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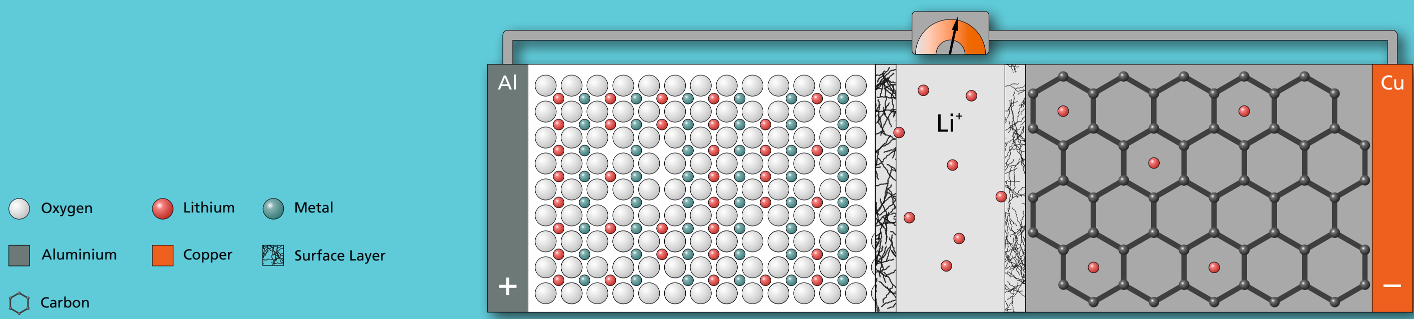

Principle of a Lithium Ion Battery

SIMULATION OF LITHIUM-ION BATTERIES

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Battery simulation software for the automotive and battery industry based on physical – electrochemical model

Battery simulations save expensive test series and help to accelerate development processes. The software ISET-LIB simulates all relevant physical and electrochemical processes in Lithium Ion batteries under different operating conditions. The model inputs are constructive data as well as characteristic parameters of the cell chemistry.

The battery models of the Fraunhofer Institute for Wind Energy and Energy System Technology (Fraunhofer IWES) have been deployed successfully for more than 15 years in the international automotive industry.

Ask for further information to benefit from our experience!

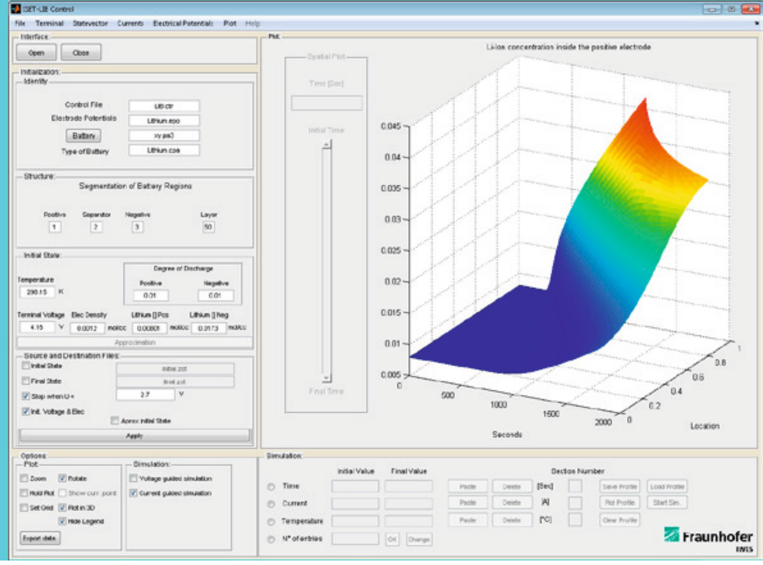
Properties

- Non-linear model
- Prediction of the terminal behaviour
- High precision over the complete operational range
- Simulation of any desired battery state

- Insight into the interior processes
- Exact knowledge of the battery condition
- Developing and testing of battery management algorithms
- Evaluation of cellular concepts

- Parameterisation through design data
- No measurements required
- Simulation of any desired ageing condition

- Real time variant for "Hardware in the Loop" tests available



Simulation and "Hardware in the Loop" tests play an important role in modern development processes, since they promise significant time and cost savings. This applies also to the area of electrical systems, where storage devices, such as Lithium Ion batteries often are a key component. For such applications Fraunhofer IWES offers a detailed simulation model known as ISET-LIB.

The model

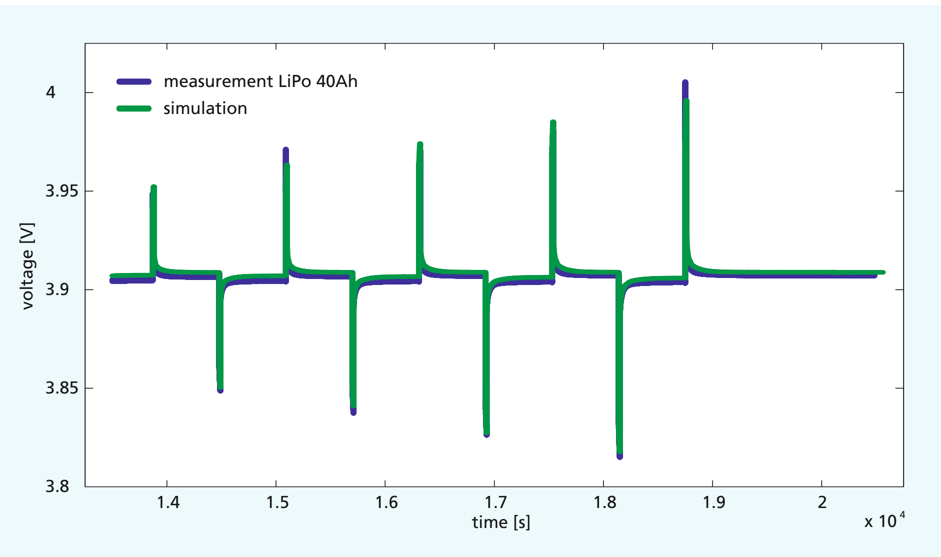
ISET-LIB simulates the behaviour of Lithium Ion batteries under any desired operating condition starting with the modelling of all relevant physical, electrical and chemical processes. The model inputs are constructive data as well as characteristic parameters of the cell chemistry. Nearly any desirable construction form can be recreated without having to conduct expensive test series for parameterisation. By doing so a wide variety of ageing conditions may also be simulated, as long as the respective physical and chemical changes are known. The approach allows a detailed insight into the state as well as the interior processes of a Lithium Ion battery, which provides significant advantages especially for the development of new cell concepts and battery management systems. For example battery state algorithms can be tested and continuously developed through this approach.

The model simulates the highly non-linear behaviour of a Lithium Ion battery on a cellular level through which a high simulation precision over the complete operational range is achieved. Input variables are the temperature and either the current or voltage profile. The connection of several cells to a stack with the respective interactions on a thermal and electrical level can be modelled as well.

The software

ISET-LIB is provided as a sub function for use with Matlab/Simulink. An implementation for further simulation environments is available upon request. The software provides a graphical user interface for the parameterisation, initialisation and evaluation of the simulation. All interior processes and states can be visualized and analysed along with the terminal and temperature behaviour.

A real-time version for deployment in most common "Hardware in the Loop" platforms is also available. In combination with a suitable electrical power supply a virtual battery emulator, which exactly mimics the terminal behaviour of a real battery can be achieved for instance.



1 Test of an electrical vehicle on the chassis dynamo meter of the Fraunhofer IWES with support of a virtual battery

2 Graphical user interface for ISET-LIB

3 Comparative measurement / simulation on a 40 Ah LiPo cell with electrical pulses of 20-40 A after a discharge to 75% SOC at 25 °C