IEEE ENERGY CONVERSION CONGRESS & EXPO Detroit, Michigan, USA Oct. 9-13

Detailed Plan for Special Session

1. Title of the Special Session

Reliability of Power-Electronic Systems for Solar Energy

2. Session Organizers

1. Sudip K. Mazumder
   a. Professor, University of Illinois Chicago, mazumder@uic.edu
2. Frede Blaabjerg
   a. Professor, Aalborg University, fbl@energy.aau.dk
3. Patrick McCluskey
   a. Professor, University of Maryland at College Park, mcclupa@umd.edu
4. Jack D. Flicker
   a. Principle Member of the Technical Staff, Sandia National Laboratories, jdflick@sandia.gov

3. Abstract and Tentative Talk Titles

One of the most important elements for market acceptance of new technologies is ensuring reliability. Nowhere is this more true than in the shift from well characterized fossil fuel technologies to newer renewable and sustainable energy technologies. The key enabling technology driving these shifts is the development of power converters. As such, this special session will present reliability issues, mechanisms, and impacts associated with emerging power-electronic systems. The topics and their detailed contents include:

Talk 1 – Multilevel String Solar Inverter Reliability: In this presentation, the focus will be on reliability issues associated with string multilevel solar inverters. The focus will be on component, system, and network level reliabilities and provide the interplay among these pathways to assess how they affect the lifetime and useful life of the inverters. Additional focus will be on the types of reliability characterizations and how they reflect on long term reliability prognosis. A final focus will be on the reliabilities that originate at the cyber-physical interface of these new class multilevel solar inverter energy system.

Talk 2 - Physically Informed AI in Solar Power Electronics Reliability Design: To improve efficiency and reduce life-cycle-cost, currently adopted solutions utilize many trial-and-error tests or establish complicated multi-physics models. Even though these methods are effective, they are time-consuming and usually end up with sub-optimal operating points. Artificial Intelligence (AI) can minimize this gap by numerically quantifying the failure mode probability under such circumstances and providing corresponding reliability indices in accordance. However, the data applied for existing data-driven solutions from power electronic systems are usually noisy, sparse, and heterogeneously sampled. It can only indicate system behaviors in limited scenarios with high-level uncertainty. Consequently, these results can be inaccurate in low-probability high-impact events, which leads to poor performance or failure. In this presentation, we will address this challenge by devising a physics-informed AI based framework to automate power electronics reliability by fusing data-driven methods and deterministic physical principles. Not only will this principle address the uncertainty, but it will also reduce the computational resources by a large margin.

Talk 3 – Prognostics of Power Electronic Converters: Conventional approaches to assess reliability of power electronic devices have severe drawbacks. Frequent redesigns, often with new parts having no historical data, limits the usefulness of methods based on historical data. Conversely, physics-of-failure often does not capture the most relevant failure mechanisms, including those related to operationally induced electrical overstress and software. In this presentation, we will discuss the latest developments in prognostics and reliability assessment for power electronic converters that utilize advancements in artificial intelligence, machine learning, and data analytics, along with new techniques for characterizing and modeling failure mechanisms to drastically improve power electronics reliability.

Talk 4 – PV Inverter Reliability - Advanced Inverter Functionality: Historically, PV inverters have been designed to inject as much power a possible into the grid. However, as the penetration of renewables has increased, PV inverters are expected to perform grid support functionality, such as voltage and frequency support (known as advanced inverter functions). This talk will discuss impacts of these advanced inverter functions on system reliability based on experimental evaluation and power system modeling.

4. Session Presenters/Panelists and Delivery (100 minutes)

This session has a format of combination of presentations similar to a technical session and discussions similar to a panel session. The session is planned for in-person attendance at ECCE 2022. The presenters, panelists and attendees will be onsite at the ECCE 2022 venue. The overall 100-minute session will comprise 4 presentations each of duration of about 15 minutes including short Q&A while the remaining time of the session will be spent on extended and active interactions among the participating audience and the 4 presenters. The input from the audience are strongly encouraged.

The session program includes:

Time	**Topics**	**Presenters & Panelists**
0:00 – 0:15	Solar inverter resilience	Sudip K. Mazumder
0:15 – 0:30	Physically informed AI in power electronics reliability design	Frede Blaabjerg
0:30 – 0:45	Prognostics of power electronic converters	Patrick McCluskey

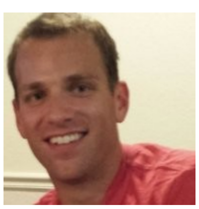
0:45 – 1:00	PV inverter reliability: Advanced inverter functionality	Jack D. Flicker
1:00 – 1:40	Panel discussions, with active interactions among attendees	Sudip K. Mazumder Frede Blaabjerg Patrick McCluskey Jack D. Flicker
1:40	Session Adjourned	

5. Short Bio of Session Organizers, Speakers and Panelists

Sudip K. Mazumder is the Director of Laboratory for Energy and Switching-Electronics Systems (LESES) and a Professor in the Department of Electrical and Computer Engineering at the University of Illinois at Chicago (UIC). He has over 30 years of professional experience and has held R&D and design positions in leading industrial organizations and has served as Technical Consultant for several industries. He also serves as the President of NextWatt LLC, a small business organization that he setup in 2008. He is a Fellow of IEEE and Fellow of AAAS and the Editor-at-Large for TPEL.

Frede Blaabjerg, a Fellow of the IEEE, is a Full Professor of power electronics and drives in 1998 at AAU Energy. From 2017 he became a Villum Investigator. His current research interests include power electronics and its applications such as in wind turbines, PV systems, reliability, harmonics and adjustable speed drives. He is the past President of the IEEE Power Elctronics Society, past Editor in Chief of the IEEE Transactions on Power Electronics, and Member of the Danish National Academy of Engineering.

Patrick McCluskey: is a Professor of Mechanical Engineering at the University of Maryland, College Park and the Department's Director of Undergraduate Studies. He has over 25 years of research experience in the areas of thermal management, reliability, and packaging of electronic systems for use in extreme temperature environments and power applications. Dr. McCluskey has co-authored three books, 5 US Patents, and nearly 200 peer-reviewed technical articles with over 3700 citations. He is an associate editor of the IEEE Transactions on Components, Packaging, and Manufacturing Technology, a member of the board of governors of the IEEE Electronic Packaging Society, a fellow and member of the Executive Council of IMAPS, and a member of ASME and AIAA.



Jack D. Flicker: is a Principle Member of the Technical Staff at the Sandia National Laboratories. His research focuses on all aspects of power electronics and power conversion systems that enable improvements in power system operation: from incorporation of new materials and devices in power conversion systems to utilizing new topologies and controls at the system level. Jack's research touches on all areas of the power electronics value chain ranging from usage of new devices (wide- and ultra-wide bandgap semiconductors) to new topologies and controls to evaluation of system-level behavior. The nature of his work spans multiple TRL levels and incorporates everything from basic analysis to optimization and simulation to experiment and field-deployment.