

<https://eomys.com/produits/manatee/howtos/article/what-is-spectrogram-synthesis-algorithm-synthesized-spectrogram>



# What is Spectrogram Synthesis Algorithm (synthesized spectrogram)?

- Products - MANATEE - Howtos -

Publication date: Monday 16 January 2017

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## Objectives

The accurate calculation of noise and vibrations of electric motors requires to evaluate their **vibro-acoustic behaviour at variable speed, taking a high number of speed steps** to correctly catch structural resonances. This can represent a high computational load, as operational magnetic loads must be updated at each operating point as well as NVH calculations.

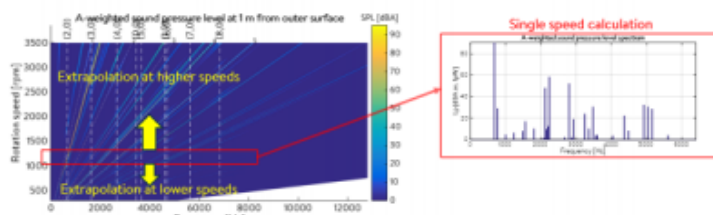
In [MANATEE software](#), two techniques allow to significantly reduce this computing time, making it possible to **quickly rank electric motor noise behaviour during early electromagnetic design phases**:

- ▶ [Electromagnetic Vibration Synthesis](#)
- ▶ Spectrogram Synthesis Algorithm

This article presents the Spectrogram Synthesis technique.

## Principle

**Spectrogram Synthesis Algorithm** is a method to accelerate the calculation of Maxwell force harmonics at variable speed using a limited number of single speed calculations (from 1 to 6 single speed calculation of harmonic forces).



### Illustration of spectrogram synthesis technique in MANATEE software

A variable speed vibroacoustic spectrum can be obtained based on a single speed vibroacoustic simulation when **the evolution of the magnetic excitation with speed can be predicted** in terms of magnitude and frequencies (including rotation direction).

As an example, the magnitude of the flux density and resulting Maxwell stress in an open circuit permanent magnet synchronous machine is independent of speed: the frequencies of the magnetic force harmonics change with speed but their magnitude is unchanged. This means that the **vibroacoustic behaviour of the electrical machines can be quickly calculated at variable speed without significant additional calculations**.

At partial load for PMSM, some specific single speed calculations are run with different current angles to capture the evolution of forces with current, and the evolution of magnetic force harmonics with speed can be deduced from torque and current angle maps as a function of speed and current magnitude. This technique is also used to quickly generate [acoustic noise maps](#) on all the operational points of the machine in torque / speed plane.

The synthesized spectrogram technique can also be used at no-load on induction machine, accounting for field weakening control.

If the number of time steps defined at nominal speed is not enough, a part of the excitation spectrum may be missing

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when extrapolating magnetic excitations at low speed. Generally, vibrations are proportional to speed so at low speed electromagnetic excitation occur low frequency, and the frequency limitation does not affect the vibroacoustic results. This limitation is well identified in MANATEE software with a warning message which looks like "WARNING, synthesized spectrograms may not be valid below 9.3796 Hz / 187.5916 rpm (try increasing Nt\_tot above 7684)".

Spectrogram Synthesis Algorithm is independent from both electromagnetic and structural models. It can therefore be used when importing the flux density calculated with [another FEA software](#), or when using MANATEE coupling with external structural FEA software such as Optistruct and Ansys (e.g. during [Electromagnetic Vibration Synthesis](#) process).

## GUI implementation

TBC

## Scripting implementation

This calculation is activated in MANATEE with

```
Input.Simu.is_spectro_synthesis=1
```

It is an alternative to the variable speed mode obtained with

```
Input.Simu.is_varspeed=1
```

where all electromagnetic and vibroacoustic calculations are repeated at each different speed. The total number of speed steps to used is specified in

```
Input.Simu.Nspeeds_sona=100
```

Contrary to speed by speed calculations, a high number of speeds can be used as the computation time is very low.

## Plot commands

All the standard variable speed command lines starting with *plot\_VS* are available in the Synthesized Spectrogram mode:

- [spectrograms](#), for instance with [plot\\_VS\\_ASPL\\_sonagram](#)
- [Order Tracking analysis](#), for instance with [plot\\_VS\\_ASWL\\_order\\_analysis](#)
- Operational Deflection Shapes, for instance with `plot_VS_ODS`

## Validation cases

The following validation cases favorably compares the Synthesized Spectrogram Algorithm with single speed full

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NVH calculations:

- validation [ALG\\_001](#)
- validation [ALG\\_018](#)