Altair® FluxMotor® 2025.1

Induction machines – Squirrel cage - Inner & outer rotor

Motor Factory – Export

General user information

Altairhyperworks.com

Contents

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.

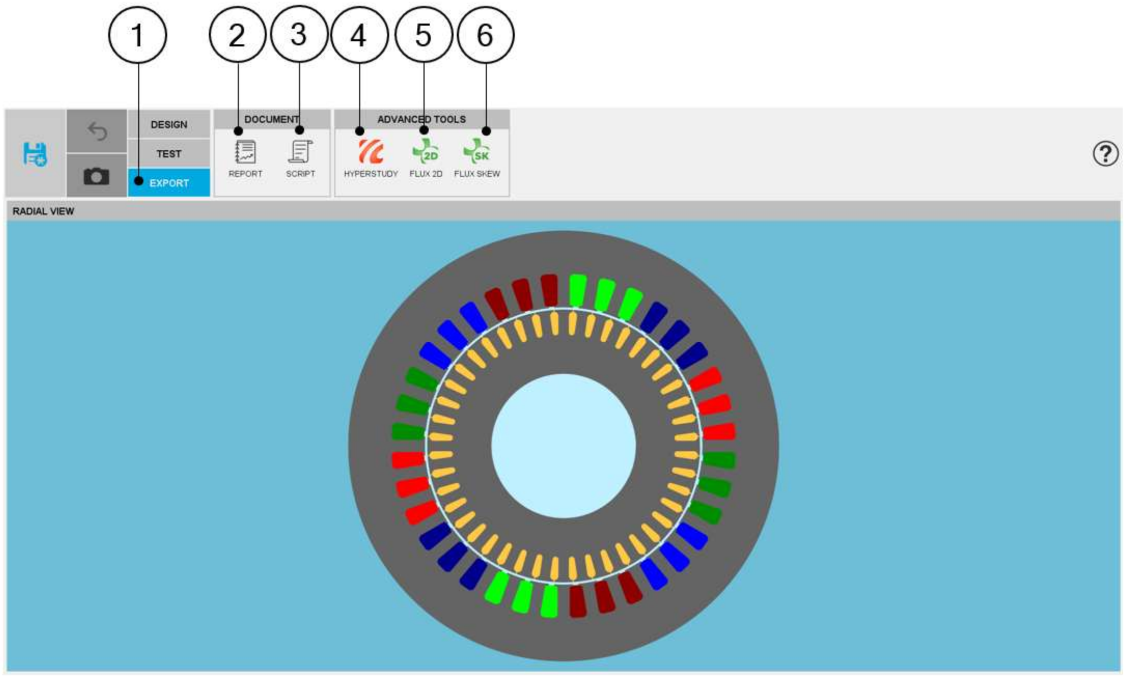
Then, the function “SCRIPT” allows to build and export a python script of a current motor in the application Script Factory or in a targeted folder.

1.2 “ADVANCED TOOLS “

In “ADVANCED TOOLS”, the function “HYPERSTUDY” allows to build and export a connector in Altair® HyperStudy® for performing studies like optimization or Design of Experiment (DOE).

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

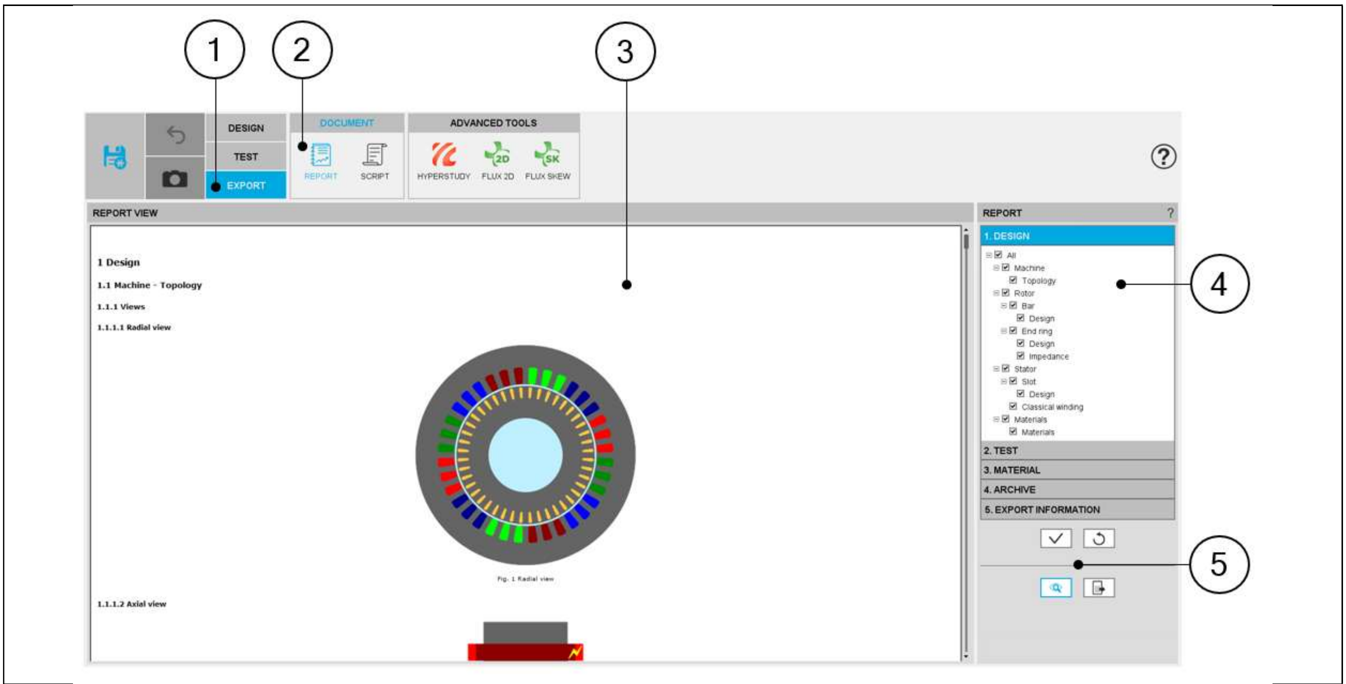
1	Selection of the EXPORT area of Motor Factory.
2	Access to the area “REPORT” in which a report can be made
3	Access the area “SCRIPT” for generating a python file in which all the needed command lines are written to rebuild the motor
4	Access the area “HYPERSTUDY “ in which a connector can be made and sent to Altair® HyperStudy®
5	Access to the area “FLUX 2D“ in which a model can be made and be sent to Flux® 2D
6	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 this export is to build and quickly export a report showing all the work achieved to design and test 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

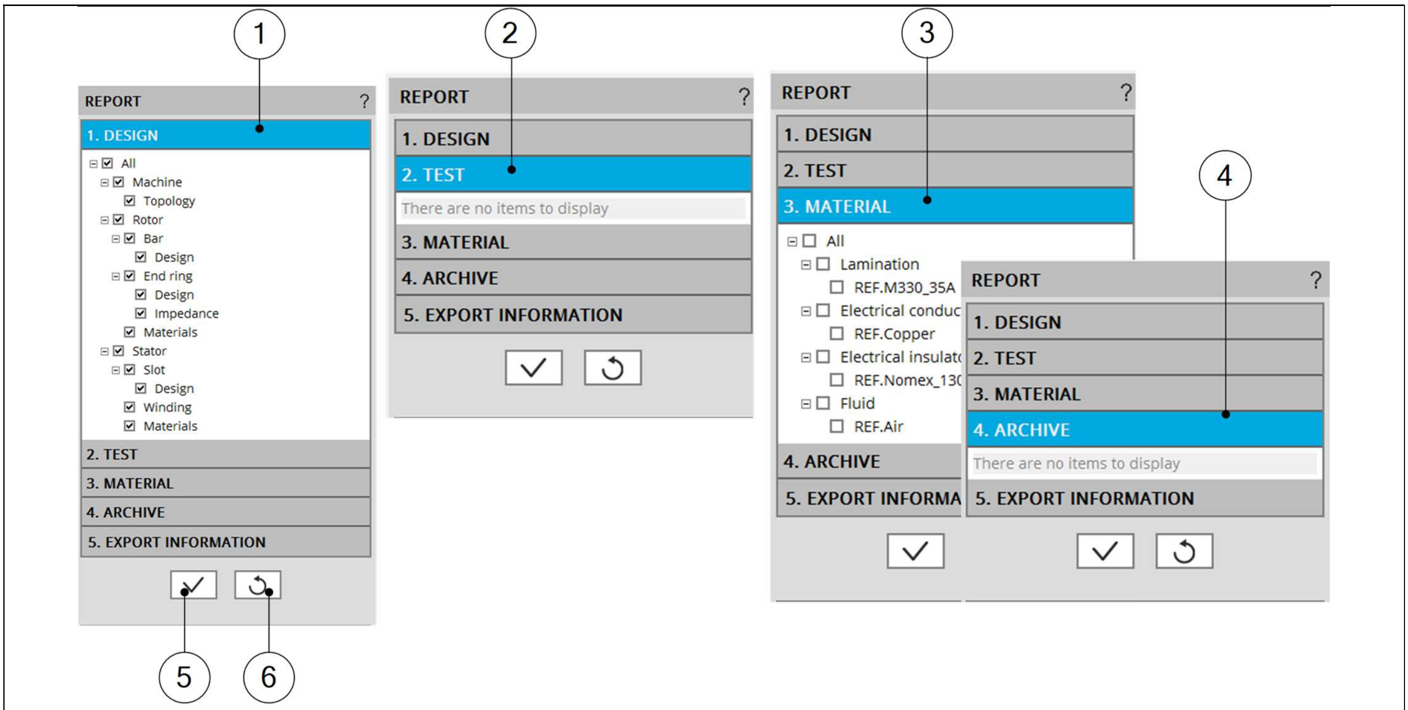
2.3 Steps to build and export a report

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.

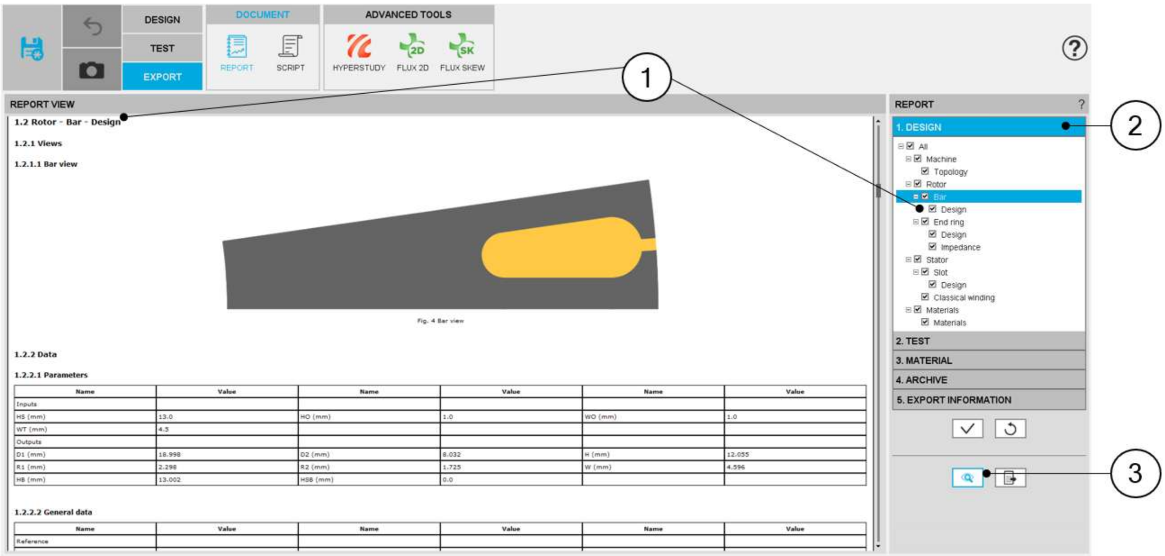
2.4 Section selection

2.4.1 List of sections available to build the report



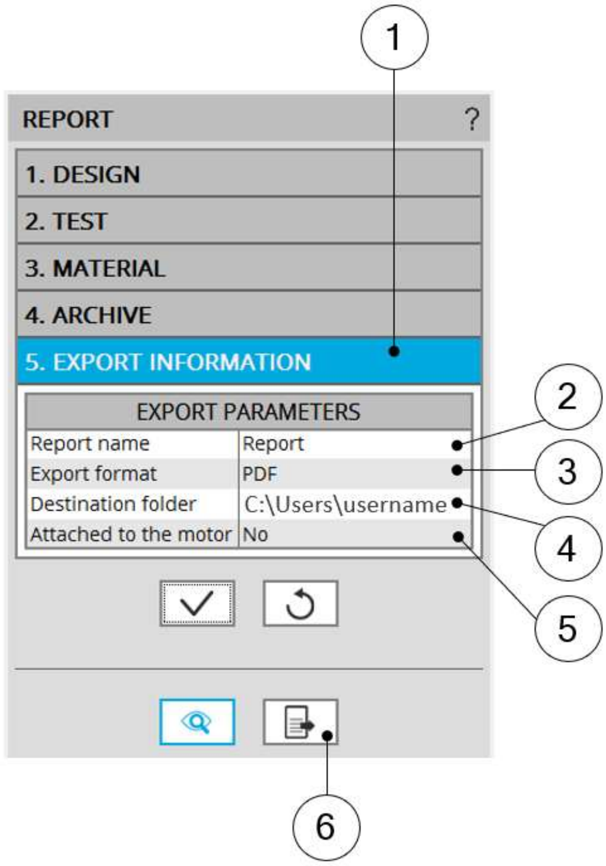
Motor Factory - EXPORT AREA – Export a report – Chapters to be selected	
1	Chapter which describes the DESIGN. Machine, Rotor and Stator characteristics.
2	Chapter which describes the TEST results. (At the moment no test is available) All the test results are available as soon as the corresponding computations 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. These 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

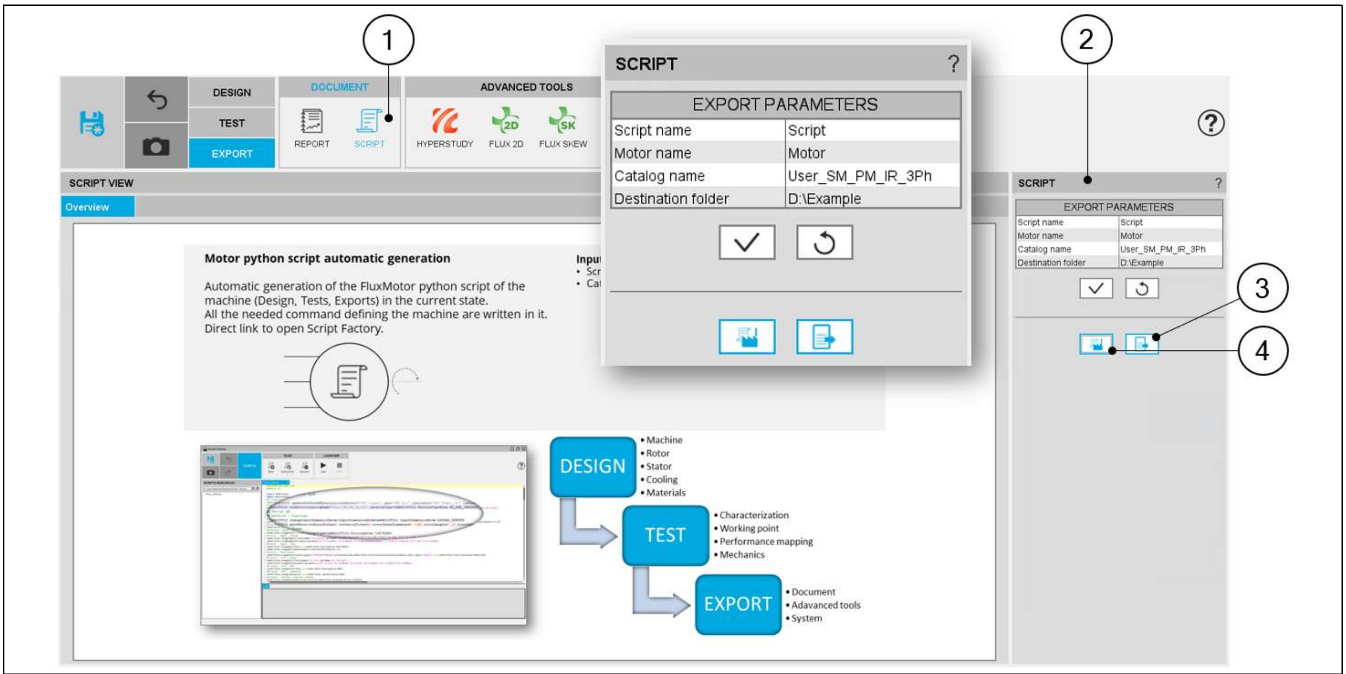
1	Select the area to define export parameters
2	A file name must be written (Default name = “Report”)
3	The file format must be chosen (pdf or html) to build the report
4	A folder must be selected via the browser for storing the report
5	It is possible to attach the report (HTML or PDF file) to the motor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

3 EXPORT A SCRIPT

3.1 Overview

Next to the function “Report”, the function “Script” gives the capability to build and export a python script file, in which all the needed command lines are written to rebuild the considered motor. The script is generated with all the needed sections and sub-sections in the Motor Factory, dedicated to the design, the test, and the exports.
Then Script Factory can be used to automate some study such like running serial tests or serial design configurations.

3.2 Area to build the script export



Motor Factory – EXPORT AREA – Export a python script

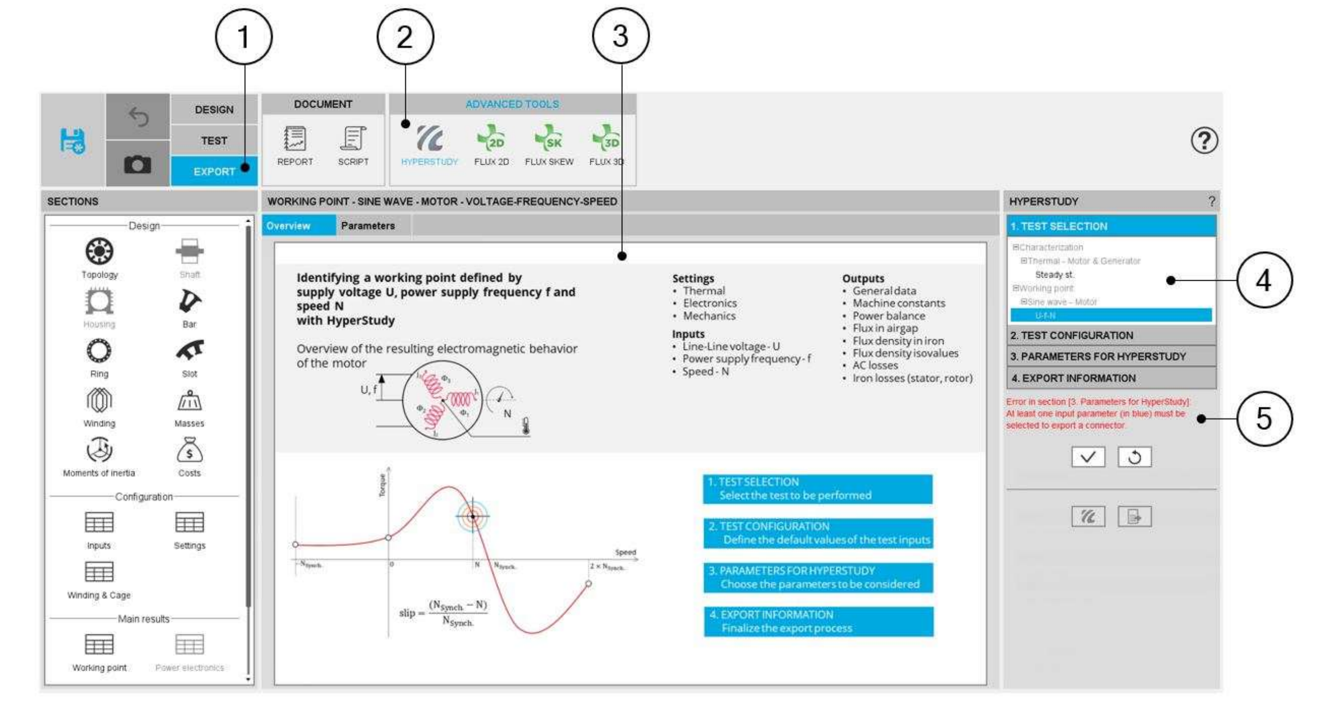
1	In Motor Factory select EXPORT / SCRIPT environment.
2	The EXPORT / SCRIPT environment user input allows to define the name and the location of the new script file + the name of the motor to be rebuilt from the new python script file, with the catalog name in which it will be stored. Note: Without defining other names for the motor and/or the catalog, the original motor would be overwritten while running the new python script file.
3	Button to build and to export the resulting python file.
4	Button to build and open it directly in the “Script Factory”

4 BUILD AND EXPORT A CONNECTOR FOR ALTAIR® HYPERSTUDY®

4.1 Overview

The aim of this export is to build a connector, allowing Altair® HyperStudy® to drive Altair® FluxMotor® for performing motor optimizations 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”.

4.2 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 input/output 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®

4.3 Steps to build and export a connector.

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

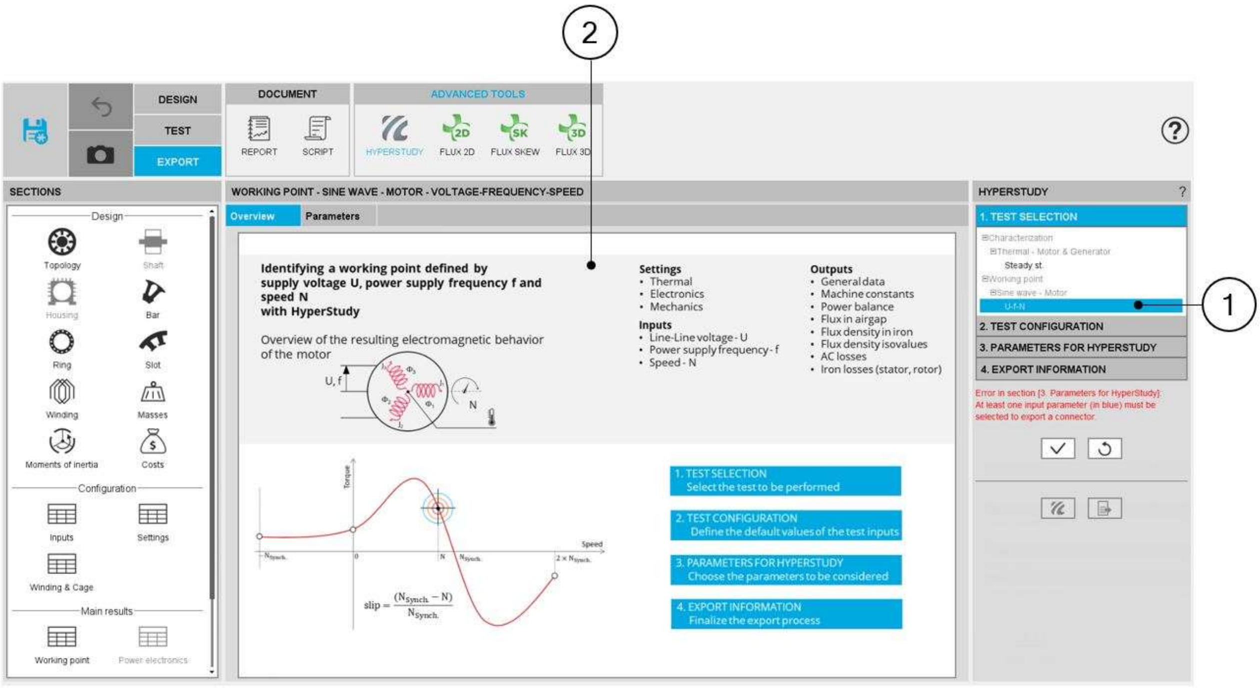
1) Select the test which will be performed by HyperStudy®
2) Define the test configuration, that means the user inputs/outputs parameters needed to define the test (settings and user inputs of the considered test)
3) Select the inputs/outputs parameters for performing studies with HyperStudy®
4) Define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

4.4 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

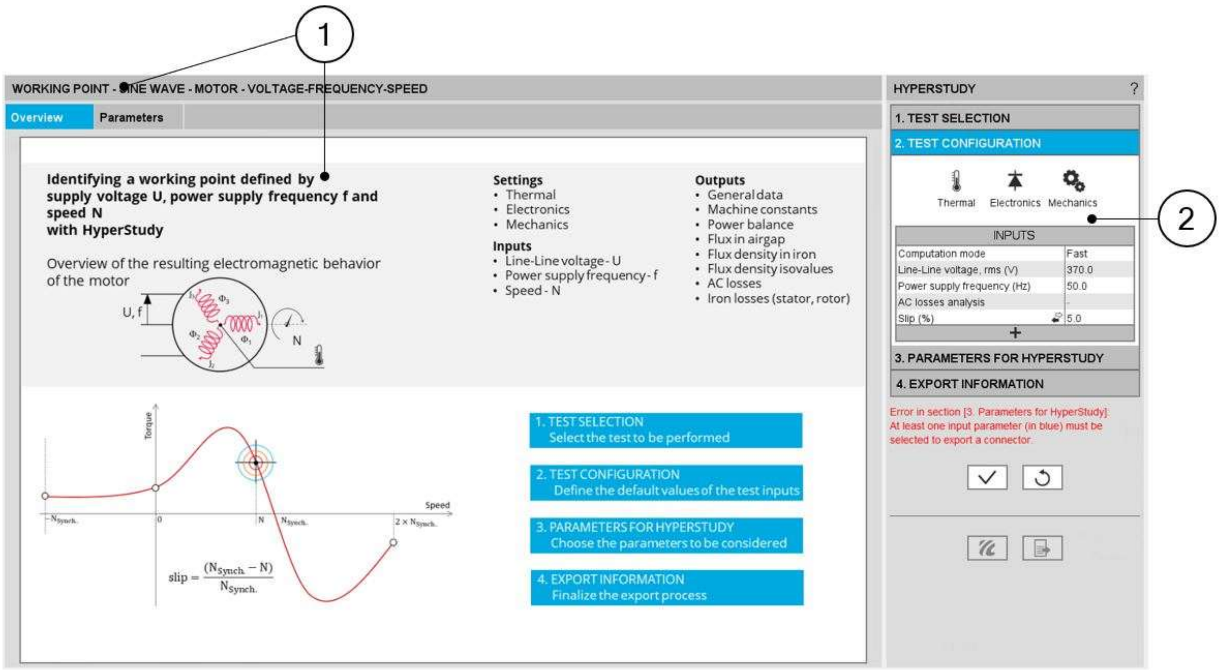
When a test is selected, the corresponding overview is displayed at the center of the screen, showing the main inputs to be considered.



Motor Factory – EXPORT AREA – Export connector for HyperStudy®	
1	Selection of a test to be performed by HyperStudy®
2	Display of general information (overview) dealing with the selected test

4.5 Test configuration

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



Motor Factory – EXPORT AREA – Export connector for HyperStudy®

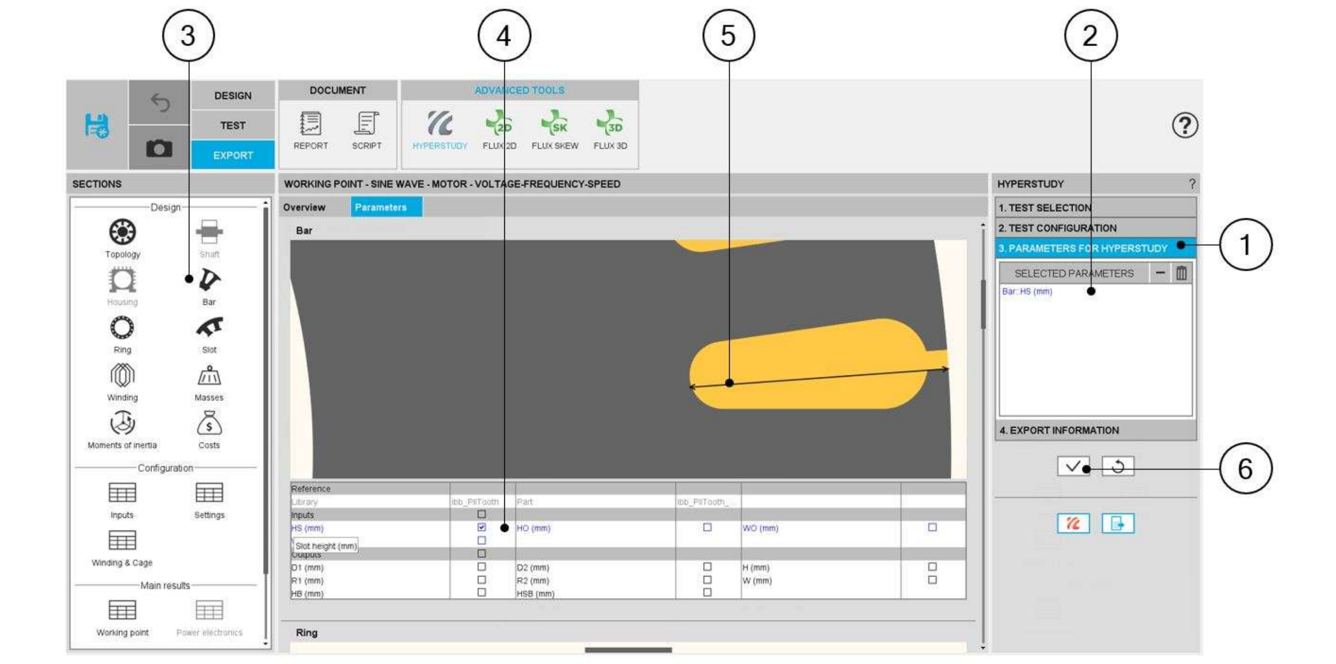
1	Overview of the selected test is displayed
2	User inputs can be defined in the test area

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.

4.6 Parameters for HyperStudy®

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

4.6.1 Selection of design parameters

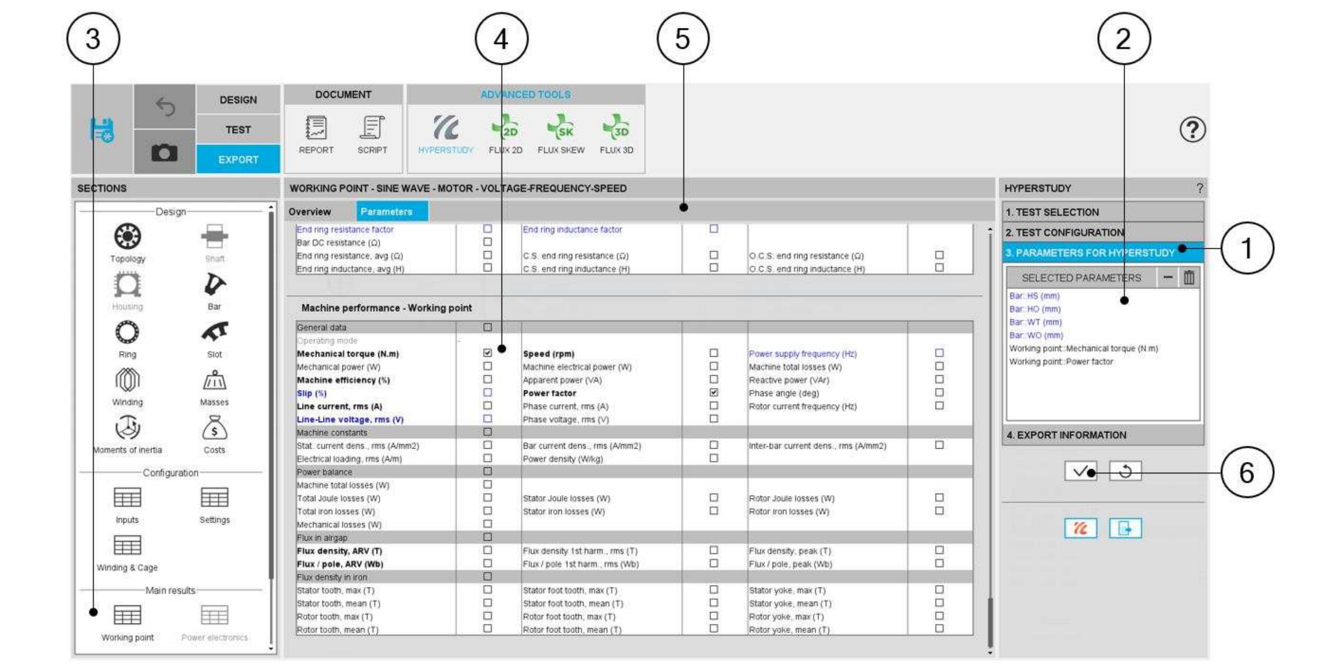


Motor Factory – EXPORT AREA – Export connector for HyperStudy® Design parameters selection	
1	Tab to be expanded to choose input/output parameters for HyperStudy®
2	Area in which input/output parameters are stored for HyperStudy®
3	Shortcuts to select the part of the design to be considered for the selection of parameters
4	All available design inputs are displayed. The corresponding dimension is highlighted when selected - arrow (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 quickly differentiate between the input data and output data inside data tables.

4.6.2 Selection of test data

The test data groups test results as well as the 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	Display of data which can be selected for HyperStudy® studies
6	Button to validate the previous choices

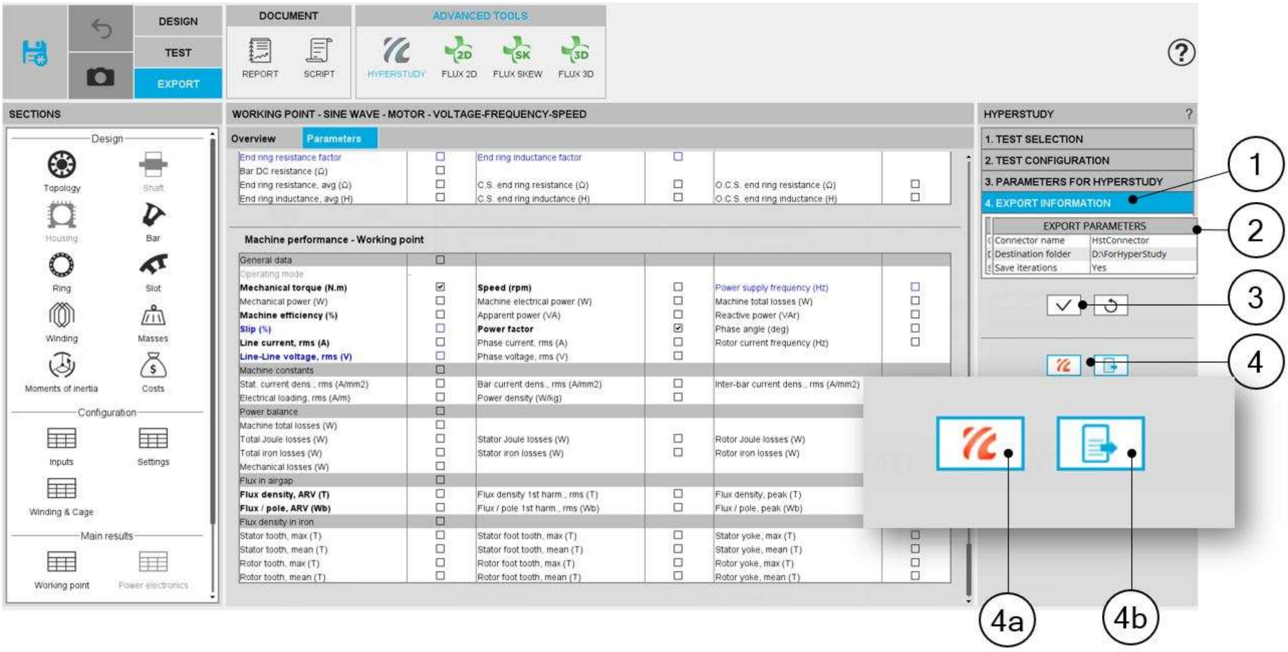
Note: Data which are given by the user are written in blue. These are inputs data. Data resulting from internal computations (outputs) are written in black. This allows the users to quickly differentiate between the input data and output data inside data tables.

4.7 Export information

The last step for building the 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) “ indicates if the results of the HyperStudy® 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 these can be edited in the Motor Factory very quickly.

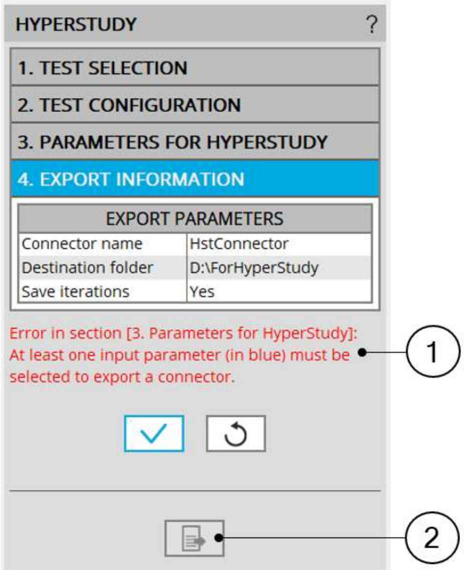


Motor Factory – EXPORT AREA – Export connector for HyperStudy® – Export information

1	Tab to be expanded to define the 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.
4a	To finalize this operation from FluxMotor, a first button allows to directly and automatically launches HyperStudy, builds and load the connector to perform the optimization.
4b	Button to finalize the export of the connector. When one clicks on this button opened the folder where the connector is stored.

Note: When one clicks on this button (4a), HyperStudy is automatically opened, with the connector built by FluxMotor uploaded. The studies can be initialized and run immediately in HyperStudy. The input variables as well as the Output responses that have been selected in FluxMotor are automatically identified and uploaded.

Note: When data is missing in the third table; "Parameters for HyperStudy®" for instance, an error message is displayed in the red colored font which indicates, what is missing and where. If all the needed information is missing, exporting a connector is not allowed.

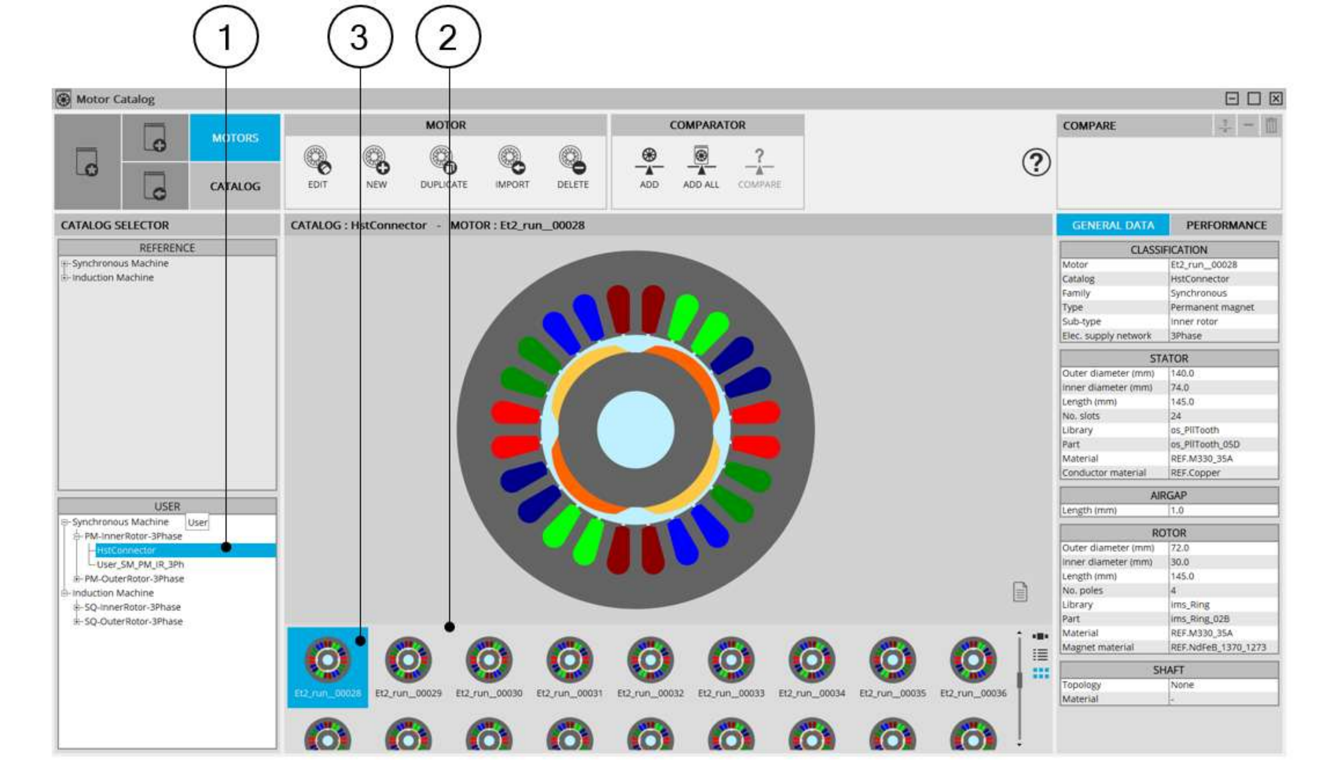


Motor Factory – EXPORT AREA – Export connector for HyperStudy® – Error message

1	Error message written in red font
2	The two buttons to export the connector and run launch HyperStudy are not active if the needed data is missing.

4.8 Get back HyperStudy® results in FluxMotor®

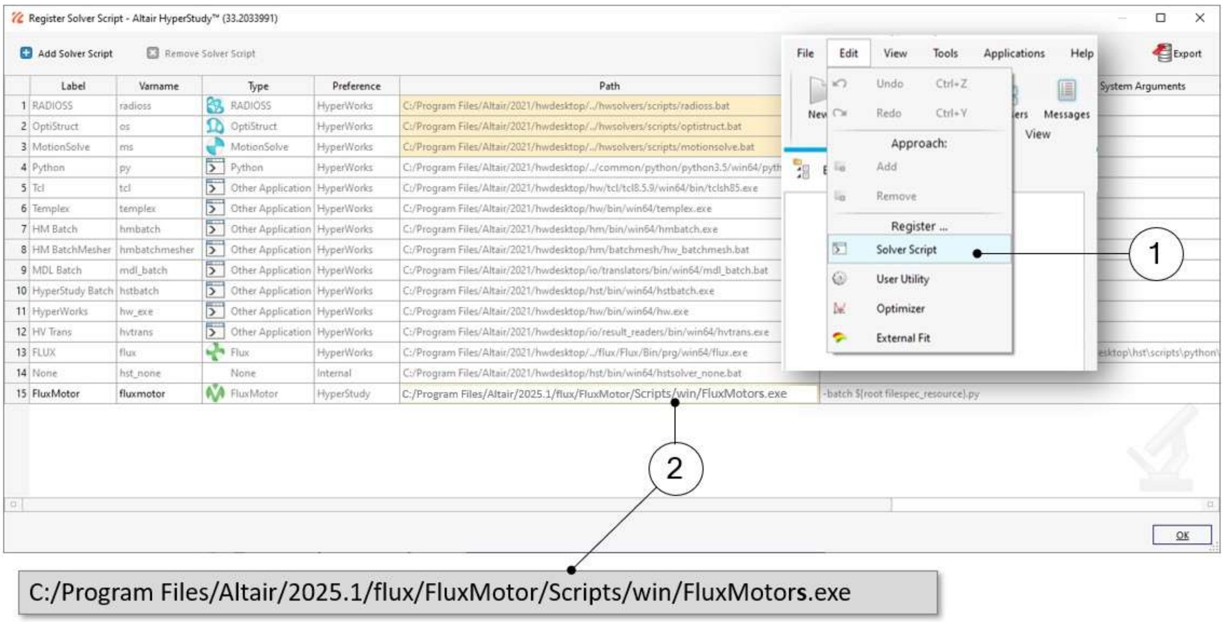
All the motors resulting from the operations performed with HyperStudy® can be used back in Motor Catalog of FluxMotor®, and then these can be edited in Motor Factory very quickly.



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 operations from HyperStudy® are stored in the dedicated catalog
3	Each motor can be selected, visualized and edited in the Motor Factory, to be evaluated more in depth

4.9 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 while using the coupling for the first time.



Connection between FluxMotor® and HyperStudy®

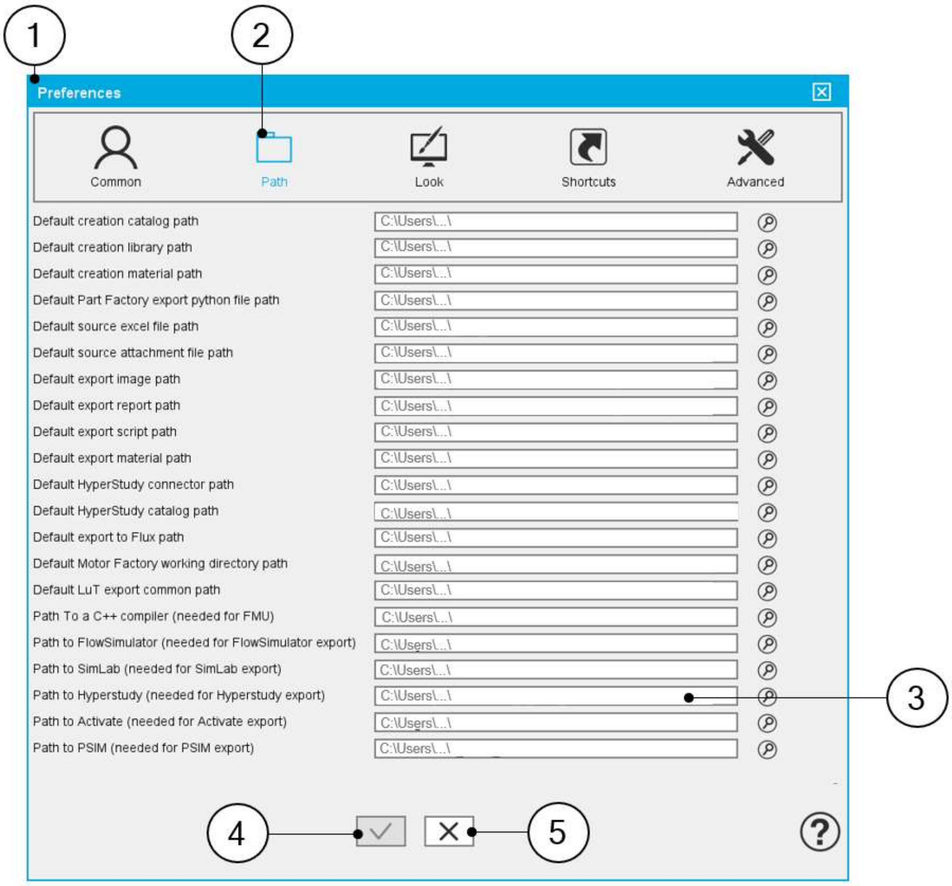
1	Open the area in HyperStudy® to register FluxMotor® 2025.1 script
2	Path where FluxMotor**s**.exe must be selected to be registered as a new solver in HyperStudy®. **Note**: FluxMotor**s**.exe with a "s" at the end of FluxMotor**s.** This must be defined only while using the coupling for the first time.

Note: The new auto generating the HyperStudy Study in HyperStudy Application (described above) allows to automatically register FluxMotor® as a new solver script in HyperStudy®. If HyperStudy is not install in the same folder (by default: C:\Program Files\Altair\2025.1\hwdesktop\hst), the path must be defined in the user preferences via the supervisor of FluxMotor (Path to HyperStudy – Needed for HyperStudy export – Ref. 3 below)

Warning: 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 FluxMotor solver.
A connector provided with FluxMotor version N-1 (or older) cannot be used in HyperStudy where the FluxMotor Solver Version N (or newest) is selected.

Since the FluxMotor 2022.3 version, each time a connector is generated, a ConnectorUpdater.py file is provided and located in the same folder as the connector.
Thanks to this script, the user can update an older HyperStudy connector generated with a former version of FluxMotor.
Please refer to the document MotorFactory_Introduction.pdf for additional information in the section dedicated to HyperStudy.



Path to HyperStudy – Needed for HyperStudy export – It must be defined in the user preferences (Supervisor of FluxMotor)

5 BUILD AND EXPORT A MODEL IN FLUX® 2D ENVIRONMENT.

5.1 Overview

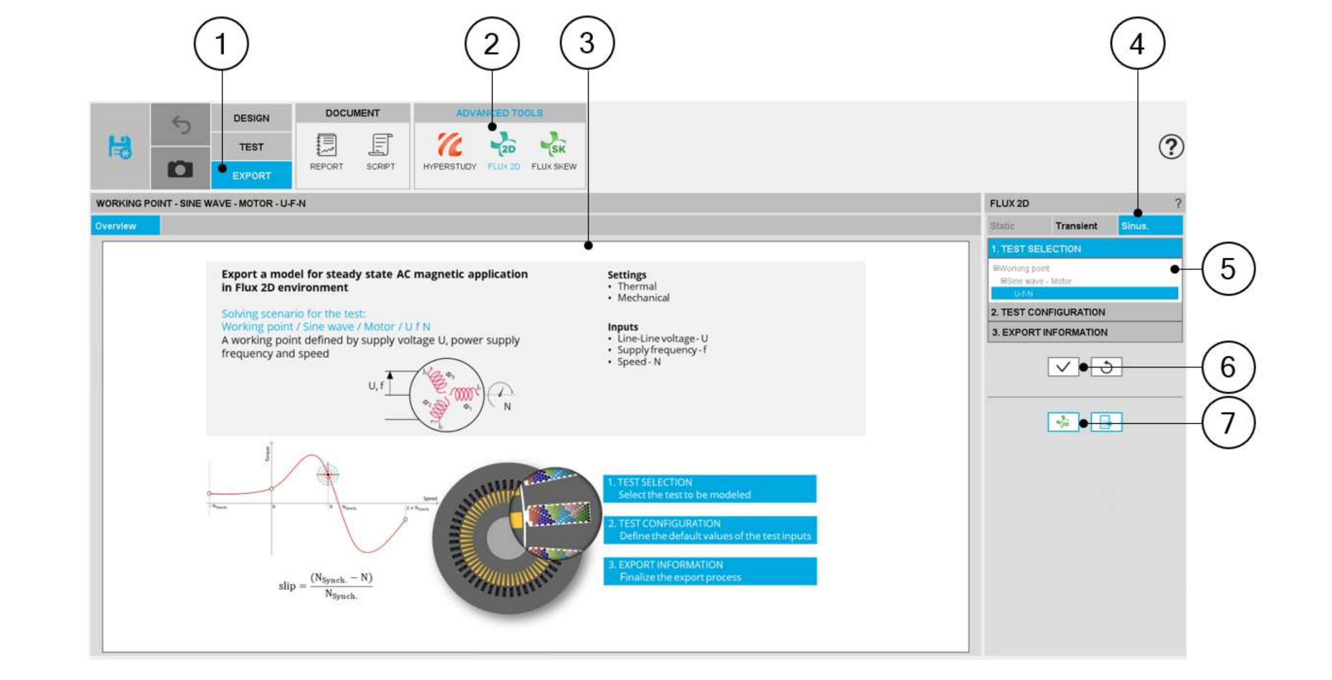
The aim of this export is to provide a python file which allows a full parametrized model, ready to be used in Flux® 2D environment.
In the current version, models can be exported for harmonic application or transient application in Flux® 2D environment.

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
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.

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



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	Exports the python file for building the model in Flux® 2D environment or launch the project directly in Flux® 2D.

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

In EXPORT / ADVANCED TOOLS / FLUX 2D area, one must indicate that on which application of Flux® 2D environment, the models 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).

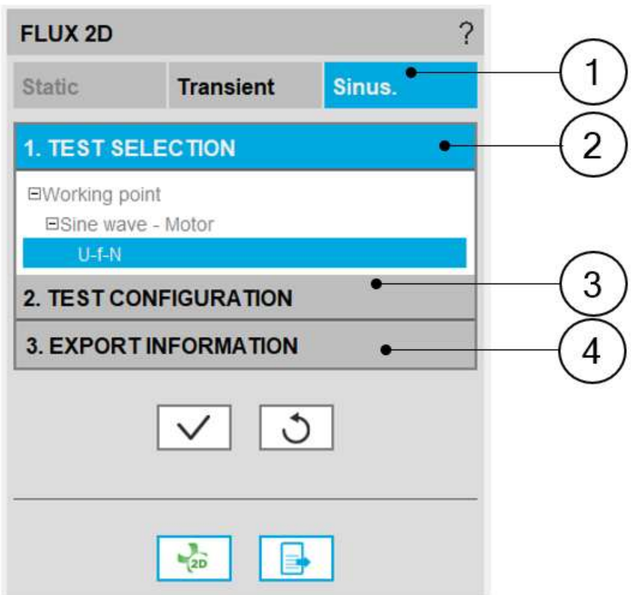
   This means defining the simulation, that one wants to perform in Flux® 2D environment for evaluating the electromagnetic behavior of the considered machine.

2) Define the test configuration. This is to give an initial value for the 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 the user inputs is given.

3) Define the export information.

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

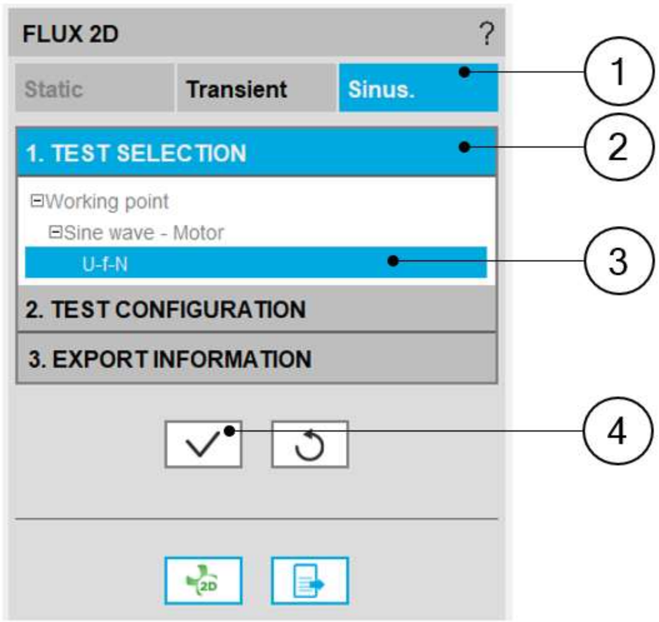


Motor Factory – EXPORT AREA – Export model for Flux® 2D environment

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

5.4 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.

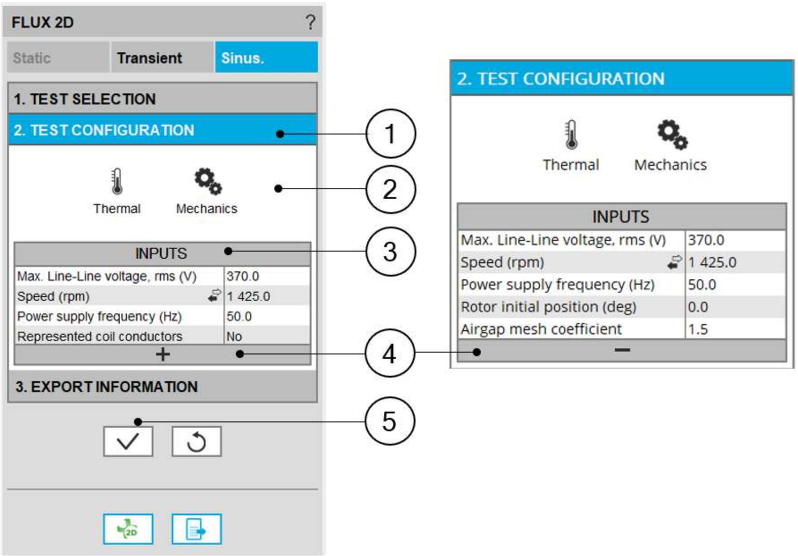


Motor Factory – EXPORT AREA – Export a model for Flux® 2D – Test selection

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

5.5 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.



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

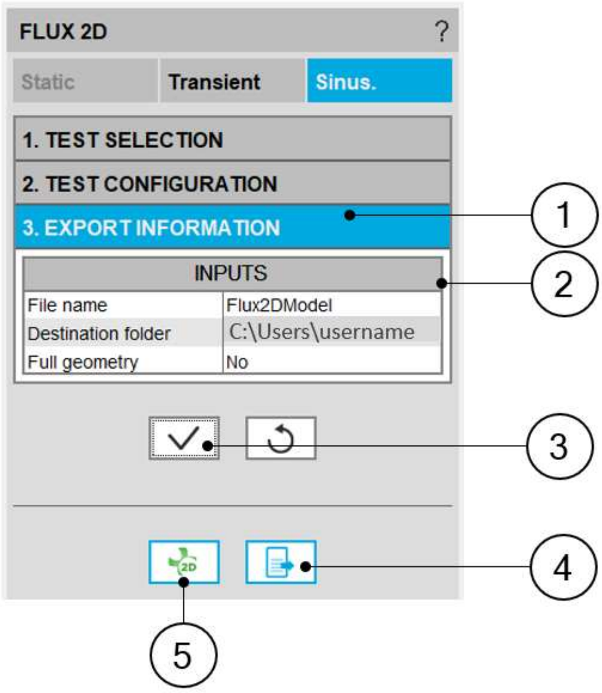
More details about the inputs and settings can be found at chapter 5.7

5.6 Export information

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

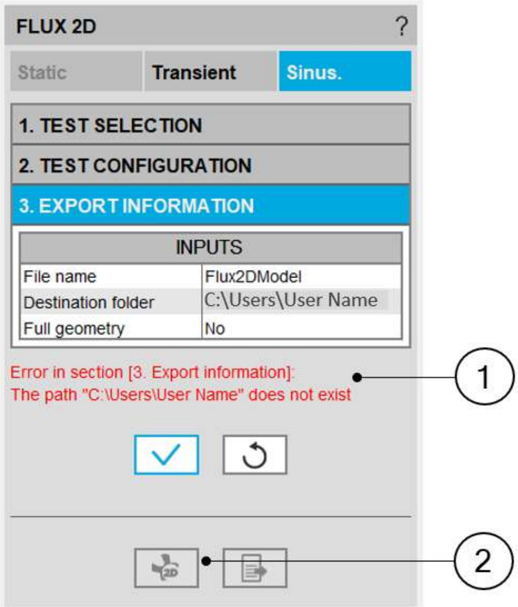
There are three data to be defined:

- 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.



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, the folder gets opened 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 displayed in the red colored font which indicates the missing data. If all the needed information is missing, exporting a model is not allowed.



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

1	Error message display in red colored 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.

5.7 Available models to be exported and user inputs.

5.7.1 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:

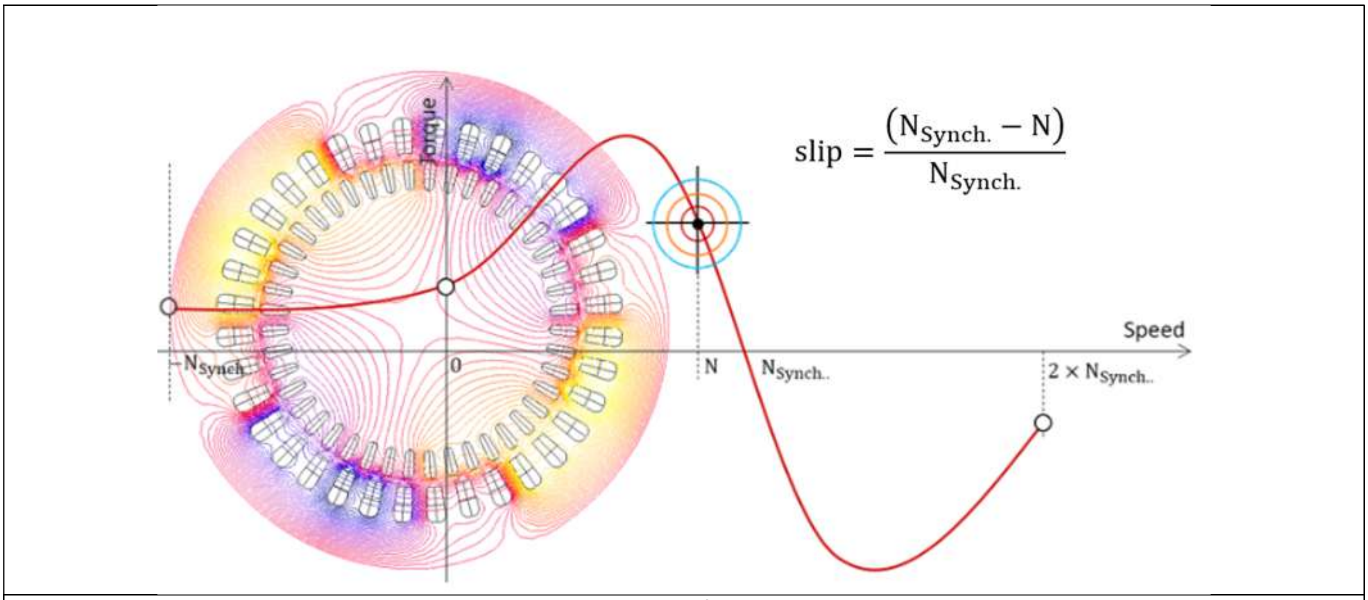
Application	Model family	Package	Convention	Model / Test
SINUS	Working point	Sine wave	Motor	U-f-N
TRANSIENT	Working point	Sine wave	Motor	U-f-N
	Working point	Sine wave	Motor	U-f-N (Hairpin)

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

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

5.7.2.1 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.



Working point – U-f-N - Illustration

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.

5.7.2.2 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 machines) dealing with the test settings.

5.7.2.3 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 ($N_{Synch.}$) and rotor speed N:

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

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.

5.7.2.4 Advanced inputs

The lists of advanced inputs dedicated to this export are listed below.
For more details please refer to the section 5.7.5 - 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.

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

5.7.3.1 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.

5.7.3.2 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 machines) dealing with the test settings.

5.7.3.3 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 ($N_{Synch.}$) and rotor speed N:

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

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.

5.7.3.4 Advanced inputs

The list of advanced inputs dedicated to this export are listed below.
For more details, please refer to the section 5.7.5 - 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.

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

5.7.4.1 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.

5.7.5 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 one decreases the value of “**Airgap mesh coefficient**”, the size of the mesh elements reduces, 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:

MeshPoint = (airgap) x (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 the need of huge numerical memory, and the respective computation time increases considerably.

5.7.6 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.

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

6.1 Overview

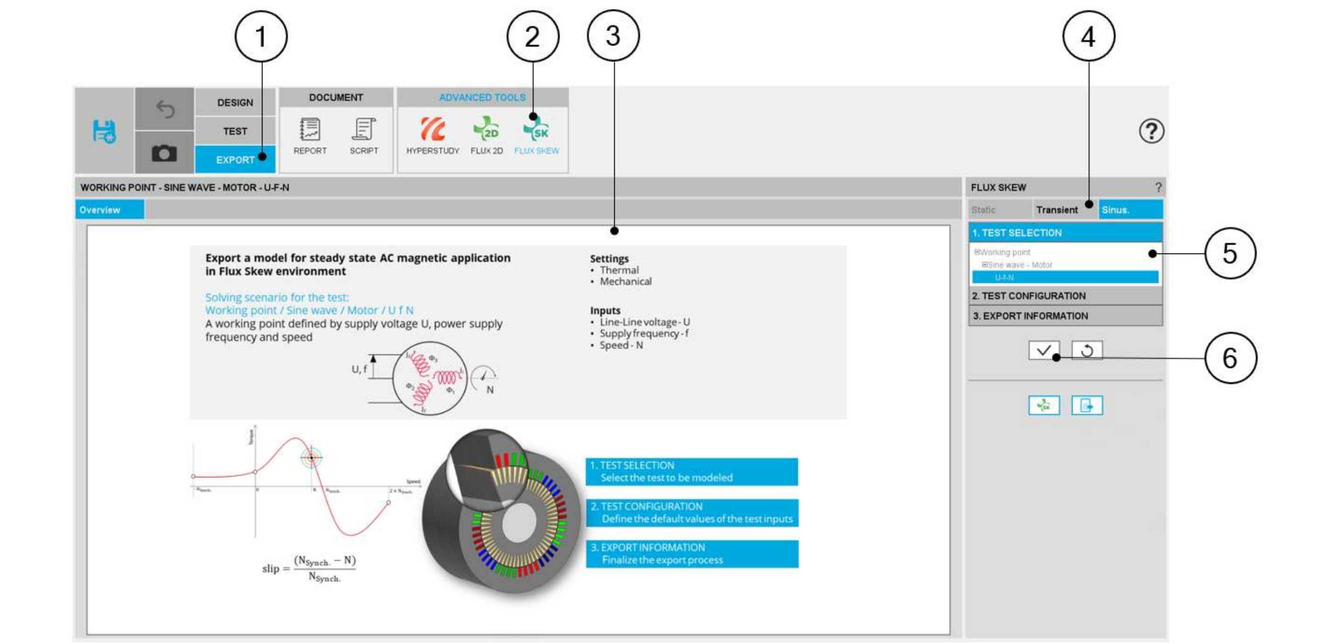
The aim of this export is to provide a python file which allows to get a full parametrized model ready to be used in Flux® SKEW environment.
In the current version models can be provided for steady state AC Magnetic application or transient application in Flux® SKEW environment.

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.

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

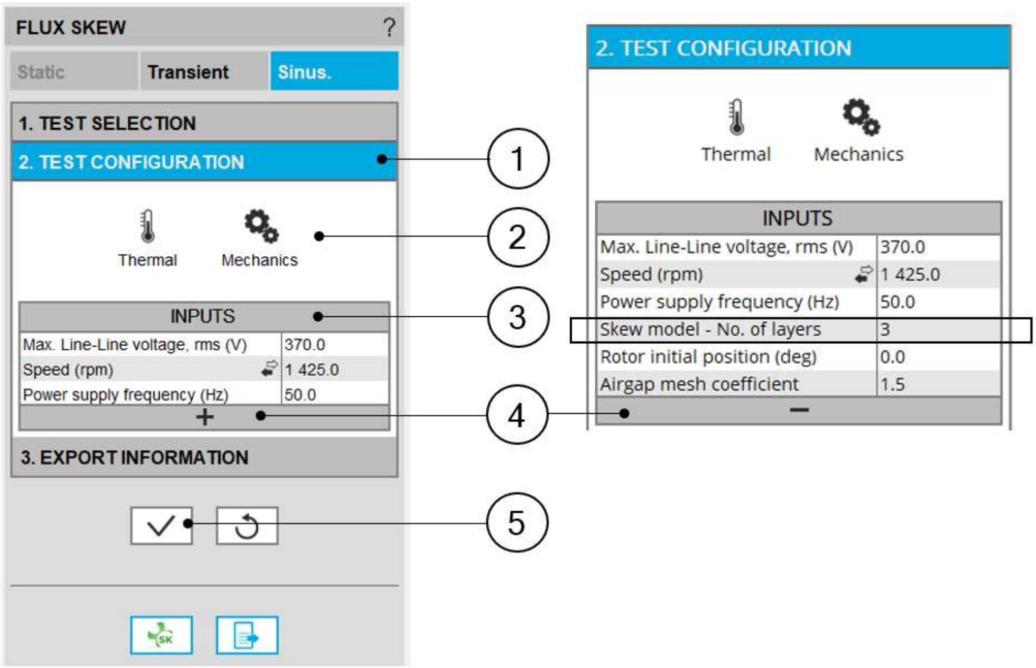


Motor Factory – EXPORT AREA – Export model for Flux® Skew environment	
1	Selection of the EXPORT area of Motor Factory.
2	Access to the area in which a model for Flux® Skew environment can be made
3	Zone to visualize the overview of the selected model to be exported
4	Click on the tab to select the application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

6.3 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 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”, the “**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.



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

7 BUILD AND EXPORT A MODEL IN ALTAIR® FLUX® 3D ENVIRONMENT

7.1 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 Altair® Flux® 3D environment.

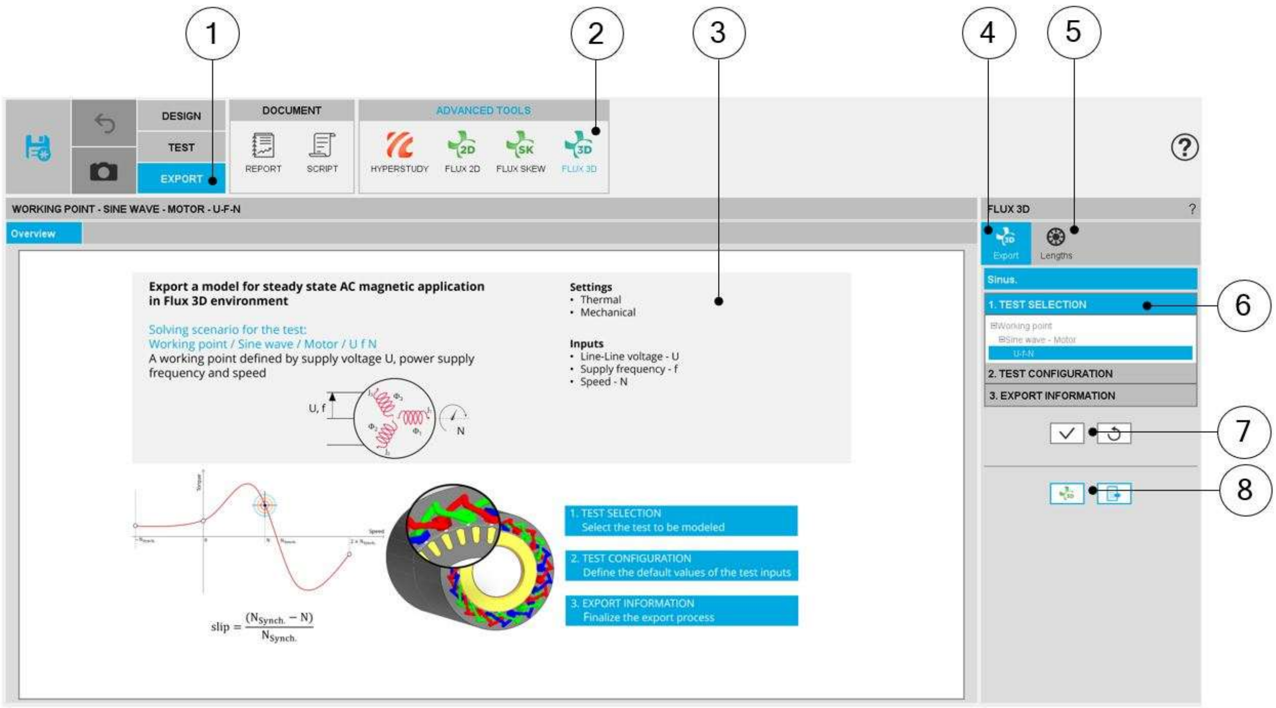
In the current version of FluxMotor® the only application type available for Flux® 3D export is the Steady State.

Application	Model family	Package	Convention	Model / Test
Steady State AC	Working point	Sine wave	Motor	U-f-N

Note: This export is only available for inner rotor machines.

The following section gives a short description of the process to export the model into Flux® 3D environment.

7.2 Area to build and to export a model to Flux® 3D environment.



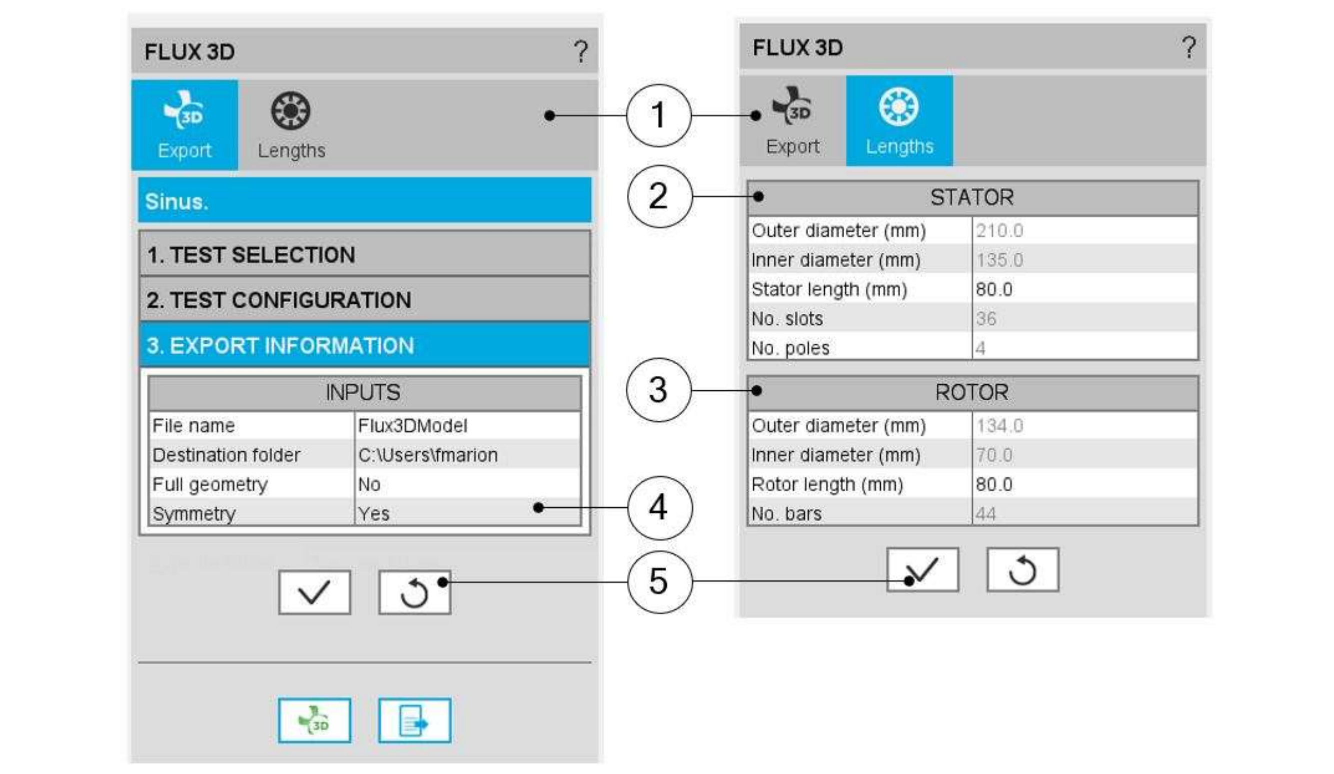
Motor Factory – EXPORT AREA – Export model for Flux® 3D environment

1	Selection of the EXPORT area of Motor Factory.
2	Access to the area in which a model for Flux® 3D 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 (in the current version, only Steady state AC is available)
5	Different lengths for rotor and stator can be chosen by clicking on this tab.
6	3 steps to build the model to be exported for Flux® 3D environment
7	Button to validate inputs and export the python file for building the model in Flux® 3D environment.
8	Buttons to export the python file for building the model in Flux® 3D environment or to launch directly Flux® 3D.

7.3 Particularities in building and exporting a model to Flux® 3D environment.

A user who wants to build and export a model to Flux® 3D must follow the same steps and recommendations, as with the function “FLUX 2D”.

The main particularity of function “FLUX 3D” is that rotor and stator axial lengths are inputs, that must be defined. Their default values equal the machine length defined in “Design”. These two lengths can set to different values.



Motor Factory – EXPORT AREA – Export a model for Flux® 3D

1	Tab selector to define general export parameters and axial lengths in Flux® 3D environment
2	Table containing stator topology features. Stator length may be modified.
3	Table containing rotor topology features. Rotor length may be modified.
4	To reduce computation time in Flux® 3D, full geometry and symmetry options are offered. By default, these options are set to assure minimum computation time without accuracy loss.
5	Button to validate the previous choices

Note 1: Default values for rotor and stator lengths are equal to the machine design length. However, a change in these values only affect the Flux® 3D export and it never changes the design length value.

Note 2: Symmetry allows to represent only half of the topology in the axial direction, saving the simulation time. This option is available only when all the dimensions are equal on both sides of the machine (Connection Side and Opposite Connection Side), especially for the end winding and the rotor end-ring dimensions.

A warning message is provided in the “Design environment” each time an asymmetric topology is defined, to inform the user that the Flux® 3D export input “symmetry” has been set to “No”. This also occurs when the asymmetry is due to the end shafts, even if they are not represented in the 3D environment.

Note 3: Export to Flux® 3D is not available for skewed topologies. In this case Flux® Skew export is recommended.

8 BUILD AND EXPORT A MODEL IN ALTAIR® FLOW SIMULATOR™ ENVIRONMENT

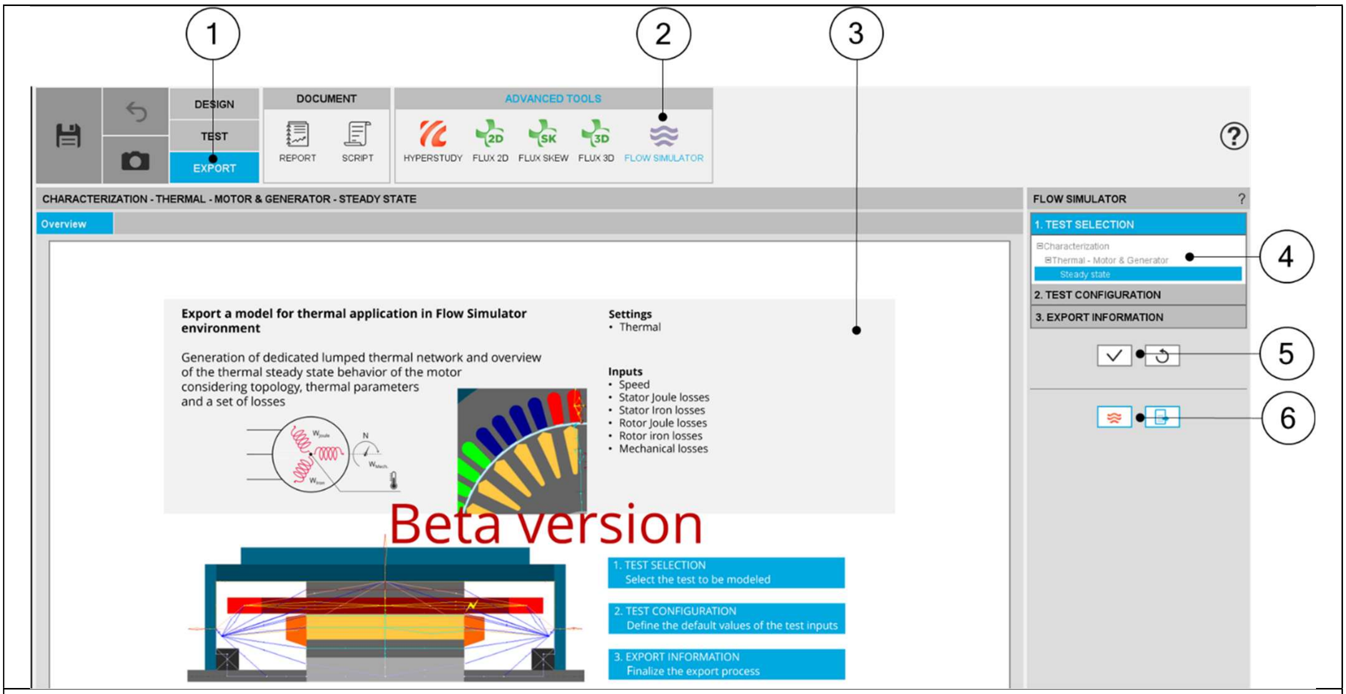
8.1 Overview

The aim of this export is to provide a ".flo" file which allows to get a machine model ready to be used in Altair® Flow Simulator™ environment which will allow to represent the thermal behavior of the machine through a customizable lumped thermal parameter model coupled with a flow network when necessary.

In the current version of FluxMotor® the tests available for Flow Simulator® export are the steady state and the transient thermal analysis for three-phase inner rotor SMPM, SMRSM and IMSQ.

The following section gives a short description of the process to export the model into Flow Simulator™ environment.

8.2 Area to build and to export a model to Flow Simulator™ environment



Motor Factory – EXPORT AREA – Export model for Flow Simulator™ environment

1	Selection of the EXPORT area of Motor Factory.
2	Access to the area in which a model for Flow Simulator™ environment can be made
3	Zone to visualize the overview of the selected model to be exported. Zone to visualize the overview of the selected model to be exported. Currently, there are two models: thermal analysis in steady state and one in transient. The one in transient is in beta mode.
4	3 steps to build the model to be exported for Flow Simulator™ environment
5	Button to validate the inputs.
6	Buttons to export the ".flo" file for building the model in Flow Simulator™ environment or to launch directly Flow Simulator™

Note 1: ". flo" files are text files used by Flow Simulator™ to stock all the information about a project, e.g., the background images, the thermal/flow network components including their values, placements, etc.

8.3 Steps to build an export Flow Simulator™

8.3.1 Introduction

In EXPORT / ADVANCED TOOLS / FLOW SIMULATOR area, 3 steps are needed to build and export data:

1) Define the thermal model to be exported into Flow Simulator™. For the moment only the thermal steady state model is available.
2) Define the test configuration, that means the user inputs/outputs parameters needed to perform the test (settings and user inputs of the considered test)
3) Define the export information.

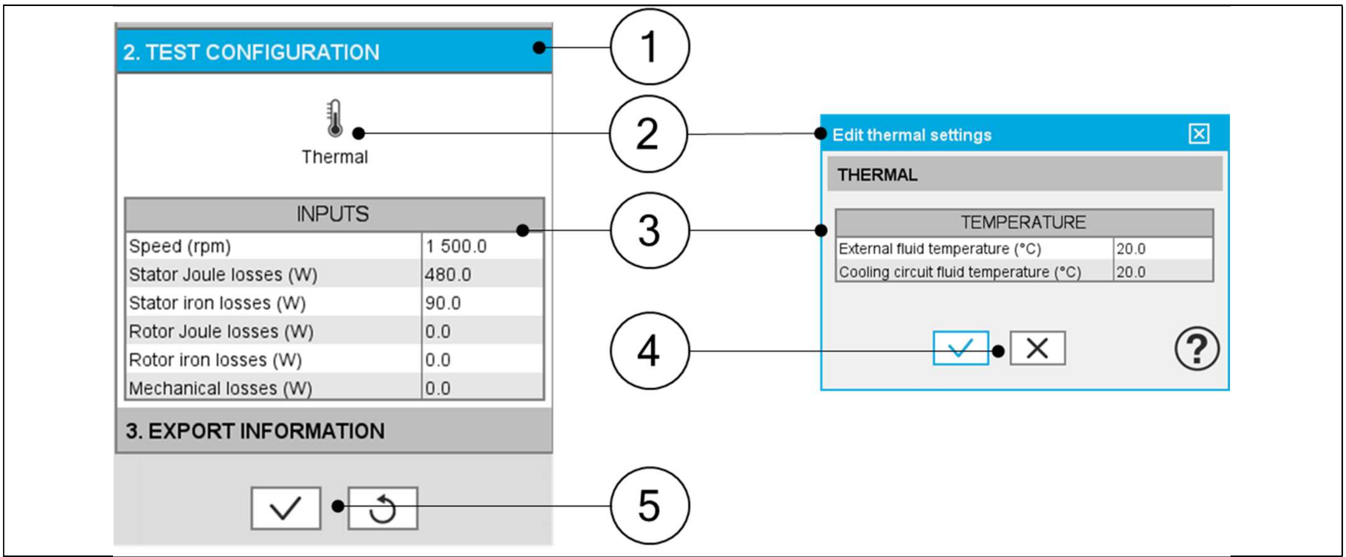
8.3.2 Test selection

In the current version of FluxMotor®, two tests can be selected:

- Characterization / Thermal – Motor & Generator / Steady State
- Characterization / Thermal – Motor & Generator / Transient

8.3.3 Test configuration

After selecting the test, the corresponding test inputs (settings and user inputs) must be defined. This allows us to define the initial conditions for the simulation process in Flow Simulator environment.



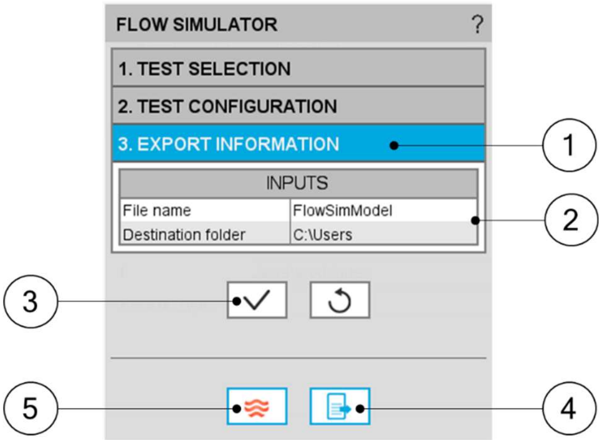
Motor Factory – EXPORT AREA – Export a model to Flow Simulator

1	Tab to define the initial conditions for the simulation process in Flow Simulator environment
2	Access to thermal settings
3	User inputs and settings dealing with the considered test should be defined
4	Buttons to validate or cancel thermal settings
5	Buttons to validate inputs or to return to default values.

8.3.4 Export information

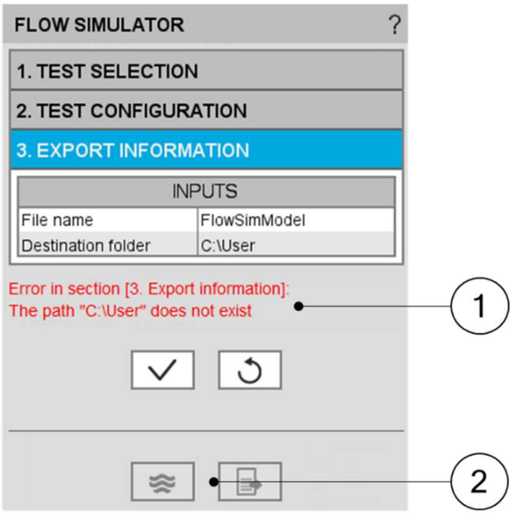
The last step for building a model for Flow Simulator is to define the export information.
There are two data to be defined:

- The name of the ".flo" file which will build the model in Flow Simulator environment.
- The folder in which the provided file will be stored.



Motor Factory – EXPORT AREA – Export model for Flow Simulator – Export information	
1	Tab to be expanded to define export information for Flow Simulator
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. It opens the folder where the ".flo" file is generated.
5	Button to finalize the export of the model. It launches Flow Simulator and builds the model.

Note 1: When data is missing / wrong in third table; "Export information" for instance, an error message is displayed in the red colored font which indicates what data is missing / wrong. If needed information is missing, exporting a model is not allowed.



Motor Factory – EXPORT AREA – Export model for Flow Simulator – Error message	
1	Error message displayed in the red colored font
2	The button to export the model is not active if the needed data are missing

Note 2: Exporting a model to Flow Simulator (i.e. provide the ".flo" file to build the model) can take a few seconds, since it is necessary to run some pre-calculations to build the lumped parameter thermal model.

8.4 Available models to be exported and user inputs

8.4.1 Overview

In the current version only one Flow Simulator export is available the steady state thermal analysis for three-phase inner rotor SMPM. Thermal transient export and more machine types will be addressed in future versions.

8.4.2 Characterization – Thermal - Motor & Generator – Steady State

8.4.2.1 Positioning and objective

The aim of this export is to represent the steady state 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.

The following section describes all the user inputs and settings to initialize the exported model.

8.4.2.2 Settings

One button gives access to the following setting definition:

- External fluid temperature
- Cooling circuit fluid temperature

For more details, refer to the section dealing with the test settings.

8.4.2.3 Standard inputs

1) Speed

The speed of the machine to be considered.

2) Set of losses

The losses to be defined are the following ones:

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

8.4.2.4 Advanced inputs

There are no advanced inputs required for this export.

8.4.3 Characterization – Thermal - Motor & Generator – Transient

8.4.3.1 Positioning and objective

The aim of this export is to represent the transient 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 transient thermal circuit built in Flow Simulator, it corresponds to the thermal model used in Flux Motor to run both, thermal and coupled tests.

The following section describes all the user inputs and settings to initialize the exported model.

8.4.3.2 Settings

One button gives access to the following setting definition:

- External fluid temperature
- Cooling circuit fluid temperature

For more details, refer to the section dealing with the test settings.

8.4.3.3 Inputs

The main inputs of this test correspond to a set of losses to be considered for evaluating the thermal behavior of the machine in a transient mode.

8.4.3.4 Standard inputs

1) Speed

The speed of the machine to be considered.

2) Set of losses

The losses to be defined are the following ones:

- Stator Joule losses
- Stator iron losses
- Rotor Joule losses
- Rotor iron losses
- Mechanical losses

3) Time definition

The time during which the test is performed, defined by:

- Maximum evaluation duration
- Time step

8.4.3.5 Advanced input

There are no advanced inputs required for this test.