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Lithium-ion battery based energy storage and battery management systems for electric and hybrid vehicles

ESReC
Energy Storage Research Center

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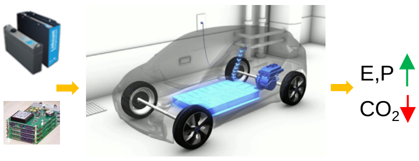
Objective

Optimal operation of rechargeable batteries e.g. lithium-ion batteries as well as reliable battery management systems (BMS) are essential for obtaining an optimized energy consumption and the highest possible CO_2 emission reduction and at the same time an increase of hybrid and electric vehicle performance.



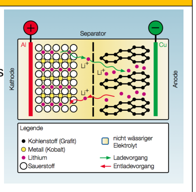
Our main objective is to lower the entry barrier of rechargeable batteries in today's mobility market. For this, we perform research and development of:

- batteries at cell, module and system level
- battery management systems

Within the framework of SCCER Efficiency in Mobility, we have increased our R&D infrastructure through the creation of the BFH-CSEM Energy Storage Research Center (ESReC), the largest Swiss battery technology research platform available for R&D projects with the Swiss industry.

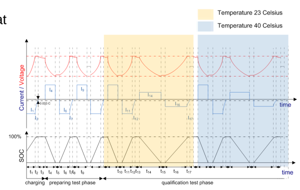
Battery Characterization Methods

We characterize lithium-ion battery based electrochemical energy storage systems in terms of electron transfer capability between electrodes by applying various charging and discharging methods and rates at various temperatures.

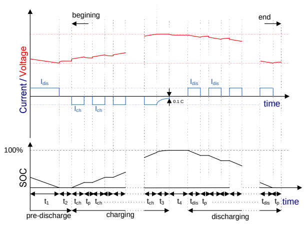


The experimental methods are optimized to derive fundamental and complex battery behaviour under various real-world conditions in order to develop mathematical models for advanced BMS:

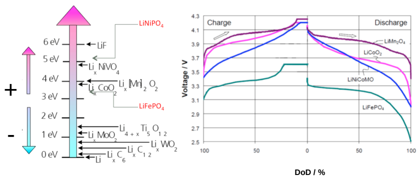
A)
Characterization at constant charging / discharging rate



B)
Characterization applying pulsed charging / discharging currents

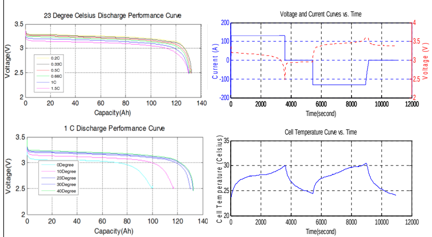


Effect of Cell Chemistry on I-U Characteristics

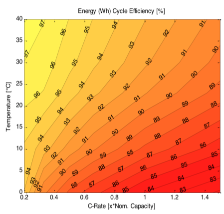


Cell chemistry defines battery characteristics (energy density, energy efficiency) and performance: cycle life, calendar life and, more interestingly for us at BFH, electron transfer behavior i.e. I-U characteristics during charging and discharging.

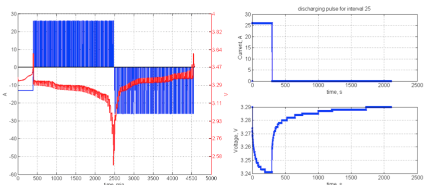
Effect of Constant Current Rate and Temperature



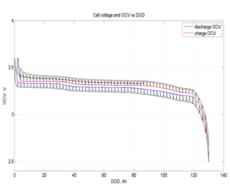
Energy cycle efficiency varies depending on charge/discharge current and temperature. While higher temperatures result in higher efficiencies, battery aging processes are catalyzed as well.



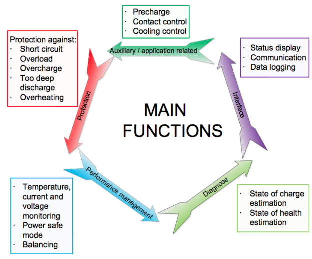
Characterization of Open Circuit Voltage



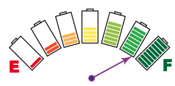
Charging and discharging pulses permit relaxation of lithium-ions towards thermodynamic equilibrium, making accurate OCV measurements possible.



Battery Management Systems

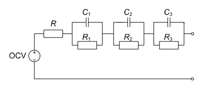


In order to achieve an optimum operation of battery based hybrid and electric vehicles it is necessary to develop accurate mathematical models for an accurate estimation of the state of charge (SoC), the temperature distribution within the battery, the residual capacity, the internal resistance and the lifetime, taking into account the operation by the user.

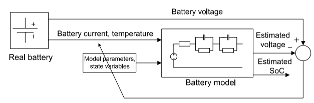


We aim at the development of highly efficient and reliable model-based software able to calculate the SoC accurately regardless of the type of I-U-characteristics in order to provide secure and reliable battery solutions.

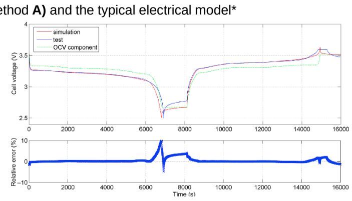
Typical electrical model of a lithium-ion cell*:



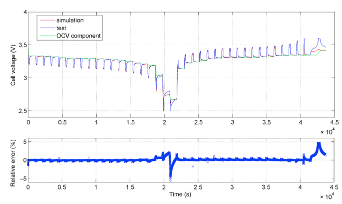
Illustrative diagram of SoC estimation using *state observer* principle:



Model validation for round trip cycle after applying characterization method **A)** and the typical electrical model*



Model validation for round trip cycle after applying characterization method **B)** and the typical electrical model*



Acknowledgements

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