POWER-SWITCHING CONVERTERS

Medium and High Power

By Dorin O. Neacsu

Taylor & Francis
Taylor & Francis Group
Boca Raton London New York

CRC is an imprint of the Taylor & Francis Group, an informa business

Published in 2006 by
CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

Printed in the United States of America on acid-free paper
10 9 8 7 6 5 4 3 2 1

International Standard Book Number-10: 0-8247-2625-1 (Hardcover)
International Standard Book Number-13: 978-0978-0-8247-2625-6 (Hardcover)

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Preface

Power electronics represents a branch of electronics dedicated to the controlled conversion of electrical energy. This conversion includes the adaptation of power to diverse applications such as voltage or current power sources, electrical drives, active filtering in power systems, electrochemical processes, inductive heating, lighting and cooking control, distributed generation, and naval or automotive electronics. This very broad range of applications has stimulated research and development, and new control methods of power hardware are suggested each day. Because of this great number of technical solutions with many variations of the same concepts, it is somehow difficult for the practicing engineer or for a student to keep track of new developments or to find the most appropriate solution in the given time. Furthermore, medium- and high-power converter systems require interdisciplinary knowledge of basic power electronics, digital control and hardware, sensors, analog preprocessing of signals, protection devices, and mathematical calculus.

Libraries and bookstores offer a great number of books on power electronics, but the dynamics of this field sometimes makes them obsolete. This requires new publications able to systematize the information from research in a better way. This field has a slow incremental development with new ideas on hardware implementation and more comprehensive views on existing methods. The challenge of a first-rate book on power electronics is, therefore, to find the simplest and most concise but complete explanation for a group of methods already proved by both academia and industry.

This book is a digest of the latest research results in the field of medium- and high-power converters presented in a precise manner, with a fair amount of examples and references. From the numerous papers, patents, and research notes published throughout the world during the last 20 years, only those methods accepted by the industry have been selected. The most incisive focus of this book is dedicated to the PWM algorithms, and I hope that this book presents this concept at its best.

The presentation flows from simple facts to advanced research topics, and readers require only a minimal background in electrical engineering or power electronics. Each chapter ends with problems to help the readers improve their understanding of the field. This combination of theory and examples is the result of several years of teaching at different universities as well as vast industrial "hands-on" experience.

This book begins with an industrial overview of power converters and power semiconductors dedicated to medium- and high-power operation, including aspects about the market. After a brief review of power semiconductors in Chapter 2, Chapters 3–5 define the basics of operating a conventional three-phase inverter with pulse width modulation. Chapters 6–8 are dedicated to the practical aspects of implementation with many examples from the well-known digital platforms used by industry. Chapters 9–11 are dedicated to other special three-phase topologies and their control. Chapter 12 introduces a solution that has been used more frequently during the past few years to achieve higher power from the conventional lower-power converters. The parallel or interleaved operation of conventional three-phase inverters helps increase the power capacity by the addition of multiple low-power units already available on the market.

This book covers the entire field of medium- and high-power converters used nowadays in three-phase DC/AC or AC/DC conversion and can serve as a textbook for graduate students or as a reference book for design engineers working in industry.

Author

Dorin O. Neacsu was born in Suceava, Romania, in 1964. He received M.S. and Ph.D. degrees in electronics from the Technical University of Iasi, Iasi, Romania, in 1988 and 1994, respectively. He also holds an M.Sc. in engineering management from the prestigious Gordon Institute of Tufts University, Medford, Massachusetts. Since 1988, he has been with TAGCM-SUT Iasi, Romania; Technical University of Iasi, Romania; Universite du Quebec a Trois Rivieres, Canada; Delphi-Energy and Engine Management Systems, Indianapolis, Indiana; International Rectifier, El Segundo, California; SatCon Technology, Cambridge, Massachusetts; and Solectria Corporation, Woburn, Massachusetts.

Dr. Neacsu has published more than 70 papers and research notes in *IEEE Transactions*, conferences, proceedings, and other international journals; he has presented five tutorials at IEEE conferences and holds one U.S. patent. He has co-written several university textbooks in Canada and Romania and a book on simulation-modeling of power converters. He is a senior member of IEEE, has served as a reviewer for several *IEEE Transactions*, and has been a member of the technical program committees or organizing committees at various IEEE conferences. His research activities are in static power converters, power semiconductor devices, PWM algorithms, microprocessor control, modeling, and simulation of power converters.

Acknowledgments

I would like to thank all the professors, managers, and colleagues who helped in my personal development as an engineer and also in acquiring the knowledge shared in this book. Their leadership and vision in power electronics helped me depict the cutting-edge trends in modern high-power switching converters, and I hope that this book will aid engineers in the field of power electronics to a great extent. “It is the role of leaders to find leaders and to unlock for them the possibility that they can make a positive impact.”

I am grateful to Professors Mihai Lucanu and Dimitrie Alexa, who encouraged me during the initial years at the Technical University of Iasi, Romania. Many of the research results published in this book are the results of the educational programs I attended under their guidance. Special thanks go to Professors Ventakachari Rajagopalan (Canada) and Frede Blaabjerg (Denmark), who introduced me to the IEEE and the world of highly competitive modern technologies.

I would like to thank all my colleagues from the U.S. industry, including Kaushik Rajashekara, James Walters, T.V. Sriram, Fani Gunawan, and Balarama Murty of Delphi Automotive; Toshio Takahashi, David Tam, Brian Pelly, and Eric Person of International Rectifier; Ted Lesster, Bogdan Borowy, William Bonnice, and Evgeny Humansky of SatCon Technology Corporation; and James Worden, Viggo Selchau-Hansen, Lance Haines, Beat Arnet, Lu Jiang, and Don Lucas of Solectria/Azure Dynamics.

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