manatee by EOMYS

Manatee software V2.2.3 - available modules

Electrical engineers
= V2.0 March 2021

Electrical engineers
+Mechanical engineers
= V2.1 June 2021

Electrical engineers
+Mechanical engineers
+Acoustic engineers
= V2.2 (April 2022)

Electrical engineers
+Mechanical engineers
+Acoustic engineers
+NVH test engineers
= V2.3 (early 2023)

Last update : October 18th, 2022
Manatee software version V2.2.3

QUICK e-NVH SIMULATION DEFINITION

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
COLLABORATIVE, USER-FRIENDLY GUI	GUI	Integrated user-friendly GUI made for all engineers involved in the design of electrical systems	Graphical User Interface designed for **acoustic, mechanical and electrical engineers** to ease their collaboration during the development of complex systems involving electric machine operation. Possibility to handle several simulation projects in the same interface.	V2.0	Available
QUICK e-NVH SIMULATION DEFINITION *Solutions to easily define variable-speed e-NVH calculations including advanced post-processing tools*	SIM.WF	e-NVH pre-defined simulation workflows & post processing along e-machine development cycle	MANATEE **pre-defined simulation workflows** combining the modelling level options which are the most adapted to electrical machine topology and different stages of **V-model electrical machine development cycle**, from **early design phase** to **detailed design phase**. Examples of workflows include e-NVH along max torque speed curve using semi analytic electromagnetic & vibroacoustic models in open circuit/full load with sine current, e-NVH along torque speed curve using Load Interpolation Algorithm coupled to FEMM, e-NVH along torque speed curve refined with Electromagnetic Vibration Synthesis calling third party FEA structural model, etc. After calculations, some **predefined post-processing and visualizations** adapted to chosen predefined workflows are run. Includes more than **50 pre-defined plots** (permeance, flux, force, vibration and noise) including FFT in 1D or 2D spaces.	V2.0	Available

**Optional modules*

QUICK e-NVH SIMULATION DEFINITION

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
QUICK e-NVH SIMULATION DEFINITION *Solutions to easily define variable-speed e-NVH calculations including advanced post-processing tools*	SIM.FS	Fixed-speed e-NVH calculations	Calls Manatee on a single Operating Point to compute current / flux / forces / vibration / noise and provide the corresponding post-processing.	V2.2.3	Available
	SIM.VS	Quasi-static variable speed e-NVH calculations	Calls **several Manatee fixed-speed steady state simulations** with varying supply based on control strategy (e.g. max torque/speed curve, torque/speed plane). Dedicated variable speed NVH post processing are available (overall SPL/SWL as a function of speed, noise and vibration **waterfalls, order tracking analysis,** force / vibration / noise **spectrograms**, operational deflection shape).	V2.0	Available
	SIM.MAP **Optional modules*	Torque / speed plane e-NVH calculations (acoustic noise maps)	Calls several Manatee simulations based on input Id/Iq maps to characterize the e-motor **NVH behavior in torque/speed plane** on two quadrants (traction / braking), including noise map plots and detailed post processings. Can be combined with ALG.MLUT and ALG.EVS to speed up calculations (using semi analytic NVH models, full map can be obtained in less than 5min of calculation). Only applicable to PMSM.	V2.1	Available

FAST & ACCURATE e-NVH CALCULATIONS

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
FAST AND ACCURATE e-NVH CALCULATIONS *A series of unique, proprietary algorithms to speed-up e-NVH accurate calculations and give more physical insights to design engineers*	ALG.MLUT	Load Extrapolation Algorithm or Load Interpolation Algorithm based on MLUT concept	**Accelerated variable speed magnetic load calculation** based on **force extrapolation or interpolation algorithms.** Depending on topology and supply inputs (e.g. open circuit, constant Id/Iq angle), Manatee automatically shortens the calculation time of variable speed magnetic loads using the concept of air-gap **Magnetic Look Up Table** as a function of operating point. MLUT can be built based on flux import (IO.FLUX), or on magnetic FEA calculation (ex: EM2.PMSM). ALG.MLUT also reduces computing time of skewed PMSM.	V2.0	Available
	ALG.EVS	Electromagnetic Vibration Synthesis to speed up variable-speed FEA-based vibration calculations, or optimization of electromagnetic excitations with respect to vibration	**Speeds up magnetic vibration calculations** while giving more **physical insights and transfer path analysis** by applying **elementary electromagnetic loads** in radial & tangential directions (wavenumbers identified automatically by Manatee) on the structural model, calculating the **Frequency Response Functions of both rotor and stator**, and synthesizing the overall vibration response under operational loads. Can be used with any type of structural model provided in structural module SM (analytic or FEA). EVS is particularly useful when a high number of operational loads have to be calculated, for instance in variable speed calculations (e.g., NVH maps on torque speed plane) or in optimization mode (e.g., pole shaping).	V2.0	Available

**Optional modules*

ACCELERATED e-NVH POST PROCESSING

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
ACCELERATED e-NVH POST PROCESSING *Solutions to quickly post process multiphysic calculation results*	PLOT.F1D	Spectrum visualization for single operating point spectra	Interface for 1D spectrum/waveform visualization, includes **A-weighting** and dB scaling.	V2.1	Available
	PLOT.F2D	Spectrum visualization for variable operating points spectra	Interface for 2D spectrum/waveform visualization, includes A-weighting and dB scaling. Possibility to display **spectrogram orders** and **natural frequencies**.	V2.0	Available
	PLOT.SPEC	Spectrogram for variable speed operating points	Interface for Spectrogram visualization, includes A-weighting and dB scaling and possibility to add mains modes and to identify main orders.	V2.0	Available
	PLOT.OT	Order Tracking analysis for variable speed operating points	Interface for Order Tracking visualization, includes A-weighting and dB scaling. Automatically associates to a given frequency the most influent magnetic Load Case.	V2.0	Available
	PLOT.OFS	Operational Forces Shape analysis	Interface to visualize the operational forces (radial, tangential or both) on the external structure for each operating points. Including possibility to animate the forces.	V2.2	Available
	PLOT.ODS **Optional modules*	Operational Deflection Shape analysis	Interface to visualize and animate how the envelope nodes radiating surface vibrates at a given speed and frequency (**ODS**). Can be used for both analytic or 3D FEA mechanical model.	V2.0	Available

e-NVH ROOT CAUSE ANALYSIS

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
ADVANCED e-NVH ROOT CAUSE ANALYSIS *Solutions to carry early-stage e-NVH analysis or identify noise and vibration root cause with advanced post processing*	RCA.QC*	Quick Campbell Harmonic analysis for e-NVH troubleshooting in early design stage	Draws a **Campbell diagram** of magnetic excitations per physical origin with magnitude estimates. Identifies all **main magnetic force harmonics (frequencies and wavenumbers)** based on slot/pole/phase combinations, electrical machine topology and load state using theoretical analytic work (instantaneous calculations). Provides the physical origin of a given force harmonic in terms of **permeance, magnetomotive force, flux waves combinations** as well as in terms of excitation sources (**rotor/stator mmf, slotting, winding or PM** space harmonics). Available for PMSM/WRSM & SCIM.	V2.0	Available
	RCA.MC*	e-NVH investigation based on modal basis and unit-magnitude stress waves	Projects unit magnitude forces on the given modal basis to **quickly analyze which structural modes are excited by each magnetic Load Case,** in particular modes excited by radial ripple, torque ripple, and UMP when applied to stator or rotor.	V2.1	Available
	RCA.SPAT*	Spatiogram (spectrogram filtered per Load Case)	Draws vibration/noise spectrograms **per magnetic Load Case** when ALG.EVS has been used. This way the contribution of **airborne paths** (e.g. external stator excitation) Vs **structure borne path** (e.g. internal rotor excitation) can be differentiated, as well as the **impact of each force wavenumber** and direction.	V2.1	Available
	RCA.LCC*	e-NVH contribution of Load Case	Draws vibration/noise overall contribution **per magnetic Load Case** when ALG.EVS has been used. Possibility to split between air-borne/structure-borne and radial/circumferential contributions	V2.2	Available

**Optional modules*

e-NVH CONTROL SOLUTIONS

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
PREDEFINED NOISE CONTROL TECHNIQUES *A series of dedicated noise control environments for the design optimization of control, magnetic or structural-based e-NVH mitigation techniques*	SOL.SKEW*	Skew pattern application	Dedicated GUI to automatically define a parameter sweep to find the optimal skew pattern (linear, step-skew, zig-zag, V-shape) with the best tradeoff between noise and torque. The vibroacoustic model can be of any type depending on Manatee inputs (semi-analytic, numerical, or with imported FRF).	V2.2	Available

**Optional modules*

e-NVH ROBUST DESIGN

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
ROBUST DESIGN INCLUDING TOLERANCES *Solutions to carry robust e-NVH design of electric motors*	ROB.ECC*	Manufacturing tolerance simulation of eccentricities	Handles **static and dynamic 2D or 3D eccentricities due to manufacturing tolerances** when calculating magnetic loads. **Eccentricity** can be modelled even when importing flux density with IO.FLUX without the need to carry electromagnetic calculations without symmetry. Healthy electromagnetic calculations are perturbated at first order to estimate the impact of eccentricities.	V2.1	Available
	ROB.UAG*	Manufacturing tolerance simulation of uneven stator bore radius	Handles **stator uneven roundness (such as ovalization) due to manufacturing tolerances** when calculating magnetic loads such as **and uneven airgap**. **Uneven roundness** can be modelled even when importing flux density with IO.FLUX without the need to carry electromagnetic calculations without symmetry. Healthy electromagnetic calculations are perturbated at first order to estimate the impact of uneven airgap.	V2.1	Available

**Optional modules*

e-NVH IMPORT EXPORT SOLUTIONS

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
SMOOTH INTEGRATION INTO CAE WORKFLOW *Solutions to ease Manatee integration within existing CAE workflow, including use of Manatee post processing on experimental data*	IO.FLUX*	Import of airgap magnetic field distribution	**Imports the airgap flux density distribution calculated with third party electromagnetic software** at single speed or variable speed or using MANATEE Magnetic Look Up Table (MLUT) format, and projects the airgap Maxwell stress on the inner and outer structures to calculate magnetic forces and resulting e-NVH behavior. Handles variable speed import and skewed machines.	V2.0	Available
	IO.MODAL*	Import of measured or calculated modal basis	**Import of structural modal basis** (.disp/.fem from Optistruct, .rst from Ansys, other formats can be added upon request) to perform modal expansion, modal force and modal participation factors calculation. The modal basis can come numerical simulation or experiments. Import Nastran / Abaqus not yet available, can be developed on demand.	V2.1	Available
	IO.EXTN*	External (non magnetic) noise source import	Possibility to import external noise harmonics (gear, aerodynamic noise for instance) - compatible with Manatee acoustic post-processing (PLOT.OT and PLOT.SPEC for instance). Includes a template to ease import of gear whine from Romax.	V2.2.3	Available
	IO.DXF	Import of slot, notch, magnet or cooling channel shape from .DXF file	Imports a .DXF file to draw the electrical machine magnetic circuit.	V2.1	Available

**Optional modules*

EFFICIENT e-NVH DESIGN EXPLORATION

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
EFFICIENT e-NVH DESIGN EXPLORATION *Solutions to carry parameter sweep, multi-objective optimization and simulation comparison*	LAB.PS*	Parameter Sweep	Calculates e-NVH **responses with respect to design variables** (e.g., to study the effect of +/- 5% pole width or slot numbers on noise). Design variables can be chosen among geometrical templates of magnetic circuit geometry. Skew, Eccentricity (ROB.ECC) and uneven stator bore radius (ROB.UAG) are available as design variables as well. User defined response variables can be added to track and visualize flux / forces / vibration / noises harmonic amplitude for each design.	V2.1	Available
	LAB.DE*	Multidimensional design space explorer	Dedicated GUI to visualize all the design of a parameter sweep solution on 5D graph (X, Y, Z, point colour and point size) to find the design with the best trade-off between design and response variables.	V2.2	Available

**Optional modules*

e-NVH ELECTROMAGNETIC MODELS (semi-analytical models)

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
e-NVH ELECTROMAGNETIC MODELS *Electromagnetic models for magnetic field calculation in both early and detailed design phase for all electrical machine topologies*	EM1.PMSM	Fast electromagnetic analytical module based on permeance / mmf and winding functions for permanent magnet synchronous machines	Calculates the airgap rotor and stator radial flux density time and space distribution based on permeance / mmf model. Includes rotor skewing, any winding type (**star of slot** method included). Hybridation with FEMM to calculate rotor mmf of PMSM. Assumes infinitely deep slots, but any shape of surface/interior magnet, and infinite permeability of magnetic materials. Most suitable for early design phase to capture the main airborne resonances due to radial forces.	V2.0	Available
	EM1.SCIM*	Fast electromagnetic analytical module based on permeance / mmf and winding functions for inner rotor induction machines, including squirrel cage induction machine (SCIM)	Calculates the airgap rotor and stator radial flux density time and space distribution based on permeance / mmf model. Includes rotor skewing, any winding type (**star of slot** method included). Full load PMMF model is simulated in the frequency domain to avoid any spectral leakage problems. Most suitable for early design phase to capture the main airborne resonances due to radial forces in induction machines. NL= no load FL = full load	V2.0 (NL) V2.2 (FL)	Available

**Optional modules*

e-NVH ELECTROMAGNETIC MODELS (numerical finite element model)

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
e-NVH ELECTROMAGNETIC MODELS *Electromagnetic models for magnetic field calculation in both early and detailed design phase for all electrical machine topologies*	EM3.PMSM	Electromagnetic finite element module for surface, inset or interior permanent magnet synchronous machines	Couples Manatee with open-source electromagnetic software FEMM for nonlinear magnetostatics problem (automatic drawing, meshing and post processings). Calculates the airgap radial and tangential flux density time and space distribution, as well as torque, and flux linkages. Includes skewing and any winding type, inner and outer rotor. Can be used to calculate the flux density look up tables of ALG.MLUT.	V2.0	Available
	EM3.WRSM	Electromagnetic finite element module for wound rotor synchronous machines	Couples Manatee with open-source electromagnetic software FEMM for nonlinear magnetostatics problem (automatic drawing, meshing and post processings). Calculates the airgap radial and tangential flux density time and space distribution, as well as torque, and flux linkages. Can be used to calculate the flux density look up tables of ALG.MLUT.	V2.2.3	Available
	EM3.IM*	Electromagnetic finite element module for inner rotor induction machine at no-load and load conditions, including squirrel cage induction machines (SCIM)	Couples Manatee with open-source electromagnetic software FEMM for **non-linear magnetostatics** problem (automatic drawing, meshing and post processing). Stator and rotor currents are calculating using enforced Equivalent Electrical Circuit. Calculates the airgap radial and tangential flux density time and space distribution, as well as torque, and flux linkages. Includes skewing and any winding type, inner rotor. NL= no load FL = full load	V2.0 (NL) V2.2 (FL)	Available

**Optional modules*

e-NVH STRUCTURAL MODELS

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
e-NVH STRUCTURAL MODELS *Structural models for vibration calculation in both early and detailed design phase*	SM.MEXP	Structural Mechanics finite element module based on modal expansion	Performs **modal expansion techniques** based on a **modal basis** to calculate **dynamic vibrations** of radiating envelope or specific user-defined nodes. Can be used when performing ALG.EVS under unit-magnitude stress waves or using an operational magnetic force loading.	V2.0	Available
	SM.ANLR	Structural Mechanics semi-analytical module for radial flux machines	Calculates the natural frequencies of the outer structure (rotor or stator) based on an **equivalent cylinder** for radial flux machines. Calculates dynamic radial deflections of the outer structure under magnetic forces with an equivalent 2D ring model. Possibility to enforce modal parameters.	V2.0	Available

**Optional modules*

e-NVH ACOUSTIC MODELS

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION	VERSION	RELEASE
e-NVH ACOUSTIC MODELS *Acoustic models for noise calculation in both early and detailed design phase*	AC.ANLR	Acoustics semi-analytical model for radial flux machines	Calculates analytically the **sound power level** radiated by the machine based on **analytic models of cylindrical shells** radiation factors (infinite cylinder or pulsating sphere) – only compatible with SM.ANLR	V2.0	Available
	AC.ERP	Acoustic model based on Equivalent Radiated Power	Calculates the **sound power level** radiated by the machine based on **Equivalent Radiated Power** - compatible with 3D FEA mechanical model.	V2.0	Available
	AC.SPL	Sound Pressure Level computation	Calculates the **sound pressure level** radiated by the machine based on the sound power level with the possibility to set directivity coefficient, distance to the source and field type.	V2.2	Available
	AC.SYN	Sound synthesis as .wav file	Synthesis the Sound Pressure Level as a normalized .wav file to listen the simulated noise (from SQ.SPL)	V2.1	Available
	AC.SQM*	Sound Quality metrics	Loudness (Zwicker method for stationary signal), Specific loudness (Zwicker method for stationary signal), Sharpness (DIN 45692), Roughness (Daniel & Weber method), Specific Roughness (Daniel & Weber method) are available as post-processing of .wav generated by SQ.SYN.	V2.2	Availble

**Optional modules*