Simulation Environment for Evaluation of Micro Hybrid Architectures and Strategies

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Content

› Micro hybrid architectures and strategies

› Intedis simulation environment approach

› Generic models & simulation configuration

› Use cases & simulation example
Key Facts Intedis

Intedis GmbH & Co. KG
Independent Engineering and Consulting company focusing on the automotive E/E Architecture

Employees
67

Turnover
6 m.€ (2012)

Locations
Würzburg, Germany (Headquarter)
Erlangen (Germany), Shanghai (China), Pune (India)*, Toulouse (France)**

* Legal structure Hella India Electronics Private Limited
** Legal structure Hella Engineering France S.A.S.
## Services

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Examples of Micro Hybrid EM Architectures

12V architecture with DCDC for stabilization

12V architecture with sec. battery for stabilization

12V architecture with Ultracap for stabilization

48V for high power loads

Floating alternator with Ultracap for recup.

48V for boosting, recup. & high power loads

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Main Strategies to Save Fuel and CO2 with Voltages < 60V

**Direct** fuel saving

- **Switch off engine and save fuel because of no fuel injection**
  - Save Fuel by... Engine off time
  - Save Fuel by... Extended Engine off time

**Indirect** fuel saving

- **Save el. Extra Energy while deceleration and use it later by deactivation of alternator**
  - Save E by... Passive el. recup. <=16V braking adv. Alternator Control
  - Save E by... Forced recup. with >16V while braking / deceleration Modified Alternator
  - Stored by... AGM Battery
  - Stored by... Add. Ultra Cap Add. Li Battery DC/DC
  - Used by... Switch off Generator while Acceleration
  - Used by... Switch off Generator while acceleration and if SoC = High

- **Stop start**
  - Save by... Enhanced Stop start (<10 Km/h)
  - Save by... Engine stop while driving (>10 Km/h)

- **Engine off time**
  - Enhanced Stop start

- **Extended Engine off time**

- **Extended Engine off time**

- **Switch off Generator while Acceleration**

- **Switch off Generator while acceleration and if SoC = High**

- **Add. Ultra Cap Add. Li Battery**

- **Add. Li Battery DC/DC**

- **Drive electric: Boosting, Creeping, Sailing,**
Components Involved in Main Strategies

**Direct fuel saving**
- Switch off engine and save fuel because of no fuel injection
  - Engine off time
  - Extended Engine off time
- Save fuel by
- Stop start
- Enhanced Stop start (<10 Km/h)
- Engine stop while driving (>10 Km/h)

**Indirect fuel saving**
- Save el. Extra Energy while deceleration and use it later by deactivation of alternator
  - Forced recup. with >16V while braking / deceleration
  - Modified Alternator
  - Forced recup. 48V while braking / deceleration
  - ISG up to 15kW

**Components Involved in Main Strategies**
- 12V/48V DC/DC <=3kW Power Converter
- Battery Management Electronics
- DC/DC stabilizer <500W
- <1kW Storage Module
- Intelligent Battery Sensor
- AGM Battery
  - Add. Ultra Cap
  - Add. Li Battery
  - DC/DC
- Passive el. recup. <=16V braking adv. Alternator Control
- Forced recup. while braking / deceleration
- Modified Alternator
- Drive electric: Boosting, Creeping, Sailing,
- Add. Li Battery DC/DC
- Switch off Generator while Acceleration
  - Switch off Generator while acceleration and if SOC = High
- Enhanced Stop start (<10 Km/h)
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- Forced recup. 48V while braking / deceleration
- ISG up to 15kW
- Drive electric: Boosting, Creeping, Sailing,
Multitude of Possible Realizations

Fast identification of optimized realization necessary done with special Simulation environment
Simulation Environment

Challenges
› Several EM strategies/architectures and component performance classes are possible
› Future components are not existing today
› Time pressure for decisions

Requirements
› Combination of SW algorithm, state charts and physical systems
› Showing the general behavior of the system and components
› Easy changes of models to new realizations and integration of new technologies
› Fast simulations

Usage of Generic Models with Matlab©/Simulink© & Toolbox Simscape©

State charts and SW algorithm
Electrical, mechanical and thermal systems

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Intedis Approach – from EM Library to Scenarios

System Elements

Technologies & Variants

Parameters

Driving Cycles

Car types & use cases

Compact Car

Luxury class

Winter

Summer

Combination of component models to the specific architectures and solutions
Development of Generic Models

1. Setup of data base with
   › Datasheets
   › Measurements

2. Extraction of general behaviors and equations
3. Build up of generic Look-Up-Tables
4. Definition of standard interfaces

5. Adaption to other technologies or variants
6. Validation of generic models by test case simulations & measurements
Verification of Generic Models

Verification of single components

Verification of EM systems

Battery validation

Alternator validation

Laboratory measurements

Driving tests

Driving profile

Currents

Battery voltage

Alternator validation

Laboratory measurements

Driving tests
Overview of Complete Vehicle Model

- Simulation of complete vehicle or independent simulation of electrical / mechanical subsystems possible
- Easy exchange of subsystems

**Mechanical part**
- Engine
- Start/Stop Control
- Transmission
- Clutch
- Brake
- External forces

**Electrical part**
- Alternator (Control)
- Electrical Machines
- Batteries
- Loads
- Cables
- DCDC Converter

**Additional Calculations for analysis**
- Simulation of complete vehicle or independent simulation of electrical / mechanical subsystems possible
- Easy exchange of subsystems
Electrical System Example

- Easy build up of power distribution architectures

Easy exchange of different technologies and variants
Mechanical Subsystem Example

- Longitudinal vehicle model with basis chassis functionalities
- Engine model integrated with mechanical parts and logic control
Configuration of Vehicle

To build up EM Architectures generic component models are chosen and connected.

- Configuration of components to a specific vehicle / solution
- Setting parameters with calibration values:
  - Global vehicle data (e.g. mass)
  - Components configurations (LuT, parameters)
Configuration of Mission Scenarios

Selecting the driving cycles or alternator speed

Setting the commands of the loads

Setting the environmental profile (outside temperature, road properties / profile)

(...various parameter sets)

(various parameter sets mission profiles)
Field of applications

Fast validation and estimation of different EM architectures and strategies

- Dimension of main harness wires
- Estimation of power losses
- Energy Flow Analysis
- Voltage stability
- Recuperation Energy
- Performance class of EM components
- Effects of Cranking

Fuel savings of EM architectures and strategies

Fuel Consumption

<table>
<thead>
<tr>
<th>Reference Architecture</th>
<th>Architecture solution 1</th>
<th>Architecture solution 2</th>
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<tr>
<td>4.2</td>
<td>4.3</td>
<td>4.4</td>
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<tr>
<td>4.5</td>
<td>4.6</td>
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<td>4.8</td>
<td>4.9</td>
<td>5</td>
</tr>
<tr>
<td>5.1</td>
<td>5.2</td>
<td>5.3</td>
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</table>

DCDC voltage stabilisation

<table>
<thead>
<tr>
<th>Voltage stabilisation</th>
<th>DCDC Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery current</td>
<td>0</td>
</tr>
<tr>
<td>Battery cables, 25mm²</td>
<td>10</td>
</tr>
<tr>
<td>Battery voltage, 10mm²</td>
<td>20</td>
</tr>
</tbody>
</table>

Cold Start

- Battery current, cold start
- Positive voltage, reference
- Positive voltage, with charge OFF
- Positive voltage, with charge ON

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Simulation Example

Use Case
Validation of fuel savings of alternator control strategy for different driving cycles (braking = 16V, acceleration = 0V)

NEDC has less and weaker braking phases

Fuel savings are expected bigger for WLTP

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Simulation Example Results

Examination of energy balance

For regaining balanced SoC the alternator performance class need to be increased
Simulation Example Results

Examination of fuel savings

**NEDC - Battery SoC**
- reference car, 1.3kW alternator
- with advanced alternator control, 2.2kW alternator

**WLTP - Battery SoC**
- reference car, 1.3kW alternator
- with alternator control, 1.8kW alternator

- **0% fuel savings**
- **2% fuel savings ~100ml/100km**

WLTP shows bigger fuel savings with alternator control than NEDC
Conclusion

Many possible micro hybrid architectures lead to the necessity of an evaluation tool of the most promising solution

Intedis Simulation environment…

› offers the ability to have fast validation results for the decision & predevelopment phase

› can be used to validate component realization in the electrical system during series development

› is capable for extensions and the integration of specific component models
Thank you for your attention!