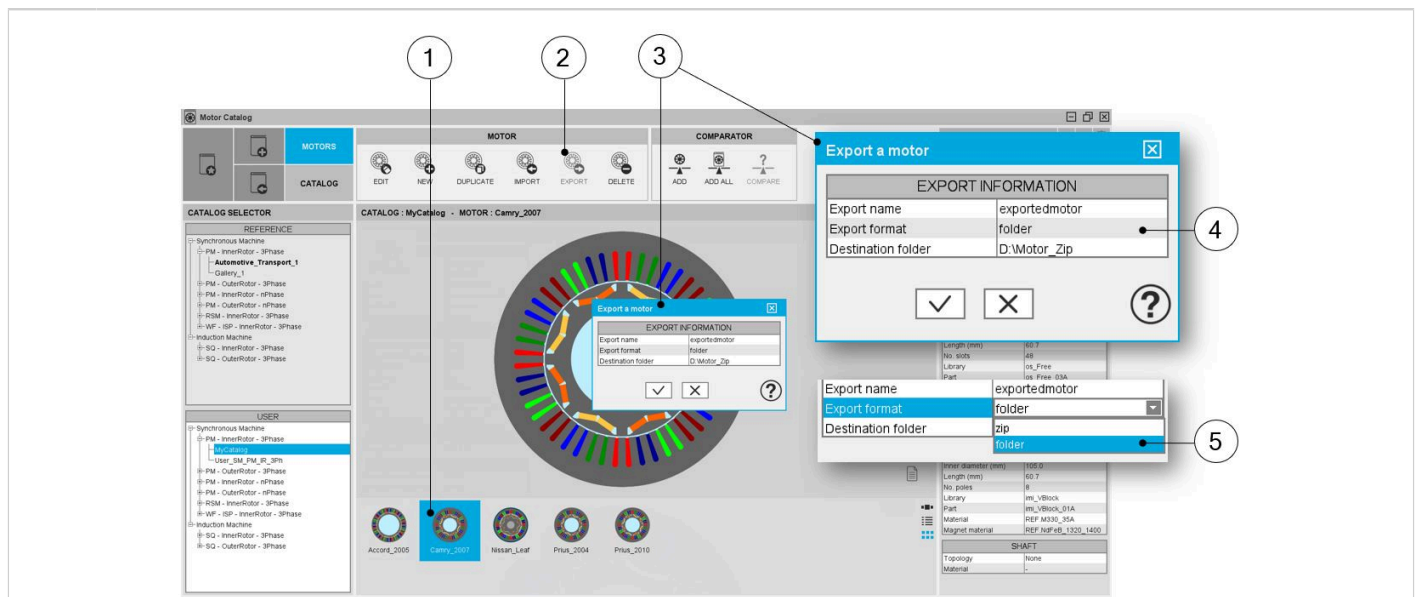
2.5 Importing / Exporting Motors and Parts

A new efficient way for importing / exporting Motors in Motor Catalog, and Parts in Part Factory

To facilitate the exchange of motor design and part topology between users, new functionalities have been developed allowing the import/export of motors in Motor Factory application and import / export parts in Part Library application.

Any motor from Motor Catalog can be exported to:

- A folder,
- or a zip file.



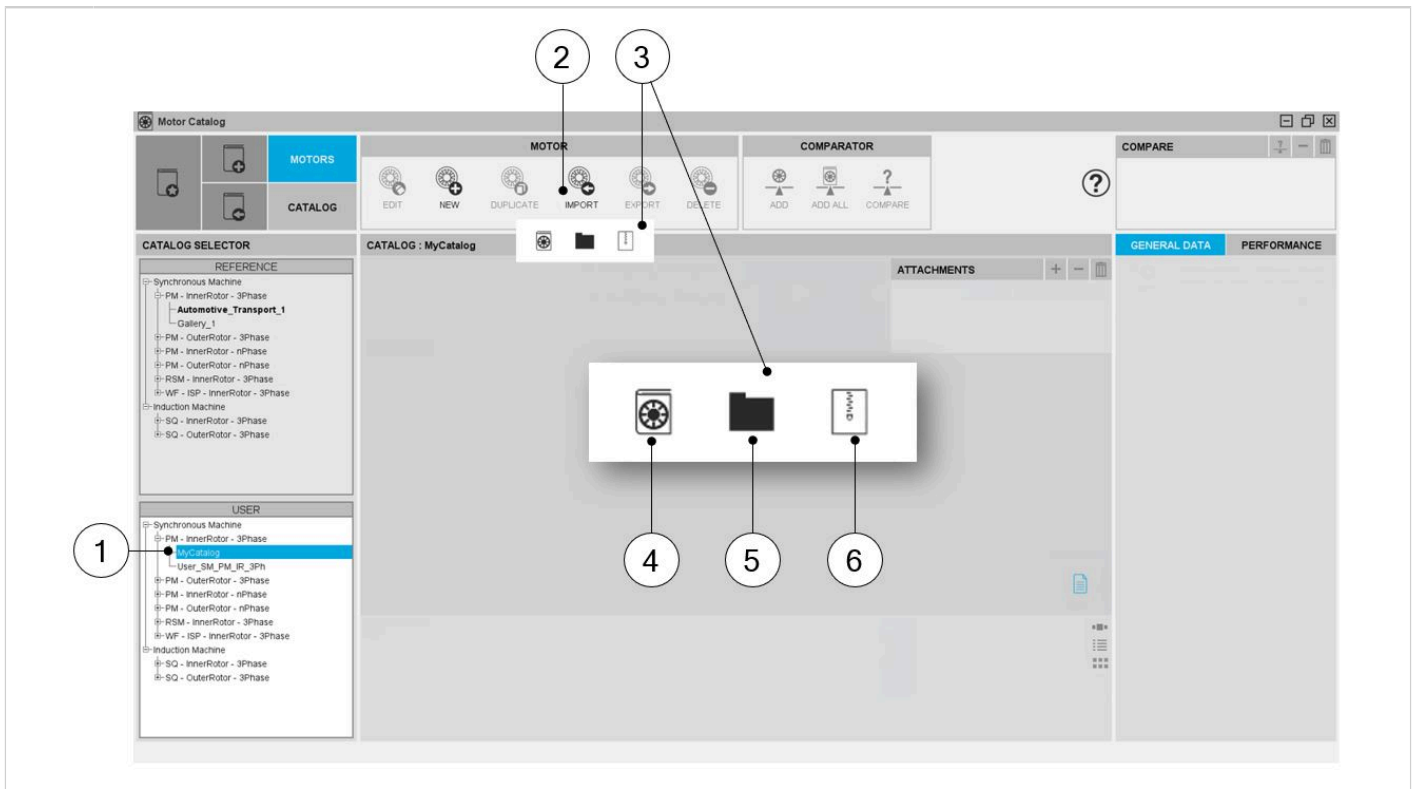
New Export function in Motor Catalog

1	Select one or several motor(s) to be exported.
2	Clicking on the button "Export" opens a dialog box to export motors stored in a folder or in a zip file.
3	Dialog box to give "Export information" for exporting the motors.
4	The export information is: <ul style="list-style-type: none"> • Export name, • Export format: either folder or zip, • Destination folder.
5	The selected motor(s) can be stored either inside a folder or in a zip file before being exported.

A motor can be imported into the Motor Catalog if it:

- exists in a reference catalog of FluxMotor (the old type of import),
- or is stored in a folder,
- or is stored in a zip file.

An internal process checks if the motor provided in the folder or the zip file is compatible with the intended motor catalog.

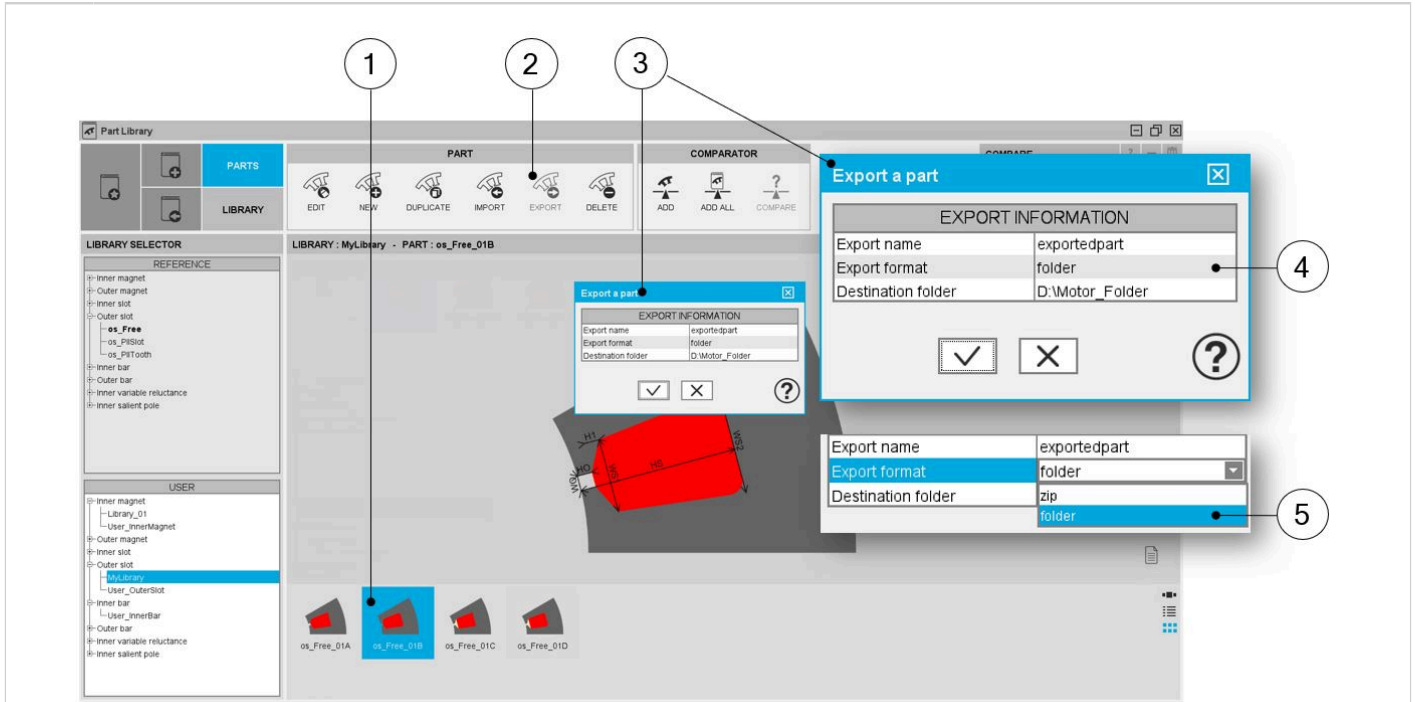


New Import function in Motor Catalog

1	Selection of a user's catalog in which the motors to import will be stored. <div style="border: 1px solid #ccc; padding: 5px; margin-top: 10px;"> <p> Note: In this example, the catalog in which motors will be imported is currently empty.</p> </div>
2	Click on the button "IMPORT".
3	Clicking on the icon "IMPORT" opens a dialog box, allowing three ways to import motors.
4	1st solution: Import motors from another catalog
5	2nd solution: Import a motor from a folder
6	3rd solution: Import a motor from a zip file

Any part from the Part Library can be exported to:

- a folder,
- or a zip file.



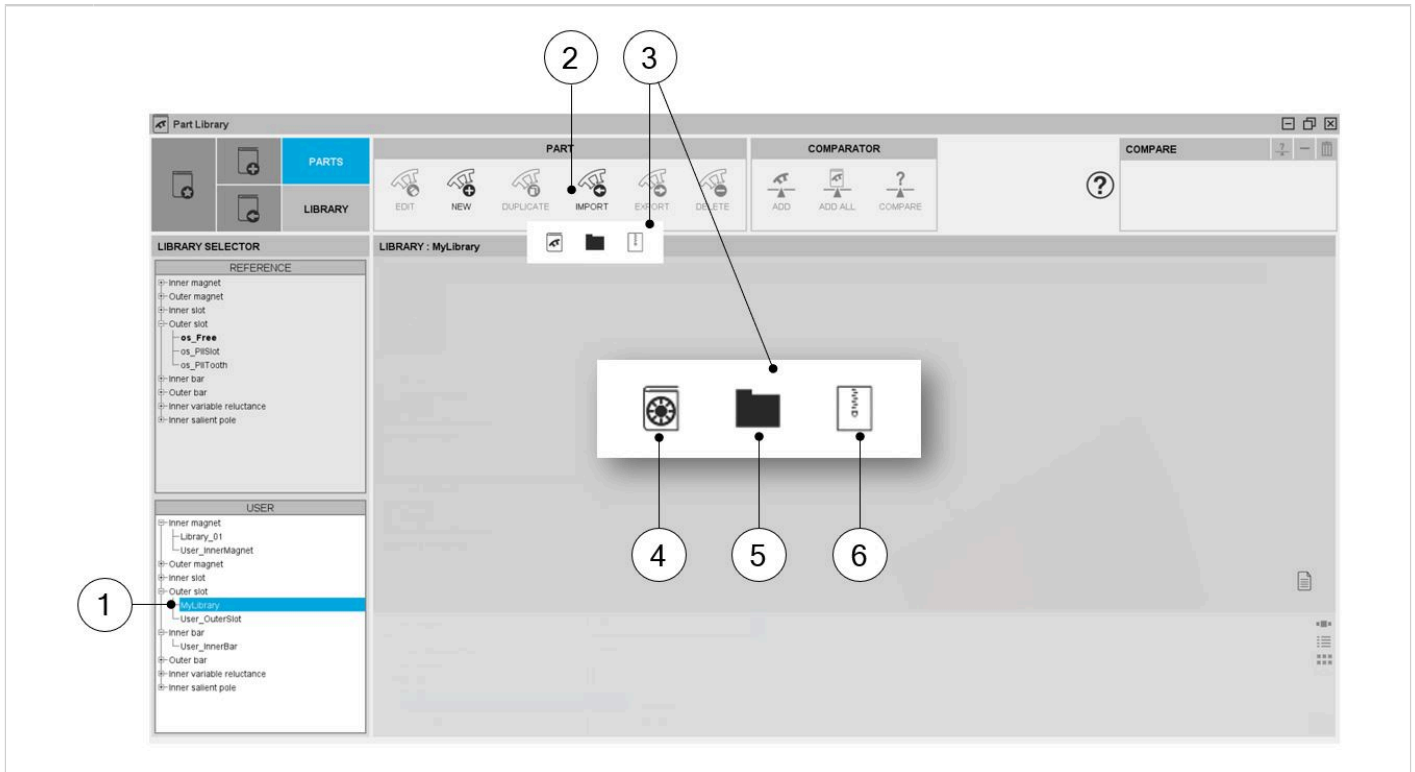
New Export function in Part Library

1	Select one or several motor(s) to be exported.
2	Clicking on the button "Export" opens a dialog box to export motors stored in a folder or in a zip file.
3	Dialog box to give "Export information" for exporting the motors.
4	The export information is: <ul style="list-style-type: none"> • Export name, • Export format: either folder or zip, • Destination folder.
5	The selected motor(s) can be stored either inside a folder or in a zip file before being exported.


And a part can be imported to the Part Library if it:

- exists in a reference library of FluxMotor (the old type of import),
- or is stored in a folder,
- or is stored in a zip file.

An internal process checks if the part provided in the folder or the zip file is compatible with the intended part library.



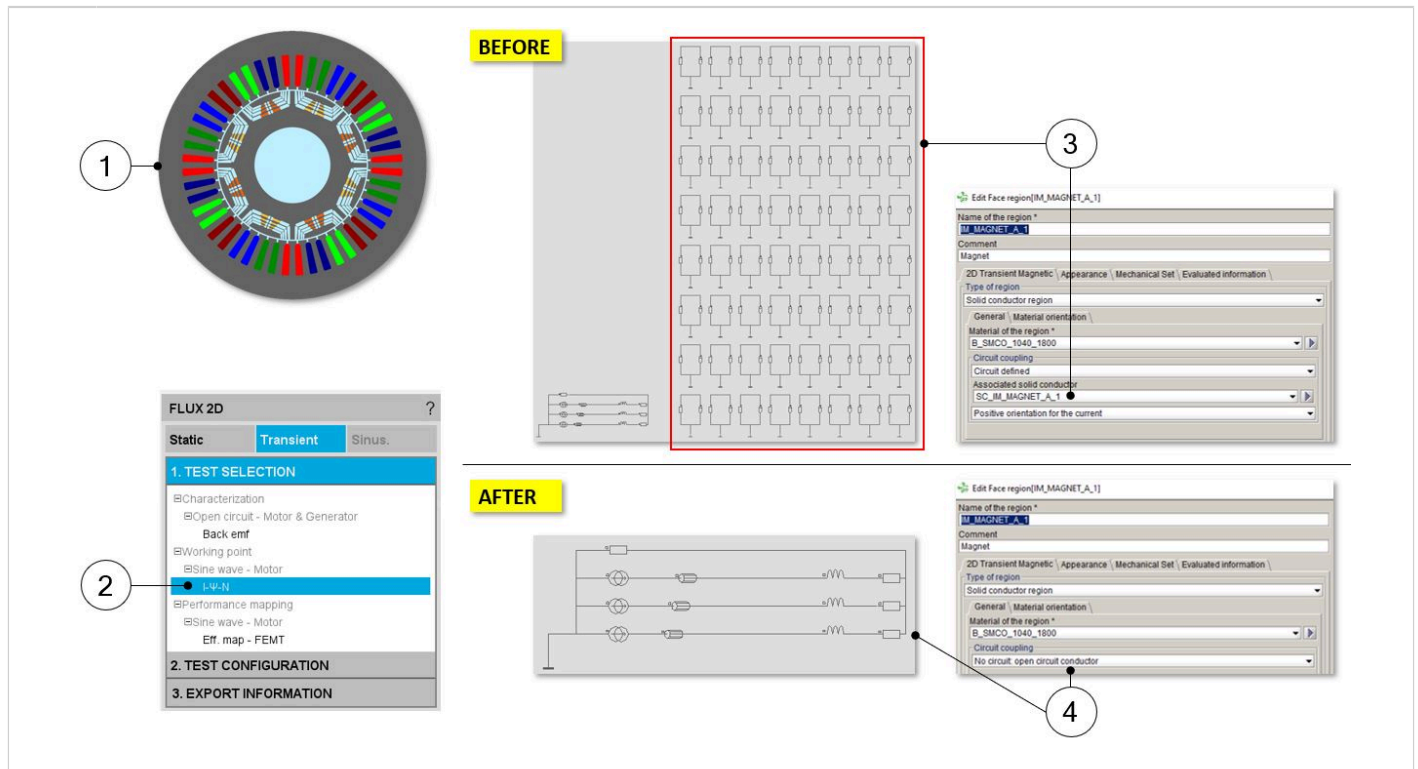
New Import function in Part Library

1	<p>Selection of a user's catalog in which the motors to import will be stored.</p> <div style="border: 1px solid gray; padding: 5px; margin-top: 10px;"> <p> Note: In this example, the catalog in which motors will be imported is currently empty.</p> </div>
2	Click on the button "IMPORT".
3	Clicking on the icon "IMPORT" opens a dialog box, allowing three ways for importing motors.
4	1st solution: Import motors from another catalog
5	2nd solution: Import a motor from a folder
6	3rd solution: Import a motor from a zip file

2.6 Magnets in electrical circuit

A more effective way for considering the magnets in electrical circuit (SMPM machines)

The electric circuit of magnets in SMPM is removed from the Flux project of all transient exports and the Flux project of backend computation in FluxMotor, resulting in faster export to Flux and faster preparation for tests in FluxMotor. Joule losses within the magnet are still calculated with the same level of accuracy as before.



A comparison between how magnets are considered in transient exports of SMPM in Flux

1	A SMPM with multiple magnets is selected.
2	Choose a transient export from the list
3	Before FluxMotor 2024, all magnets were assigned electric circuits for the Joule loss computation in magnets
4	From FluxMotor 2024, Joule losses of magnet are computed with no need for the representation of electric circuit of magnets

List of fixed issues and major improvements

This chapter covers the following:

- [3.1 All machines](#) (p. 48)
- [3.2 Synchronous machines – Motor Factory – Test environment](#) (p. 50)
- [3.3 Induction machines – Motor Factory – Test environment](#) (p. 51)

3.1 All machines

Negative end winding resistance with low value of X-Factors.

Here are a few explanations for this issue:

This issue has been introduced while considering the solid conductors inside the slot. Since the solid conductors are considered, the corresponding resistance (in the straight part of the machine) is deduced from the material properties and the size of the wires.

- With $X\text{-factor}=1$, we have $(R_{\text{phase } 0})=(R_{\text{straight } 0})+(R_{\text{end winding } 0})$
 $R_{\text{phase } 0}$ is the initial value of the phase resistance (with $X\text{-Factor} = 1$)
 $R_{\text{straight } 0}$ is the initial value of the phase resistance in the straight part of the machine (with $X\text{-Factor} = 1$)
 $R_{\text{end winding } 0}$ is the initial value of the phase resistance in the straight part of the machine (with $X\text{-Factor} = 1$)
- With $X\text{-factor}\neq 1$, we have $(R_{\text{phase } 1})=(R_{\text{straight } 1})+(R_{\text{end winding } 1})$
 $R_{\text{phase } 1}$ is the initial value of the phase resistance (with $X\text{-Factor} \neq 1$)
 $R_{\text{straight } 1}$ is the initial value of the phase resistance in the straight part of the machine (with $X\text{-Factor} \neq 1$)
 $R_{\text{end winding } 1}$ is the initial value of the phase resistance in the straight part of the machine (with $X\text{-Factor} \neq 1$)

The target is to get the following results:

$$(R_{\text{phase } 1})=X\text{Factor}\times(R_{\text{straight } 0})$$

With

$$(R_{\text{straight } 1})= (R_{\text{straight } 0})$$


This leads to the value for the end winding resistance:


$$(R_{\text{end winding } 1})=X\text{Factor}\times(R_{\text{straight } 0}+R_{\text{end winding } 0})-(R_{\text{straight } 0})$$

$$(R_{\text{end winding } 1})=R_{\text{straight } 0}\times(X\text{Factor}-1)+X\text{Factor}\times(R_{\text{end winding } 0})$$

When $X\text{-Factor}$ is very low, the end winding resistance can be negative.

We will reconsider how to apply the calibration factor to the winding resistance. Perhaps this will lead to applying the $X\text{-Factor}$ only to the end winding and the winding connections not to then straight part.

 **Note:** This problem doesn't impact the phase resistance value, nor the resulting computations, like the total Joule losses in the winding. (ref.: FXM-16113).

 **Note:** When a non-relevant winding resistance factor leads to a negative end-winding resistance the "DESIGN" and "WINDING" buttons become red, a warning message asks to the user to increase the winding resistance factor and the tests cannot be performed

This issue has been corrected.

Trouble with Script - Export script - Export python - Export python in ScriptFactory

Removing selected folders in which are stored python files leads to troubles while using the "Search directory function" (ref.: FXM-16164).

This issue has been corrected.

Hairpin architecture

Solving tests or exporting projects to Flux is not allowed when the Hairpin winding is built with two layers. This will be fixed for the next version (ref.: FXM-15516).

This issue has been corrected.

Excel export does not work for the test Model - Maps

For the Synchronous machines with Permanent Magnets – SMPM (ref.: FXM-15465).

This issue has been corrected.

3.2 Synchronous machines – Motor Factory – Test environment

Export a project is not possible for polyphase machines.

Sometimes, the test working point (I, Ψ , N) from the Export to Flux and Flux Skew area is not possible for polyphase synchronous machines.

However, this issue is very difficult to reproduce. When it occurs, close and reopen the project to fix the issue (ref.: FXM-16136).

This issue has been corrected.

3.3 Induction machines – Motor Factory – Test environment

Run the basic test twice consecutively can lead to wrong results.

When you run the test Characterization / Model /Basic twice consecutively by only changing the line-line voltage, the results you get at the end of the second run are wrong.

Indeed, in that case, you will see that the line-line voltage is inconsistent with the phase voltage meaning that our internal process considers that the voltage has not been modified especially for computing the no-load performance leading to wrong results for the equivalent scheme parameters (ref.: FXM-16302).

This issue has been corrected.

Computation of working point using the accurate mode is not possible for slips higher or equal to 1.

The internal process is not compatible with such values of slip (ref.: FXM-16163).

This issue has been corrected.

This chapter covers the following:

- [4.1 All machines](#) (p. 53)
- [4.2 Synchronous machines – Motor Factory – Test environment](#) (p. 57)
- [4.3 Induction machines – Motor Factory – Design environment](#) (p. 58)
- [4.4 Induction machines – Motor Factory – Test environment](#) (p. 59)

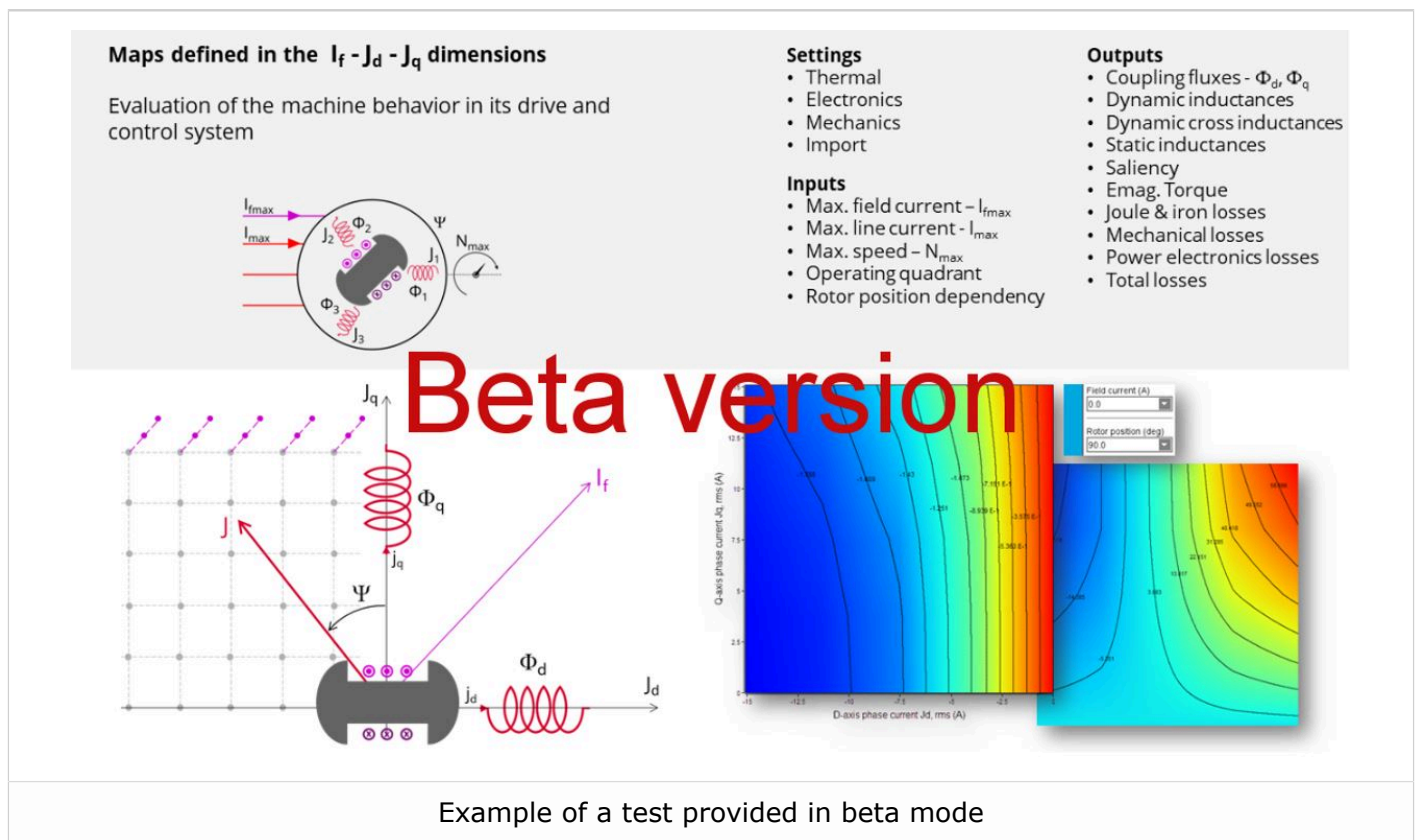
4.1 All machines

Features available in beta mode.

Sometime, 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.



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.

Transient thermal computations - Displaying of iso-temperatures.

In the test "Performance mapping – Sine wave – Motor – Efficiency map", when a cycle is considered with transient thermal solving, the representation of the temperature iso-values inside the machine can be visualized all along the cycle with an animation.

The animation can run for both the axial and radial views. However, both animations are not well synchronized. Therefore, there can be troubles while using both at the same time.

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.

Preferences – Beta level mode

In the tab "Advanced settings / Preferences", Altair® FluxMotor® "User Level" can be Standard or Beta. By default, the user level is Standard. In Beta level, the entire qualified features are not available for evaluation.

The FluxMotor® Beta level mode allows performing NVH computations for induction machines – Inner rotor. It gives access to the application "Script 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.

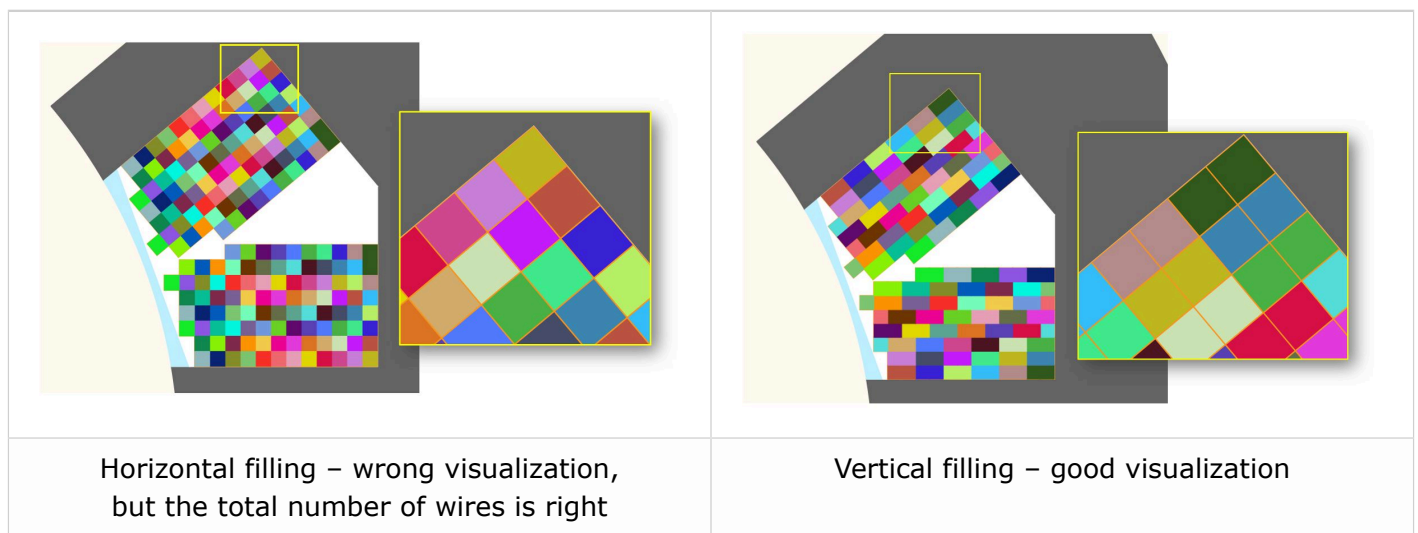
Problems with slot filling

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.



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 L_{frame} and the stack length of the machine L_{stk} . In any case, this ratio must be lower than 1.5:

$$L_{Frame}/L_{stk} \leq 1.5$$

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.

This chapter covers the following:

- [5.1 All machines](#) (p. 61)
- [5.2 Synchronous machines – Motor Factory – Test environment](#) (p. 64)
- [5.3 Induction machines – Motor Factory – Test environment](#) (p. 65)
- [5.4 Part Factory](#) (p. 67)
- [5.5 Script Factory](#) (p. 68)
- [5.6 Materials](#) (p. 69)
- [5.7 Supervisor – Preferences](#) (p. 70)

5.1 All machines

Thermal computation results can be very different between FluxMotor and 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).

Wrong thermal analysis

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

When creating a Flux skewed project, issue with project

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

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).

Script Factory does not stop correctly.

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)

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).

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).

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).

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 characters 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.

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).


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).

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).

IMSQ - 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 Part Factory

Wrong management of part borders

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

5.5 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 (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).

5.6 Materials

Define iron loss parameters from a map

The fitting function for defining the iron loss parameters from a map (Excel file 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 in using the "Flux Material Identification" tool in Altair® Flux® for defining the parameters.

(ref.: FXM-16789).

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).