



Design of Smart Power Grid Renewable Energy Systems

Second Edition

ALI KEYHANI



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DESIGN OF SMART POWER GRID RENEWABLE ENERGY SYSTEMS

I dedicate this book to my parents,
Dr. Mohammed Hossein Keyhani
and
Mrs. Batool Haddad

PREFACE

Sustainable energy production and the efficient utilization of available energy resources, thereby reducing or eliminating our carbon footprint, is one of our greatest challenges in the twenty-first century. This is a particularly perplexing problem for those of us in the discipline of electrical engineering. This book addresses the problem of sustainable energy production as part of the design of microgrid and smart power grid renewable energy systems.

Today, the Internet offers vast resources for engineering students; it is our job as teachers to provide a well-defined learning path for utilizing these resources. We should also challenge our students with problems that attract their imaginations. This book addresses this task by providing a systems approach to the global application of the presented concepts in sustainable green energy production, as well as analytical tools to aid in the design of renewable microgrids.

In each chapter, I present a key engineering problem, and then formulate a mathematical model of the problem, followed by a simulation test bed in MATLAB, highlighting solution steps. A number of solved examples are presented, while problems designed to challenge the student are given at the end of each chapter. Related references are also provided at the end of each chapter.

This book is accompanied by a companion website (www.wiley.com/go/smartpowergrid2e), which includes a Solution Manual and PowerPoint lecture notes with animation that can be adapted and changed as instructors deem necessary for their presentation styles. Solutions to the homework problems presented at the end of each chapter are also included in the Solution Manual. A prerequisite for the book is a basic understanding of electric circuits. The book presents a historical perspective of energy use; an analysis of fossil fuel use is provided through a series of calculations of human's carbon footprints in relation to fossil fuel consumption or that of a single household appliance. The book integrates and presents three areas of electrical engineering:

design of smart, efficient photovoltaic (PV), how to compute the energy yield of photovoltaic modules and the angle of inclination for modules with respect to their position to the sun for maximum energy yields, and wind microgrids. The book builds its foundation on the design of distributed generating system and the design of PV generating plants by introducing design-efficient, smart residential PV microgrid, including energy monitoring systems, smart devices, building load estimation, and load classification and real-time pricing. The book presents basic concepts of phasor systems, three-phase systems, transformers, loads, DC/DC converters, DC/AC inverters, and AC/DC rectifiers, which are all integrated into the design of microgrids for renewable energy as part of bulk interconnected power grids. The focus is on the utilization of DC/AC inverters as a three-terminal element of power systems for the integration of renewable energy sources; MATLAB simulations of PWM inverters are also provided. Topics covered are the basic system concepts of sensing, measurement, integrated communications, and smart meters; real-time pricing; cyber-control of smart grids; high green energy penetration into the bulk interconnected power grids; intermittent generation sources; and the electricity market and the basic modeling and operation of synchronous generator operations, the limit of power flow on transmission lines, power flow problems, load factor calculations and their impact on the operation of smart grids, real-time pricing, and microgrids, power grid bus admittance and bus impedance as well as a power flow analysis of microgrids as part of interconnected bulk power systems. In the final part of the book, the Newton formulation of power flow, the Newton–Raphson solution of a power flow problem, and the fast decoupled solution for power flow studies and short circuit calculations are presented.

This book provides the fundamental concepts of power grid integration with microgrids using green energy sources, which are on the technology road map of virtually all nations. The design of smart microgrids is the driver for the modernization of infrastructure using green energy sources, sensor technology, computer technology, and communication systems.

ALI KEYHANI

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ABOUT THE COMPANION WEBSITE

This book is accompanied by a companion website:

www.wiley.com/go/smartpowergrid2e

The website includes:

- Solution Manual for instructors
- PowerPoint presentations for instructors

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