52. IWK

Internationales Wissenschaftliches Kolloquium

International Scientific Colloquium

PROCCEDINGS | 10 - 13 September 2007

FACULTY OF COMPUTER SCIENCE AND AUTOMATION

COMPUTER SCIENCE MEETS AUTOMATION

VOLUME I

Session 1 - Systems Engineering and Intelligent Systems

Session 2 - Advances in Control Theory and Control Engineering

Session 3 - Optimisation and Management of Complex Systems and Networked Systems

Session 4 - Intelligent Vehicles and Mobile Systems

Session 5 - Robotics and Motion Systems

TECHNISCHE UNIVERSITÄT ILMENAU

Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbiografie; detaillierte bibliografische Daten sind im Internet über **http://dnb.ddb.de** abrufbar.

ISBN 978-3-939473-17-6

Impressum

Herausgeber: Der Rektor der Technischen Universität Ilmenau
Univ.-Prof. Dr. rer. nat. habil. Peter Scharff

Redaktion: Referat Marketing und Studentische Angelegenheiten
Kongressorganisation
Andrea Schneider
Tel.: +49 3677 69-2520
Fax: +49 3677 69-1743
e-mail: kongressorganisation@tu-ilmenau.de

Redaktionsschluss: Juli 2007

Verlag:
Technische Universität Ilmenau/Universitätsbibliothek
Universitätsverlag Ilmenau
Postfach 10 05 65
98684 Ilmenau
www.tu-ilmenau.de/universitaetsverlag

Herstellung und Auslieferung: Verlagshaus Monsenstein und Vannerdat OHG
Am Hawerkamp 31
48155 Münster
www.mv-verlag.de

Layout Cover: www.cey-x.de

Bezugsmöglichkeiten: Universitätsbibliothek der TU Ilmenau
Tel.: +49 3677 69-4615
Fax: +49 3677 69-4602

Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

Table of Contents

C O N T E N T S

Page

1 Systems Engineering and Intelligent Systems

Paper submitted after copy deadline

2 Advances in Control Theory and Control Engineering

52nd Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
10 – 13 September 2007

T. Behrmann / M. Lemmel

Vehicle with pure electric hybrid energy storage system

Abstract

Hybrid systems to power vehicles are developed to compensate certain disadvantages of the main power supply, like low power dynamics in respect to the environmental factors or low power density relative to mass and costs. The advantages of hybrid systems are bought by higher level of system complexity and the need to handle these additional degrees of freedom. The quality of energy management systems is essential for the performance of the whole hybrid system.

The basis of this presentation is the German pilot project EFRB[1] - funded by the BMWi. The main focus of this project was the development, implementation and proving of a hybrid energy storage system consisting of different storage components. Well-known German automotive and energy storage manufacturer like DaimlerChrysler, Varta, Epcos etc. were partners within a consortium that was coordinated by BIBA/MAQ[2].

Within this research project a flexible automotive concept has been developed, which enables flexible adaptation of the operation mode appropriate to power requirements of the hybrid vehicle application. The key idea is a composition of different electric energy storages into one energy storage system. The objective is to achieve both: large mileage and high acceleration in the same vehicle. The results can be transferred on other usual hybrid combinations of fuel cells, combustion engines, batteries and UltraCaps. The system components developed in this project could lead to an optimised possibility for building hybrid vehicles.

The system complexity of a hybrid vehicle leads to new degrees of freedom which require an operating control combined with an optimised energy management. It has the objective to set the power flow of each storage device appropriate to drive situation and the optimised working point of the combined system. Basic and advanced methods of control theory, modelling, rapid control prototyping, optimised control and model

[1] Mobile electric storage system for vehicles with great mileage and high acceleration

[2] Bremen Institute of Industrial Technology and Applied Work Science at the University of Bremen Division Metrology, Automation and Quality Science

predictive control are the tools used for the development process.

1. Basic idea and concept

The comparison of energy density and power density shows that energy storages can either be optimized for a maximum energy density with considerable reduced power density or alternatively for a maximum power density thus in a decreased energy density. Electric energy storages with different properties of energy and power density have been chosen purposely for application in vehicles (see Fig. 1). The target is to compensate these divergent design objectives by combining different energy storages.

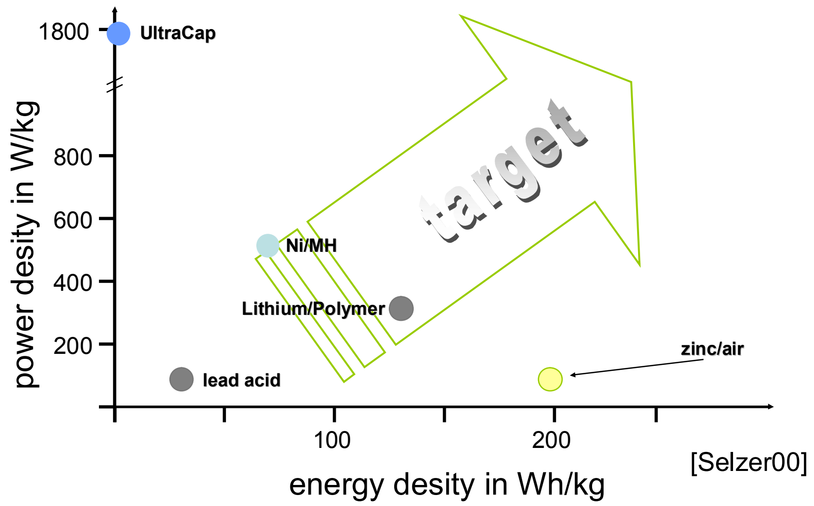

Fig 1 Ragone diagram of typical battery systems according to [Selz00]

Great mileage is covered by a long-term energy supply. Electric Fuel Company provides a zinc/air-battery with a high energy density. It has a relative low power density. In practice the fuel cells and small internal combination engines with generator have similar technical features, so that the results can be transferred on this issue.

The supercapacitor UltraCap from Epcos has a high power density and is able to supply and sink high currents. In recuperation mode it stores energy from breaking manoeuvres. This component is an ideal for covering short term power demand. This brings high acceleration abilities into electric vehicles while energy balance increases.

A Ni/MH battery from Varta provides mid-term energy and power supply. It supports in case of sustaining acceleration processes the zinc/air basic supply and serves as recuperation storage for long down hill routes.

To handle the hybrid storage system energy management is essential. It identifies active drive situation (drive, roll, break, stop, acceleration, stop and go etc.) and computes the state-of-charges (SOC) of the storage units. Depending on this an assessment the power flows will be controlled according to the expected drive state [Stan03]. The state-of-charges will instead be controlled for strategic planning depending on the expected drive state [Qu04]. E.g. an empty UltraCap is useful in case of high probability of breaking manoeuvres like in city traffic. It influences the overall efficiency.

The schematic image in Fig. 2 shows the drive train and the energy storage system with all vehicle components. On the left hand side the logical in- and output units for the operating system are shown. The Energy management for the control of the power converters and reaction to the drivers' decisions is situated at the centre.

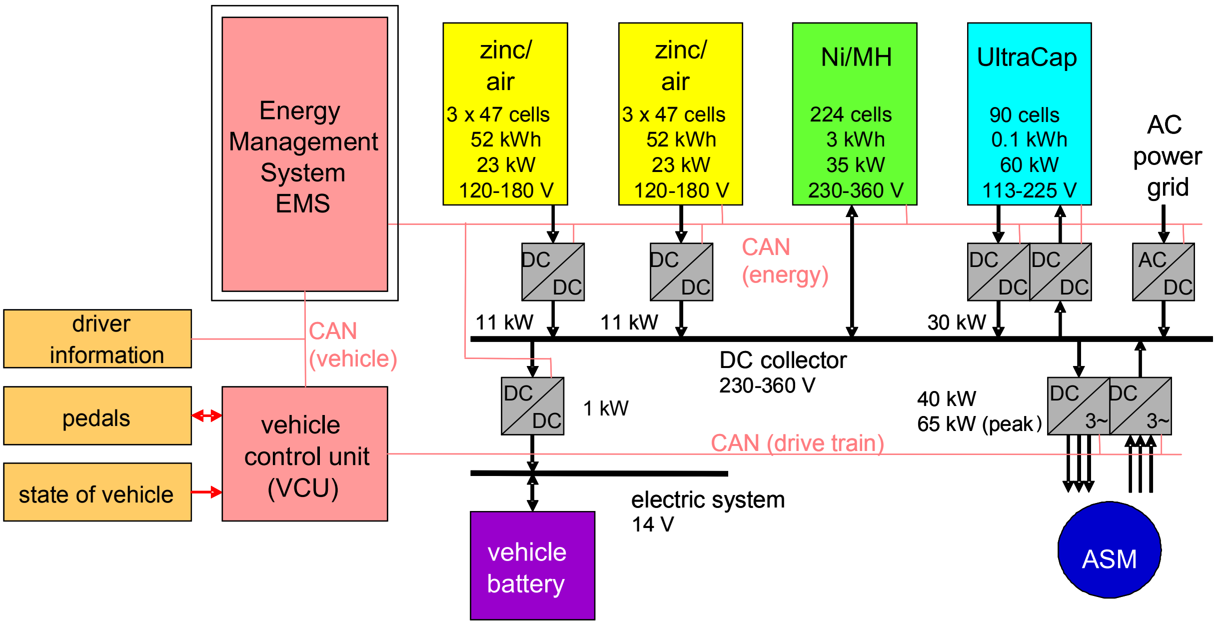

Fig 2 Schematic picture of the EFRB hybrid energy storage concept

The energy storages have different voltage operating ranges, so DC/DC converters are necessary for the connection over a main power bus. Direct connection of the Ni/MH battery keeps the bus voltage almost constant and has a robust behaviour in emergency situations. The zinc/air battery is connected by a unidirectional DC/DC converter with continuous power profile, while the UltraCap has to be operated bidirectional with high peak power characteristic.

The real-time communication of the active components of the storage system is implemented by a storage systems CAN bus.

2. The management of the traction energy

The two main components of the vehicle power supply are the energy management system (EMS) and the operating system (BFS). They ensure the operation of the three storage components and take care for optimal power flow. See Fig 3.

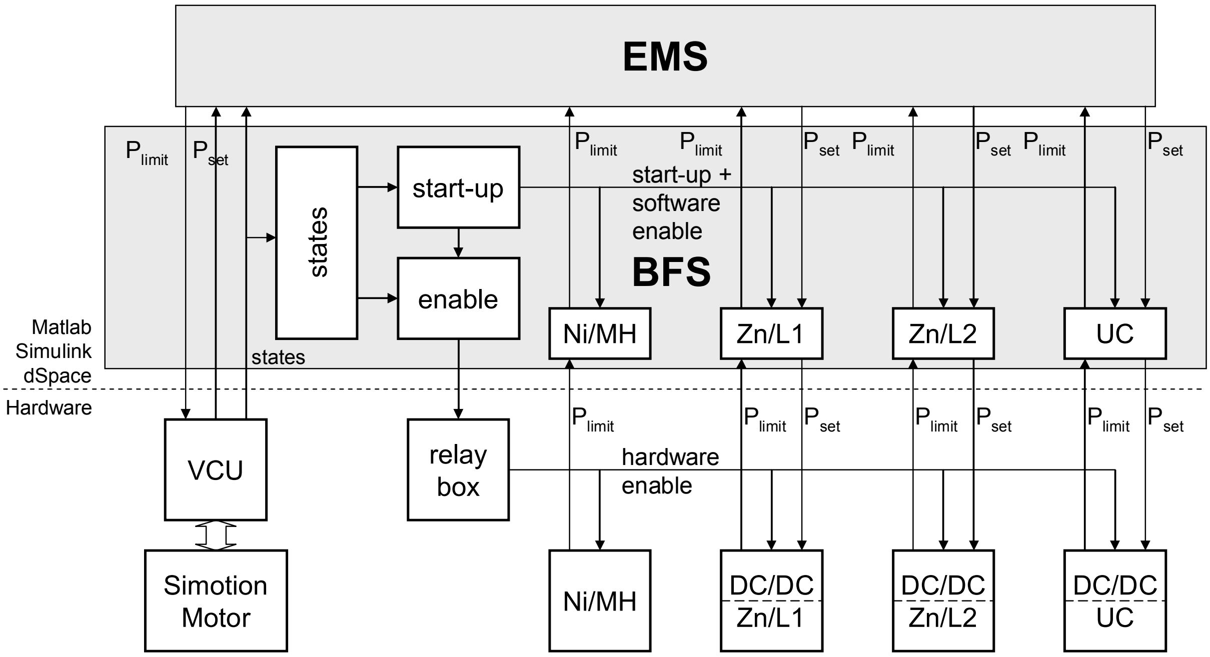

Fig 3 Scheme for the management of the supply of traction energy

The operating system (BFS) coordinates the boot process by enabling the single components in correct order. It supervises thresholds and global safety parameter and activates emergency modes if necessary. It interfaces the access of the available components to the energy management system (EMS).

The energy management contains several levels of decision and processing, which are illustrated schematically in Fig. 4 from left to right. Input data feeds are marked with arrows from the bottom.

The strategic planning components on the left hand side of the block diagram in Fig. 4 lead to the controller of the state of charge (SOC) of the energy storages. This controls the fraction of power supplied by each component (P-Mix-Planning). The planning components are implemented in rule based fuzzy controllers [Sorg04].

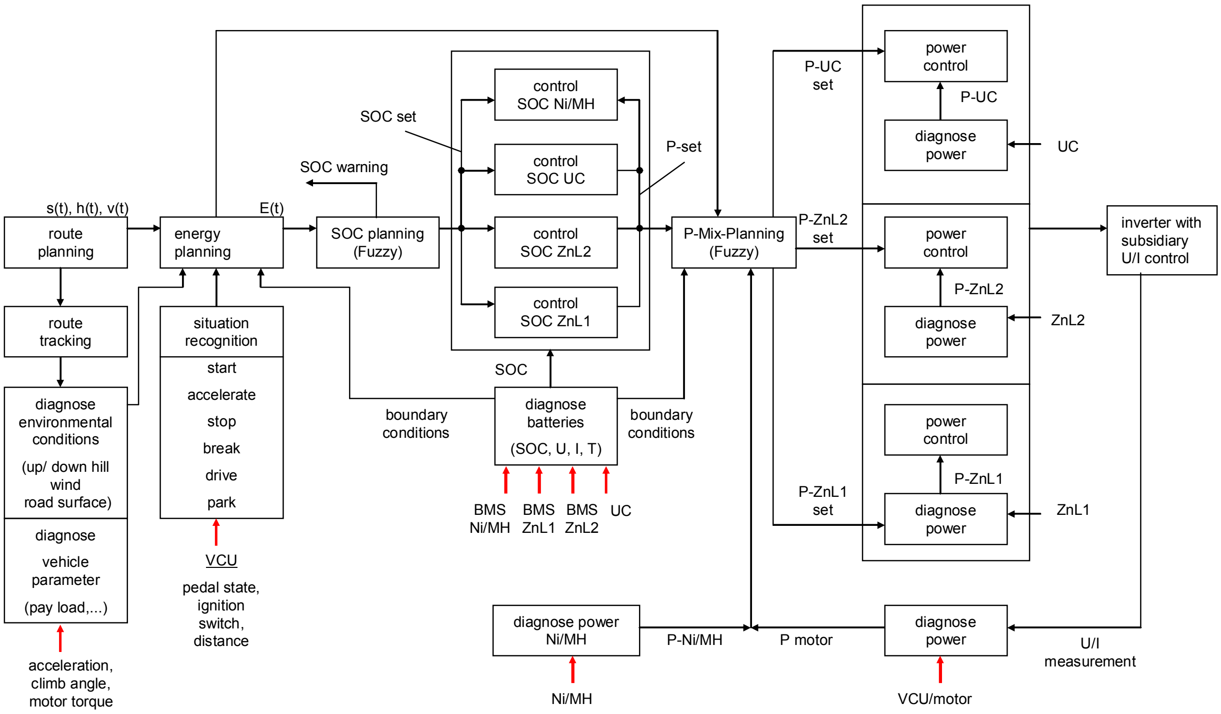

Fig. 4 Schematic overview of the energy management system (EMS) [Sorg04]

3. Conclusion

It has been shown, that the option to use a low power energy supply like zinc/air batteries or fuel cells can be supported by additional mid- and short-term components like Ni/MH batteries and UltraCaps. This situation dependant energy management leads to an up-to-date drive appeal with high efficiency. The results can be transferred to other hybrid constellations.

References:

[Selz00] H. Selzer, Dr. Ch. Ament, M. Sorg: Electric storage system for great mileage and high acceleration; ISATA; Dublin; 2000

[Sorg04] M. Sorg: Batterie-Tray mit modularem Batteriemanagementsystem; 26. Kolloquium der Automatisierungstechnik; Salzhausen, 05.11.-06.11.2004

[Qu04] Qu. Yu, M. Sorg, R. Stanislowski, Ch. Ament, H. Selzer: Fuzzy Prediction Control Strategy of EMS with Energy Hybridization of High Energy and High Power; Asian Electric Vehicle Conference(AEVC-3), Jeju Island, South Korea; 24.-29.03.2004

[Stan03] R. Stanislowski, G. Goch, Ch. Ament, C. Bredemeier: Energy Management System for Combined Electric Storage System for High Energy and High Power; EVS, CA/USA; 2003

Authors:

Dipl.-Ing. Thomas Behrmann
BIBA/MAQ
Hochschulring 20
28359 Bremen
Phone: +49 421 218 5627
Fax: +49 421 218 5625
E-mail: RT@biba.uni-bremen.de

Dr. Marc C. Lemmel
BIBA/MAQ
Hochschulring 20
28359 Bremen
Phone: +49 421 218 5627
Fax: +49 421 218 5625
E-mail: lem@biba.uni-bremen.de