Preface

The basic purpose of this book is to teach machinery and power system principles at a level suitable to the one-semester or two-quarter junior-level survey course found in many electrical engineering programs. It retains the core topics from my *Electric Machinery Fundamentals,*[1] and adds material on transmission lines, power system representation, power-flow studies, and fault analysis.

Many electrical engineering programs traditionally offered a two-semester sequence covering electrical machinery and power systems, with one semester devoted to machines and one to power systems. Unfortunately, the pressure in recent years to cram more and more into the EE curriculum has caused this sequence to be scaled back to a shorter survey course at many schools. This shorter course attempts to select specific topics from the machinery/power spectrum, and to give students the "flavor" of the field. Its content varies widely from school to school, which means that a text intended for the course must include far more material than can be covered, structured so that the topics can be chosen on an *a la carte* basis. This text is intended to fulfil that requirement.

Another problem with traditional power books is that they have tended to be heavily dominated by "how to" recipes, at the expense of explaining basic principles. For example, most power system textbooks devote one or two entire chapters to calculating the series inductance and shunt capacitance of transmission lines for different geometries. In the real world, though, very few engineers ever do this. Instead, they look up the per-mile characteristics of transmission lines in prepared lookup tables. In contrast, this book derives transmission line inductance and capacitance for one simple case, and uses those equations to describe the physical principles that operate on all transmission lines. It then concentrates on how to *use* the transmission line values, without spending the two chapters on how to *calculate* them.

Another example occurs with the bus admittance matrix $\mathbf{Y}_{bus}$ and the bus impedance matrix $\mathbf{Z}_{bus}$ of a power system. Traditional power texts teach a number of ways to build $\mathbf{Y}_{bus}$ and $\mathbf{Z}_{bus}$, often taking up most of two chapters with this material. This book teaches a *single* way to derive $\mathbf{Y}_{bus}$, and calculates $\mathbf{Z}_{bus}$ as the inverse of $\mathbf{Y}_{bus}$ using MATLAB. This is not the most efficient way to perform the calculation for systems of 1000 busses, but it works well for any power system that could be reasonably included in a classroom exercise. The time saved by not doing all the different versions of the calculations is spent on actually using $\mathbf{Y}_{bus}$ and $\mathbf{Z}_{bus}$ to solve power-flow and fault current problems. This is consistent with the way most engineers actually work, since the mechanics of building $\mathbf{Y}_{bus}$ and $\mathbf{Z}_{bus}$ are usually buried

[1] *Electric Machinery Fundamentals*, third edition, by Stephen J. Chapman, McGraw-Hill, 1999

inside commercial power system software packages, and the engineers concentrate on the power-flow and fault current calculations that result.

Another example occurs with power-flow calculations. Most books spend a great deal of time introducing the details of network representations with special components such as tap-changing or phase-shifting transformers. They introduce multiple techniques to solve the resulting systems of equations: Gauss-Seidel iteration and Newton-Raphson iteration. They also tend to include only partial examples because the complete calculations are just too difficult and time-consuming to do by hand. This book introduces only the simplest solution technique: Gauss-Seidel iteration. By using MATLAB, the examples can be complete solutions, because the mathematics is no longer tedious. In addition, the book introduces a functional MATLAB power-flow analysis program, which the students can use to solve significant power-flow problems and learn about system behavior. The end of chapter problems then support "What if?" exercises. For example, one problem examines the effect of capacitors on voltage and current levels in lines. Other problems examine the steady-state effects of adding or removing transmission lines from a power system.

In general, if there are multiple ways to solve a problem, this book introduces only the most straightforward method. It provides software to ease calculations, exposing the underlying principles. In this way, the book attempts to compress the course material while preserving its essence.

THE CONTENT OF THIS BOOK

This book is divided into three major sections: basic principles, power system components, and power systems. The basic principles are covered in Chapters 1 and 2. Chapter 1 provides an introduction to basic electrical and mechanical machinery concepts. Chapter 2 is a review of basic three-phase circuit theory, which may be skipped if the topic has been adequately covered in earlier courses.

Power system components are covered in Chapters 3 through 9. Chapter 3 covers transformers. Chapter 4 covers basic AC machinery principles, while Chapter 5 covers the operation of synchronous generators and motors. Chapter 6 is an optional chapter that discusses the operation of synchronous generators in parallel with large power systems. Chapter 7 covers induction motors, Chapter 8 covers DC machines, and Chapter 9 covers transmission lines. Chapter 4 is a prerequisite for Chapters 5 and 7, and Chapter 5 is a prerequisite for Chapter 6. Otherwise, these component chapters are largely independent, so an instructor can pick and choose the topics of interest among them.

The operation of power systems as a whole is covered in Chapters 10 through 13. Chapter 10 deals with power system representations (one-line diagrams, symbols, etc.) and the basic equations of power systems. Chapter 11 covers the power-flow problem. Chapter 12 covers symmetrical three-phase faults, and Chapter 13 covers unsymmetrical faults. Chapter 10 is a prerequisite for the remaining power system material. After that chapter, an instructor can choose to cover power flows, faults, or both, in any order, since the two topics are structured to be independent.

SUPPLEMENTAL MATERIALS

Supplemental materials supporting the book are available from the book's World Wide Web site, at URL www.mhhe.com/chapman. The materials available at that address include MATLAB source code, pointers to sites of interest to machinery and power students, a list of errata in the text, and the MATLAB-based tools used in the book.

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