


# Reliability of Modern Power Electronics Based Power System (PEPS)

**Frede Blaabjerg, Dao Zhou, Saeed Peyghami**
**Department of Energy Technology, Aalborg University**
**Aalborg, Denmark**
fbl@energy.aau.dk, zda@ energy.aau.dk, sap@ energy.aau.dk

**Jose Rueda Torres**
**Electrical Sustainable Energy Department, Delft University of Technology**
**Delft, The Netherlands**
J.L.RuedaTorres@tudelft.nl

## Tutorial Objectives:

Reliable and secure power delivery is essential for the electric power system modernization with low to zero carbon footprint. It requires deploying new technologies and infrastructure as well as deregulating the electricity sector. Some stablished technologies have a considerable role in power system modernization including renewable energy resources, storage systems, electronic transmission and distribution systems, and e-mobility. Notably, power electronics play an underpinning role in the grid modernization. However, it imposes new challenges to reliable planning and operation of power system. So far, the reliability of power electronics has been comprehensively discussed in device- and converter-level, including physics of failure analysis and design for reliability. However, the reliability modeling and enhancement in power system level requires more investigation. This tutorial aims to discuss the reliability of future power electronics-based power system (PEPS) by emerging different aspects of concepts from component up to system level. It contains the following four parts. The first part explains the structure of modern electric grids and its challenges with the restructured environment. The second part describes the fundamentals of reliability in power systems. The next section covers the reliability of PEPS. The last section discusses the approach to bridge the reliability of modern PEPS from converter to power system levels. The main objectives of the tutorial are summarized in the following:

- Introduction to grid modernization, restructuring the power systems, important components of future power grids, the induced challenges by the new technologies (e.g. power electronics, renewable energies, storages, etc.), and the importance of reliability in modern power system.
- Overview on the fundamentals of the conventional power system reliability and risk, failures in power systems, reliability assessment methods and reliability of onshore and offshore power networks.

Bridge between the reliability of power systems and power electronics, reliability modelling and enhancement in PEPS, mission profile analysis and time variant reliability modelling in power electronic systems.

## Target Audience:

This tutorial will be beneficial for academic and industrial researchers and engineers who are active in design of power converters and design and planning of modern power electronic based power systems.

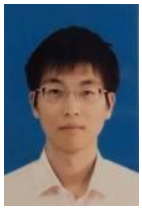
## Monday, 5 September 2022 - 1st Tutorial Day:

Schedule:

| | |
|---|---|
| 09:30 – 10:00 | Introduction to grid modernization and its challenges |
| 10:00 – 10:45 | Conventional power system reliability |
| 10:45 – 11:00 | Coffee break |
| 11.00 – 11:45 | Reliability in power electronics system |
| 11:45 – 12:30 | Modern power electronic based power system reliability |
| 12:30 – 12:45 | Summary and discussion |

## About the Lecturers:

**Frede Blaabjerg** (S'86–M'88–SM'97–F'03) received the Ph.D. degree in electrical engineering from Aalborg University, Aalborg, Denmark in 1995. He is honoris causa from University Politehnica Timisoara, Timisoara, Romania and Tallinn Technical University, Tallinn, Estonia. He was with ABB-Scandia, Randers, Denmark, from 1987 to 1988. He became an Assistant Professor in 1992, an Associate Professor in 1996, and a Full Professor of power electronics and drives in 1998. He became a Villum Investigator in 2017. He has authored or coauthored more than 600 journal papers in the fields of power electronics and its applications. He is the Co-author of four monographs and Editor of ten books in power electronics and its applications. His current research interests include power electronics and its applications in wind turbines, PV systems, reliability, harmonics, and adjustable speed drives. Dr. Blaabjerg was the recipient of 29 IEEE Prize Paper Awards, the IEEE PELS Distinguished Service Award in 2009, the EPE-PEMC Council Award in 2010, the IEEE William E. Newell Power Electronics Award 2014, and the Villum Kann Rasmussen Research Award 2014. He was the Editor-in-Chief of the IEEE TRANSACTIONS ON POWER ELECTRONICS from 2006 to 2012. He has been a Distinguished Lecturer for the IEEE Power Electronics Society from 2005 to 2007 and for the IEEE Industry Applications Society from 2010 to 2011 as well as from 2017 to 2018. In 2018, he was the President-Elect of IEEE Power Electronics Society. He serves as the Vice-President of the Danish Academy of Technical Sciences. He was nominated by Thomson Reuters to be between the 250 most.



**Dao Zhou** (S'12, M'15, SM'18) is currently an Assistant Professor at Aalborg University with the Center of Reliable Power Electronics (CORPE), where he is the leader of a working package involving system-level reliability and robustness. His current research interests are various aspects of power electronics technology including reliability in the application of renewable energy systems. He has contributed more than 90 journal and conference papers including 6 book chapters in the field of power electronics and reliability. He is one of the lecturers for an Industrial/PhD course on "Reliability in Power Electronic Systems" at Aalborg University. Dr. Zhou received the B.S. from Beijing Jiaotong University, Beijing, China, the M. S. from Zhejiang University, Hangzhou, China, in 2010, and the Ph.D. from Aalborg University, Aalborg, Denmark, all in electrical engineering. He currently serves as an Associate Editor for IET Renewable Power Generation and IET Power Electronics, and he received of a few IEEE prized paper awards.

**Saeed Peyghami** (S'14–M'17) received the B.Sc., M.Sc., and Ph.D. degrees in electrical engineering from the Department of Electrical Engineering, Sharif University of Technology, Tehran, Iran, in 2010, 2012, and 2017, respectively. From 2015 to 2016, he was a Visiting Ph.D. Scholar with the Department of Energy Technology, Aalborg University, Aalborg, Denmark, where he was a Postdoctoral Researcher. In 2019, he was a Visiting Researcher with Intelligent Electric Power Grids, Delft University of Technology, Delft, The Netherlands. He is currently an Assistant Professor in electrical power engineering with Aalborg University. His research interests include reliability, control, and stability of power electronic-based power systems, and renewable energies.

**JOSÉ L. RUEDA-TORRES** (SM'12) was born in 1980. He received the Ph.D. degree in electrical engineering from the Universidad Nacional de San Juan, San Juan, Argentina, in 2009. He is currently pursuing the Habilitation (qualification) degree with the Institute of Electrical Power Systems, University of Duisburg-Essen, Essen, Germany. From 2003 to 2005, he worked in Ecuador in the fields of industrial control systems and electrical distribution networks operation and planning. From 2009 to 2014, he was a Postdoctoral Research Associate with the Institute of Electrical Power Systems, University of Duisburg-Essen. Currently, he is Associate Professor and leads the team on Stability, Control, and Optimization, within the Intelligent Electrical Power Grids Section, Department of Electrical Sustainable Energy, Delft University of Technology, Delft, The Netherlands. His research interests include power system stability and control, system identification, power system planning, and probabilistic and artificial intelligence methods. Currently, he is member of the Technical Committee on Power and Energy Systems of IFAC (International Federation of Automatic Control), Chairman of the IEEE PES Working Group on Modern Heuristic Optimization, and Secretary of CIGRE JWG C4/C2.58/IEEE Evaluation of Voltage Stability Assessment Methodologies in Transmission Systems