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## TUTORIAL

### **Power Electronics for PV Power Systems Integration Presented by**

Remus Teodorescu, Aalborg University  
Pedro Rodriguez, UPC Barcelona  
Marco Liserre, Politecnico di Bari

### **Synopsis**

Future PV power converters should ensure smart and efficient integration of PV energy into existing electrical networks. To achieve this goal, new essential issues should be addressed by engineers and researchers. This tutorial, divided into 3 parts.

First part is devoted to PV inverter topologies with focus on the new trend on transformerless ones and control structure of PV inverters, goes deeper into issues related to efficiency and leakage current. The most relevant topologies used in PV inverters are presented in this lecture. These topologies will be classified into H-bridge based topologies and neutral point clamped (NPC) based topologies. A general overview of the PV inverter control structure will be given.

Second block deals with the grid monitoring task in PV inverters, characterizing the grid state in point of connection. This block also tackles grid synchronization and provides essential clues about design of single-phase PLL systems including frequency-adaptive structures. The effectiveness of conventional grid synchronization techniques under unbalanced and distorted conditions will be evaluated and advanced solutions will be presented and discussed

The third block introduces the islanding phenomenon and makes a review of different passive and active anti-islanding detection methods for photovoltaic utility-interactive power systems. A review of the grid requirements for PV grid

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integration in different countries will be given together with a discussion about the process of harmonization.

The tutorial is divided in the following parts:

- Topologies and control of PV inverters – Remus Teodorescu – 45 min
- Monitoring and synchronization of PV inverters- Pedro Rodriguez- 45 min
- Break – 15 min
- Anti-islanding techniques for PV inverters – Marco Liserre- 45 min
- Panel Discussion – 30 min

This tutorial is intended to electrical and control engineers and researchers dealing with grid power converters and interested in go deeply into essential issues related to the integration of PV and also other renewable energy into electricity networks.

### About the Speakers

**Remus Teodorescu** received the Dipl.Ing. degree in electrical engineering from Polytechnical University of Bucharest, Romania in 1989, and PhD. degree in power electronics from University of Galati, Romania, in 1994. In 1998, he joined Aalborg University, Institute of Energy Technology, power electronics section where he currently works as full professor

He has more than 100 papers published, 1 book and 3 patents (pending). He is the co-recipient of the Technical Committee Prize Paper Awards at IEEE IAS Annual Meeting 1998, and Third-ABB Prize Paper Award at IEEE Optim 2002. He is a Senior Member of IEEE, Associate Editor for IEEE Power Electronics Letters and chair of IEEE Danish joint IES/PELS/IAS chapter. His areas of interests are: design and control of power converters used in renewable energy systems, distributed generation mainly wind power and photovoltaics, computer simulations, digital control implementation. Remus Teodorescu is the founder and coordinator of the Green Power Laboratory at Aalborg University focusing on the development and testing of grid converters for renewable energy systems.

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**Pedro Rodriguez** received the MSc and PhD degree in Electrical Engineering from the Technical University of Catalonia (UPC), Spain in 1994 and 2004, respectively. In 1990, he joined the Electrical Engineering Department, at the UPC, where he is currently an associate professor teaching power electronics and circuit analysis as well as supervising PhD students. Since 1998, he focused his interest on Power Electronics applied to Power Quality Conditioning and Distributed Energy Systems Integration. Currently, he is leading the Renewable Electrical Energy Systems (REES) research group at the UPC. He stayed as a researcher in the Center for Power Electronics

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Systems (CPES) at Virginia Polytechnic Institute and State University, USA, and in the Institute of Energy Technology (IET) at Aalborg University, Denmark, respectively in 2005 and 2006. He has participated in 6 research project dealing with power electronics applied to renewable energies integration and power quality improvement. He has 3 patents about active filtering and authored more than 50 technical papers published in international journals and conferences. Pedro Rodriguez has organized special sessions about power electronics for renewable energies in different international conferences and currently is the general chairman of the IEEE IES Student Forum.

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**Marco Liserre**, received the MSc and PhD degree in Electrical Engineering from the Polytechnic of Bari, respectively in 1998 and 2002. From January 2004 he is an assistant professor in the same university teaching courses of power electronics, industrial electronics and electrical machines.

Recently his research interests are focused on industrial electronics applications to distributed power generation systems based on renewable energies. He has co-authored some 100 technical papers, 20 of them in international peer-reviewed journals and 3 chapters of a book.

He has been a visiting Professor at Aalborg University (Denmark) and he has been giving lectures in different universities including three tutorials in international conferences.

Marco Liserre is member of the Industrial Electronics Society, Power Electronics Society and Industry Applications Society. He has served them as reviewer both for conferences and journals. Within the IES he has been active as responsible of student activities, AdCom member, editor of the newsletter, responsible of region 8 membership activities, and chairman of the subcommittee "Power Electronics Applications in Power Systems and Renewable Energies" of the committee "Power Electronics" chaired by Prof. Greg Asher. He has been involved in IEEE conferences organization in different capacities. He is an Associate Editor of the IEEE Transactions on Industrial Electronics. He is Editor-in-Chief of the IEEE Industrial Electronics Magazine.

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