

ALTAIR

Altair[®] FluxMotor[®] 2022.1

Induction machines – Squirrel cage - Inner & outer rotor

Motor Factory – Export

General user information

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1 MOTOR FACTORY – EXPORT AREA – HOME PAGE VIEW

The area “EXPORT” of Motor Factory groups two main families of functions:

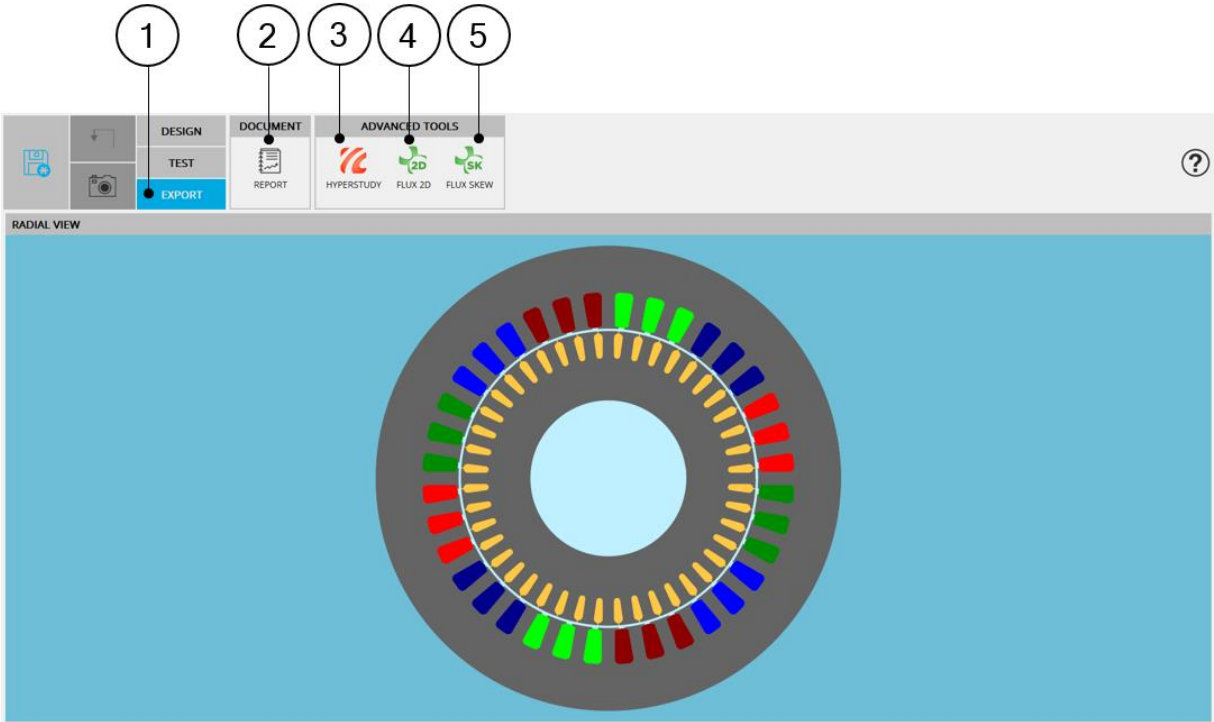
1.1 “DOCUMENT”

In “DOCUMENT” the function “REPORT” allows building reports automatically to describe all the work achieved for the design and the tests.

1.2 “ADVANCED TOOLS “

In “ADVANCED TOOLS” the function “FLUX 2D” allows to build and export a model in Altair® Flux® 2D environment for performing advanced studies either with magneto harmonic or transient applications.

On the other hand, the function “FLUX SKEW” allows to build and export a model in Altair® Flux® SKEW environment for performing advanced studies either with magneto harmonic or transient applications.



Motor Factory - EXPORT area

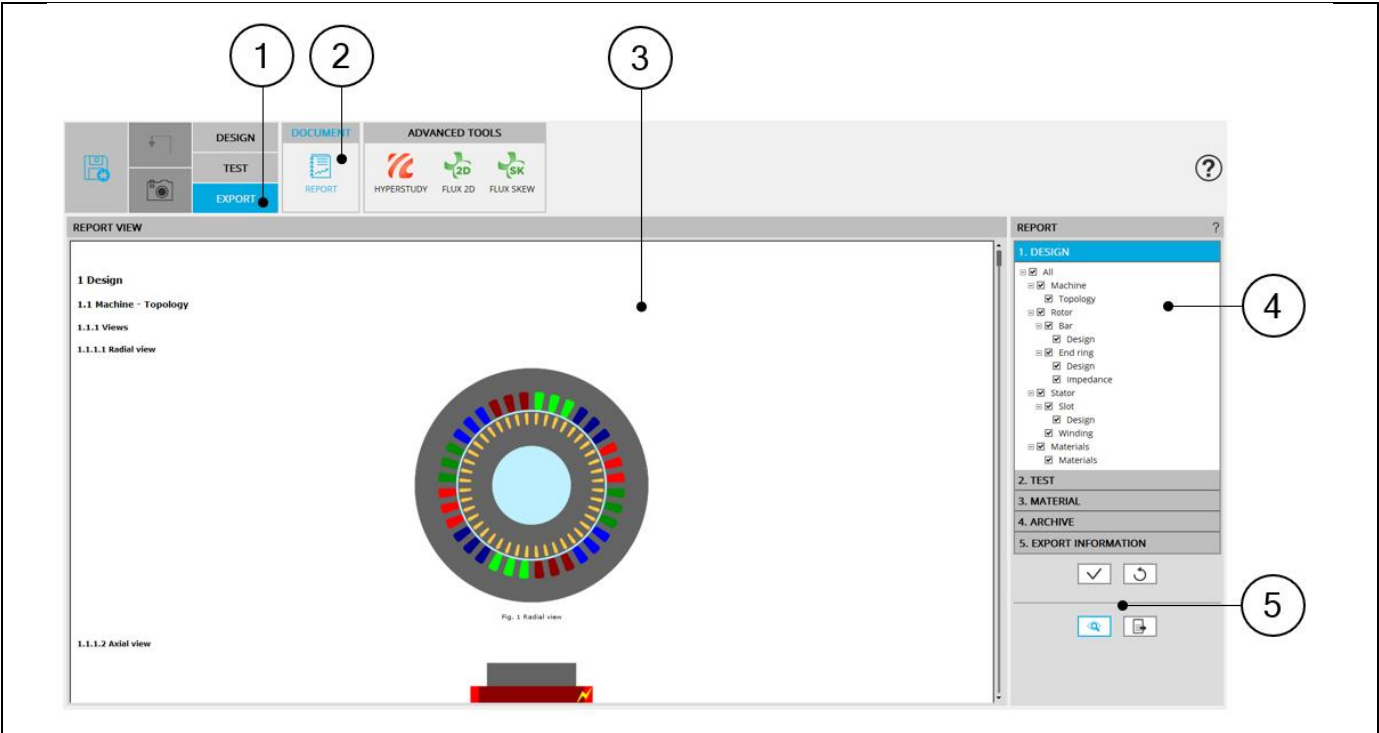
1	Selection of the EXPORT area of Motor Factory.
2	Access the area “HYPERSTUDY “ in which a connector can be made and be sent to Altair® HyperStudy®
3	Access to the area “REPORT” in which a report can be made
4	Access to the area “FLUX 2D” in which a model can be made and be sent to Flux® 2D
5	Access to the area “FLUX SKEW” in which a model can be made and be sent to Flux® SKEW

2 MAKE A REPORT

2.1 Overview

The aim of the export is to quickly build and export, a report showing all the work achieved for designing and testing the machine. As a result, the report can be exported in a pdf or html file format. It can also be attached to the motor in the "Motor Catalog" or simply displayed in the report area.

2.2 Area to build the report



Motor Factory – EXPORT AREA – Export a report

1	Selection of the EXPORT area of Motor Factory.
2	Access to the area in which a report can be made
3	Zone to visualize the report (= preview)
4	Steps to build the report which user needs
5	Buttons to validate inputs, display a preview and export a report

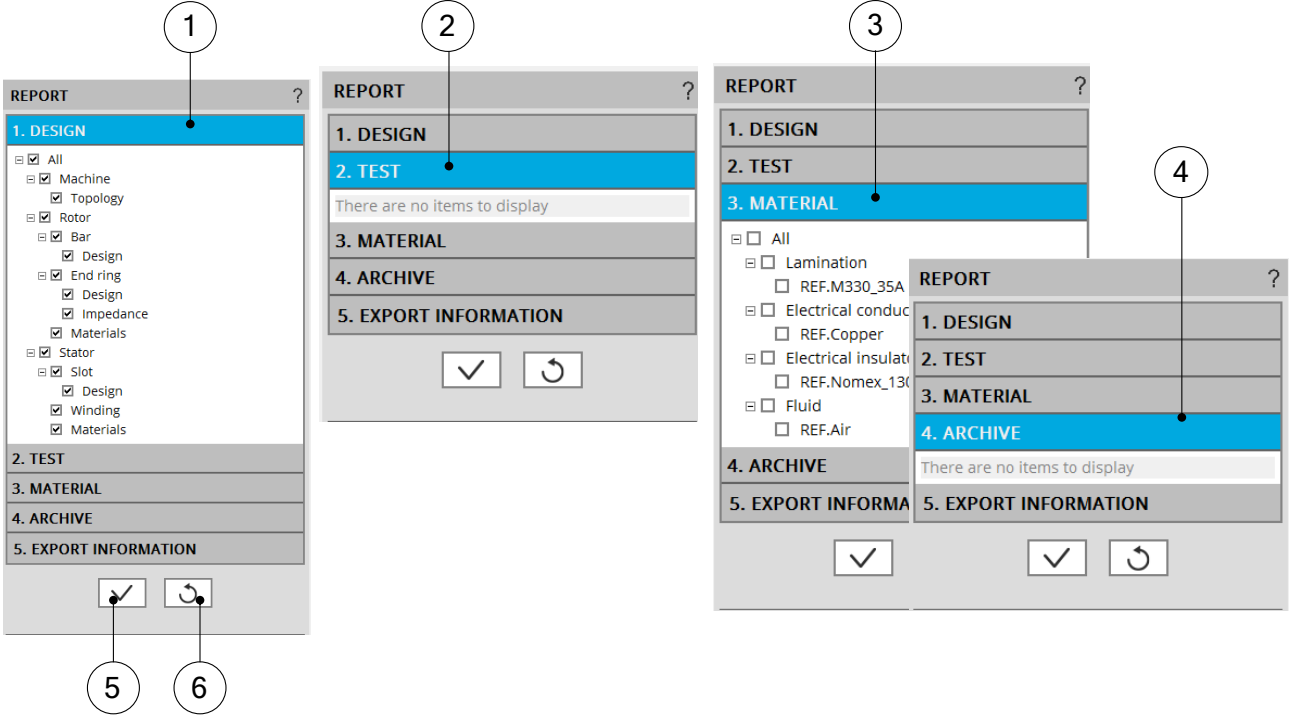
2.3 Steps to build and export a report

Five steps are needed to build and export a report: In EXPORT / DOCUMENT / REPORT area:

- 1) Select the sections to add the parameters dealing with the design.
- 2) Select the sections to add the parameters dealing with the tests.
- 3) Select the sections to add the parameters dealing with the materials.
- 4) Select the "saved test results" that are to be added as archive in the report.
- 5) Define the export information.

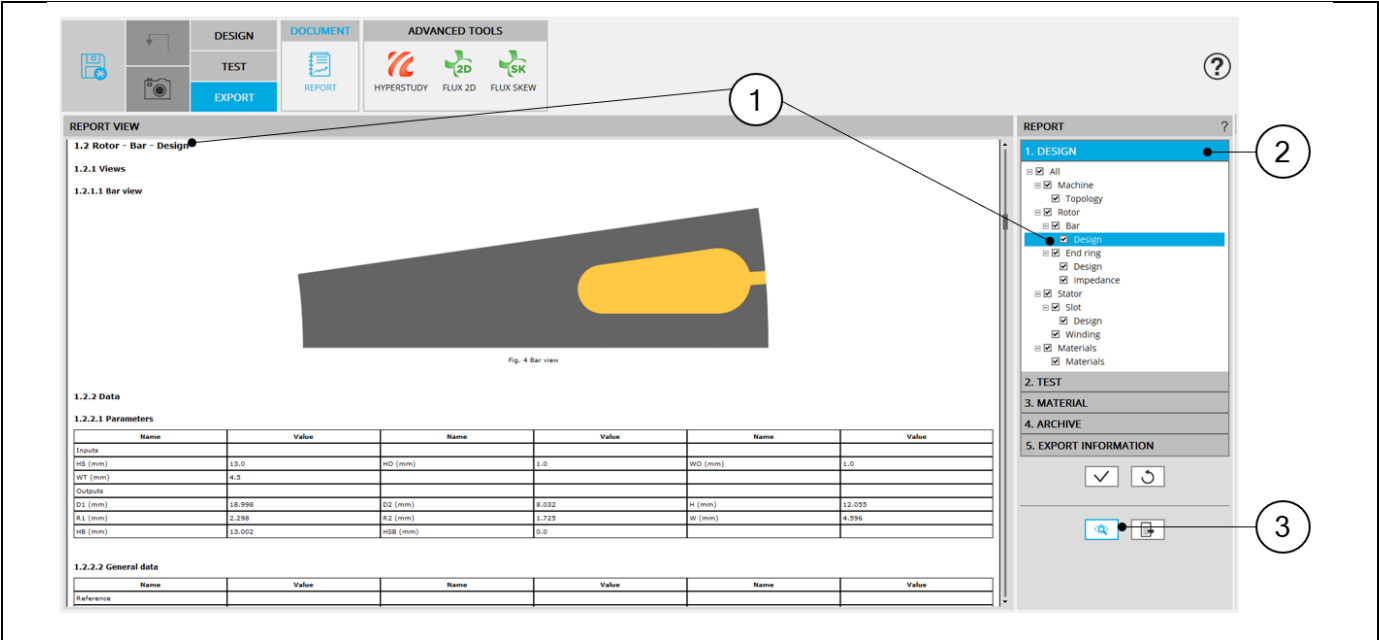
2.4 Section selection

2.4.1 List of sections available to build the report



Motor Factory - EXPORT AREA – Export a report – Chapters to be selected	
1	Chapter which describes the DESIGN. Machine, Rotor and Stator characteristics.
2	Chapter which describes the TEST results. (At the moment no test is available) All the test results are available as soon as the corresponding computations are performed.
3	List of materials used to build the machine can be added to the report with all their physical properties.
4	Archive chapter groups all the tests which have been saved during the process. They can be added to the report. (At the moment no test is available) Note: A maximum of five results per test can be added to the report.
5	Button to apply the selection of the user input selections (selection of chapters)
6	Button to restore default values

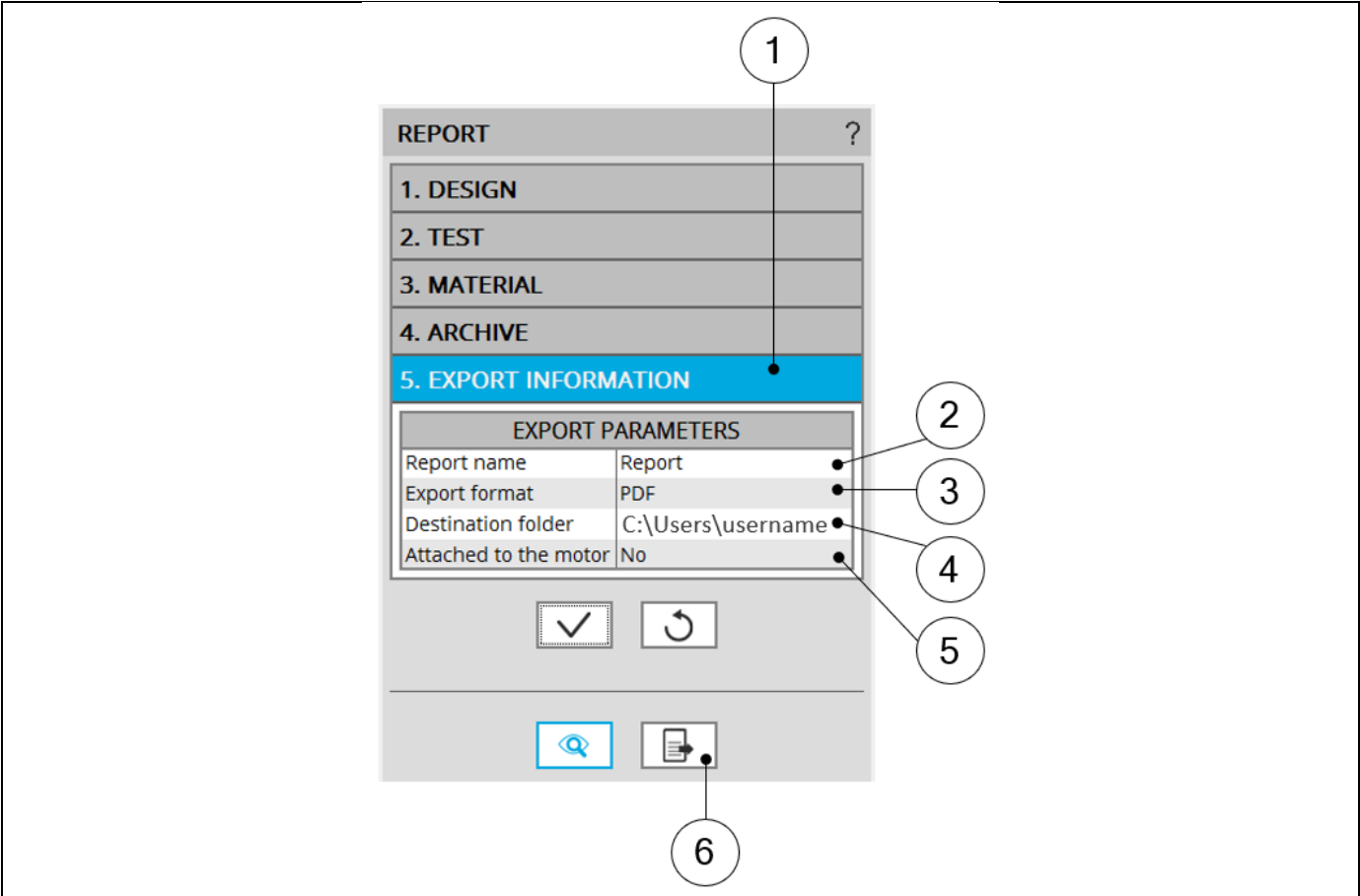
2.4.2 Selection of sections



Motor Factory - EXPORT AREA – Export a report – Chapters to be selected

1	Section names are shortcuts for displaying the corresponding section of the report
2	Check the section to add chapters to the report
3	Button "Preview" considers the selected chapters and displays the report

2.5 Export information



Motor Factory - EXPORT AREA – Export a report – Export information	
1	Select the area to define export parameters
2	A file name must be written (Default name = "Report")
3	The file format must be chosen (pdf or html) to build the report
4	A folder must be selected via the browser for storing the report
5	It is possible to attach the report (HTML or PDF file) to the motor in the "Motor Catalog"
6	Button to export the report by considering all the previous defined parameters

3 BUILD AND EXPORT A CONNECTOR FOR ALTAIR® HYPERSTUDY®

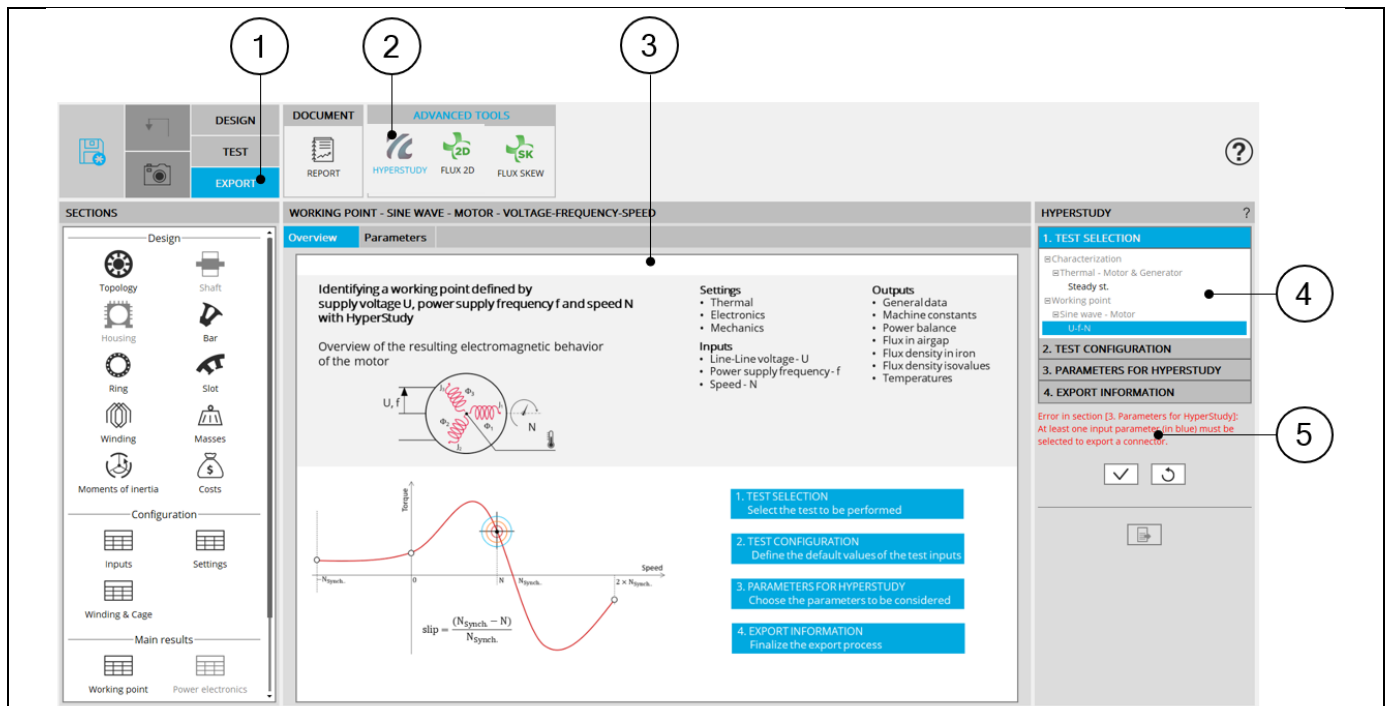
3.1 Overview

The aim of this export is to build a connector allowing Altair® HyperStudy® to drive Altair® FluxMotor® to perform optimizations of a motor based on computation processes embedded into FluxMotor®.

This can be done on an eligible test list by using input/output parameters defined in FluxMotor®.

Then, after having performed studies with HyperStudy® (Optimization or Design Of Experiment - DOE- for instance), the results can be visualized by selecting the resulting machine in the “Motor Catalog”.

3.2 Area to build a connector



Motor Factory – EXPORT AREA – Export connector for HyperStudy®

1	Selection of the EXPORT area of Motor Factory.
2	Access the area in which a connector for HyperStudy® can be made
3	Zone to visualize either the overview of the selected test or the corresponding user inputs/outputs parameters
4	4 steps to build the connector to be exported for HyperStudy®
5	Buttons to validate inputs, display a preview and export the built connector for HyperStudy®

3.3 Steps to build and export a connector

In EXPORT / ADVANCED TOOLS / HYPERSTUDY area 4 steps are needed to build and export a report:

- 1) Select the test which will be performed by HyperStudy®
- 2) Define the test configuration, that means the user inputs/outputs parameters needed to define the test (settings and user inputs of the considered test)
- 3) Select the inputs/outputs parameters for performing studies with HyperStudy®
- 4) Define the export information

3.4 Test selection

In the current version of FluxMotor®, 2 tests can be selected for induction machines:

- Characterization / Thermal / Motor & generator / Steady state
- Working point / Sine wave / Motor / U-f-N

When a test is selected the corresponding overview is displayed in the center of the screen showing the main inputs to be considered.

2

1

Motor Factory – EXPORT AREA – Export connector for HyperStudy®

1	Selection of a test to be performed by HyperStudy®
2	Displaying of general information (Overview) dealing with the selected test

3.5 Test configuration

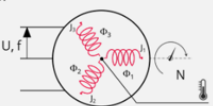
After selecting a test, the corresponding test inputs (settings and user inputs) must be defined. This allow to define the initial conditions for testing.

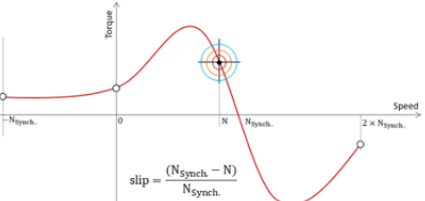
WORKING POINT SINE WAVE - MOTOR - VOLTAGE-FREQUENCY-SPEED

OverviewParameters

Identifying a working point defined by supply voltage U, power supply frequency f and speed N with HyperStudy

Overview of the resulting electromagnetic behavior of the motor





1. TEST SELECTION
Select the test to be performed

2. TEST CONFIGURATION
Define the default values of the test inputs

3. PARAMETERS FOR HYPERSTUDY
Choose the parameters to be considered

4. EXPORT INFORMATION
Finalize the export process

Settings

- Thermal
- Electronics
- Mechanics

Inputs

- Line-Line voltage - U
- Power supply frequency - f
- Speed - N

Outputs

- General data
- Machine constants
- Power balance
- Flux in airgap
- Flux density in iron
- Flux density isovalues
- Temperatures

HYPERSTUDY ?

1. TEST SELECTION

2. TEST CONFIGURATION

ThermalElectronicsMechanics

2

INPUTS

Line-Line voltage, rms (V)	370.0
Power supply frequency (Hz)	50.0
Slip (%)	5.0

+

3. PARAMETERS FOR HYPERSTUDY

4. EXPORT INFORMATION

Error in section [3. Parameters for HyperStudy]:
At least one input parameter (in blue) must be selected to export a connector.


✓↺

Motor Factory – EXPORT AREA – Export connector for HyperStudy®

1	Overview of the selected test is displayed
2	User inputs can be defined in the test area.

Note: The user help information about the test parameters is defined in the user help guide of the corresponding test. Please refer to the corresponding section.

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3.6 Parameters for HyperStudy®

This section allows to select the parameters which must be available for optimization in HyperStudy®. This can be design parameters, parameters to define the test conditions (inputs and/or settings) or test results.

3.6.1 Selection of design parameters

Reference	Library	ibb_PITtooth	Part	ibb_PITtooth...	
Inputs					
HS (mm)		<input checked="" type="checkbox"/>	HO (mm)	<input type="checkbox"/>	WO (mm)
WT (mm)		<input type="checkbox"/>			
Outputs					
D1 (mm)		<input type="checkbox"/>	D2 (mm)	<input type="checkbox"/>	H (mm)
R1 (mm)		<input type="checkbox"/>	R2 (mm)	<input type="checkbox"/>	W (mm)
HB (mm)		<input type="checkbox"/>	HSB (mm)	<input type="checkbox"/>	

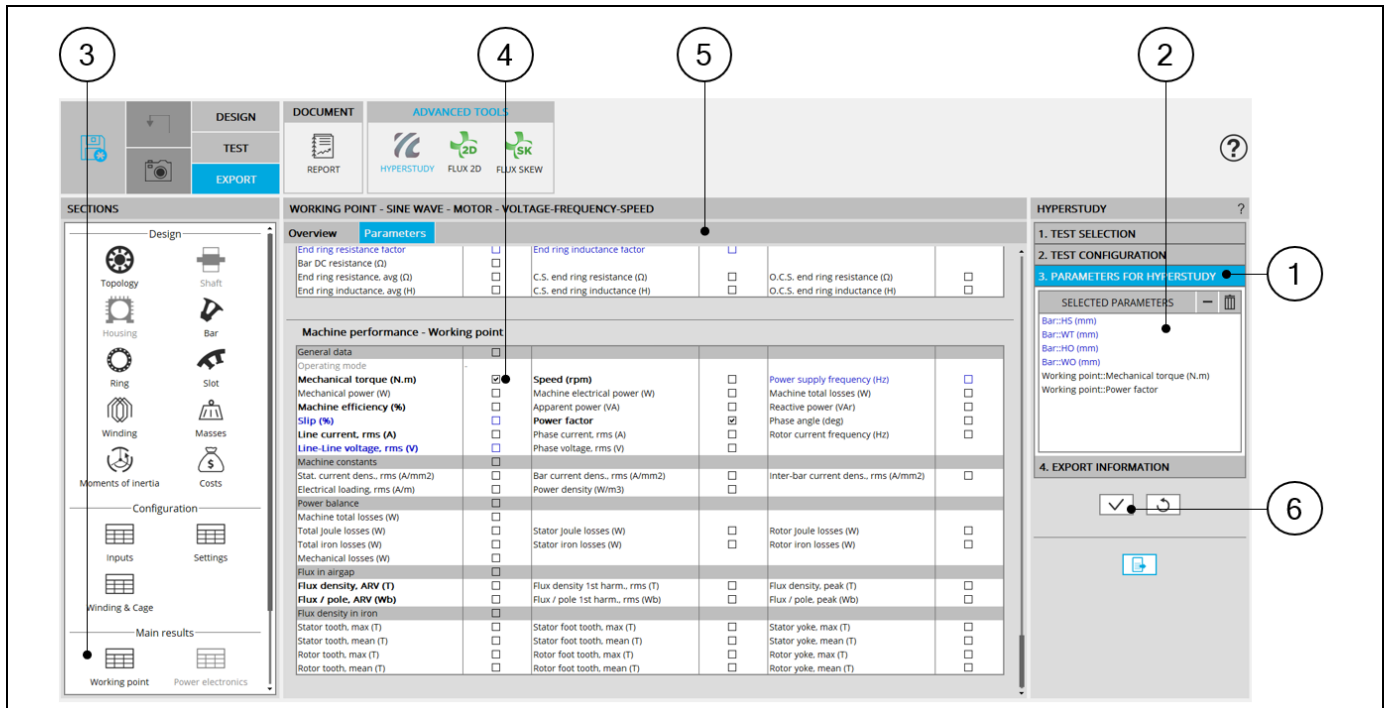
Motor Factory – EXPORT AREA – Export connector for HyperStudy®
Design parameters selection

1	Tab to be expanded to choose input/output parameters for HyperStudy®
2	Area in which input/output parameters are stored for HyperStudy®
3	Shortcuts to select the part of the design to be considered for the selection of parameters
4	All available design inputs are displayed. The corresponding dimension is highlighted when selected - arrows (5). When a parameter is chosen, the associated box is ticked (4), and the parameter name is stored in the selected parameters area (2).
5	Arrow illustrating the selected design input parameter
6	Button to validate the previous choices

Note: Data which are given by the user are written in blue. They are inputs data. Data resulting from internal computations (outputs) are written in black. This allows the users to quick see what are input data and output data inside data tables.

3.6.2 Selection of test data

The test data groups test results as well as user inputs and settings. All these data can be selected for optimization in HyperStudy®.



Motor Factory – EXPORT AREA – Export connector for HyperStudy® – Test data selection

1	Tab to be expanded to choose input/output parameters for HyperStudy®
2	Area in which input/output parameters are stored for HyperStudy®
3	Shortcuts to select the part of the Test condition and test results to be considered for the selection of parameters
4	All available test data (test results as well as user inputs) are displayed. When a data is chosen, the associated box is ticked (4), and the parameter name is stored in the selected parameters area (2).
5	Displaying of data which can be selected for HyperStudy® studies
6	Button to validate the previous choices

Note: Data which are given by the user are written in blue. They are inputs data. Data resulting from internal computations (outputs) are written in black. This allows the users to quick see what are input data and output data inside data tables.

3.7 Export information

The last step for building a connector for HyperStudy® is to define the export information.

There are three data to be defined:

- The name of the connector
- The folder in which the connector must be stored
- The last answer “Save iteration (Yes/No) “ allows to indicate if the results of HyperStudy® studies must be stored in a dedicated catalog of Motor Catalog application. When “Yes” is answered all the resulting motors can be visualized in Motor Catalog and then they can be edited in Motor Factory very quickly.

Motor Factory – EXPORT AREA – Export connector for HyperStudy® – Export information

1	Tab to be expanded to define export information for HyperStudy®
2	Area in which the export parameters to be defined are listed
3	Button to validate the previous choices
4	Button to finalize the export of the connector. When one clicks on this button opened the folder where the connector is stored.

Note: When data are missing in a third table “Parameters for HyperStudy®” for instance, an error message is written in red font and indicates what is missing and where. If all the needed information is missing, exporting a connector is not allowed.

HYPERSTUDY?

1. TEST SELECTION

2. TEST CONFIGURATION

3. PARAMETERS FOR HYPERSTUDY

4. EXPORT INFORMATION

EXPORT PARAMETERS

Connector name	HstConnector
Destination folder	D:\ForHyperStudy
Save iterations	Yes

Error in section [3. Parameters for HyperStudy]:
At least one input parameter (in blue) must be
selected to export a connector.

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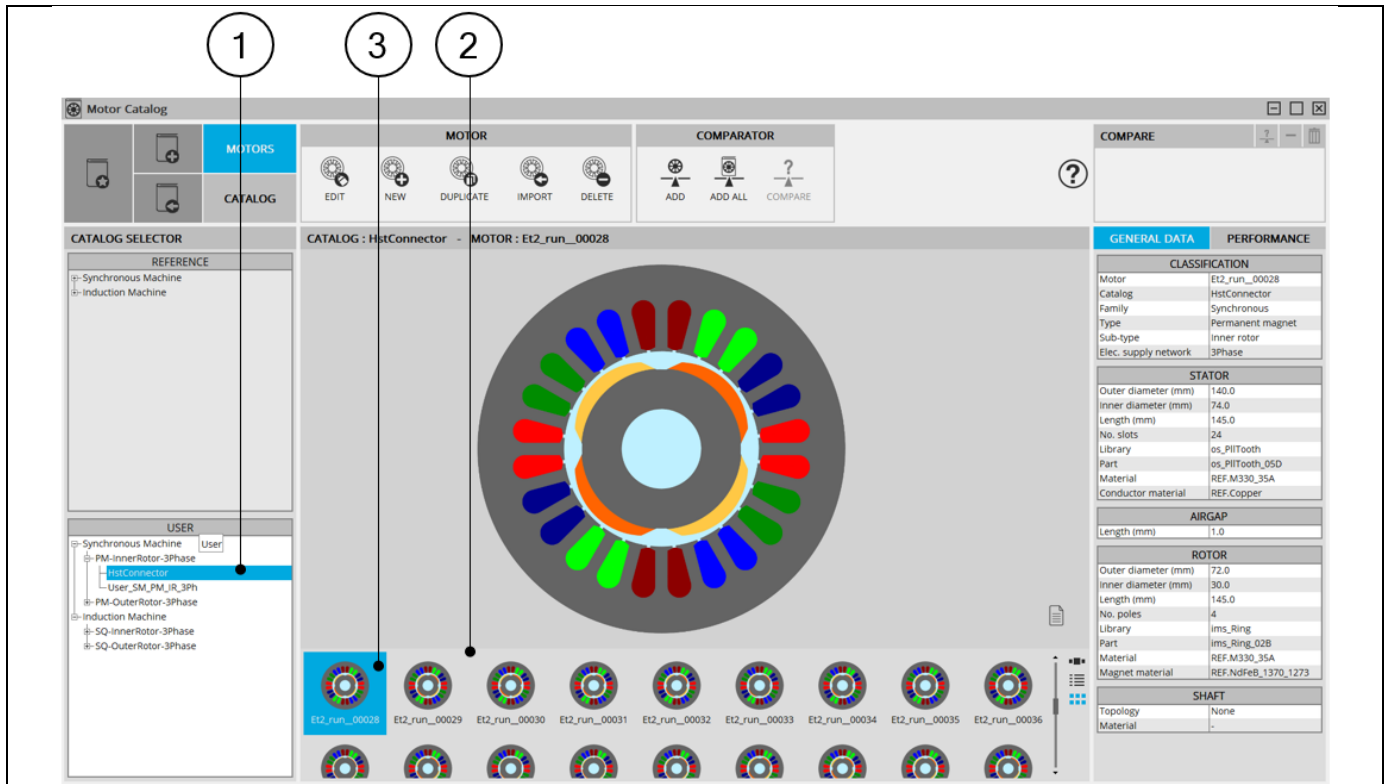
2

Motor Factory – EXPORT AREA – Export connector for HyperStudy® – Error message

1	Error message written in red font
2	The button to export the connector is not active if the needed data are missing

3.8 Get back HyperStudy® results in FluxMotor®

All the motors resulting from the runs performed with HyperStudy® can be used back in Motor Catalog of FluxMotor® and then they can be edited in Motor Factory very quickly.



Motor Catalog – Visualization of results got from HyperStudy® – Illustration for a synchronous machine

1	A catalog is automatically built by using the name of the connector defined by the user
2	All the runs from HyperStudy® are stored in the dedicated catalog
3	Each motor can be selected, visualized and edited in Motor Factory to be evaluated more in depth

3.9 Connection between FluxMotor® and HyperStudy®

Before starting new studies in HyperStudy® by using connectors exported from FluxMotor®, FluxMotor® must be registered as a new solver script in HyperStudy®.
This must be defined only when using the coupling for the first time.

	Label	Vname	Type	Preference	Path
1	RADIOSS	radioss	RADIOSS	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/./hwsolvers/scripts/radioss.bat
2	OptiStruct	os	OptiStruct	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/./hwsolvers/scripts/optistruct.bat
3	MotionSolve	ms	MotionSolve	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/./hwsolvers/scripts/motionsolve.bat
4	Python	py	Python	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/./common/python/python3.5/win64/pyth
5	Tcl	tcl	Other Application	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/hw/tcl/tcl8.5.9/win64/bin/tclsh85.exe
6	Templex	templex	Other Application	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/hw/bin/win64/templex.exe
7	HM Batch	hmbatch	Other Application	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/hm/bin/win64/hmbatch.exe
8	HM BatchMesher	hmbatchmesher	Other Application	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/hm/batchmesh/hw_batchmesh.bat
9	MDL Batch	mdl_batch	Other Application	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/io/translators/bin/win64/mdl_batch.bat
10	HyperStudy Batch	hstbatch	Other Application	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/hst/bin/win64/hstbatch.exe
11	HyperWorks	hw_exe	Other Application	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/hw/bin/win64/hw.exe
12	HV Trans	hvttrans	Other Application	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/io/result_readers/bin/win64/hvttrans.exe
13	FLUX	flux	Flux	HyperWorks	C:/Program Files/Altair/2021/hwdesktop/./flux/Flux/Bin/prg/win64/flux.exe
14	None	hst_none	None	Internal	C:/Program Files/Altair/2021/hwdesktop/hst/bin/win64/hstsolver_none.bat
15	FluxMotor	fluxmotor	FluxMotor	HyperStudy	C:/Program Files/Altair/2022.1/flux/FluxMotor/Scripts/win/FluxMotors.exe

C:/Program Files/Altair/2022.1/flux/FluxMotor/Scripts/win/FluxMotors.exe

Connection between FluxMotor® and HyperStudy®

1	Open the area in HyperStudy® to register FluxMotor® 2022.1 script
2	Path where FluxMotors.exe must be selected to be registered as a new solver in HyperStudy®. Note: FluxMotors.exe with a "s" at the end of FluxMotors. This must be defined only when using the coupling for the first time.

4 BUILD AND EXPORT A MODEL IN FLUX® 2D ENVIRONMENT

4.1 Overview

The aim of this export is to provide a python file which allows a full parametrized model, ready to be used in Flux® 2D environment. In the current version models can be provided for harmonic application or transient application in Flux® 2D environment.

Three models can be exported to Flux® 2D environment:

Application	Model family	Package	Convention	Model / Test
SINUS	Working point	Sine wave	Motor	U-f-N
	Working point	Sine wave	Motor	U-f-N
TRANSIENT	Working point	Sine wave	Motor	U-f-N
	Working point	Sine wave	Motor	U-f-N (Hairpin)

Note: These models are considered for inner rotor machines and outer rotor machines.

4.2 Area to build and to export a model to Flux® 2D environment

1

2

3

4

DESIGNDOCUMENTADVANCED TOOLS

TESTREPORTHYPERSTUDYFLUX 2DFLUX SKEW

EXPORT

WORKING POINT - SINE WAVE - MOTOR - U-F-N

Overview

Export a model for steady state AC magnetic application in Flux 2D environment

Solving scenario for the test:
Working point / Sine wave / Motor / U f N
A working point defined by supply voltage U, power supply frequency and speed

$slip = \frac{(N_{synch} - N)}{N_{synch}}$

Speed

Settings

- Thermal
- Mechanical

Inputs

- Line-Line voltage - U
- Supply frequency - f
- Speed - N

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

FLUX 2D

StaticTransientSinus?

1. TEST SELECTION

Working point

Sine wave - Motor

U-f-N

2. TEST CONFIGURATION

3. EXPORT INFORMATION

✓↺

5

6

7

Motor Factory – EXPORT AREA – Export model for Flux® 2D environment

1	EXPORT area of Motor Factory.
2	Access to the area in which a model for Flux® 2D environment can be made
3	Zone to visualize the overview of the selected model to be exported
4	Click on the tab to select the application (HARMONIC or TRANSIENT)
5	Build the model to be used for exporting in Flux® 2D environment
6	Buttons to validate inputs before building the model in Flux® 2D environment.
7	Export the python file for building the model in Flux® 2D environment or launch the project directly in Flux® 2D.

4.3 Steps to build and export a model to Flux® 2D environment

In EXPORT / ADVANCED TOOLS / FLUX 2D area one must indicate the application of Flux® 2D environment in which the model must be built: Steady state AC Magnetic application (SINUS) or transient application (TRANSIENT).

Then, the 3 next steps to be followed are:

- 1) Define the type of scenario one wants to get in Flux® 2D environment (Test selection).
This means defining the simulation that one wants to perform in Flux® 2D environment for evaluating the electromagnetic behavior of the considered machine.
- 2) Define the test configuration. This is to give an initial value for user inputs which will be set in the scenario of the simulation available in the Flux® 2D model.

Note: For each Flux® 2D model available in the current version, a short description of user inputs is given.

- 3) Define the export information

The resulting models are fully parameterized, and they are built in Flux® 2D environment for Steady state AC Magnetic application or Transient applications.

FLUX 2D

Static

Transient

Sinus.

1. TEST SELECTION

Working point

Sine wave - Motor

U-f-N

2. TEST CONFIGURATION

3. EXPORT INFORMATION

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1

2

3

4

Motor Factory – EXPORT AREA – Export model for Flux® 2D environment

1	Select application (SINUS or TRANSIENT) in which the model must be built in Flux® 2D
2	Choose one scenario (or test) to be used for testing
3	Define the initial conditions for the simulation process in Flux® 2D environment
4	Define export information

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ALTAIR

4.4 Test selection

After having selected an application type (SINUS or TRANSIENT), the corresponding test inputs (settings and user inputs) must be defined. This allows to define the initial conditions for testing.

FLUX 2D

StaticTransientSinus.

1. TEST SELECTION

Working point

Sine wave - Motor

U-I-N

2. TEST CONFIGURATION

3. EXPORT INFORMATION

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2D

1234

Motor Factory – EXPORT AREA – Export a model for Flux® 2D – Test selection

1	Selection of application (SINUS or TRANSIENT) in which the model must be built for Flux® 2D
2	Tab to choose one scenario (or test) to be provided
3	Selection of the scenario (or test) to be provided
4	Button to validate the previous choices

4.5 Test configuration

After having selected an application type (SINUS or TRANSIENT), the corresponding scenario (or test) inputs (settings and user inputs) must be defined. This allows to define the initial conditions for the simulation process in Flux® 2D environment.

FLUX 2D

StaticTransientSinus.

1. TEST SELECTION

2. TEST CONFIGURATION

ThermalMechanics

INPUTS

Max. Line-Line voltage, rms (V)	370.0
Speed (rpm)	1 425.0
Power supply frequency (Hz)	50.0
Represented coil conductors	No

+

3. EXPORT INFORMATION

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2. TEST CONFIGURATION

ThermalMechanics

INPUTS

Max. Line-Line voltage, rms (V)	370.0
Speed (rpm)	1 425.0
Power supply frequency (Hz)	50.0
Rotor initial position (deg)	0.0
Airgap mesh coefficient	1.5

•

—

Motor Factory – EXPORT AREA – Export a model for Flux® 2D

1	Tab to define the initial conditions for the simulation process in Flux® 2D environment
2	Settings like thermal and mechanical conditions can be defined
3	User inputs dealing with the considered test can be defined
4	The tab corresponding to advanced parameters can be expanded. Advanced parameters can also be defined if needed.
5	Button to validate the previous choices

More details about the inputs and settings can be found at chapter 4.7

4.6 Export information

The last step for building a model for Flux® 2D is to define the export information.

There are three data to be defined:

- The name of the python file which will build the model in Flux® 2D environment.
- The folder in which the provided file must be stored
- The “Full geometry” allows the user to get a full geometry in the provided model even if it is possible to work with a reduced model considering the number of poles, the number of slots and bars.

FLUX 2D

StaticTransientSinus.

1. TEST SELECTION

2. TEST CONFIGURATION

3. EXPORT INFORMATION

INPUTS

File name

Flux2DModel

Destination folder

C:\Users\username

Full geometry

No

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1

2

3

4

5

Motor Factory – EXPORT AREA – Export model for Flux® 2D – Export information

1	Tab to be expanded to define export information for Flux® 2D
2	Area in which the export parameters to be defined are listed
3	Button to validate the previous choices
4	Button to finalize the export of the model. When one clicks on this button opened the folder where the python file to build the model is stored.
5	Button to finalize the export of the model. This button launches Flux® 2D and builds the model.

Note 1: When data are missing from the third section “Export information” for instance, an error message is written in red font and indicates the missing data. If all the needed information is missing, exporting a model is not allowed.

FLUX 2D

StaticTransientSinus.

1. TEST SELECTION

2. TEST CONFIGURATION

3. EXPORT INFORMATION

INPUTS

File name	Flux2DModel
Destination folder	C:\Users\User Name
Full geometry	No

Error in section [3. Export information]:
The path "C:\Users\User Name" does not exist

✓

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Motor Factory – EXPORT AREA – Export model for Flux® 2D – Error message

1	Error message written in red font
2	The button to export the model is not active if some needed data is missing

Note 2: Exporting a model to Flux® 2D (i.e. provide the python file to build the model) can take a few seconds.

Proprietary Information of Altair Engineering

ALT AIR

4.7 Available models to be exported and user inputs

4.7.1 Overview

All the models to be exported are first classified by considering the type of application for which they are built (SINUS or TRANSIENT). Then, the current version models are associated with a motor convention of operation and grouped into packages and model families. Three models can be exported to Flux® 2D environment:

Application	Model family	Package	Convention	Model / Test
SINUS	Working point	Sine wave	Motor	U-f-N
TRANSIENT	Working point	Sine wave	Motor	U-f-N
	Working point	Sine wave	Motor	U-f-N (Hairpin)

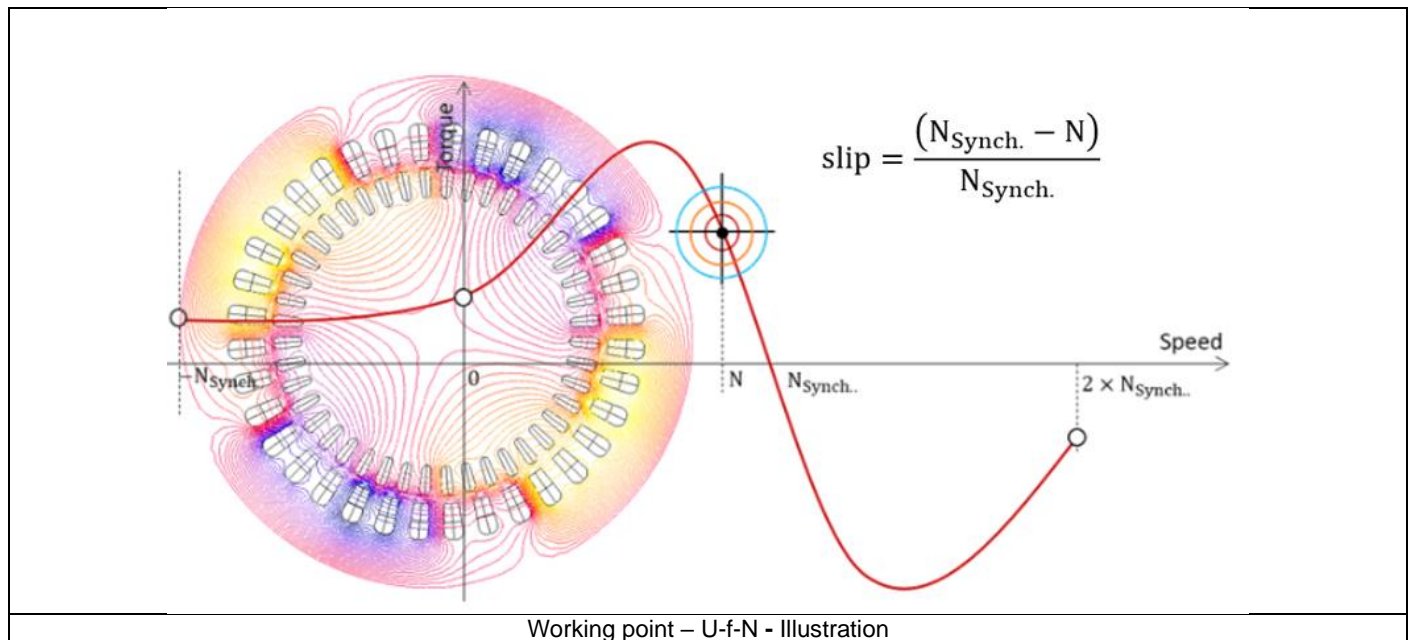
The following section give a short description of all the models available for exportation to Flux® 2D environment.

4.7.2 Steady state AC Magnetic application (SINUS) – Working point – Sine wave – Motor – U-f-N

4.7.2.1 Positioning and objective

This export allows the users to build a model of induction machine in Flux® 2D, which can be used to run steady state AC Magnetic application.

User inputs like line-line voltage, power supply frequency and speed are predefined to allow quick access into Flux® 2D environment for performing computations. The resulting model is full parameterized.



The following section describes all the user inputs to initialize the exported model. All these parameters can be modified in Flux® 2D environment if needed.

4.7.2.2 Settings

One button gives access to the following setting definition:

- Temperature of winding straight part and end winding
- Temperature of squirrel cage bars and end rings
- Mechanical losses

For more details, refer to the generic section (applicable for all types of machine) dealing with the test settings.

4.7.2.3 Standard inputs

1) Line-line voltage, rms

The line-line voltage supplied to the machine: “**Line-line voltage, rms**” (*Line-line voltage, rms value*) must be provided.

2) Slip or Speed mode

There are two usual parameters to define the working point. It can be defined by the slip “**Slip**” or by the mechanical speed “**Speed**”.

3) Slip

If the “Definition mode” is “**Slip**”, the value of the machine’s slip must be provided, and the corresponding speed is deduced.

The slip “s” in the following relations) corresponds to the relative difference between the synchronous speed ($N_{\text{Synch.}}$) and rotor speed N:

$$s = \frac{(N_{\text{Synch.}} - N)}{N_{\text{Synch.}}}$$

4) Speed

If the “Definition mode” is “**Speed**”, the targeted rotor speed must be provided, and the resulting slip is deduced.

5) Power supply frequency

The power supply frequency corresponds to the electrical frequency of the stator magnetic field.

4.7.2.4 Advanced inputs

The lists of advanced inputs dedicated to this export are listed below.

For more details please refer to the section 4.7.5 - List of generic advanced inputs.

1) Rotor initial position

2) Mesh order

The default level is second order mesh.

3) Airgap mesh coefficient

Airgap mesh coefficient is set to 1.5 by default.

4.7.3 Transient application – Working point – Sine wave – Motor – U, f, N

4.7.3.1 Positioning and objective

The aim of the test **“Working point – Sine wave – Motor – U, f, N”** is to characterize the behavior of the machine when operating at the targeted input values U, f, N (Line-line voltage, power supply frequency and speed).

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

The results of this test give an overview of the electromagnetic analysis of the machine considering its topology. It also gives the capability to make comparisons between results obtained from measurements with FluxMotor®.

The following section describes all the user inputs to initialize the exported model. All these parameters can be modified in Flux® 2D environment if needed.

4.7.3.2 Settings

One button gives access to the following setting definition:

- Temperature of winding straight part and end windings
- Temperature of squirrel cage bars and end rings

For more details, refer to the generic section (applicable for all types of machine) dealing with the test settings.

4.7.3.3 Standard inputs

1) Line-line voltage, rms

The line-line voltage supplied to the machine: **“Line-line voltage, rms”** (*Line-line voltage, rms value*) must be provided.

2) Slip or Speed mode

There are two usual parameters to define the working point. It can be defined by the slip **“Slip”** or by the rotor speed **“Speed”**.

3) Slip

If the “Definition mode” is **“Slip”**, the value of the machine's slip must be provided, and the corresponding speed is deduced.

The slip “s” in the following relations) corresponds to the relative difference between the synchronous speed ($N_{\text{Synch.}}$) and rotor speed N:

$$s = \frac{(N_{\text{Synch.}} - N)}{N_{\text{Synch.}}}$$

4) Speed

If the “Definition mode” is **“Speed”**, the targeted rotor speed must be provided, and the resulting slip is deduced.

5) Power supply frequency

The power supply frequency corresponds to the electrical frequency of the stator magnetic field.

6) Represented coil conductors

In transient application, it is possible to export a project into Flux® environment where the elementary wires will be modeled with solid conductors. The geometry, the meshing and the corresponding electric circuit will be defined to well represent them.

Three choices are possible:

- “No”: The coils will be represented with face regions. The elementary wires won't be represented in the Finite Element model (Flux®).
- “One phase”: The elementary wires will be represented for only one phase. This will allow to compute AC losses for conductors into the first phase. This choice allows to get a good ratio between the quality of results and computation time.
- “All phases”: The elementary wires will be represented into all the phases

4.7.3.4 Advanced inputs

The list of advanced inputs dedicated to this export are listed below.

For more details, please refer to the section 4.7.5 - List of generic advanced inputs.

1) Number of computations per electrical period

The default value is equal to 50. The minimum allowed value is 13.

2) Number of computed electrical periods

The default value is equal to 2. The minimum allowed value is 1 and the maximum value is equal to 10.

3) Rotor initial position

4) Mesh order

The default level is second order mesh.

5) Airgap mesh coefficient

Airgap mesh coefficient is set to 1.5 by default.

4.7.4 Working point – Sine wave – Motor - U, f, N - Hairpin

4.7.4.1 Positioning and objective

The aim of the test “**Working point – Sine wave – Motor – U, f, N**” is to characterize the behavior of the machine when operating at the targeted input values U, f, N (Line-line voltage, power supply frequency and speed) in case of the machine is built with a hairpin winding technology.

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

Note: The same principle than for the test “Working point – Sine wave – Motor – U, f, N” is applied.

Inputs are the same, but in that case only “All phases” option is available for defining the represented coil conductors.

4.7.5 List of generic advanced inputs

1) Number of computations per electrical period (for transient application)

The number of computations per electrical period “**No. comp. / elec. period**” (Number of computations per electrical period) influences the accuracy of results and the computation time.

The default value is 50. The minimum allowed value is 13. The default value provides a good compromise between the accuracy of results and computation time.

2) Number of computed electrical periods (for transient application)

The default value is 2. The minimum allowed value is 1 and the maximum value is 10.

3) Rotor initial position

The computation of the test « Steady State Performance / Working Point / U-f-N » is performed by considering an initial position of the rotor. The default value is 0. The range of possible values is [-360, 360].

Flux harmonic application (2D and SKEW) allows to compute average quantities over an electrical period for each set position for the rotor.

Note:

- With Flux® Steady state AC Magnetic application (SINUS), torque ripple is wrongly estimated. In fact, the simulation is done over an electrical supply period for a fixed rotor position. During an electrical supply period the rotor rotates, and we also have rotor squirrel cage currents which slip from bar to bar. So, with Flux® Steady state AC Magnetic application all the phenomena are not considered which is why the torque ripple torque is wrongly estimated.
- High space harmonics impacts are not correctly considered for the same reasons described above, about the ripple torque.

4) Mesh order

To get results, Finite Element Modelling computations are performed.

The geometry of the machine is meshed.

Two levels of meshing can be considered: First order and second order.

This parameter influences the accuracy of results and the computation time.

The default level is second order mesh.

5) Airgap mesh coefficient

The advanced user input “**Airgap mesh coefficient**” is a coefficient which adjusts the size of mesh elements inside the airgap. When you decrease the value of “**Airgap mesh coefficient**”, you reduce the size of mesh elements, thereby increasing the mesh density inside the airgap and the accuracy of results.

The imposed Mesh Point (size of mesh elements touching points of the geometry), inside the Flux® software, is described as:

$$\text{MeshPoint} = (\text{airgap}) \times (\text{airgap mesh coefficient})$$

Airgap mesh coefficient is set to 1.5 by default.

The variation range of values for this parameter is [0.05; 2].

0.05 gives a very high mesh density and 2 gives a very coarse mesh density.

Caution:

Be aware, a very high mesh density does not always mean a better result quality. However, this always leads to a huge number of nodes in the corresponding finite element model. So, it means a need of huge numerical memory and increases the computation time considerably.

4.7.6 Warning about electromagnetic torque in steady state AC Magnetic application (SINUS)

For a motor exported to Flux® (2D or SKEW) with steady state AC Magnetic application, the electromagnetic torque is defined through a power balance which uses the direct components (reverse and homopolar components are not considered) of the currents.

That approach for the power balance will be used for the implementation of tests in steady state AC application for the next versions of FluxMotor®.

The computation of the direct components of currents and the resulting “electromagnetic torque” are included in the exported motor to steady state AC application (SINUS).

To visualize the electromagnetic torque obtained by power balance after exporting a motor from FluxMotor®, the user must use the I/O parameter “T_EM” in Flux® instead of the classical “TorqueElecMag()” predefined function.

5

BUILD AND EXPORT A MODEL IN ALTAIR® FLUX® SKEW ENVIRONMENT

5.1

Overview

The aim of this export is to provide a python file which allows to get a full parametrized model ready to be used in Flux® SKEW environment.

In the current version models can be provided for steady state AC Magnetic application or transient application in Flux® SKEW environment.

Two models can be exported to Flux® SKEW environment:

Application	Model family	Package	Convention	Model / Test
HARMONIC	Working point	Sine wave	Motor	U-f-N
TRANSIENT	Working point	Sine wave	Motor	U-f-N

Note: These models are considered for inner rotor machines as well as for outer rotor machines.

5.2

Area to build and to export a model to Flux® SKEW environment

The screenshot shows the 'EXPORT' area of the Motor Factory software. It features a top navigation bar with 'DESIGN', 'DOCUMENT', and 'ADVANCED TOOLS' (containing 'EXPORT', 'REPORT', 'HYPERSTUDY', 'FLUX 2D', and 'FLUX SKEW'). The main workspace is titled 'WORKING POINT - SINE WAVE - MOTOR - U-F-N' and includes an 'Overview' tab. The overview contains text about exporting a model for steady state AC magnetic application, a diagram of a motor, and a speed slip graph. A settings panel on the right lists 'Settings' (Thermal, Mechanical) and 'Inputs' (Line-Line voltage - U, Supply frequency - f, Speed - N). A 'FLUX SKEW' sidebar on the far right has tabs for 'Static', 'Transient', and 'Sinus', with a '1. TEST SELECTION' step highlighted. At the bottom, there are buttons for validation and export.

Motor Factory – EXPORT AREA – Export model for Flux® Skew environment

1	Selection of the EXPORT area of Motor Factory.
2	Access to the area in which a model for Flux® Skew environment can be made
3	Zone to visualize the overview of the selected model to be exported
4	Click on the tab to select the application (SINUS or TRANSIENT)
5	3 steps to build the model to be exported for Flux® Skew environment
6	Buttons to validate inputs and export the python file for building the model in Flux® Skew environment.

5.3 Particularities in building and to exporting a model to Flux® SKEW environment

A user who wants to build and export a model to Flux® SKEW has just to follow the same steps and recommendations as with the function “FLUX 2D”.

The main particularity of function “FLUX SKEW” is that the “**Skew number of layers**” is an input that must be defined. Its default value is 3.

Even the design of the machine is defined with “continuous skew” that “**Skew number of layers**” is necessary for Flux® to define the finite elements model in the Flux® SKEW environment. A high number of layers gives more accurate finite elements computations. However, it needs higher computation time. For that purpose, the value 3 is a good compromise between accuracy and speed.

FLUX SKEW

StaticTransientSinus.

1. TEST SELECTION

2. TEST CONFIGURATION

ThermalMechanics

INPUTS

Max. Line-Line voltage, rms (V)	370.0
Speed (rpm)	1 425.0
Power supply frequency (Hz)	50.0

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3. EXPORT INFORMATION

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2. TEST CONFIGURATION

ThermalMechanics

INPUTS

Max. Line-Line voltage, rms (V)	370.0
Speed (rpm)	1 425.0
Power supply frequency (Hz)	50.0
Skew model - No. of layers	3
Rotor initial position (deg)	0.0
Airgap mesh coefficient	1.5

—

Motor Factory – EXPORT AREA – Export a model for Flux® SKEW

1	Tab to define the initial conditions for the simulation process in Flux® SKEW environment
2	Settings like thermal and mechanical conditions can be defined
3	User inputs dealing with the considered test can be defined
4	The tab corresponding to advanced parameters can be expanded. Advanced parameters can also be defined if needed.
5	Button to validate the previous choices