MEMBAT - Modellierung, Emulation und Management hochkomplexer Traktionsbatterien

The industrial development of alternative hybrid-electric and pure electric automotive propulsion systems requires tremendous efforts in the areas of battery technology, power electronics, electric motors, as well as new approaches for energy-efficient control strategies. The latter are realized in electronic control units like e.g. the battery managements system (BMS) or the hybrid control unit (HCU). The proper functioning of these ultimately determines the power-flow and thus the efficiency of the whole powertrain system.
An efficient end economically viable development process thus requires a strong reduction of time effort for the conduction of reproducible test runs. There is therefore a growing demand for battery emulators (also denoted as battery simulators), which emulate of the real battery. Technically, a battery emulator is a controllable DC voltage source that could emulate the impedance behavior of a real battery or supercapacitor. Fig. 1 shows the main components of an electric power train (left) and a 4-whell test bed with an e-Storage Emulator^{TM} (right) of AVL List GmbH.

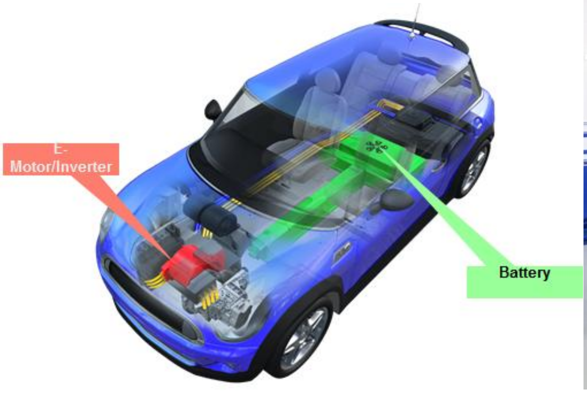

Fig. 1

The MEMBAT project comprised three subject areas: battery emulator control, real-time battery models, and battery management system.
Based on an intensive literature research, a promising approach was selected for control design, which provides a systematic model design of the control path together with online-optimization. The model was implemented for a dedicated real-time platform and has been successfully tested. In that scope of work, a ready for serial production signal processor board was designed to utilize the full capabilities of the developed control algorithm. The specifications for this purpose were generated from MEMBAT project conclusions.
Generic non-linear models have been selected for the real-time battery models in order to simulate any non-linear dynamic behavior of cell chemistry or any other type of electrical energy storage system. The battery model was implemented with MATLAB/Simulink. For validation an optimized dynamic current profile was applied to one single lithium-iron phosphate-cell. The model network was trained with the recorded voltage curve. The resulting model of a virtual battery pack for plug-in hybrid vehicles was generated by means of scaling. With that model, the

battery emulator showed a good relation to a real battery regarding charge- and discharge, as well as for dynamic load changes.
For the battery management system topic, a demonstrator board for cell voltage measurement was designed and manufactured. The demonstrator was for behavior and road capability investigations for active cell balancing and was tested with 12 lithium-ion-cells.
Furthermore, a precise battery state monitoring (state of charge etc.) was examined with focus on integration and real-time capability of the designed model. The resulting model was successfully tested on real cells – packs.
Also, robust fault detection was explored in that subject area. A fault can be cell-to-cell differences, increasing resistance, decreasing capacity etc. The algorithms for fault detetion showed good results.

Overall, the MEMBAT project achieved usable results and implementations for product development, as well as 6 international publications, 4 patents, and one dissertation, one master thesis, one bachelor thesis, respectively.

Project partners:

AVL List GmbH

Vienna University of Technology

University of Applied Sciences JOANNEUM Kapfenberg