Preface

Our motivation and purpose for writing this book stems from our belief that there is a practical need for a learning platform which will allow the motivated reader to gain a basic understanding of the modern multidisciplinary principles which govern electrical drives. The book in question should appeal to those readers who have an elementary understanding of electrical circuits and magnetics and who have an interest or need to comprehend advanced textbooks in the field of electrical drives. Consideration has also been given to those interested in using this book as a basis for teaching this subject matter. In this context, a Springer website *Extra Materials* has been set up which contains the simulation examples and tutorials discussed in this book. Furthermore, all the figures in this book are available on the Springer website, in order to assist lecturers with the preparation of electronic "power point" type lectures.

Electrical drives consist of a number of components: the electrical machine, converter, and controller, all of which are discussed at various levels. A brief résumé of magnetic and electrical circuit principles is given in Chap. 1 together with a set of generic building modules which are used throughout this book to represent dynamic models. Chapter 2 is designed to familiarize the reader with the process of building a dynamic model of a coil with the aid of generic modules. This part of the text contains an introduction on phasors as required for steady-state analysis. The approach taken in this and the following chapters is to present a physical model, which is then represented by a symbolic model with the relevant equation set. A generic model is then presented which forms the basis for a set of *build and play* simulations set out in various steps in the tutorial at the end of the chapter.

Chapter 3 introduces a single-phase *ideal transformer* (ITF) which forms the basis of a generic transformer model with leakage and magnetizing inductance. A phasor analysis is given to familiarize the reader with the steady-state model. The *build and play* tutorials at the end of the chapter give the reader the opportunity to build and analyze the transformer model under varying conditions. It is emphasized that the use of these *build and play* sets are essential components of the learning process throughout this book.

Chapter 4 deals with star and delta connected three-phase systems and introduces the generic modules required to model such systems. The space vector-type representation is also introduced in this part of the text. A set of *build and play* tutorials are given which reinforce the concepts introduced in this chapter.

Chapter 5 deals with the concepts of real and reactive power in single-as well as three-phase systems. Additional generic modules are introduced in this part of the text, and tutorial examples are given to familiarize the reader with this material.

Chapter 6 extends the ITF concept introduced earlier to a space vector-type model which is represented in a symbolic and generic form. In addition, a phasor-based model is also given in this part of the text. The *build and play* tutorials are self-contained step-by-step simulation exercises which are designed to show the reader the operating principles of the transformer under steady-state and dynamic conditions. At this stage of the text, the reader should be familiar with building and using simulation tools for space vector-type generic models which form the basis for a transition to rotating electrical machines.

Chapter 7 introduces a unique concept, namely, the *ideal rotating transformer* (IRTF), which is the fundamental building block that forms the basis of the dynamic electrical machine models discussed in this book. A generic space vector-based IRTF model is given in this part of the text which is instrumental in the process of familiarizing the reader with the torque production mechanism in electrical machines. This chapter also explores the conditions under which the IRTF module is able to produce a constant torque output. It is emphasized that the versatility of the IRTF module extends well beyond the electrical machine models discussed in this book. These advanced IRTF-based machine concepts are used in our second book *Advanced Electrical Drives* [2] and also in our third book *Applied Control of Electrical Drives* [10]. The latter-mentioned book has been recently introduced to facilitate the transition to experimental drives by the reader. The *build and play* tutorials at the end of this chapter serve to reinforce the IRTF concept and allow the reader to "play" with the conditions needed to produce a constant torque output from this module.

Chapters 8–9 deal with the implementation of the IRTF module for synchronous and asynchronous machines. In both cases, a simplified IRTF-based symbolic and generic model is given of the machine in question to demonstrate the operating principles. This model is then extended to a "full" dynamic model as required for modeling standard electrical machines. A steady-state analysis of the machines is also given in each chapter. In the sequel of each chapter, a series of *build and play* tutorials are introduced which take the reader through a set of simulation examples which steps up from a very basic model designed to show the operating principles, to a full dynamic model which can be used to represent the majority of modern AC electrical machines in use today.

Chapter 10 dealt with the DC machine, for which a dynamic model is introduced. In addition, the steady-state torque/speed characteristics of this machine with either PM or field excitation are discussed.

Chapter 11 deals with the converter, modulation, and control aspects of the electrical drive at a basic level. Both half- and full-bridge converter concepts are

discussed together with the pulse width modulation (PWM) strategies that are in use in modern drives. A model-based current control algorithm is presented in combination with a DC machine. The *build and play* tutorials in the sequel of this chapter clearly show the operating principles of PWM-based current-controlled electrical drives.

The purpose, content, and approach of our book have been presented above. On the basis of this material, the following set of unique points are presented below in response to the question as to why prospective readers should purchase this book:

- The introduction of an *ideal rotating transformer* (IRTF) module concept is a basic didactic tool for introducing the elementary principles of torque production in electrical machines to the uninitiated reader. The apparent simplicity of this module provides the reader with a powerful tool which can be used for the understanding and modeling of a very wide range of electrical machines well beyond those considered in this book.
- The application of the IRTF module to AC machines provides a unique insight into their operation principles. The book shows the transitional steps needed to move from a very basic IRTF model to a full IRTF-based dynamic model usable for representing the dynamic and steady-state behavior of most machines in use today. In addition the IRTF based module can be readily extended to include more specific machine effects such as "skin effect" in asynchronous machines. Furthermore, the IRTF module can be extended to machine models outside the scope of this book. Examples which appear in the book *Advanced Electrical Drives* by the authors of this text are the salient pole PM machine and the single-phase IRTF-based induction machine.
- This text is designed to bridge the gap between advanced textbooks covering electrical drives and textbooks at either a fundamental electrical circuit level or more generalized mechatronic books. Our text is accompanied by a set of tutorials which are located in the *Extra Materials section* at the Springer website. This book should fit well into the undergraduate curriculum for students who have completed first or second year and who have an interest in seeking a career in the area of electrical drives. The book should also appeal to engineers with a non-drive background who have a need to acquire a better understanding of modern electrical drive principles.
- The use of *build and play*-type tutorials is of fundamental importance to understanding the theory presented in the text. The didactic role of modern simulation tools in engineering cannot be overestimated, and it is for this reason that extensive use is made of generic modules which are in turn used to build complete models of the drive. Such an approach allows the reader to visualize the complex equation set which is at the basis of these models. The simulation tool used in these tutorials is "PLECS®" which can be used with MATLAB/SIMULINK or (as is the case in this book) as "stand-alone" software. The said tutorials are linked directly to the generic modules discussed in the corresponding chapter and are included in the *Extra Material, Springer website:extras.springer.com* linked to this book.
- A series of "demonstration" laboratories are introduced which are used to experimentally verify key theoretical concepts/models introduced in this book.

Hence, it is hoped that the critical reader will be convinced that the material presented in this book is applicable to actual electrical drives.

The second edition of this book has been tailored to the text *Advanced Electrical Drives* by the same authors. Notably some changes have been made to ease the readers' transition to our textbooks *Advanced Electrical Drives* as well as *Applied Control of Electrical Drives*. Notably the new edition makes use of so-called "amplitude invariant" space vectors, which is in line with the approach used in *Applied Control of Electrical Drives*. Specifically, Chap. 3 has been extensively revised to introduce the so-called "universal-oriented model approach" at an early stage. Furthermore, Chap. 10 on DC machines has been simplified. Finally, in Chap. 11 the term "incremental flux" has been omitted and replaced by the variable *average voltage per sample* given its use in our other books. The said chapter has also been extended to cover "H-bridge" operation.

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http://www.springer.com/978-3-319-29408-7

Fundamentals of Electrical Drives

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2016, XXI, 341 p. 297 illus., 243 illus. in color.,
Hardcover
ISBN: 978-3-319-29408-7