TITLE

Lithium-ion Battery Systems and Power Electronics Solutions for Stationary and E-mobility Applications

NAME AND AFFILIATION OF THE AUTHORS

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SCOPE AND BENEFITS

The importance of the Lithium-ion (li-ion) batteries is booming and after dominating the portable electronics applications, they are entering into new sectors like grid support applications and propelling of the electric vehicles. The penetration of renewables in the power system is considered to significantly increase in near future; thus, batteries can play a crucial role in the reliable and cost efficient grid integration of intermittent energy sources. Besides, the grid support applications, li-ion batteries are playing a major role in the automotive market. The use of batteries in automotive applications is a promising option in order to replace the internal combustion engine cars with ideally, zero emissions vehicles (full electric vehicles), or with controlled emission vehicles (hybrid electric vehicles and plug-in hybrid electric vehicles).

The objective of this tutorial is to provide the audience with an extensive overview of the lithium-ion battery energy storage technology, its operating principles, advantages and drawbacks, system integration issues and requirements. Moreover, a part of the tutorial is dedicated to the performance modelling of the lithium-ion batteries. Different modelling methods will be introduced and their characteristics (e.g., accuracy, complexity etc.) will be assessed.

On the other hand, new battery applications require new power electronics solutions in order to assure lithium-ion battery pack safety, high-efficiency and reliable operation. Power electronics play three important roles in the battery applications: charge/discharge management, battery cell balancing, and safety protection. In consequence, this tutorial will provide extensive state of the art on battery management systems objectives and functionalities. This will be supplemented by an overview of power electronics solutions for battery charge/discharge management in the stationary and e-mobility applications.

At last but not at least, new solutions will be discussed as the so-called Smart Modular Battery Packages. In this topology, individual battery cells are not connected directly in series, but through individual DC-DC converters allowing flexibility in the individual loading of each cell. This provides many advantages such as more compact design due to the integration of battery

management system (BMS) and battery charger by means of DC-DC converters, improved battery pack energy management and lifetime, and possibility of bypassing underperforming or failing battery cells in battery packs.

CONTENTS

Monday, 11 September 2017 - Tutorial day (Location: WUT, Warsaw, Poland)

08:00 - 09:30	Registration for full day and morning Tutorials
09:30 - 11:00	Part 1: **Lithium-ion battery basics and systems in stationary and e-mobility applications** a. Overview of lithium-ion battery systems b. Lithium-ion batteries – status and challenges c. Overview of stationary and e-mobility applications of lithium-ion battery systems
11:00 - 11:30	Coffee break
11.30 - 13:00	Part 2: **Lithium-ion battery performance and performance modelling** a. The need for performance models – requirements and challenges b. Performance modelling approaches – overview and comparison c. Electrical modelling of lithium-ion batteries – examples
13:00 - 14:00	Lunch break and registration for the afternoon tutorials
14:00 - 15:30	Part 3: **Battery Management System functionality** a. The need and role of the lithium-ion BMS b. BMS topologies and functionality c. Diagnostics and battery state estimation
15:30 - 16:00	Coffee break
16:00 - 17:30	Part 4: **Power electronics converter topologies used for battery applications** a. E-mobility (battery chargers) b. Grid connected battery storage systems c. New modular battery energy system architectures with distributed battery management system

WHO SHOULD ATTEND

The main purpose of this tutorial is to provide a basic understanding of lithium-ion battery status, challenges, applications and performance modelling methods. Moreover, the tutorial will provide information about power electronics solutions used for battery management systems and power electronics converters used in lithium-ion battery stationary and automotive applications.

The tutorial is divided into two parts (lithium-ion battery specific and power electronics specific). Thus, this tutorial can be treated as a bridge between power electronics and lithium-ion battery research fields.

The tutorial is mainly addressed for power electronics engineers who would like to learn more about battery world and lithium-ion battery systems that are used for automotive and stationary applications. Moreover, the tutorial is aimed also for battery specialist who would like to get to know more about power electronics solutions used for lithium-ion battery systems.

ABOUT THE INSTRUCTORS

Remus Teodorescu (Professor, Aalborg University)

He received the Dipl. Ing. degree in electrical engineering from Polytechnical University of Bucharest, Romania in 1989, and a PhD degree in power electronics from University of Galati, Romania, in 1994. In 1998, he joined Aalborg University, Department of Energy Technology, power electronics section where he currently works as a professor. Since 2003, he is a visiting professor at Chalmers University of Technology, Gothenburg, Sweden. He has co-authored the book "Grid Converters for Photovoltaic and Wind Power Systems", ISBN-10: 0-470-05751-3 – Wiley and over 200 IEEE journals and conference papers. His areas of interests include: design and control of power converters for photovoltaics and wind power systems, grid integration with wind power, HVDC/FACTS based on MMC, SiC-based converters, storage systems for utility.

Maciej Swierczynski, (Associate Professor, Aalborg University)

He is an Associate Professor at the Department of the Energy Technology, Aalborg University, Denmark. He has two Master degrees: from AGH University of Science and Technology in Cracow, Poland (2005, Computer Engineering for Industrial Applications) and from Aalborg University, Denmark in 2009 (Power Electronics and Drives). In 2012, he received the PhD degree from Aalborg University, Denmark for his work on "Lithium-ion battery energy storage system for augmented wind power plants". During his career, he worked on several energy storage projects with research partners all over the world. His area of research is in the energy storage technologies for stationary applications, battery testing, modelling, and lifetime analyses.

Daniel Stroe (Assistant Professor, Aalborg University)

He received the Dipl.Ing. degree in electrical engineering from "Transilvania" University of Brasov, Romania in 2008, and MSc. degree in wind power systems from Department of Energy Technology, Aalborg University (AAU), Denmark, in 2010. In 2014 he received his PhD degree in "lifetime modelling of lithium-ion batteries used in virtual power plant applications" from the Department of Energy Technology, AAU where he is currently working as an assistant professor. He is the co-organizer and co-lecturer of the Industrial/PhD Course "Storage Systems based on Li-ion Batteries for Grid Support and Automotive Applications" since 2013. His main research interests are in the area of renewable energy systems, energy storage systems for stationary applications and battery testing and their performance degradation modelling.