

Preface

Distributed generation (DG) of electricity based on renewable energy sources such as wind and solar is gaining more and more attention all over the world because of ever growing concerns on energy cost, energy security, and environmental issues. Although DG has a great potential for economic and environmental benefits, how to establish efficient and reliable control over a large number of DG units is one of the fundamental problems to be solved in the near future. One promising solution to this problem is the *microgrid*, which interconnects a group of DG units and loads at a distribution voltage level in a local area such as a university or a residential community. Microgrids are small-scale power systems that facilitate the integration of distributed generators and can operate in both grid-connected and islanded modes. In normal operation, the microgrid is connected to the main grid, and its frequency is dictated by the nominal frequency of the main grid. However, the microgrid may disconnect from the main grid and go to the islanded operation due to preplanned or unplanned events. Islanding process results in active power unbalance between generation and consumption units which, in turn, may cause frequency instability.

Microgrids are established based on localized control and can operate in either a grid-connected mode or an islanded mode, which significantly reduces the complexity of DG unit control. In order to avoid high capital expenditure and low reliability in microgrid operation, decentralized control is indispensable.

This book is essentially written for senior and first-year graduate students interested in studying distributed energy systems and future power systems. The different chapters and sections are organized to treat three broad avenues, namely *architectures and integration, modeling and analysis, and communication and control*. The main perspective of these sections is to capture the main sources for expanding the present electric power grid. Our goal is to capture the spectrum of this exponential transformation, and at the same time present the plethora of open problems that this transformation poses for our control theory colleagues.

The layout of the different chapters is as follows:

- The architectures and integration avenue opens the book with visionary ideas on sustainable architectures for power system operation and control under significant penetration of highly variable renewable energy resources presented in Chap. 1.
- This is followed by a detailed discussion on the distribution generation plants and their dynamic models in Chap. 2.
- Chapter 3 addresses the problem of supply–demand in electric power grid.
- Chapter 4 illustrates several practical control methods for microgrids.
- Chapter 5 focuses on a technical survey of computational intelligence methods.
- Chapter 6 provides a system of systems approach to the modeling, analysis, and control/optimization of microgrids.
- Chapter 7 delves into novel networked control techniques for wide-area oscillation tracking in large-scale power systems.
- This is further elaborated in Chap. 8 to highlight the importance of distributed control and processing as a major tool for wide-area monitoring research.
- In Chap. 9, a hierarchical structuring and control approach is introduced to model the dynamic mechanisms of cascading failures in geographically dispersed grids.
- The book is concluded by an Appendix to complement the math analysis of the book.

Looked at in this light, this book deals with the basic concept, generation technologies, impacts, operation, control and management aspects, and economic viability and market participation issues of microgrid and active distribution networks in a broad perspective.

Each chapter includes examples/simulation cases and a list of appropriate problems at the end.

Throughout this book, the following terminologies, conventions, and notations have been adopted. All of them are quite standard in the scientific media and only vary in form or character. Matrices, if their dimensions are not explicitly stated, are assumed to be compatible for algebraic operations. In symmetric block matrices or complex matrix expressions, we use the symbol \bullet to represent a term that is induced by symmetry.

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