Behavioral alternator model in VHDL-AMS for the powernet simulation

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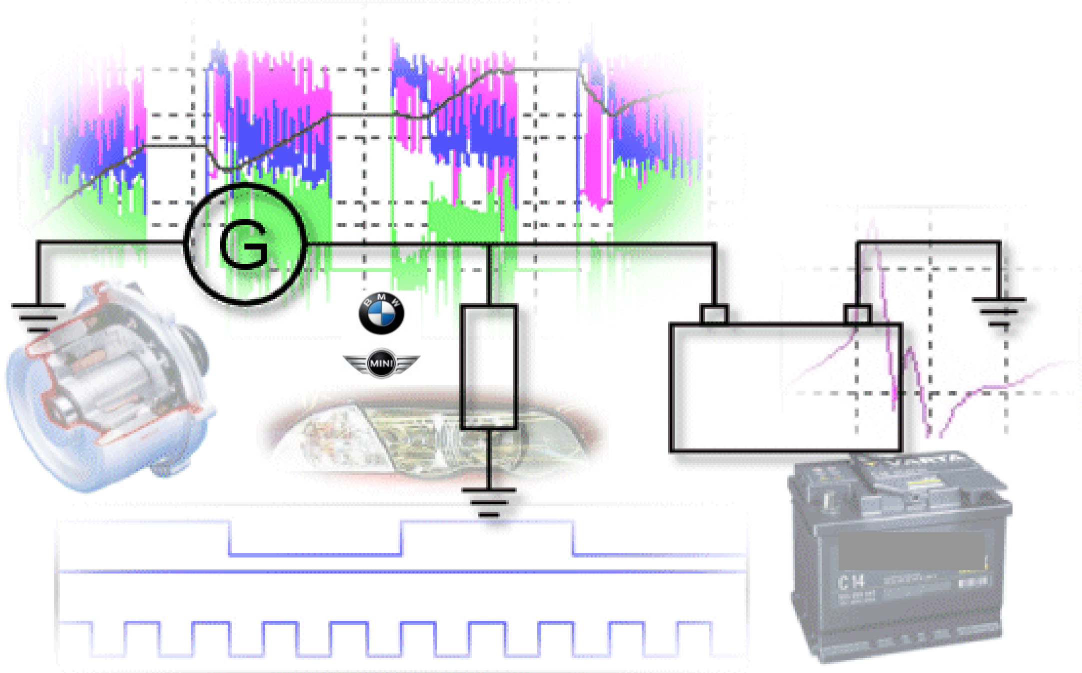

BMW Group

Behavioral alternator model in VHDL-AMS for the powernet simulation

Motivation

- Virtual simulation gains more and more impact on the automotive industry

- To fullfill the task a steady increasing number of models of different levels are required. As an example the number of BMW models in the (electrical) powernet increased from

  6 models in 1999 to

  33 models in 2003

  Mainly there are models for alternators, batteries, powermanagement, ventilators, seat heating, steering systems, high power loads...

- The increasing cross linking of the tasks requires the interchangeability of models first between OEM and supplier and secondary between the different departments in the company

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Todays State

- At the moment there is a „heterogeneous“ picture of the simulation environment because of the of utilisation of different tools and modelling languages as, i.e. MAST, Modelica and VHDL-AMS

- To guarantee the interchangeability of models both the tools and the simulation language have to meet specific requirements

- From the user‘s point of view the separation of tool and language must be stronger supported by the EDA manufacturers in the future

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Requirements of the language

- Usability for simulation of analog and digital systems
- Enabling of multi-domain (mechatronic) simulation
- Description of simple and complex systems
  using behavioral models and physical models
- File-I/0
- Easy unterstandable „readable“ and „robust “ Code

Targets

- Enabler for a high degree of acceptance of the language at
  car manufacturers, suppliers, universities (as modellelling standard)
- Basement for a broader use of the virtual simulation

The listed requirements are strongly supported by VHDL-AMS

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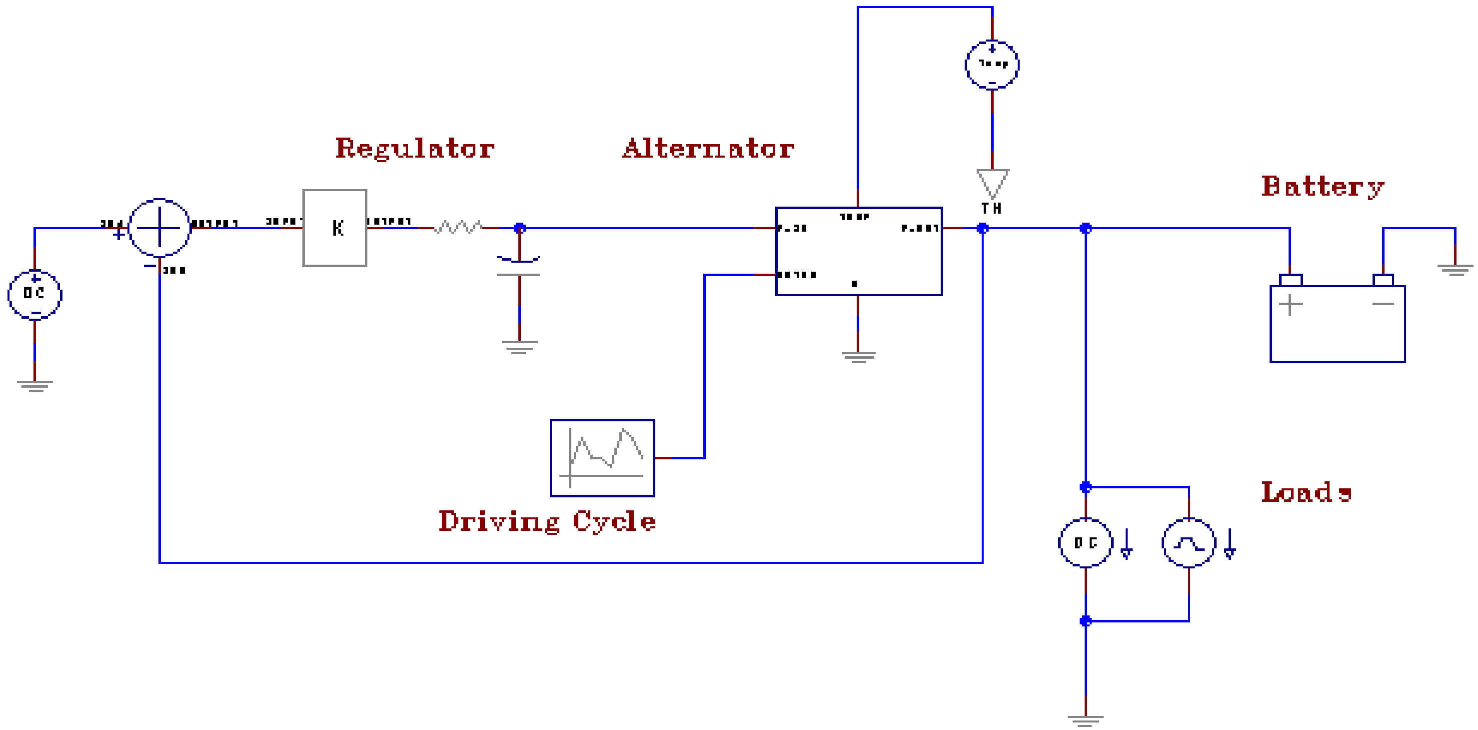
Testbench



The alternator model plays a central role in the powernet design.
The example shows a behavioral modelling of an alternator.

Two ways of implementing the pwl-function are presented and compared.

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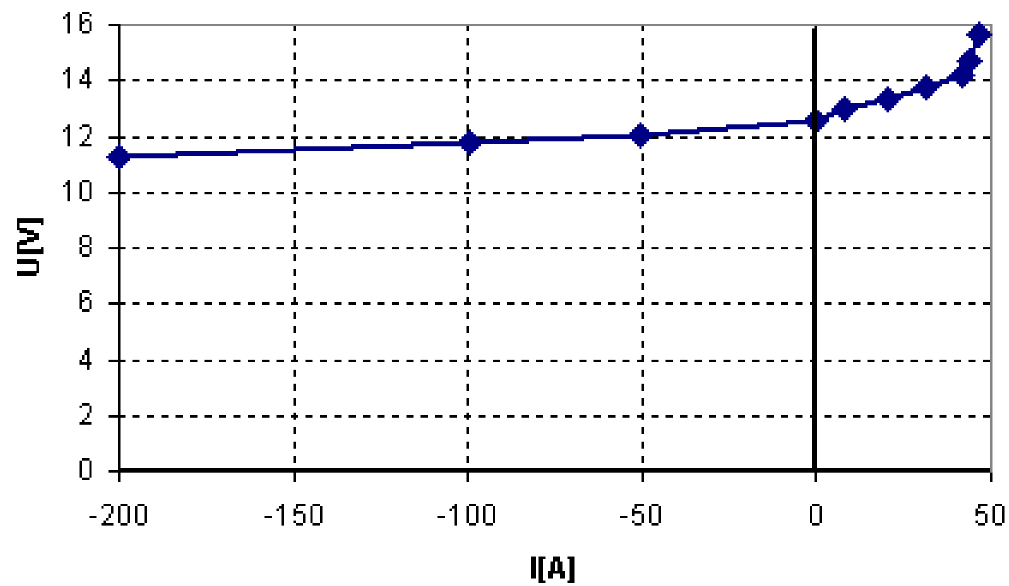
Simplified battery model

The testbench uses a model for the battery terminal voltage. The terminal voltage is modelled as a function of the terminal current. The model is based on measurements.



Capacity:	80Ah
State of charge:	80%
Temperature:	30°C

The simplified model represents one particular state of the 80Ah-battery regarding temperature and state of charge.

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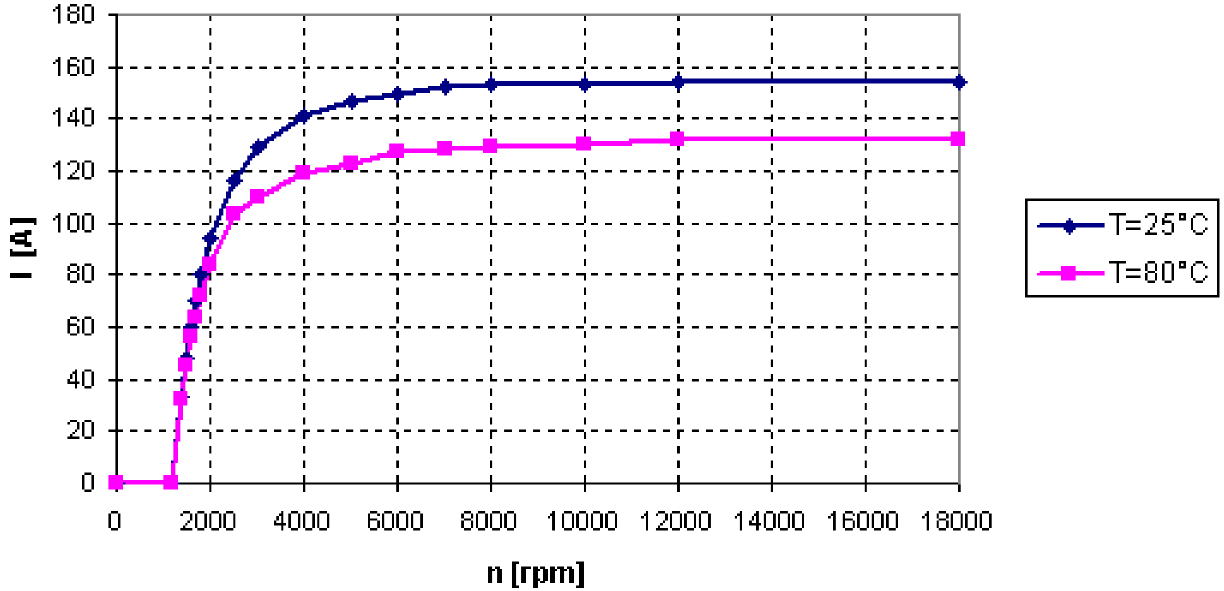
Alternator Model for Loadbalance-Simulation

The loadbalance alternator model is based on 2 characteristics:



Step 1: Interpolation within the 25°C-characteristic => $I_{25°C}$

Step 2: Interpolation within the 80°C-characteristic => $I_{80°C}$

Step 3: Interpolation between $I_{25°C}$ and $I_{80°C}$

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Alternator model for Loadbalance-Simulation

Main advantages:

- simplicity and stability
- good trade-off between functionality and performace
- easy parametrisation (alternator characteristics provided by supplier)
- one model for a wide range of alternators

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Piecewise-linear characteristic

Function declaration:

```
function pwl_1d(x:real;xv:real_vector;yv:real_vector) return real;
```

Model-Entity:

```
entity pwl_1d is
  generic (
    xv:real_vector:=( 0.0,1.0);
    yv:real_vector:=( 0.0,1.0)  );
  port(
    quantity x: in real;
    quantity y: out real  );
end entity pwl_1d;
```

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Piecewise-linear characteristic

Two possible ways of implementing the pwl charcteristic:

- as a function with the independent variable as a function parameter and the dependent variable as the return value

- as an ordinary model with the independent variable as an input and the dependent variable as an output quantity

The model has continuous access to the independent variable and is therefore able to detect discontinuities. Whenever the independent variable travels from one section of the pwl to another one, the model executes a brake-statement.

The function can not monitor the independent variable and is therefore not able to handle discontinuities.

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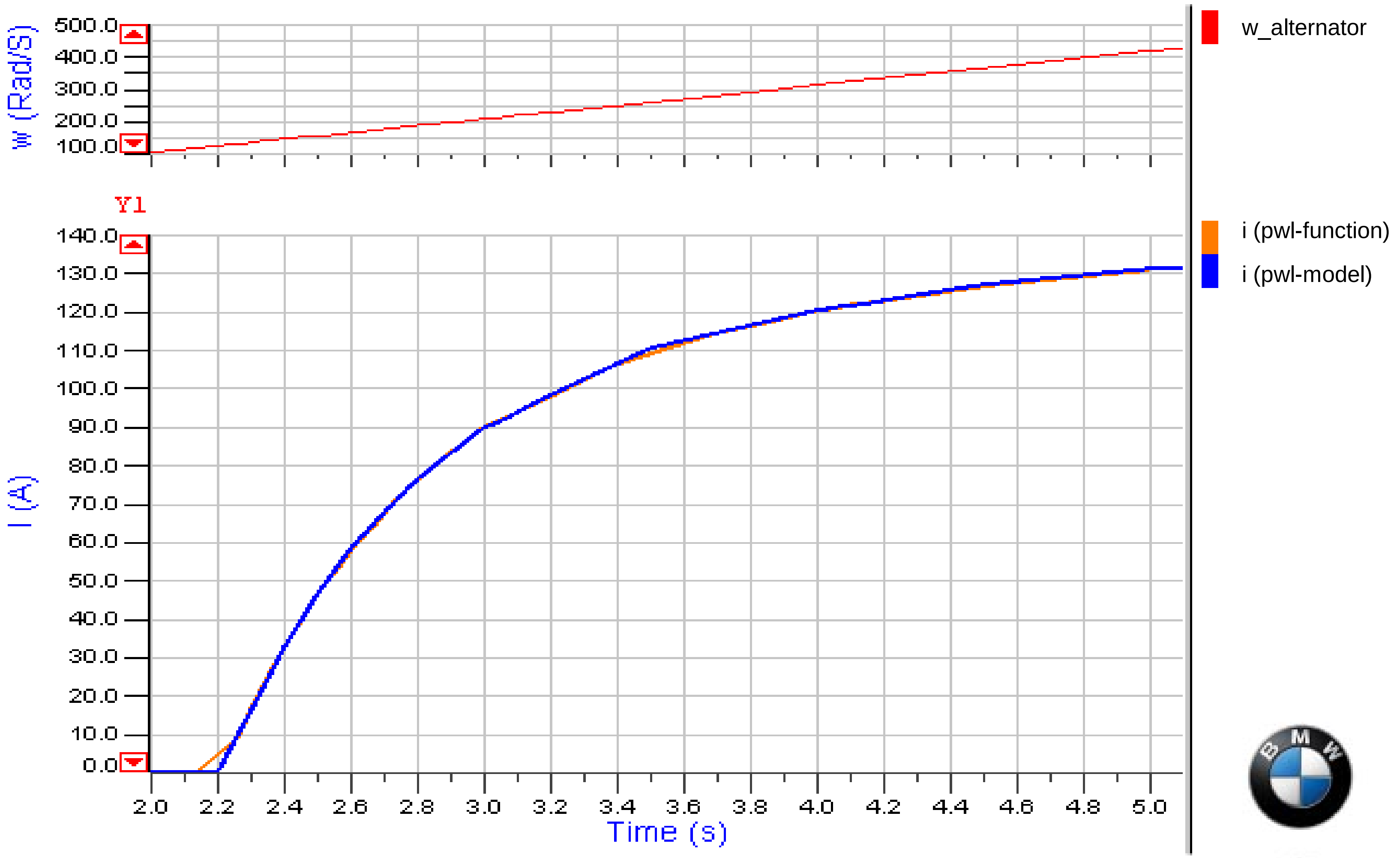
Piecewise-linear characteristics at 80°C



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Conclusions

- A simple powernet, consisting of an alternator, a regulator, a battery, loads and a drive cycle can be easily modelled with Vhdl-Ams.

- Both methods of implementing the one dimensional pwl-function are suitable. For our applications, putting the pwl-function into a separate model leads to more accurate simulation results.