IEEE ENERGY CONVERSION CONGRESS & EXPO PHOENIX, ARIZONA, USA OCT. 20-24

Tutorial Title

Harvesting the Solar Energy: Modeling, Control, and Simulation of Photovoltaic Systems

Instructor Team

Team Chair: Sabin Carpiuc, MathWorks
Co-Speakers:

Abstract

As the world increasingly turns towards sustainable energy solutions, the role of photovoltaic (PV) systems in harvesting solar energy has become paramount. However, the integration of PV systems into the existing energy infrastructure presents unique challenges, primarily due to the variable nature of solar resources and the need for advanced control strategies to ensure efficiency and reliability. This tutorial aims to delve into the intricacies of modeling, control, and simulation of photovoltaic systems, providing a comprehensive overview of the current state-of-the-art technologies and methodologies. We begin by exploring the fundamental principles of solar energy conversion and the operational characteristics of PV cells and modules, highlighting the importance of accurate modeling to predict performance under varying environmental conditions. We will then discuss various control strategies employed in maximizing the power output of PV systems, including maximum power point tracking (MPPT) algorithms and their implementation in power electronics. The tutorial will also address the simulation aspects so important in the design and analysis of PV systems. These simulations allow for the assessment of system behavior under different scenarios, facilitating the optimization of the entire PV system from individual solar cells to grid integration. Furthermore, we will examine the role of PV systems as part of a larger smart grid, including the challenges associated with grid stability and the potential for PV systems to contribute to ancillary services such as load balancing and frequency regulation. Attention will be given to the integration of storage solutions and the development of hybrid systems that can reliably supply power even during periods of low solar irradiance. Then, we will address the real-time deployment and simulation aspects. We will also present a detailed case study of a PV system, evaluating its performance in terms of energy yield, efficiency, and the provision of grid support services. This case study will be complemented by the presentation of simulation results showing the PV system's impact on overall grid performance. To conclude, we will introduce a range of analytical methods for evaluating the stability and dynamic response of PV systems in the electrical grid. Practical advice for calibrating control systems to ensure seamless integration with other power sources will be provided, along with a discussion on the future direction of PV system technology amidst an ever-changing energy paradigm.

Instructor Team Biographies

Sabin Carpiuc (IEEE Senior Member) obtained his M.Sc. and Ph.D. degrees in Systems Engineering from the "Gheorghe Asachi" Technical University of Iaşi, Romania, in 2012 and 2015, respectively. He was part of the Powertrain Division, Business Unit Hybrid Electric Vehicle, at Continental Automotive Romania's Iaşi R&D Center from 2010 to 2016. Concurrently, from October 2010 to June 2016, he served

as an Associate Teaching Assistant in the Department of Automatic Control and Applied Informatics at the "Gheorghe Asachi" Technical University of Iaşi. In 2016, he embarked on a new role at MathWorks in Cambridge, United Kingdom, where he currently holds the position of Principal Engineer on the development teams for Simscape Electrical and Simscape Battery. His research interests span physical modeling, renewable energy systems, power electronics, electric drives, control systems, optimization, and real-time simulation.