

Preface

This book has been created through a research project titled “Future Grid Initiative” funded by the Department of Energy under a grant to the NSF Power Systems Engineering Research Center (PSerc). The objective was to create a book that contains some cutting-edge research results obtained by the authors, their graduate students and research staff through PSerc and other projects funded by parties outside PSerc. The focus of the book is an overview of new applications in the most critical power system applications during disturbances: state estimation, voltage stability, oscillation monitoring, transient stability, and fault location. Since all the results obtained in this book relate to the use of field data for testing and evaluation, the proposed applications have direct practical value. As such, the book may be used for teaching a graduate course or it may be used by professionals to better understand the opportunities that come with extensive use of time-synchronized measurements.

The introductory chapter of the book provides a history of time-synchronized measurements. It gives a survey of pioneering developments and points out early designs of phasor measurement units (PMUs). The discussions go on to describe other elements of a synchrophasor measurement system: phasor data concentrator and a system for dissemination of the accurate time through the communication network or directly via interfacing PMUs to the Global Positioning System (GPS) of satellite receivers. The motivation for the book is discussed at the end of the chapter.

Chapter 2 is focused on one of the most fundamental power system data acquisition and monitoring concepts, namely state estimation (SE). The history of the Energy Management Systems is outlined and the SE approaches are surveyed. Then, several new concepts in SE are analyzed: substation state estimation, PMU-based state estimation, and quasi-dynamic distributed state estimator. The discussion supports the use of synchronized measurements in daily operations of the power grid.

Chapter 3 deals with the monitoring methods to detect occurrences of instability. The power system stability phenomena covering voltage, transient and small signal stability are surveyed. Various real-time detection methods for monitoring voltage instability, oscillations, and angle instability are demonstrated using archived data from actual power system networks.

Chapter 4 is entirely devoted to the issues of assessment of the transient stability under various power system operating conditions. The use of decision trees to

facilitate the transient stability assessment in real-time is emphasized. Some test results from applying such methods in an actual power system contingency are presented. This chapter also gives details of how such an assessment scheme may be implemented.

Chapter 5 is devoted to determining fault location using different time-synchronized concepts, namely the use of synchronized samples and the use of synchrophasors. The initial discussion describes how and why the two techniques may be used to locate faults. For each of the two approaches, both theoretical details and practical aspects are elaborated. The results are also verified using data from an actual power system.

The book opens quite a few research questions and hopefully creates an incentive for the readers to engage in future research that is informed and motivated by the approaches and results described in the book. It also illustrates how such techniques may be implemented and demonstrates the performance using field data. An extensive list of references about prior work is provided at the end of each chapter. The reader can explore various techniques in more detail by reading referenced papers and student dissertations reporting further results from the research teams led by the authors.

We hope this book will be a starting point for many research and implementation directions to be undertaken by the readers in the future.

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Application of Time-Synchronized Measurements in
Power System Transmission Networks

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2014, XI, 176 p. 102 illus., 70 illus. in color., Hardcover

ISBN: 978-3-319-06217-4