Altair® FluxMotor® 2026

Induction machines – Squirrel cage - Inner & Outer rotor

Motor Factory – Test – Performance mapping

General user information

Altairhyperworks.com

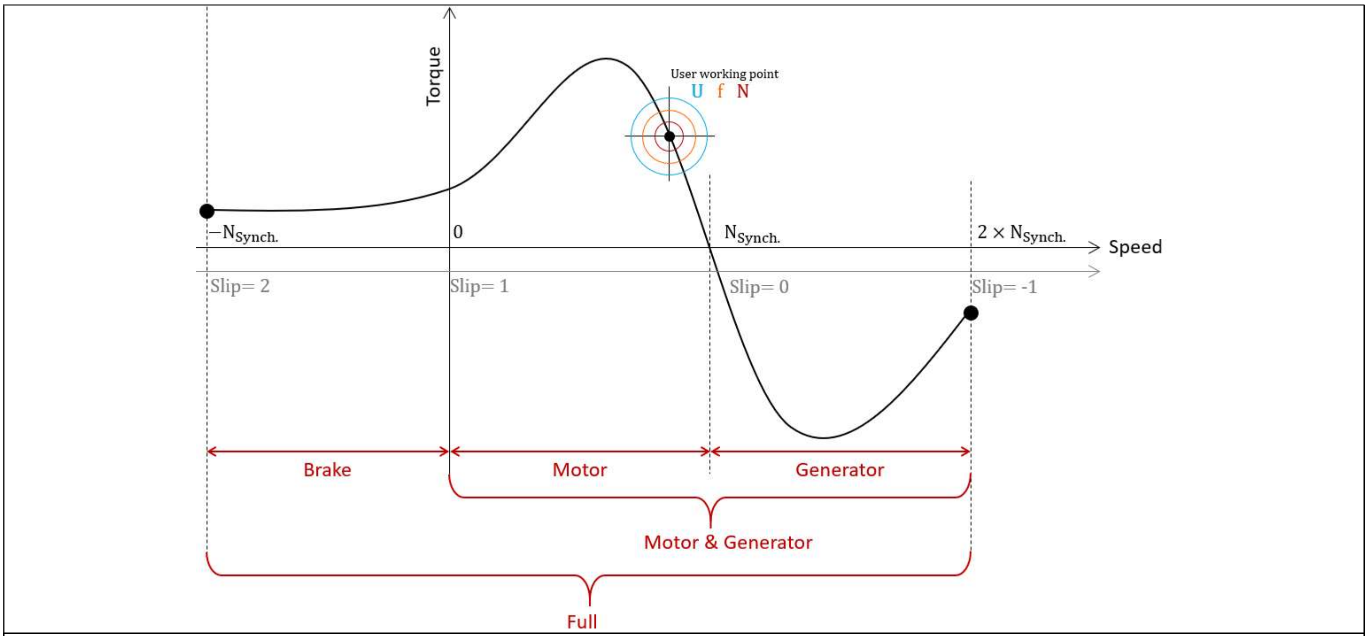
Contents

1 PERFORMANCE MAPPING – SINE WAVE – MOTOR – T(Slip)

1.1 Overview

1.1.1 Positioning and objective

The aim of the test "**Performance Mapping – Sine wave – Motor – T(Slip)"** is to characterize the behavior of the machine when operating over a speed range corresponding to a targeted operating mode ("Motor", "Generator", "Brake", "Motor & Generator", "Motor & Brake" and "Full"). This also corresponds with the operating magnitude of line-line voltage (U) and power supply frequency input values (f).
Hence, these inputs are enough to define a T(Slip) curve and to get additional curves defining all electromagnetic quantities.
Note: In addition, the input "user working point - slip" allows to target a specific working point to get all the corresponding electromagnetic quantities summarized in a table.



"Performance mapping – Sine wave – Motor – T(Slip)" Illustration

The results of this test give an overview of the electromagnetic behavior of the machine considering its topology.
For one or more operating modes, the general data of the machine, like mechanical torque, currents, power factor and power balance are computed and displayed as curves.

Note: The considered used convention is the motor one.

For the targeted user working point, in addition to the general data, machine constants, flux in airgap and the magnetic flux density in every regions of the machine's magnetic circuit are also computed for evaluating the design of the machine.
It also gives the capability to make comparisons between results got from the measurements and those got with the Altair® FluxMotor®.

The following table helps to classify the test "Performance mapping – Sine wave – Motor – T(Slip)".

Family	Performance mapping
Package	Sine wave
Convention	Motor
Test	T(Slip)

Positioning of the test "Performance mapping – Sine wave – Motor – T(Slip)"

1.2 Main principles of computation

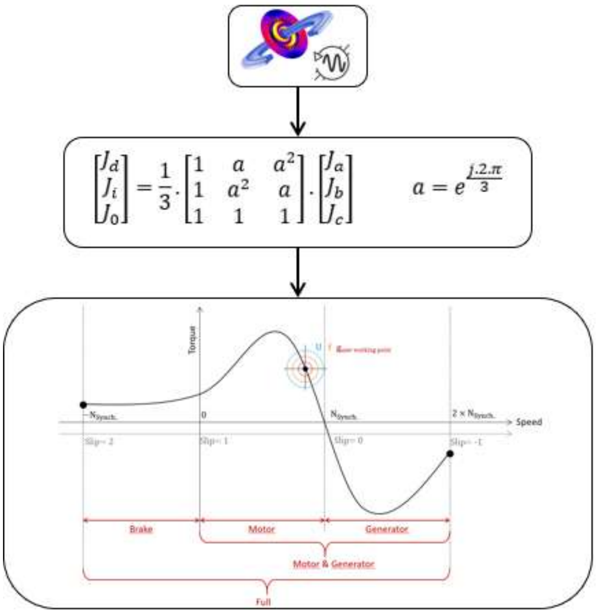
1.2.1 Introduction

The aim of this test is to give a quick overview of the electromagnetic potential of the machine (in motor convention) by characterizing performance over a speed range corresponding to a targeted operating mode and according to the line-line voltage and the power supply frequency.

The computation process is based on finite element modelling (Flux® software - Steady state AC application).

1.2.2 General data

The computation process is based on finite element modelling Flux® software - Steady state AC application).
The general performances are computed over the considered slip range and by considering the line-line voltage and power supply frequency.
The computation process considers the complex values of current and voltage. Moreover, these quantities are computed by considering the symmetrical component transformation.
Then, the power balance which includes stator and rotor iron losses, are computed.



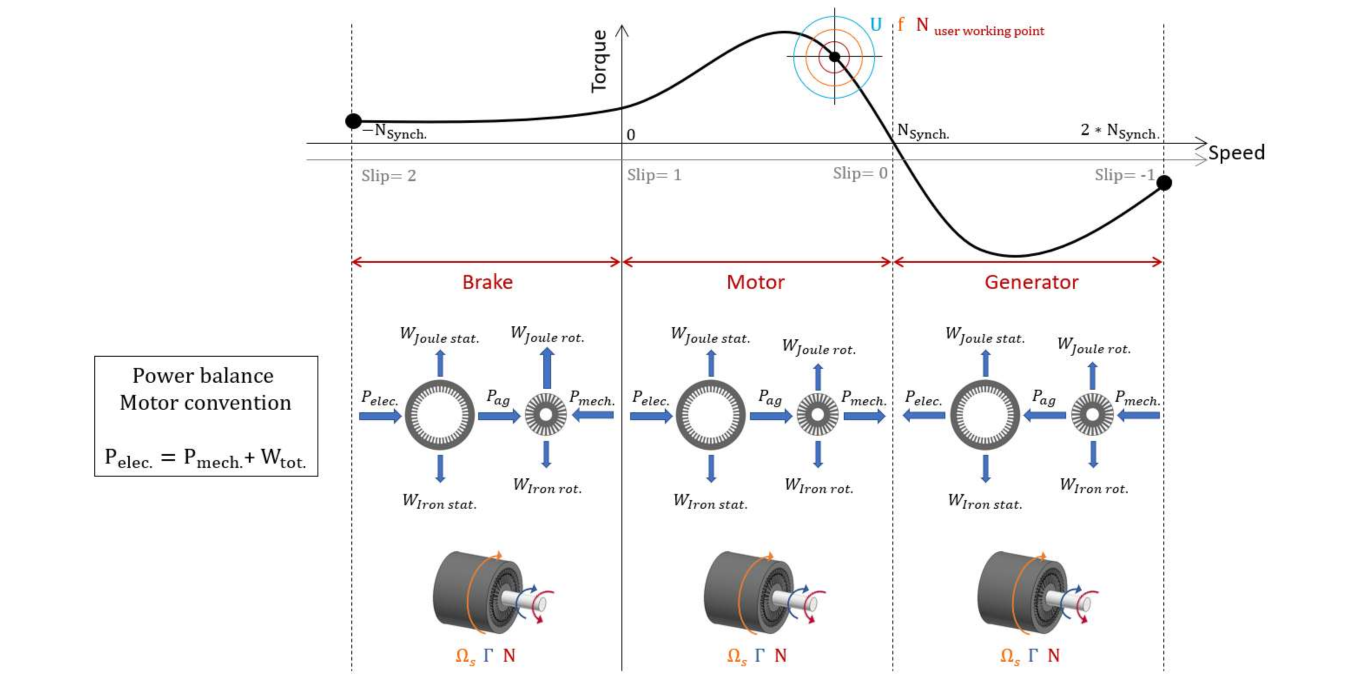
Computation process with symmetrical component transformation

The use of the symmetrical component transformation is a key point.
Indeed, when using finite element modelling with Steady state AC application, each phase of the machine sees different airgap reluctance (due to the fixed rotor position) which generates indirect currents in the stator phases.
It is not a physical phenomenon because, over an electrical period, each phase sees the same air gap reluctance variation.
So, a correction must be done by using symmetrical component transformation which allows to get only the direct component of current and voltage.
Then, power balance and all electromagnetic quantities can be calculated accurately.

1.2.3 Operating modes

1.2.3.1 Overview

Different operating modes are addressed: “Motor, “Generator” and “Brake”.
The following graph presents specifications of each mode:



“Performance mapping – Sine wave – Motor – T(Slip)” – Operating mode specifications

1.2.3.2 Motor mode

In motor mode, the torque is positive « $\Gamma > 0$ » and the speed is positive « $N > 0$ », so, the resulting mechanical power is also positive « $P_{mech.} > 0$ ». As the motor convention is used, the electrical power is regarded to be positive « $P_{elec.} > 0$ ». According to the power flow, the electrical power is greater than the mechanical power « $P_{elec.} > P_{mech.}$ ».

Note: The integration of iron losses into the power balance as well as the consideration of mechanical losses can lead to a negative mechanical power. In this case, there are too many losses to provide mechanical power. So, the operating points involved are assumed physically unreachable, therefore it is not displayed.

1.2.3.3 Generator mode

In generator mode, the torque is negative « $\Gamma < 0$ » and the speed is positive « $N > 0$ », so, the resulting mechanical power is also negative « $P_{mech.} < 0$ ». As the motor convention is used, the electrical power is regarded to be negative « $P_{elec.} < 0$ ». According to the power flow, if we look at the electrical and the mechanical power in absolute values, the mechanical is greater than the electrical $|P_{elec.}| < |P_{mech.}|$.

Note: The integration of iron losses into the power balance as well as the consideration of mechanical losses can lead to a positive electrical power. In this case, there are too many losses to provide electrical power, so, the operating points involved are assumed physically unreachable and are therefore not displayed.

1.2.3.4 Brake mode

In brake mode, the torque is positive « $\Gamma > 0$ » and the speed is negative « $N < 0$ », so, the resulting mechanical power is also negative « $P_{mech.} < 0$ ». As the motor convention is used, the electrical power is regarded to be positive « $P_{elec.} > 0$ ». According to the power flow, the electrical power is greater than the mechanical power « $P_{elec.} > P_{mech.}$ » and all of those are dissipated as losses “$W_{Joule\ stat.}, W_{Joule\ rot.}, W_{iron\ stat.}$ and $W_{iron\ rot.}$”.

Note: The integration of iron losses into the power balance as well as the consideration of mechanical losses can lead to a positive mechanical power. In this case, there are not enough losses generated to dissipate an electrical and mechanical power. So, the operating points involved are assumed physically unreachable and therefore not displayed.

1.2.4 Electromagnetic behavior

1.2.4.1 Flux in airgap

The flux in the airgap is always computed using the dedicated magneto-harmonic computation at the working point.

The airgap flux density is computed along a path in the airgap in Flux® software. The resulting signal is obtained over an electric period. The average and the peak value of the flux density are also computed. A harmonic analysis of the flux density in airgap versus rotor position is done to compute the magnitude of the first harmonic flux density.

1.2.4.2 Flux density in iron

Mean and maximum values of flux density of each iron region are computed using sensors in Flux® software.

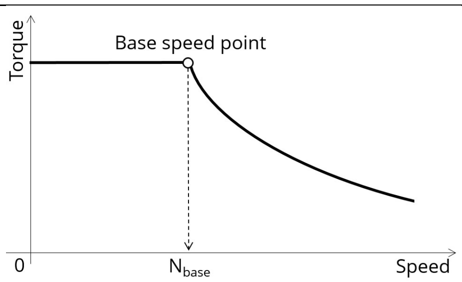
2 PERFORMANCE MAPPING – SINE WAVE – MOTOR – EFFICIENCY MAP SCALAR U-f

2.1 Overview

2.1.1 Positioning and objective

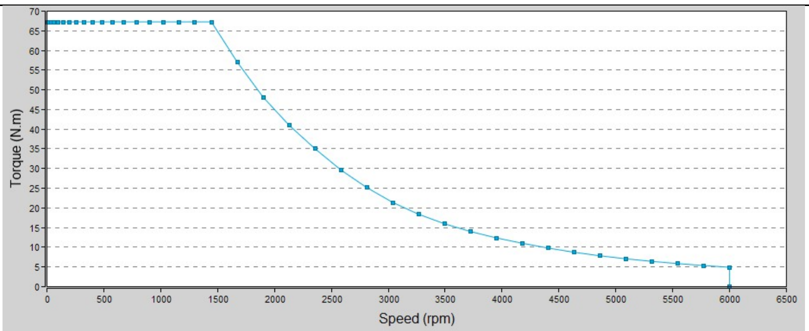
The aim of the test "**Performance mapping – Sine wave – Motor – Efficiency map scalar U-f**" is to characterize the behavior of the machine in the "Torque-Speed" area.
Input parameters like, "the maximum Line-Line voltage, the rated power supply frequency, the maximum line current and the maximum speed" of the machine are considered.

One type of command mode is available: scalar command.
Input parameters define the torque-speed area in which the evaluation of the machine behavior is performed.

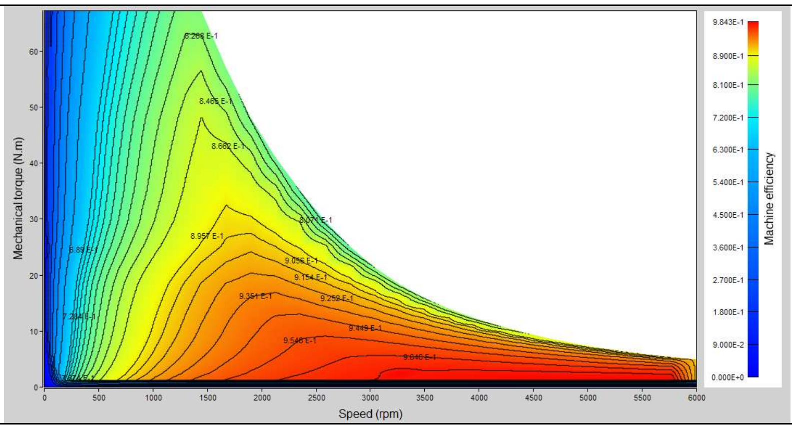


Characterization of the corner point on the torque-speed curve

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

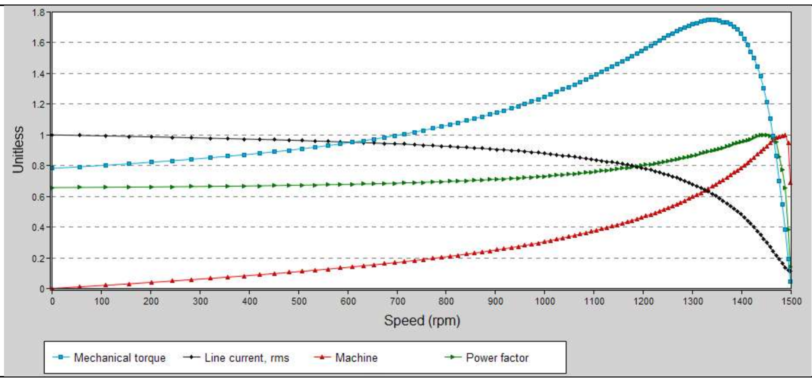


Mechanical torque versus speed - Example

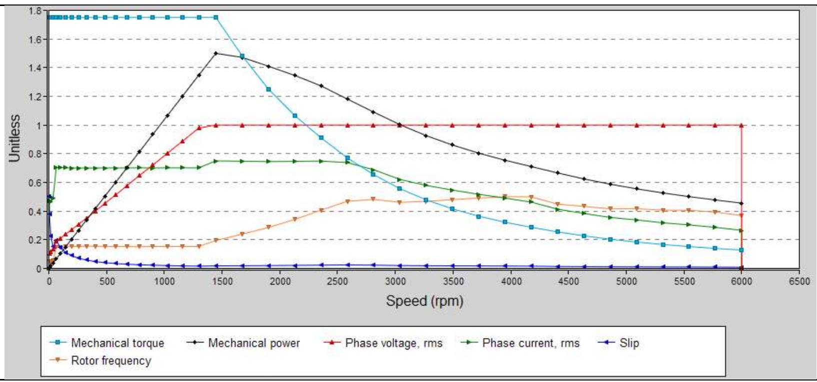


Efficiency in torque-speed area - Example

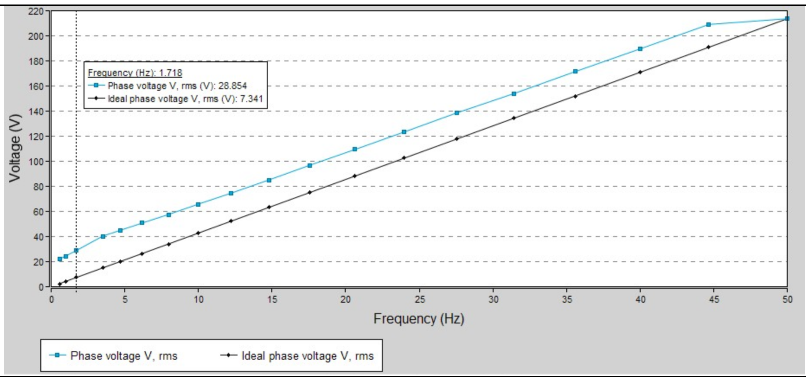
Note: Additional graphs provide an interesting overview on some topics such as, “Normalized base point curves”, “Normalized torque-speed curves” and “Voltage boost at low speed”. These results help the user to understand the possible performance of the machine in its electric environment.



Characteristic curves - Normalized base point curves - Example



Characteristics curves - Normalized torque speed curves - Example



Characteristic curves - Voltage boost - Example

The following table helps in classifying the test “**Performance mapping – Sine wave – Motor – Efficiency map scalar U-f**”.

Family	Performance mapping
Package	Sine wave
Convention	Motor
Test	Efficiency map scalar U-f

Positioning of the test “Performance mapping - Sine wave - Motor - Efficiency map scalar U-f”

2.2 Main principles of computation

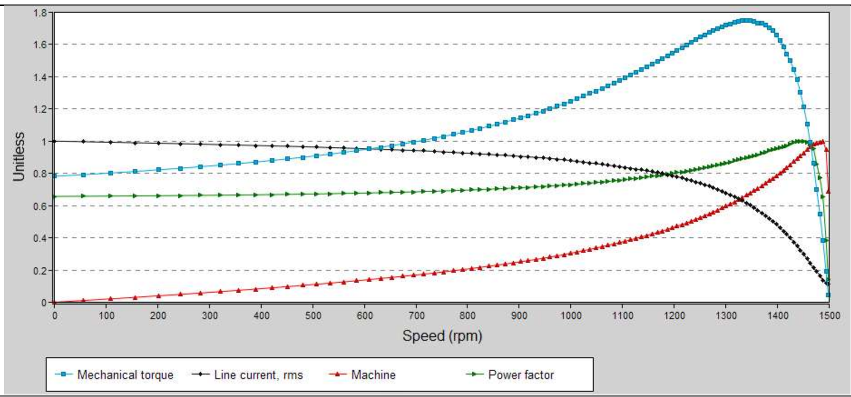
Will be completed soon.

2.2.1.1 Characteristic curves

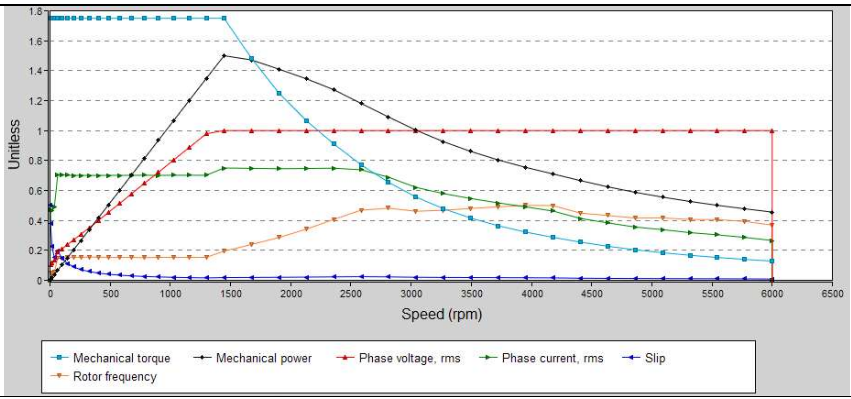
Additional graphs provide an interesting overview on some topics with:

- “Normalized base point curves” versus speed
- “Normalized torque-speed curves” versus speed
- “Voltage boost” versus speed (low speed between zero speed and base speed)

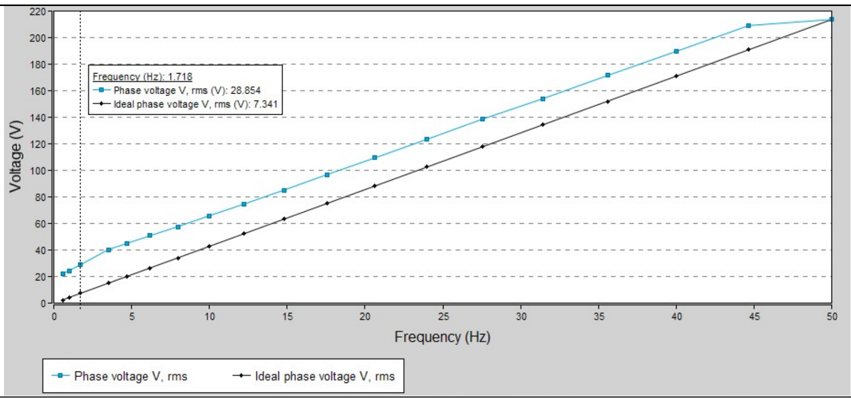
These results help the user to understand the possible performance of the machine in its electric environment.



Characteristics curves - Normalized base point curves - Example



Characteristics curves - Normalized torque speed curves - Example



Characteristics curves - Voltage boost - Example

2.2.2 Torque-speed Maps

List of torque-speed maps computed and displayed:

- Efficiency in torque-speed area
- Current in torque-speed area (Line and phase)
- Voltage in torque-speed area (Line-Line and phase)
- Slip in torque-speed area
- Frequency in torque-speed area (Stator and rotor)
- Power (Mechanical power, machine electrical power, system electrical power) in torque-speed area
- Power factor in torque-speed area
- Losses in torque-speed area (Total machine and system, total Joule, mechanical, power electronics) (iron losses are neglected for the first version of this test)
- Joule losses in torque-speed area (Total, Stator and Rotor)

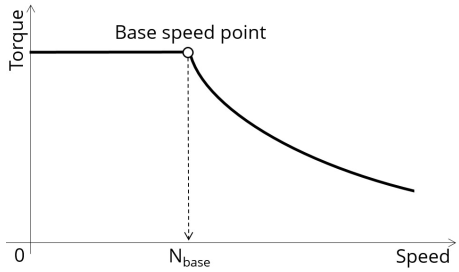
3 PERFORMANCE MAPPING – SINE WAVE – MOTOR – EFFICIENCY MAP SCALAR U-I

3.1 Overview

3.1.1 Positioning and objective

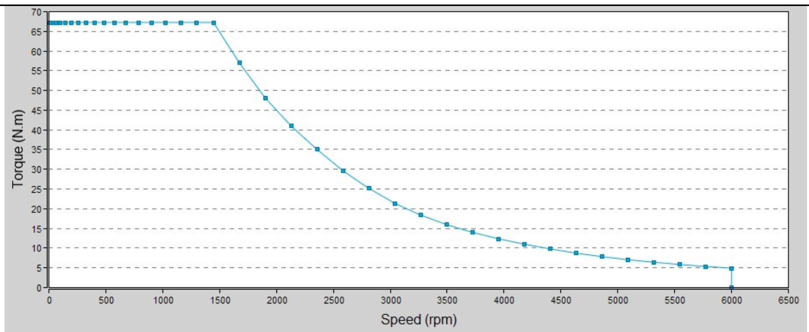
The aim of the test “**Performance mapping – Sine wave – Motor – Efficiency map scalar U-I**” is to characterize the behavior of the machine in the "Torque-Speed" area.
Input parameters like, “the maximum Line-Line voltage, the maximum line current and the maximum speed” of the machine are considered.
The main difference with the test “**Performance mapping – Sine wave – Motor – Efficiency map scalar U-f**” is that the speed of the base speed point is not fix by a user input (Rated power supply frequency) but deduced by the internal process of computation to maximize mechanical power.

One type of command mode is available: scalar command.
Input parameters define the torque-speed area in which the evaluation of the machine behavior is performed.

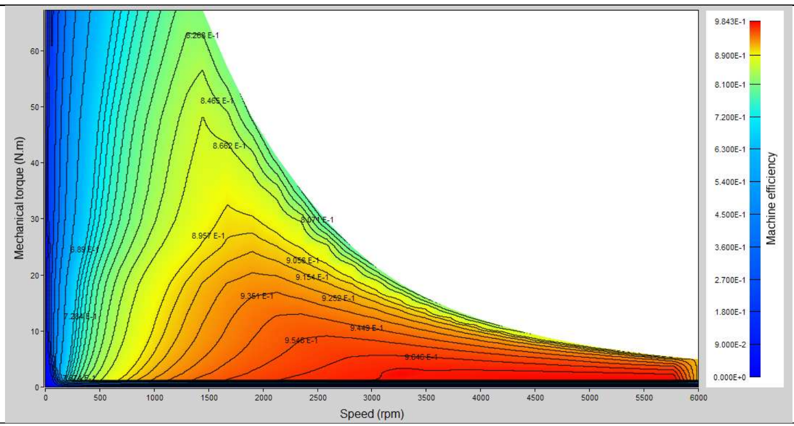


Characterization of the corner point on the torque-speed curve

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



Mechanical torque versus speed - Example



Efficiency in torque-speed area - Example

Note: Curves are calculated and displayed identical to those presented in the test “**Performance mapping – Sine wave – Motor – Efficiency map scalar U-f**”.
Please refer to the section dedicated to this test to see the corresponding illustrations.

The following table helps in classifying the test: “**Performance mapping – Sine wave – Motor – Efficiency map scalar U-I**”.

Family	Performance mapping
Package	Sine wave
Convention	Motor
Test	Efficiency map scalar U-I

Positioning of the test “Performance mapping - Sine wave - Motor - Efficiency map scalar U-I”

3.2 Main principles of computation

Will be completed soon.