

Preface to the Second Edition

The authors could perceive in the years following the publication of the first edition, that the book has been received very favourably worldwide thanks to the engineering-friendly balance between theoretically complicated interrelations and practice-relevant design guidelines. Since the first edition in 2008, more than 5 years have passed, and the technological development has not been idle. With respect to nonlinear control structures, many new developments have been introduced. This is the motivation for the authors to incorporate the new knowledge into the second edition, so that the book would not only be maintained in a timely manner, but also reflect the *state of the art* in the field.

In this second edition, the concept of degree of freedom in vector modulation is introduced in Sect. 2.6 to complete the inverter control topic. Especially, the concept of flatness-based controller design for systems with three-phase AC machines is presented in an easy to understand and pragmatical way. The idea of flatness-based control is presented first in Sect. 3.6.2. Then the flat property of the machine types IM, DFIM and PMSM is proved. Because the authors see themselves as bridge builders between theory and practice, the representation of theoretically complicated contexts which are not easily understood by engineers in the practice is deliberately dispensed with. The concreted designs are introduced in Sects. 9.2.2 for IM, 9.3.2 for PMSM and 11.3 for DFIM. To complete the topic, the important design of the so-called rest-to-rest trajectory for flatness-based tracking control, is presented succinctly in Appendix A.5.

The authors dedicate this second edition to their highly revered teacher Prof. Dr.-Ing. habil. Dr. E.h. Rolf Schönfeld, founder of the Dresden School of *Automated Electrical Drives* at TU Dresden. If he were still alive, he would have celebrated his 80th birthday on June 27, 2014.

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This book covers the area of vector control of three-phase AC machines, in particular induction motors with squirrel-cage rotor (IM), permanent excited synchronous motors (PMSM) and doubly-fed induction machines (DFIM), from the viewpoint of the practical design and development.

The German editions of this book, published in 1993 and 1999 by expert verlag, had been well received by the readers thanks to their practice-oriented and engineer-friendly approach. This experience was motivation for the authors to address now a broader audience with this revised and extended English-language edition. The new chapters take account of the recent developments in AC drive technology on the research side as well as on the application side by dedicating appropriate room for doubly-fed induction machine control and nonlinear drive control.

The book has its clear focus on motor control with the mechanical system and its superposed control loops—speed and position—providing the necessary interface to the machine-specific control functions. The latter form the core of a drive control system and may be divided into two groups:

1. Basic algorithms like space vector modulation, current control and rotor flux estimation.
2. Advanced algorithms like parameter identification, parameter adaptation, optimal state variable control and nonlinear control.

A control system with only the first group implemented may already work satisfactorily. Integration of the second group can improve the system parameters significantly, optimize utilization of machine and frequency converter and support maintenance and commissioning.

After a summary of the basic structure of a field-oriented controlled three-phase AC drive as well as of a grid voltage-oriented controlled wind power plant in Chap. 1, the inverter control by space vector modulation is extensively discussed in Chap. 2 with the help of numerous examples to illustrate the practical application. Based on the basic machine equations, the continuous and the discrete machine models of IM, PMSM and DFIM are derived in Chap. 3. The nonlinearities of the machine models are shown here. Chapter 4 answers some questions regarding

feedback acquisition and the practical implementation of field-oriented control. The design of vectorial two-dimensional current controllers using the discrete models is then discussed in detail in Chap. 5 in connection with other essential problems like control variable limitation. Several alternative controller configurations are introduced.

With Chap. 6 the focus passes to the group of advanced control algorithms by attending to problems like determining the machine parameters by calculation from name-plate data and automatic offline parameter identification. Chapter 7 brings the complex of parameter adaptation yet one step further discussing methods of online adaptation of the rotor time constant of IM, an important issue to achieve high utilization of the motor. Questions of energy efficient operation gain increasing importance, especially for high-power drives. Chapter 8 has its emphasis on these problems, particularly addressing issues like efficiency and torque optimal control strategies under consideration of state variable limitations.

Control applications for AC drives usually feature linear algorithms in spite of the machine itself being characterized by a nonlinear process model and of nonlinear operating states (limitation of state variables) to master. Control approaches which take into account system nonlinearities from the outset may fare better in a number of circumstances. One such approach, the exact linearization method, is introduced in Chap. 9 and further deepened for DFIM applications in Chap. 11. Before that, Chap. 10 introduces control concepts for the electrical system of wind power plants with DFIM, an application that has gained widespread importance in recent years.

While compiling this book, the authors had been dedicated to expose the problems as close as possible oriented on practical and implementation-related requirements. The theoretical background is detailed as much as needed to understand the subjects; numerous equations, figures, diagrams and appendices support the detailed description of the design processes.

The book is the result of the research and development practice of the authors over more than 15 years. We hope to provide the readers not only with approaches, but also with reproducible and useful solutions for their systems and problems. The authors will be grateful for any hints and inputs to improve further editions. Please confer with N.P. Quang for remarks regarding Chapters 1–3, 4.1–4.3, 5, 6.1, 6.3, 9–12, and J.-A. Dittrich for Chapters 2.5.3, 3.1.2, 4.4, 6.2, 6.4, 7, 8.

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System Development in the Practice

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