Altair® FluxMotor® 2025

Direct Current Permanent Magnet Machine - Inner rotor

Motor Factory - Test - Working point

General user information

Altairhyperworks.com

Contents

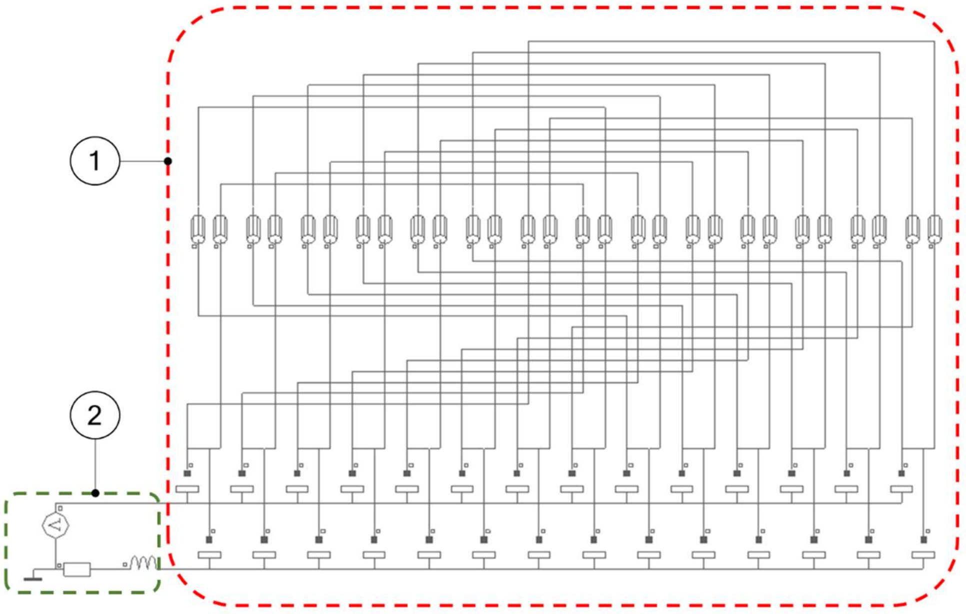
1 WORKING POINT – CONSTANT SPEED – MOTOR & GENERATOR – U-N

1.1 Overview

1.1.1 Positioning and objective

The aim of the test “**Working point – Constant Speed – U-N”** is to characterize the behavior of the machine when operating at constant speed connected to an external circuit composed of a DC voltage source and a parasitic impedance.

Note 1: The working point is mainly imposed by the external source voltage and the machine rotation speed. Since these variables have a great influence on the electrical and the mechanical sides, the working point may correspond either to a motor or a to a generator behavior.



Reference circuit simulated during the test	
1	Circuit representation of the DC machine (including brushes – commutator segment contacts)
2	Circuit feeding the DC machine (including a DC voltage source and parasitic impedances)

All the results are computed from a Finite Element Analysis (Flux) - Transient application. The results of this test give an overview of the electromagnetic behavior of the considered machine at a given working point.
The general data of the machine such as power balance, machine constant and torque ripple are computed and displayed.
The magnetic flux density is also computed in every region of the machine magnetic circuit to evaluate the design.

Warning 1: A minimum of two complete revolutions are considered for reaching a steady state behavior of the machines. However, sometimes there is not enough time to ensure a good convergence of our process; in this case the user is advised to compute a higher number of revolutions (please, see the next sections for further information).

Warning 2: Please note that power motor convention will be maintained even if the machine behaves as a generator for the selected working point.

1.1.2 User inputs

The main user input parameters are the voltage of the external DC source and the rotation speed of the machine. In addition, winding temperatures and magnets temperatures must be set.

1.1.3 Main outputs

Test results are illustrated with data, graphs and tables

1.1.3.1 Tables of results

1) Machine performance – working point
    - General data
    - Machine constants
    - Power balance
    - Iron losses
    - Flux in airgap
    - Flux density in iron

2) Ripple mechanical torque
    - Working point

1.1.3.2 Curves

1) Normalized machine voltage, current and mechanical torque versus time – Working point
2) Mechanical torque versus time – Working point
3) Voltage of a single path and global voltage of the machine versus time – Working point
4) Current flowing through a single path and global current of the machine versus time – Working point
5) Losses versus time – Working point
6) Power versus time – Working point

1.2 Settings

For this test the settings include the magnet and the winding temperatures.

1.3 User inputs

1.3.1 Introduction

The total number of user inputs is equal to 8.
Among these inputs, 2 are standard inputs and 6 are advanced inputs.

1.3.2 Standard inputs

1.3.2.1 DC voltage

Voltage provided by the external DC source.

1.3.2.2 Speed

The imposed “**Speed**” (*Speed*) of the machine must be set.

1.3.3 Advanced inputs

1.3.3.1 Circuit resistance

Parasitic resistance of the circuit connecting the DC voltage source with the DC machine.

1.3.3.2 Circuit inductance

Parasitic inductance of the circuit connecting the DC voltage source with the DC machine.

1.3.3.3 Minimum number of computations per revolution

The user input “**Min. no. comp. / revolution**” (*Minimum number of computations per revolution*) influences the accuracy of results and the computation time.
The default value is equal to 50. The default value provides a good compromise between the accuracy of results and computation time.
The minimum allowed value is 13.

1.3.3.4 No. computed revolutions

The user input “**No. computed revolutions**” (*Number of computer revolutions*) influences the computation time, it may also have an important impact to assure the steady state has been stablished (imperative condition to achieve accurate results).
The default value is 2. The minimum allowed value is 2 and the maximum value is equal to 4.

1.3.3.5 Mesh order

To get the results, the original computation is performed using a Finite Element Modeling.
Two levels of meshing can be considered for this finite element calculation: first order and second order.
This parameter influences the accuracy of results and the computation time.
By default, a second order mesh is used.

1.3.3.6 Airgap mesh coefficient

The advanced user input “**Airgap mesh coefficient**” is a coefficient which adjusts the size of mesh elements inside the airgap. When the value of “**Airgap mesh coefficient**” decreases, the mesh elements get smaller, leading to a higher mesh density inside the airgap and increasing the computation accuracy.
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 giving a very high mesh density and 2 giving 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 for huge numerical memory and increases the computation time considerably.

1.4 Test results

Once a test is finished, the corresponding results are automatically displayed in the central window.

1.4.1 Test conditions

1.4.1.1 Inputs

All the parameter values, belonging to standard inputs or advanced inputs are described in this section.
It shows the initial conditions considered for the test.
Here are the displayed subsections:

- Context
- Standard parameters
- Advanced parameters

1.4.1.2 Settings

All the settings dedicated to the test are displayed in this section.
For this test all the settings belong to the subsection thermal.

1.4.1.3 Winding and magnet characteristics

All winding and magnet characteristics are displayed in the following subsections:

- Magnet characteristics
- Winding characteristics

1.4.2 Main results

1.4.2.1 Machine performance – Working point

Output data displayed in the following subsections are described in section Working point – Sine wave –Motor.
Here are the displayed subsections:

- General data
- Machine constants
- Power balance
- Iron losses
- Flux in airgap
- Flux density in iron

1.4.2.2 Ripple mechanical torque

The analysis of the ripple torque is presented in the table “Ripple mechanical torque” with the following subsections:

- Working point

1.4.3 Curves

List of computed and displayed curves to illustrate the machine performance – Working point:

1) Normalized machine voltage, current and mechanical torque versus time – Working point

This curve is a synthesis showing the resulting torque obtained from the interaction between the machine voltage and current. For a easier analysis, the curves are normalized.
Note: The displayed torque corresponds to the electromagnetic torque because it must be compared with the machine current and voltage.

2) Mechanical torque versus time – Working point

This graph shows the curves of electromagnetic and useful torques. The electromagnetic curve is the same as obtained (with the Finite Element Analysis software – Flux®) in transient Flux® simulation.
The useful torque is the torque at the level of the motor shaft. The torque corresponding to iron losses are subtracted from the electromagnetic torque to find the useful torque.

The curves of torque also illustrate the ripple torque. The main characteristics of the ripple torque are computed and displayed in the table of results.

3) Voltage of a single path and global voltage of the machine versus time – Working point

The path voltage curve displays the resulting voltage at a single coil terminals when the rotor is rotating at the imposed speed.
In a similar way, the machine global voltage is the resulting voltage at the machine terminals (i.e., measured between the + and the – brushes).

4) Current flowing through a single path and global current of the machine versus time – Working point

The path current curve displays the current flowing through a single coil when the rotor is rotating at the imposed speed.
In a similar way, the machine global current is the resulting current flowing in (or out) of the machine.

5) Losses versus time – Working point

In this graph, the involved losses are decomposed. They are obtained from transient simulation in Flux® and from post-processing inside FluxMotor®.
Those losses are Joule losses, iron losses, and commutator losses. The total losses are also displayed to facilitate power balance.
Note: The commutator losses correspond to the Joule losses associated with the parasitic contact resistance existing between the commutator and the brushes.

6) Power versus time – Working point

The mechanical and the electrical powers of the machines are displayed.
Notice that the working point may correspond to either a motor or a generator behavior.