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TUTORIAL

Advanced Control Architectures for AC and DC Microgrids

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Abstract

Worldwide electrical grids are expected to become smarter in future. Microgrids are deemed as one of the main building blocks of the smart grids; since, they are able to facilitate implementation of many smart grid functions. It is expected that in a near future, smart grid emerges as a well-planned plug-and-play integration of microgrids which interact through dedicated highways for exchanging commands, data, and power to provide a high power quality and optimized operation.

This tutorial will start by providing basic definitions, general overview of microgrid configurations and control structures as well as some examples of microgrids in the world. Afterwards, the control of power electronic converters in microgrids will be presented by covering concepts like frequency and voltage droop control and virtual impedance. In addition, hierarchical control of microgrids will be discussed. The second part of tutorial will be focused on power quality issues in microgrids. Compensation of power quality problems such as voltage harmonics and unbalance will be addressed through proper control approaches including hierarchical and decentralized schemes. Furthermore, load sharing among distributed generators in presence of nonlinear and unbalanced loads will be discussed. The tutorial will continue by discussing advanced control schemes for dc microgrids. In this regard, cooperative and hierarchical control architectures will be addressed considering the operation of both distributed generators and storage systems. Finally, the tutorial will be concluded by introducing some real-world applications and projects (in the areas of hybrid microgrid systems, dc microgrids, electric vehicle charging stations, maritime microgrids as well as Internet of Things, IoT and cyber-physical systems) and discussing future trends in microgrids research and implementation.

Outline

Microgrids Overview

- ✓ Distributed Power Systems
- ✓ Microgrid Definition, Configurations and Examples
- ✓ Droop Control and Virtual Impedance
- ✓ Hierarchical Control of Microgrids

Power Quality in Microgrids

- ✓ Power Quality Issues in Microgrids
- ✓ Virtual Impedance for Nonlinear and Unbalanced Load Sharing
- ✓ Hierarchical Control for Power Quality Enhancement

Control and Operation of DC Microgrids

- ✓ Advanced Control for Distributed Energy Storage
- ✓ Hierarchical Control: Primary, Secondary and Tertiary Levels
- ✓ Intelligent Cooperative Control

Microgrid Applications, Projects and Future Trends

- ✓ Smart Metering for Microgrids
- ✓ Low Voltage DC Microgrids
- ✓ Smart Homes
- ✓ Electric Vehicle Charging Infrastructure
- ✓ Microgrids Maritime Applications
- ✓ IoT and Cyber-Physical Systems
- ✓ Conclusions and Future Trends

Biographies

Mehdi Savaghebi (S'06-M'15-SM'15) was born in Karaj, Iran, in 1983. He received the B.Sc. degree from University of Tehran, Iran, in 2004 and the M.Sc. and Ph.D. degrees with highest honors from Iran University of Science and Technology, Tehran, Iran in 2006 and 2012, respectively, all in Electrical Engineering. From 2007 to 2014, he was a Lecturer in Electrical Engineering Department, Karaj Branch, Azad University where he taught various courses and conducted research on power systems and electrical machines. In 2010, he was a Visiting Ph.D. Student with the Department of Energy Technology, Aalborg University, Aalborg, Denmark and with the Department of Automatic Control Systems and Computer Engineering, Technical University of Catalonia, Barcelona, Spain.

Currently, he is a Postdoctoral Fellow in Department of Energy Technology, Aalborg University. His main research interests include distributed generation systems, microgrids, power quality and smart metering. Dr. Savaghebi is a member of Technical Committee of Renewable Energy Systems, IEEE Industrial Electronics Society and also IEEE Task Force on Microgrids Stability Analysis and Modeling.

Nelson Diaz received the B.S degree in electronic engineering from the Universidad Distrital, Cundinamarca, Colombia, and the M.S. degree in industrial automation from the Universidad Nacional de Colombia, Cundinamarca. He is currently pursuing the Ph.D. degree from the Department of Energy Technology, Aalborg University, Aalborg, Denmark.

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