

ALTAIR

Altair[®] FluxMotor[®] 2026

Reluctance Synchronous Machines - Inner rotor

Motor Factory – Tests - Mechanics

General user information

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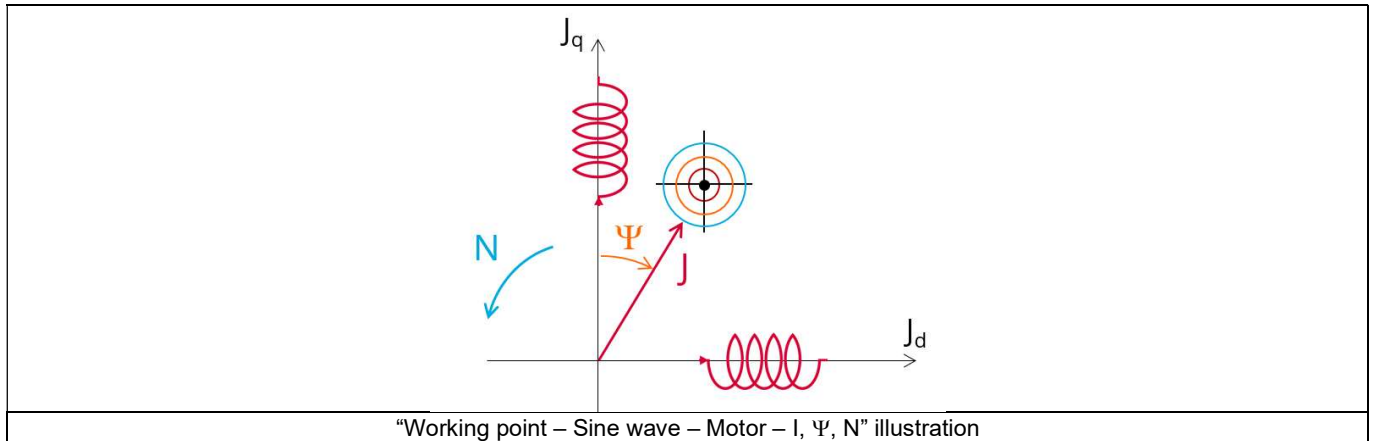
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1 MECHANICS – NVH – WORKING POINT – I - Ψ - N

1.1 Overview

1.1.1 Positioning and objective

The aim of the test “Mechanics – NVH – Working point – I- Ψ -N” is to perform NVH analysis of the machine when operating at the targeted working point defined with the following inputs values I, Ψ , N (Magnitude of current, Control angle, Speed).



This test gives data allowing NVH prediction in early electromagnetic and design stage.

The modal analysis of the stator mechanical structure, the radiated sound power and the magnetic forces applied on teeth are computed and displayed.

This test helps to answer the following question:

- Could the machine have any risks in connection with NVH? Yes / No.

The following table helps to classify the test “Mechanics – NVH – Working point – I- Ψ -N”.

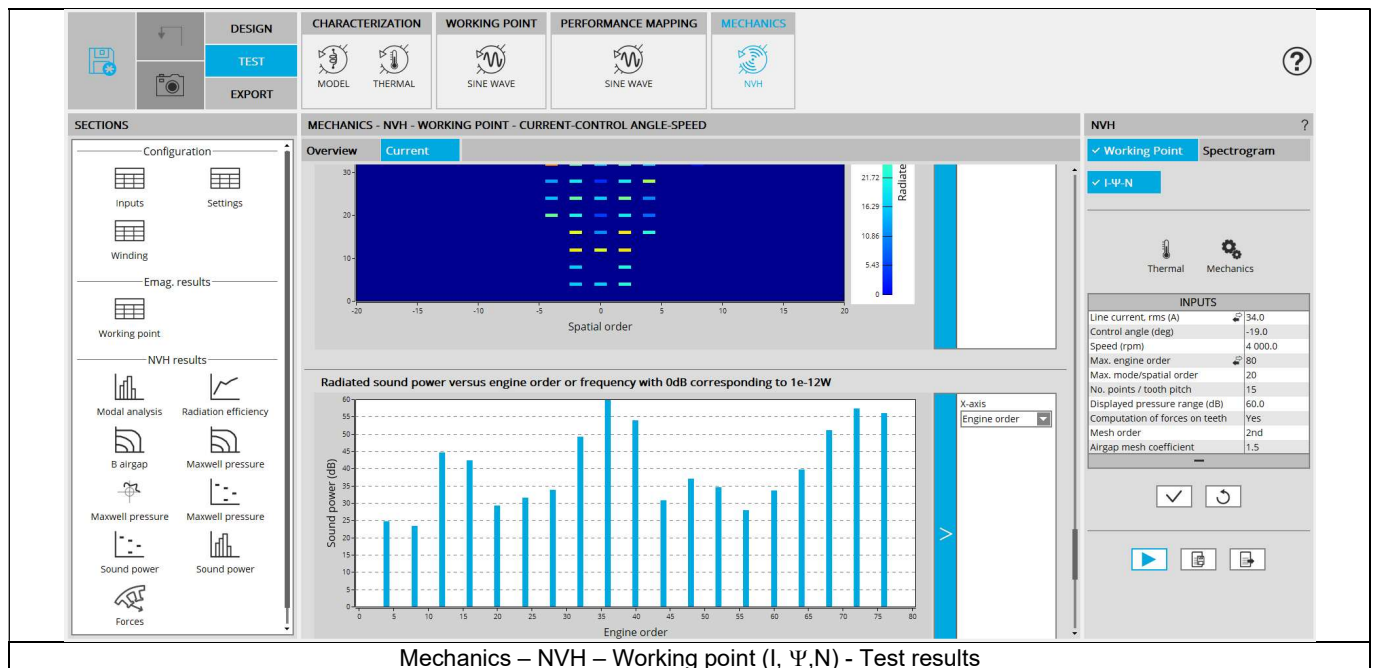
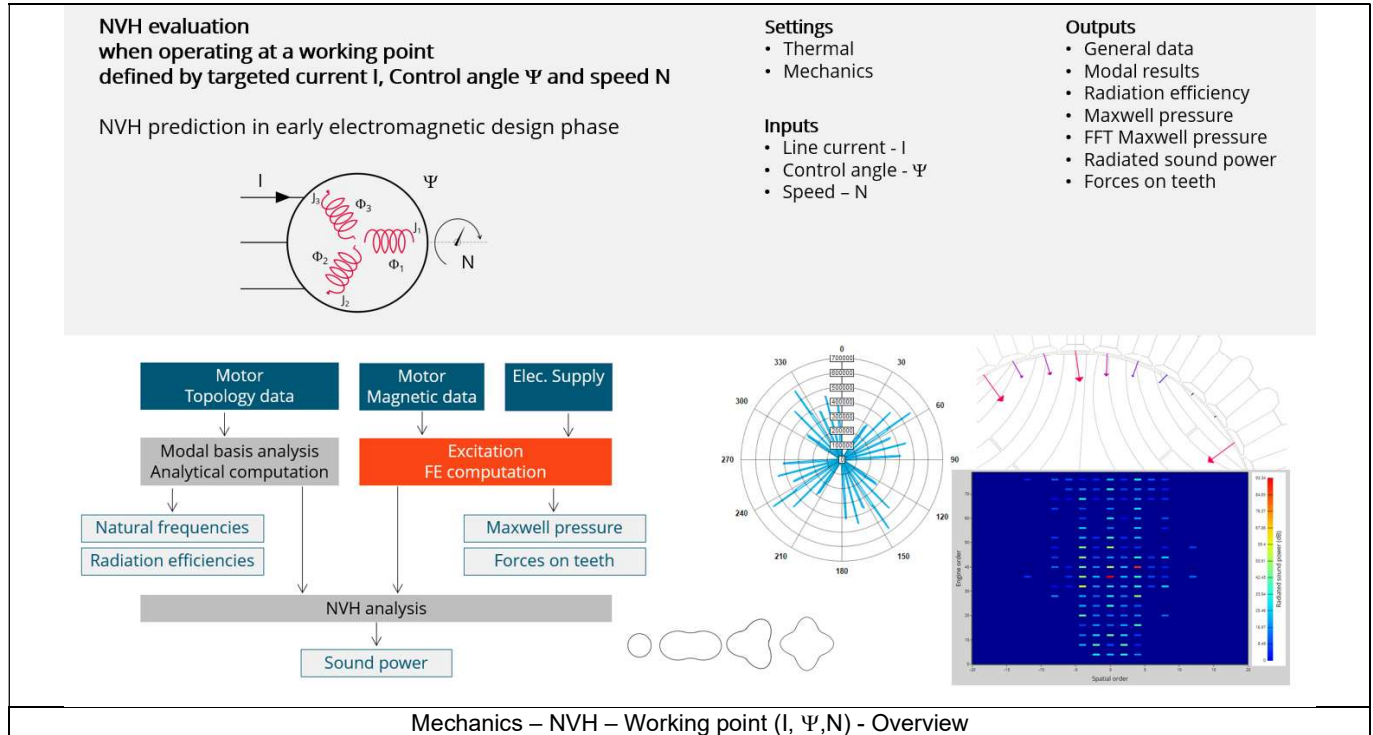
Family	Mechanics
Package	NVH
Convention	#
Test	Working point - I - Ψ - N

Positioning of the test “Mechanics – NVH – Working point – I- Ψ -N”.

1.2 Main principles of computation

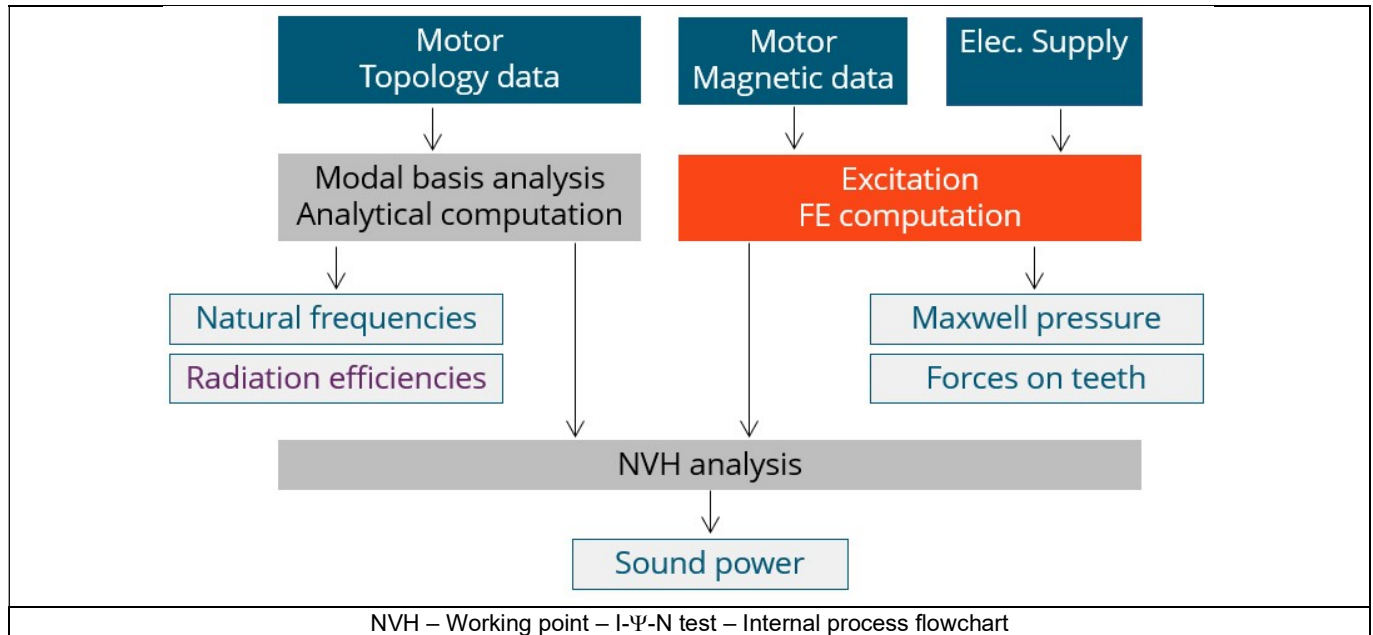
1.2.1 Introduction

Here are illustrations which give an overview of the test NVH – Working point (I, Ψ, N):



1.2.2 Flow chart

Here is the flowchart illustrating the internal process of the thermal test.



The inputs of the internal process are the parameters of:

- Motor topology data
- Motor magnetic data
- Electrical supply

The resulting NVH evaluation is based, first, on analytical computations allowing to characterize the modal analysis of the machine stator. Then, a time-space harmonic analysis of the Maxwell pressure computed in the airgap is performed. The Maxwell pressure is obtained from the normal flux density in the airgap computed in a 2D finite elements transient analysis.

Once this harmonic decomposition of the Maxwell pressure is performed, it is combined with the modal analysis of the machine to extract the acoustic power.

1.3 Limitation of computations - Advice for use

The modal analysis and the radiation efficiency are based on an analytical computation where the stator of the machine is considered as a vibrating cylinder.

The considered cylinder behavior is weighted by the additional masses like the fins or the winding and the subtractive masses like the slots and the cooling circuit holes.

This assumption allows getting fast evaluation of the behavior of machine in connection to NVH. In no way this can replace a mechanical Finite Element modeling and simulation.

Among possible reasons for deviations of results can be the following ones:

- The limits of the analytical model are reached or overpassed
- Unusual topology and/or dimensions of the teeth/slots
- Complexity of the stator-frame structure when it is composed with several components for instance
- The ratio between the total length of the frame L_{frame} and the stack length of the machine L_{stk} in any case, this ratio must be lower than 1.5:

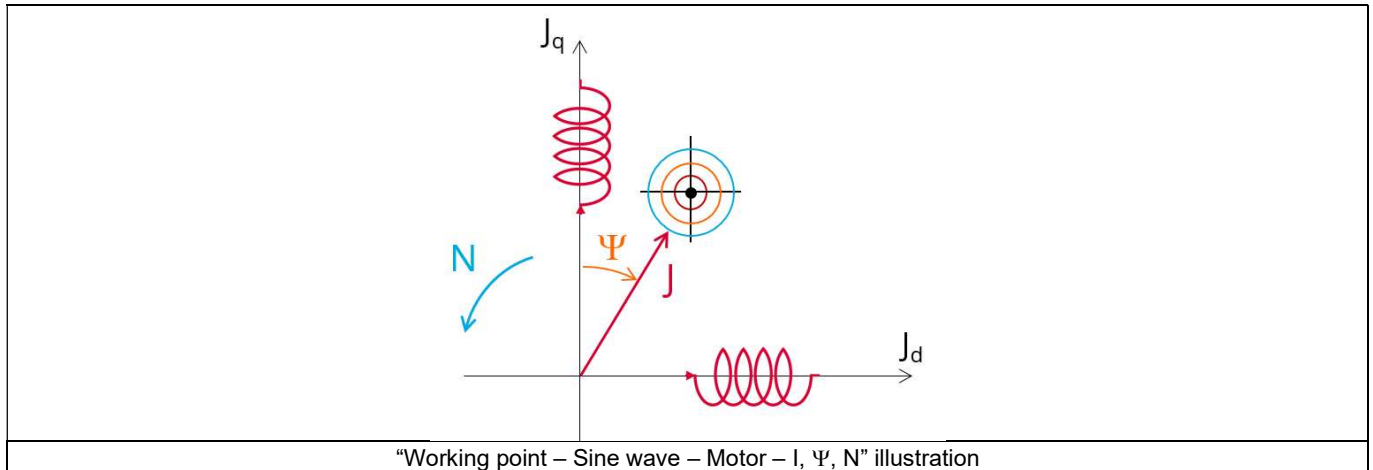
$$\frac{L_{Frame}}{L_{stk}} \leq 1.5$$

2 MECHANICS – NVH – SPECTROGRAM – I - Ψ - N

2.1 Overview

2.1.1 Positioning and objective

The aim of the test “Mechanics – NVH – Spectrogram – I- Ψ -N” is to perform NVH analysis on the machine when operating at a set of targeted working points defined with the following inputs values I, Ψ , N (Magnitude of current, Control angle, Speed).



This test give data allowing NVH prediction in early electromagnetic and design stage.

The modal analysis of the stator mechanical structure, the radiated sound power spectrogram per engine order versus speed and the resulting overall weighted radiated sound power versus speed are computed and displayed.

These results allow seeing if there are any problems linked with NVH over the considered speed range.

And finally, this test helps to answer the following question:

- Could the machine have any risks in connection with NVH? Yes / No.

The following table helps to classify the test “Mechanics – NVH – Spectrogram – I- Ψ -N”.

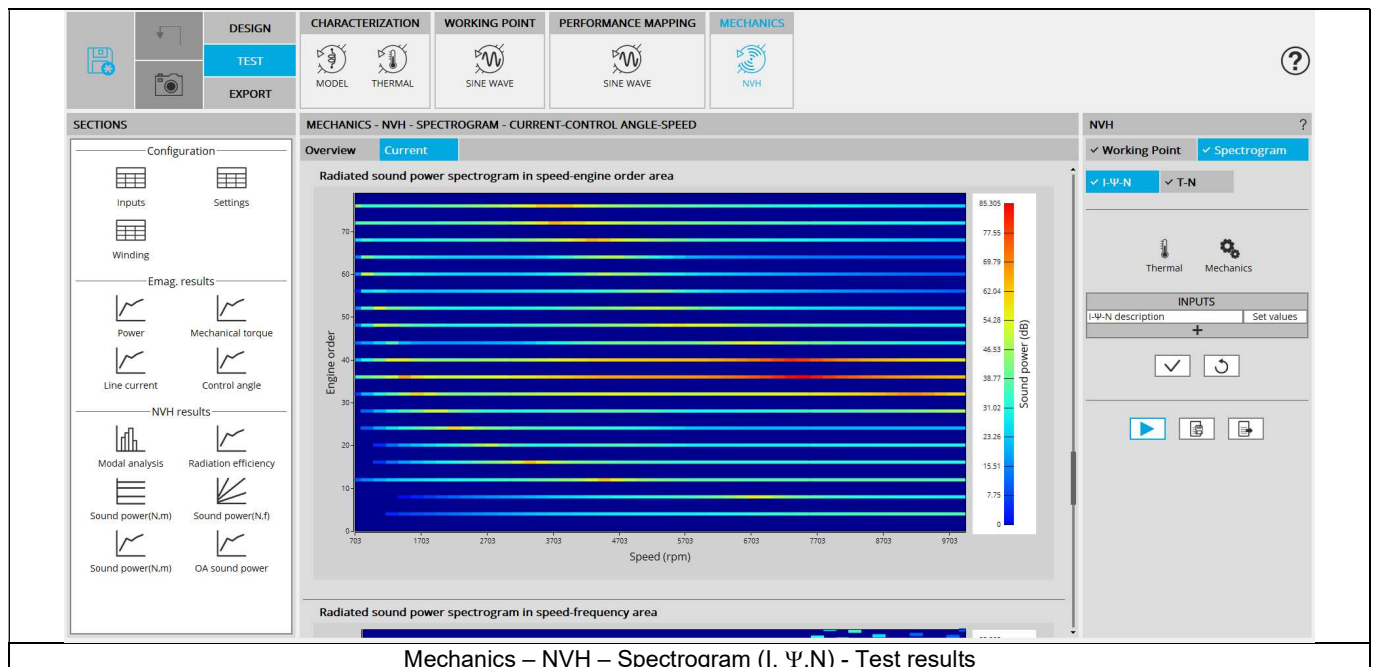
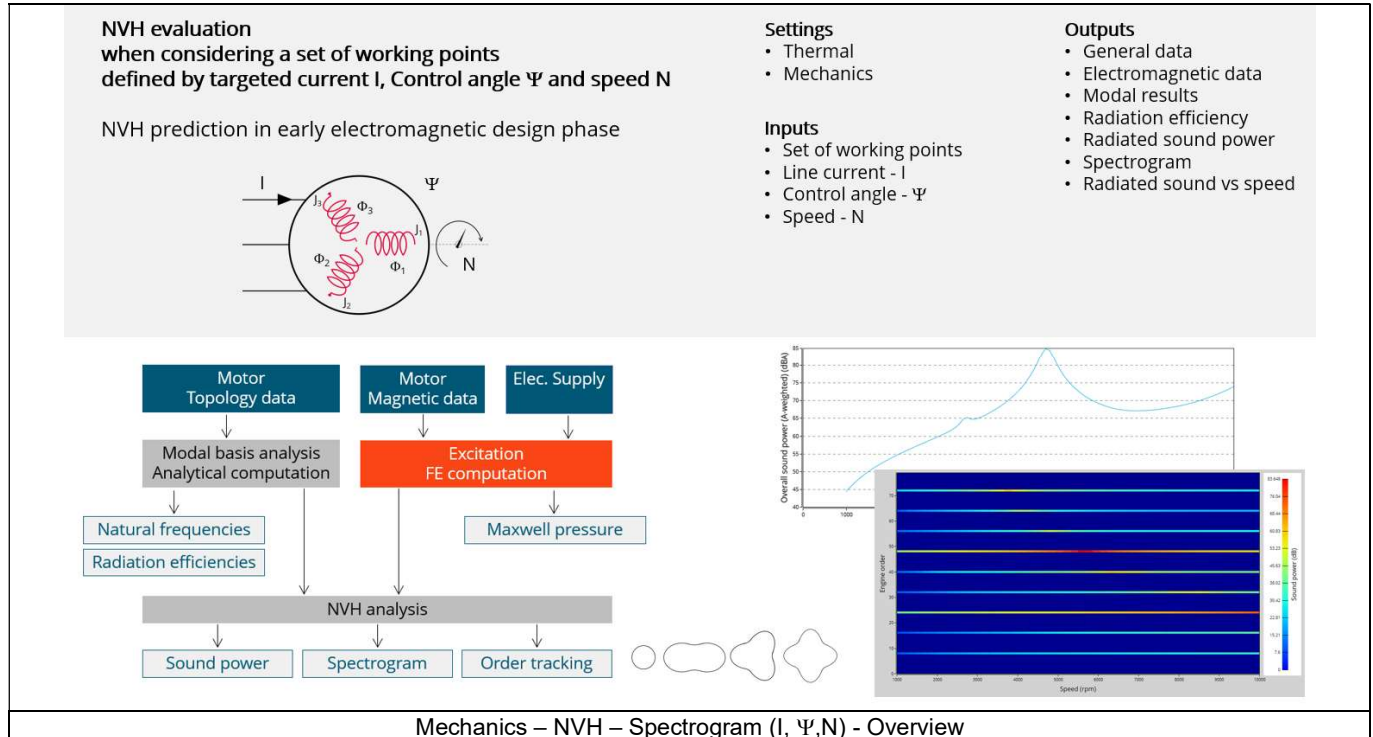
Family	Mechanics
Package	NVH
Convention	#
Test	Spectrogram - I - Ψ - N

Positioning of the test “Mechanics – NVH – Spectrogram – I- Ψ -N”

2.2 Main principles of computation

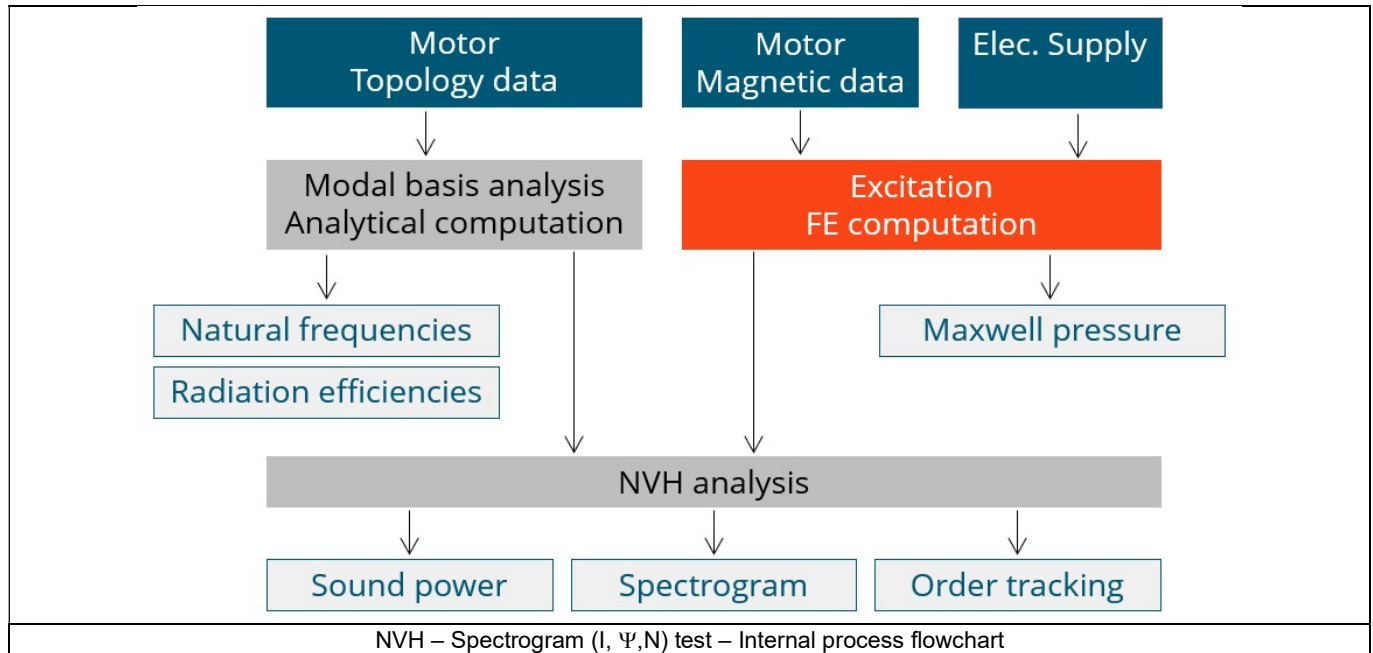
2.2.1 Introduction

Here are illustrations which give an overview of the test NVH – Spectrogram (I, Ψ, N):



2.2.2 Flow chart

Here is the flowchart illustrating the internal process of the thermal test.



The inputs of the internal process are the parameters of:

- Motor topology data
- Motor magnetic data
- Electrical supply

For each points of the I-Ψ-N description, the process described in the previous test is performed. Once it is done, interpolations between the targeted working points are made to produce a high-quality order tracking/ spectrogram graph.

2.3 Limitation of computations - Advice for use

The modal analysis as well as the radiation efficiency are based on an analytical computation where the stator of the machine is considered as a vibrating cylinder.

The considered cylinder behavior is weighted by the additional masses like the fins or the winding and the subtractive masses like the slots and the cooling circuit holes.

This assumption allows to get fast evaluation of the behavior of machine in connection to NVH. In no way this can replace a mechanical Finite Element modeling and simulation.

Among possible reasons for deviations of results can be the following ones:

- The limits of the analytical model are reached or overpassed
- Unusual topology and/or dimensions of the teeth/slots
- Complexity of the stator-frame structure when it is composed with several components for instance
- The ratio between the total length of the frame L_{frame} and the stack length of the machine L_{stk} in any case, this ratio must be lower than 1.5:

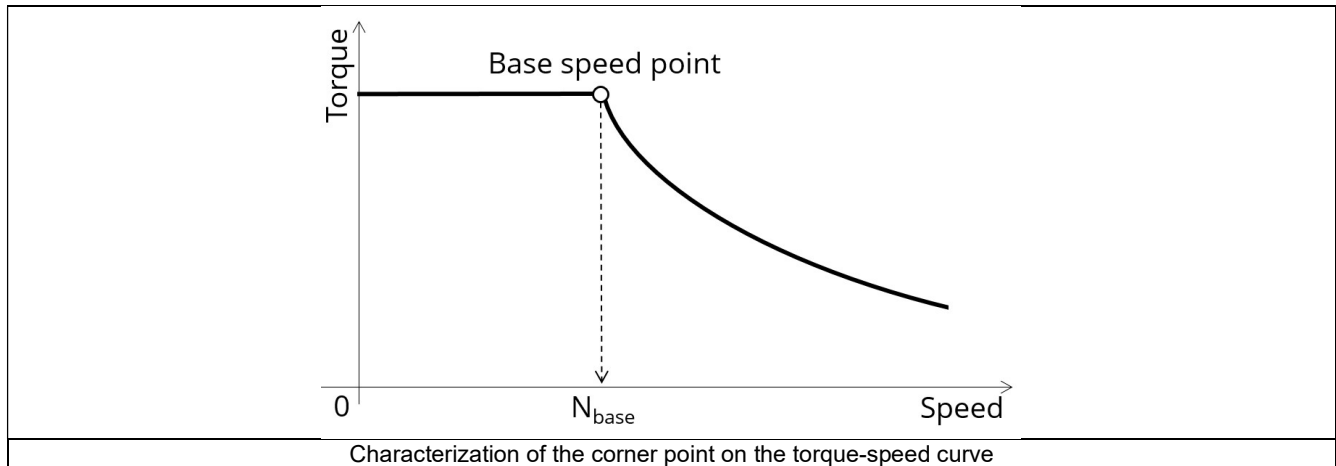
$$\frac{L_{Frame}}{L_{stk}} \leq 1.5$$

3 MECHANICS – NVH – SPECTROGRAM – T - N

3.1 Overview

3.1.1 Positioning and objective

The aim of the test “**Mechanics – NVH – Spectrogram – T-N**” is to perform NVH analysis on the machine when operating at a set of targeted working points defined with the following inputs values T, N (Mechanical torque and Speed).



Input parameters like the maximum “Line-Line voltage”, the maximum “line current” and the desired “Maximum speed” of the machine are considered.

Two types of command modes are available: The Maximum Torque Per Volt command mode (MTPV) and the Maximum Torque Per Amps command mode (MTPA).

Input parameters allow to define torque-speed envelope in the framework of which the targeted working points can be selected.

By default, the NVH evaluation is computed by considering working points on the torque-speed envelope.

But, one can define a list of working points located anywhere under (or on) the torque-speed envelope.

This test give data allowing NVH prediction in early electromagnetic and design stage.

The modal analysis of the stator mechanical structure, the radiated sound power spectrogram per engine order and versus speed and the resulting overall weighted radiated sound power versus speed are computed and displayed.

These results allow to see if there are any problem linked with NVH overall the considered speed range.

And finally, this test helps to answer the following question:

- Could the machine have any risks in connection with NVH? Yes / No.

The following table helps to classify the test “Mechanics – NVH – Spectrogram – T-N”.

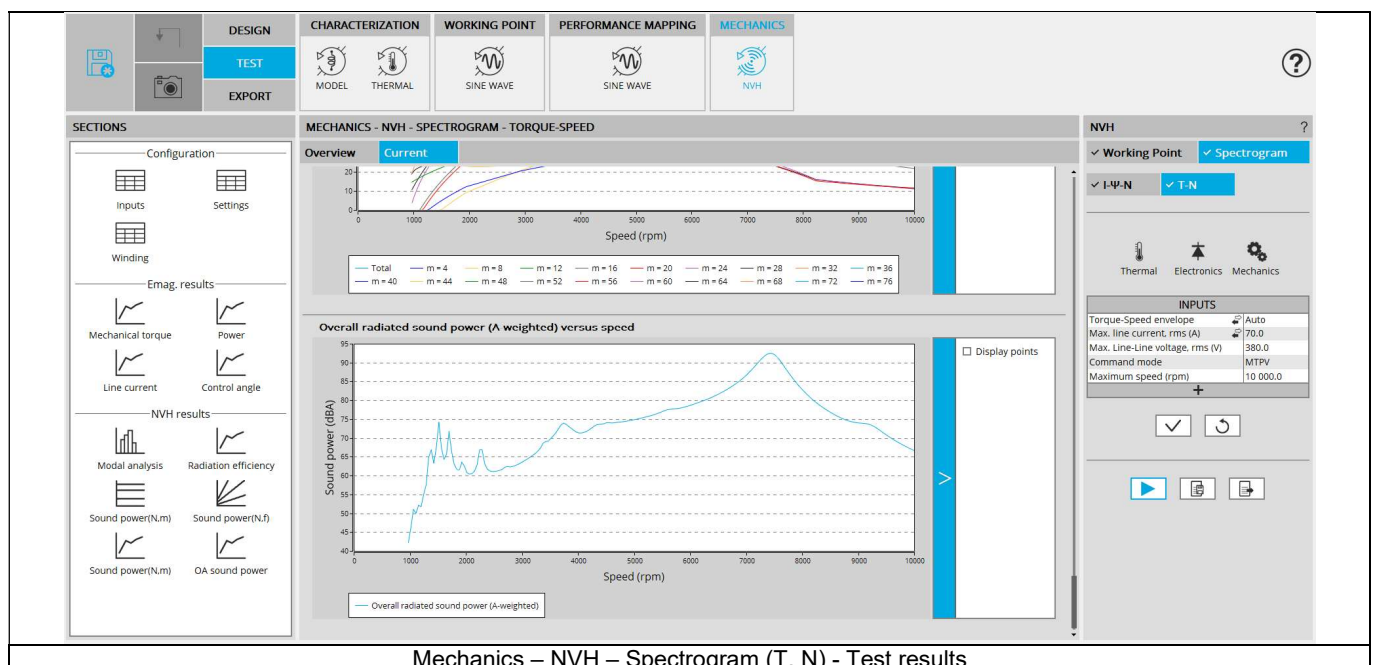
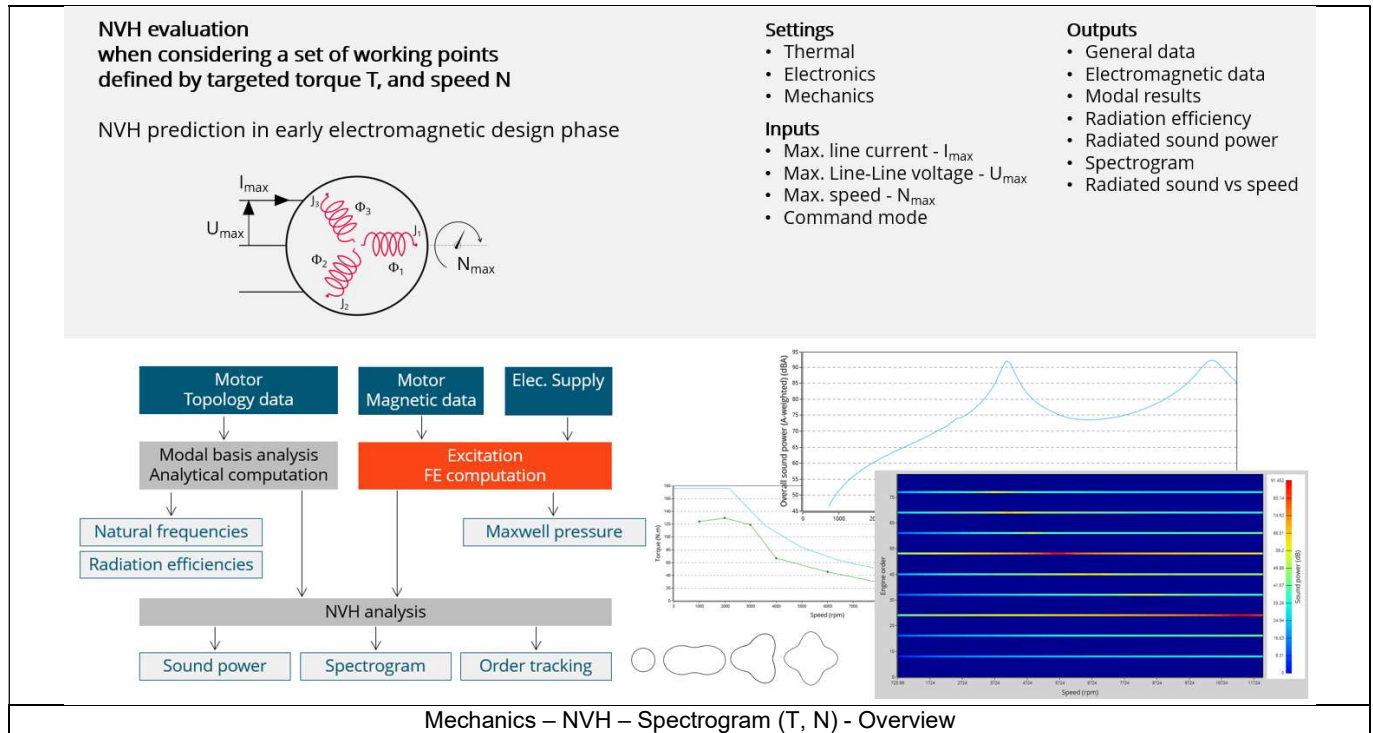
Family	Mechanics
Package	NVH
Convention	#
Test	Spectrogram - T- N

Positioning of the test “Mechanics – NVH – Spectrogram – T-N”

3.2 Main principles of computation

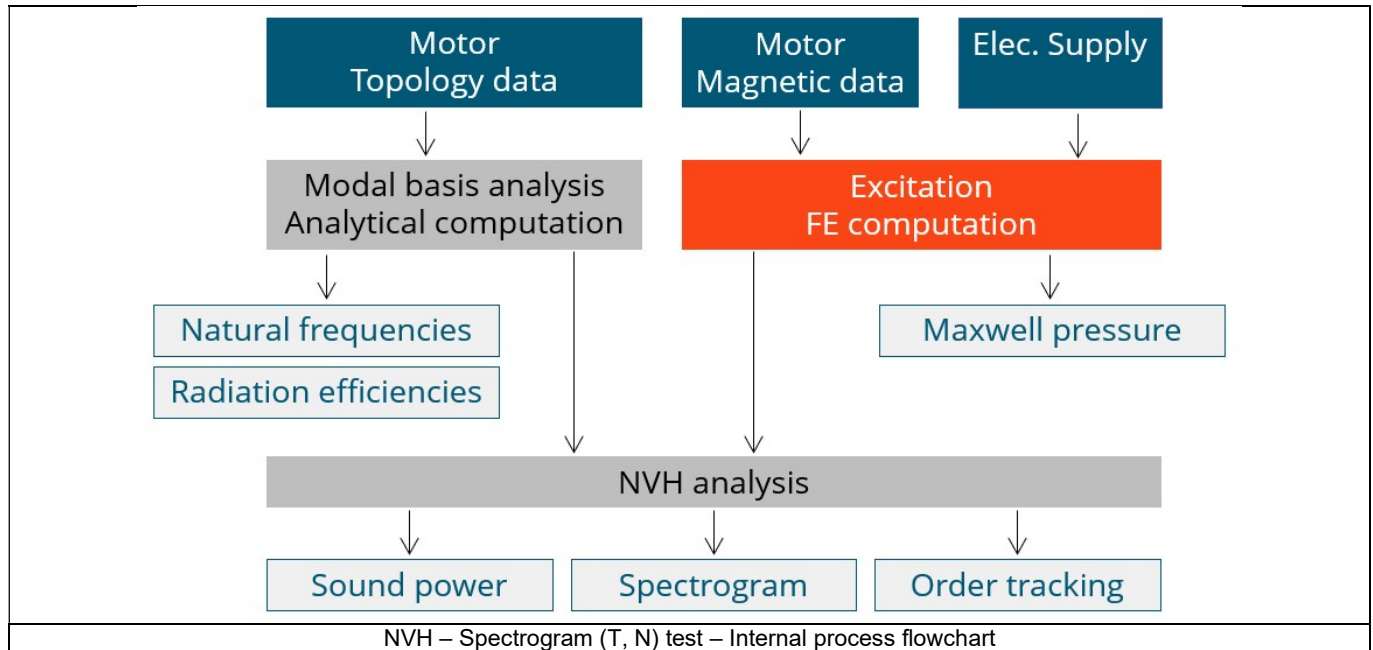
3.2.1 Introduction

Here are illustrations which give an overview of the test NVH – Spectrogram (T, N):



3.2.2 Flow chart

Here is the flowchart illustrating the internal process of the thermal test.



The inputs of the internal process are the parameters of:

- Motor topology data
- Motor magnetic data
- Electrical supply

When the user chooses the torque-speed envelope mode, the software computes the envelope similarly to the performance mapping – efficiency map test. Then, seven points are selected on the envelope over which the previous test is applied.

When the user chooses the user working point list mode, the software computes current and control angle maps similarly to the performance mapping – efficiency map test and interpolates the torque-speed data to create a current/control-angle/speed working point list. The previous test is then used once again.

3.3 Limitation of computations - Advice for use

The modal analysis and the radiation efficiency are based on an analytical computation where the stator of the machine is considered as a vibrating cylinder.

The considered cylinder behavior is weighted by the additional masses like the fins or the winding and the subtractive masses like the slots and the cooling circuit holes.

This assumption allows getting fast evaluation of the behavior of machine in connection to NVH. In no way this can replace a mechanical Finite Element modeling and simulation.

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