PREFACE

A single-semester introductory course in electric machines and energy conversion is necessary to conform to the constraints of a typical electrical engineering undergraduate core curriculum. This course should be of sufficient depth to satisfy the needs of those students who pursue specialization in other than the power area. Concurrently, the course should prepare individuals in the electric power area with adequate prerequisite foundation to enter advanced courses in the electric machines and energy conversion area for the purpose of gaining a fuller breadth in the field.

This text contains sufficient material for a single-semester core course while allowing some selectivity among the topics covered by the latter sections of Chaps. 3 to 7 in order to fit the needs and emphasis of a particular program curriculum. A presently unique feature of the text is its integrated option to introduce popular interactive computer software MATLAB to handle the tedious calculations arising in electric machine analysis. As a consequence, more exact models of devices can be retained for analysis rather than the approximate models commonly introduced for the sake of computational simplicity. A computer icon appears in the margin with each introduction of MATLAB analysis.

Chapter 1 serves the purposes of motivation and orientation. The student is made aware of the widespread application of energy conversion devices. Growth trends and technology advancement directions are presented. The material can be covered either as a one-class period lecture or as a reading assignment.

Although sinusoidal steady-state circuit analysis and power flow are topics of required core circuit courses in all electrical engineering curriculums, the compression of material in these courses typically does not allow adequate drill in the sinusoidal steady-state techniques to give most students the proficiency necessary to comfortably handle energy conversion analysis. Chapter 2 provides the needed review and drill as well as familiarization with the notation peculiar to the text. Further, the chapter introduces students to the use of MATLAB for the analysis of circuits in the sinusoidal steady state, thereby establishing the basic techniques of computer analysis for use in the chapters that follow.

Chapter 3 straightway develops from Ampere's circuit law, Faraday's law, and Lorentz' force equation interpretive rules suited for use in energy conversion device understanding and analysis. The balance of the chapter is devoted to study of the nature and behavior of magnetic circuits as they appear in transformers and electric machines, serving as an intermediary stage in the energy conversion process. Computer analysis methods in this chapter introduce the student to the use of MATLAB for the purpose of generating saturation curves and flux linkage plots given the physical dimensions of a magnetic structure and the associated *B-H*

curve. In addition, numerical techniques are established for determination of force developed by a variable-position magnetic structure due to change in stored magnetic energy with position ($F_e = \partial W_m/\partial x$). Significant use of these computer analysis methods will be made in subsequent chapters.

Chapters 4 to 7 deal with the transformers, dc machines, and ac machines that are most frequently encountered in industry. Mastery of the material in these chapters should adequately prepare the reader to specify an application-appropriate energy conversion device and to predict performance after installation. In addition, Chap. 7 presents the operational principles of the brushless dc motor (recently matured technology) and the switched reluctance motor (emerging technology). Through use of the developed computer software for each energy conversion device, the reader is able to quickly calculate and plot wide-range performance data. Also, the impact of parameter sensitivity can be easily assessed.

Another unique feature of the text is coverage of basic design principles of the energy conversion equipment after study of its performance analysis in Chaps. 4 to 7. Although the design methodologies stop short of the empirical refinement necessary for commercial product development, the scope and depth are sufficient to train engineering students in the mindset of design. The reference list at the end of each chapter serves as a beginning point for the reader to pursue additional design refinement.

The text can serve as a basis either for a course in energy device principles and analysis with an optional design project, or for a capstone design course offered subsequent to an introductory course in energy device principles. Computer software developed in the first parts of Chaps. 4 to 7 is expanded and integrated into the software to support the latter section design procedures. Each of Chaps. 4 to 7 contains problems formulated to drill the reader on the individual concepts of design as each is introduced. A completed example design in each chapter serves as a coagulant for the learned individual principles.

There is no universally acceptable presentation order for the study of energy conversion devices. However, the vast majority of instructors do cover magnetic circuit analysis first followed by study of transformers. This order of presentation has been assumed in the writing of this text to justify delay of losses in ferromagnetic materials until the transformer with its sinusoidal excitation is under study. Otherwise, the material of Chaps. 5 to 7 stands reasonably independent, leaving the order of coverage to the discretion of the individual instructor. The one exception to this claim is that the air gap traveling wave of Sec. 6.3.3 must be extracted for appropriate presentation if synchronous machines are to be studied before induction machines.

Supplemental materials supporting the book are available at *www.mhhe.com/engcs/electrical/cathey*. The materials on that site include downloadable files of the MATLAB source code, a list of errata for the text, and other useful information.

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