

This book presents a set of proposals for advanced control functionalities in order to achieve a coordinated and optimized voltage management of distribution networks comprising several Distributed Generation units, controllable loads, storage devices and microgrids. Large scale integration of Distributed Energy Resources, namely Distributed Generation at the Medium Voltage level and microgeneration at the Low Voltage level, poses several technical challenges for distribution network operation, especially concerning voltage control. Accordingly, the development of specific control solutions is required in order to maximize the integration of these units in the distribution system. The work presented here focused on the development of a conceptual framework model for regional ancillary services markets for voltage control. In addition, a methodology for voltage and reactive power control to be integrated in a tool for managing network operation in the short-term time-horizon is proposed.

Coordinated Voltage Control in MMG



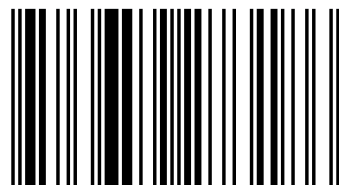
André Madureira

Coordinated Voltage Control in Multi-Microgrids

Coordinated and Optimized Voltage Management of Distribution Networks with Multi-Microgrids

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André Madureira was born in Porto, Portugal, in 1980. He received an electrical engineering degree, an MSc and a PhD in Power Systems from the Faculty of Engineering of the University of Porto, Portugal in 2003, 2005 and 2010, respectively. He is currently a Senior Researcher in the Institute of System Engineering and Computers of Porto.



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Abstract

This thesis presents a set of proposals for advanced control functionalities in order to achieve a coordinated and optimized voltage management of distribution networks comprising several Distributed Generation units, controllable loads, storage devices and microgrids.

The approach followed here is based on the exploitation and extension of the microgrid concept following a massive integration of these “active cells” in electrical distribution networks. Therefore, a hierarchical control architecture is proposed in order to manage all these Distributed Energy Resources located in the distribution system in a coordinated way, based on advanced communication solutions exploiting a smart metering infrastructure. This control structure is characterized by the inclusion of an additional controller at the Medium Voltage level – the Central Autonomous Management Controller – leading to the development of the Multi-Microgrid concept.

Large scale integration of Distributed Energy Resources, namely Distributed Generation at the Medium Voltage level and microgeneration at the Low Voltage level, poses several technical challenges for distribution network operation, especially concerning voltage control. Accordingly, the development of specific control solutions is required in order to maximize the integration of these units in the distribution system.

Consequently, the work presented in this thesis focused on the development of a conceptual framework model for regional ancillary services markets for voltage control. The approach developed is able to integrate the reactive power bids from the several providers (namely Distributed Generation units or microgrids) in order to satisfy the requested reactive power needs at the Medium Voltage level, which are set by the Distribution System Operator. The market settlement is achieved based on cost minimization for the Distribution System Operator from purchasing reactive power. An ancillary services market simulator for reactive power use was developed implementing this approach for a medium-term time horizon using data from generation scheduling and renewable generation and load forecasts.

Finally, a methodology for voltage and reactive power control to be integrated in a tool for managing network operation in the short-term time-horizon has also been developed. This approach was developed in order to ensure a coordinated operation concerning the Medium Voltage and Low Voltage levels, by managing the several resources available such as Distributed Generation units, microgrids, controllable loads, On-Line Tap Changing transformers and other reactive power compensation devices. A meta-heuristic approach is used in order to optimize operating conditions. An Artificial Neural Network model has also been developed in order to replace “active” Low Voltage networks in the optimization module, making it suitable for online use in a real-time management environment.

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