

EPE'2021 –Tutorial Announcement

Reliability and Lifetime of PV-Battery Systems

Name(s) and Affiliation(s) of the Lecturer(s):

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Scope and Benefits:

For PV-Battery systems, the reliability of the key components such as power electronics and batteries are crucial aspects to ensure the stability and profitability of the system. This tutorial aims to address the reliability challenge and solutions for power electronics and batteries for PV applications. It will start with a brief overview of PV-Battery technology with a focus on power electronics topology and battery integration. Then, the importance of reliability aspect performance for PV inverters is discussed, followed by the various sources of field experiences and the identified types of failures including single event-related catastrophic failure and long-term degradation related wear out failure of power electronic components. Various reliability engineering tools will be briefly presented as well, with a more in-depth discussion on the reliability and lifetime prediction methods and its limitations.

The second part of this tutorial will provide an overview of the Lithium-ion (Li-ion) battery storage technology, its operating principles, characteristics, advantages, and limitations. Furthermore, an important part of the tutorial will be dedicated to the performance-degradation behavior of such energy storage devices, focusing on the dependence of the battery performance parameters (e.g., capacity, power, resistance) on various parameters such as, temperature, load current, cycle depth, number of cycles. Various approaches for Li-ion battery lifetime prediction will be introduced. Finally, a systematic lifetime modeling approach for PV-Battery system will be provided step-by-step. A case study of a residential PV-Battery system will be presented, where the lifetime modeling of power electronics and batteries are used as a design tool (e.g., component sizing) to ensure the economic profitability of the system based on the mission profile.

Who should attend:

The target participants are: 1) University researcher who is interested in the reliability of power electronics and batteries application; 2) Industry power electronics and battery system designer who would like to have a better understanding of how to design a reliable product by taking into account the failure mechanisms, stress factors, and mission profiles; 3) Industry PV system designer who would like to know more about how the design, sizing, and operation of PV-Battery system can be optimized to ensure reliable operation and increase the economic profitability of the project.

Technical Level:

Technical Level: The technical level of this tutorial will be intermediate. However, beginners with a fundamental knowledge of power electronics and battery systems can also follow.

Contents:

Introduction: (10 minutes)

Part I: Reliability of PV Components and Inverters: (60 minutes)

- Why reliability performance is important for PV inverters?
- Field experiences and failure sources
- Tools to deal with reliability aspect issues
- Lifetime and reliability prediction – methods and limitations

Part II: Lithium-ion Batteries – Performance and Degradation (60 minutes)

- Energy storage technologies
- Lithium-ion batteries – status, challenges, and applications
- Performance parameters and their behavior
- Lithium-ion batteries lifetime modeling

Part III: Application-oriented Reliability Assessment (40 minutes)

- Mission profile-based lifetime evaluation - power electronics & batteries
- Case study of PV-Battery systems
- Design and control for reliability of power electronics and batteries
- From reliability to economical profitability
- Outlook and future trend

Final Q&A and Feedbacks (10 minutes)

Schedule:

Schedule is as follows

Monday, 6 September 2021 - Tutorial day (Virtual)

14:00 - 15:30	Introduction; Part I; Part II
15:30 - 16:00	Coffee break
16:00 - 17:30	Part II(cont.); Part III; Final Q&A

About the Lecturers:

Huai WANG is currently Professor and a Research Thrust Leader with the Center of Reliable Power Electronics (CORPE), Aalborg University, Denmark. His research addresses the fundamental challenges in modelling and validation of power electronic component failure mechanisms, and application issues in system-level predictability, condition monitoring, circuit architecture, and robustness design. In CORPE, he collaborates with various industry companies across the value chain from power electronic components to systems. Prof. Wang lectures

three Industrial/PhD courses on Capacitors in Power Electronics Applications, Reliability of Power Electronic Systems, and Design FMEA in power electronics at Aalborg University. He has given more than 20 tutorials at leading power electronics and reliability engineering conferences and a few keynote speeches in the above research areas. He has co-edited a book on Reliability of Power Electronic Converter Systems in 2015. Prof. Wang received his PhD degree from the City University of Hong Kong, Hong Kong, China, and B. E. degree from the Huazhong University of Science and Technology, Wuhan, China. He was a short-term visiting scientist with the Massachusetts Institute of Technology (MIT), USA, and ETH Zurich, Switzerland. He was with the ABB Corporate Research Center, Baden, Switzerland, in 2009. Dr. Wang received the Richard M. Bass Outstanding Young Power Electronics Engineer Award from the IEEE Power Electronics Society in 2016, for the contribution to reliability of power electronic converter systems. He serves as the Chair of IEEE PELS/IAS/IE Chapter in Denmark, and as Associate Editor of IET Electronics Letters and IEEE Transactions on Power Electronics.



Daniel-Ioan STROE received the Dipl.-Ing. degree in automatics from "Transilvania" University of Brasov, Romania, in 2008, and M.Sc. degree in wind power systems from Aalborg University, Aalborg, Denmark, in 2010. He has been with Aalborg University since 2010, from where he obtained his Ph.D. degree in lifetime modeling of Lithium-ion batteries in 2014. He is currently an Associate Professor with the Department of Energy Technology and the leader of the Battery Storage Systems Research program. He was a Visiting Researcher with RWTH Aachen, Germany, in 2013. He has co-authored over 120 scientific peer-review publications most of them in topics related to Lithium-ion battery performance and lifetime modeling and battery state estimation. Furthermore, he is serving as a special issue editor and topic editor for various journals. Daniel current research interests are in the area of energy storage systems for grid and e-mobility, Lithium-based batteries testing and modeling, and lifetime estimation and diagnostics of Lithium-ion batteries.



Ariya SANGWONGWANICH received the M.Sc. and Ph.D. degree in energy engineering from Aalborg University, Denmark, in 2015 and 2018, respectively. Currently, he is working as a Postdoc Fellow at the Department of Energy Technology, Aalborg University. He was a Visiting Researcher with RWTH Aachen, Aachen, Germany from September to December 2017. His research interests include control of grid-connected converter, photovoltaic systems, reliability in power electronics and multilevel converters. In 2019, he received the Danish Academy of Natural Sciences' Ph.D. prize and the Spar Nord Foundation Research Award for his Ph.D. thesis.