Simcenter Amesim for Electrical Drives Design
Transforming the way ideas come to life
The performance digital twin

Market and customer insight

Concept phase

Validation and test phase

Detailed engineering phase

Scalable 1D-3D simulation and test including real-time for MiL-SiL-HiL

Engaging with engineering services in customers’ product development practices
Hybrid-electrical vehicle example

- Control
- Electric
- Hydraulic / Pneumatic
- Mechanical
- Thermal

Mechatronic system example
Mechatronic system simulation example

Behind each block, a mathematical model describes the physical behavior.
# Model Scalability

## Performance & Range / Drivability / NVH / Durability, possible model definition for electrical vehicle

<table>
<thead>
<tr>
<th>NVH</th>
<th>Electric motor</th>
<th>Battery</th>
<th>Gearbox</th>
<th>Driveline</th>
<th>Chassis</th>
<th>Suspension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Static</td>
<td>Generic battery</td>
<td>Ratios efficiency</td>
<td>Wheel inertia</td>
<td>One inertia</td>
<td>2D linear</td>
</tr>
<tr>
<td>Level 2</td>
<td>Quasi-static</td>
<td>Advanced model (semi-empiric)</td>
<td>Flywheel inertia</td>
<td>Driveshaft stiffness and wheel inertia</td>
<td>3 DoF (2D)</td>
<td>3D multi-body</td>
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<tr>
<td>Level 3</td>
<td>Dynamic</td>
<td>Advanced model (semi-empiric) + thermal</td>
<td>Detailed rotary stiffness and inertia</td>
<td>Detailed rotary stiffness and inertia</td>
<td>18 DoF (3D)</td>
<td></td>
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<tr>
<td>Level 4</td>
<td>Cosimulation with FEM</td>
<td>Advanced model (semi-empiric) + aging</td>
<td>FEM import</td>
<td>FEM import</td>
<td>FEM import</td>
<td></td>
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</tbody>
</table>
What’s important for working with system simulation
Industry proven simulation tool must-haves

Intuitive user interface
Especially if tool isn’t used every day

Easy to analyze
Fast analysis workflows and “good looking” diagrams

Predefined libraries
Application oriented and ready to use

Scalable complexity
Dig deep only where you need to

Openness
For other CAE tools, scripting,…

Engineering experience
From engineers for engineers

System Simulation
Challenges Addressed with Simcenter Amesim

- Electric machine pre sizing
- Functional system validation
- System (Vehicle) Integration
- Controller calibration and optimization
- Cooling system design
- Model reduction for real-time simulation
Electric machines solution overview

Capabilities

- Most machine technology: PMSM, WRSM, IM, SRM, DC…
- Scalability from high frequency to functional machine models
- Efficient links with FE based tools (JMAG-RT, Flux)
- Switched and average power converter models
- Machine control blocks and SPWM command strategies
- Tools and methodologies available for model simplification

Benefits

- Architecture and technology early comparison
- Fast simulation
- Cooling system design
- Simple close loop setup
- Converter command comparison
Possible modelling time line for electric machine design
Addressed engineering problems – Pre-sizing

Features: Simple functional machine and converter component with maximum operating point limits for peak acceleration performance assessment

Benefits: Define a vehicle requirement or evaluate an architecture concept
Addressed engineering problems – Pre-sizing

**Features:** Quasi static PMSM modeling with space phasor modeling using FEM machine characteristics

**Benefits:** Validate a PMSM design early with performance and consumption validation in a fast system simulation

- FEM static and dynamic analysis
- Flux linkage and iron losses look up table
- Powertrain efficiency assessment
Possible modelling time line for electric machine design

- Powertrain Pre-sizing
- Machine sizing
- Machine analytical design
- Machine detailed design
- Motor Vibro-acoustic analysis
- Dynamic model for drivability

Electric machine design time line
Addressed engineering problems – E-Powertrain

Features: Physical models for electric machine
Benefits: Early validation of electric machine control strategies and impact on powertrain efficiency

Brake blending strategy
Electric powertrain
Energy losses
Addressed engineering problems – E-Powertrain

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Target</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Range WLTC Class 3</td>
<td>250</td>
<td>[km]</td>
</tr>
<tr>
<td>Acceleration 0 - 100 [km/h]</td>
<td>7.3</td>
<td>[s]</td>
</tr>
<tr>
<td>Acceleration 0 - 60 [km/h]</td>
<td>3.8</td>
<td>[s]</td>
</tr>
<tr>
<td>Acceleration 80 - 120 [km/h]</td>
<td>5.1</td>
<td>[s]</td>
</tr>
<tr>
<td>Maximum speed</td>
<td>150</td>
<td>[km/h]</td>
</tr>
<tr>
<td>Steep slope start with maximum permissible load</td>
<td>30</td>
<td>[%]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum motor torque</td>
<td>205</td>
<td>[Nm]</td>
</tr>
<tr>
<td>Maximum motor power</td>
<td>130</td>
<td>[kW]</td>
</tr>
<tr>
<td>Maximum motor speed</td>
<td>12000</td>
<td>[rpm]</td>
</tr>
<tr>
<td>Battery energy</td>
<td>35</td>
<td>[kWh]</td>
</tr>
</tbody>
</table>

Simulation monitor

Driver

Vehicle

Environment

Control Unit

E-motor

Reducer

Simulation monitor

Auxiliary consumer

Battery
Possible modelling time line for electric machine design

Electric machine design time line

- Powertrain Pre-sizing
- Machine sizing
- Machine analytical design
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- Dynamic model for drivability
- Motor thermal integration
Addressed engineering problems - Cooling

**Features:** Accurate prediction of electric device heat release

**Benefits:** Optimize the electric drivetrain thermal management

FEM static and dynamic analysis

Power flow chart
Possible modelling time line for electric machine design

Electric machine design time line
Addressed engineering problems – Control validation

**Features**: Simcenter Amesim interfacing capabilities and electrical libraries RT compatibility

**Benefits**: Validate a PMSM drive control with MIL or a vehicle supervisor with HIL
Electric powertrain design and simulation – Validation phase

System functional and energetic validation
Map based – quasi-static – RT

Model reduction with scripting facilities and map generation
From equivalent electrical circuit to functional models

Control validation with MIL/SIL
Equivalent electrical circuit
Siemens eCar Powertrain Systems
Designing advanced components for e-mobility with Simcenter Amesim

Forward through model-based systems engineering

- Streamlined design and customization process for all e-mobility devices
- Fulfilled market demands based on standardization and scalability
- Shorter development cycles and lower costs

Component behavior analysis for pre-sizing

- Predict the efficiency of required powertrain electric components
- Re-use knowledge capitalized from past work and experience

Full vehicle assessment for performance and efficiency optimization

“The implementation of model-based systems engineering is driving our innovation platform, and enables us to combine architecture definition with simulation capabilities to validate technical choices early in the design cycle”

Wolfgang Nebe, Director System Technology, eCar Powertrain Systems business unit
Renault
Reaching high energy savings in hybrid vehicles using Simcenter Amesim

Operating complex multi-domain analyses

- Battery behavior simulation
- Internal combustion engine analysis

“Simcenter Amesim enables us to get a deep insight on energy performance of hybrid architectures and helps us select optimal architectures that fit our requirements early in the design process.”

Eric Chauvelier, Method and Simulation Manager

• Delivered high-quality product on-time and with reasonable costs
• Created flexible development platform to support future projects
• Shortened time-to-market

• Facilitate communication and decision-making thanks to a common platform
• Implement co-simulations to assess the energy synthesis of any hybrid configuration
Electrical Machines solution
Unique value proposition

**A flexible tool**
Designed to address complex electric systems

**A multi-domain platform**
Interactions between mechanics, electrics, thermal, hydraulics phenomenon & control are natively accounted

**A multi-level approach**
Pre-sizing with tabulated machine, system integration with physical motor model, control evaluation

**Ability to address various design issues**
Impact of electrical architecture on the system, power convertor thermal design, optimization of energy efficiency…
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