INSTANTANEOUS POWER THEORY AND APPLICATIONS TO POWER CONDITIONING

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This book is dedicated
to all the scientists and engineers who have participated in
the development of Instantaneous Power Theory and
Applications to Power Conditioning

and

to our families
Nobuko, Chieko, and Yukiko,
Yukiko, Edson Hiroshi, and Beatriz Yumi,
Marilia, Mariah, and Maynara.

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PREFACE

The concept of "instantaneous active and reactive power" was first presented in 1982 in Japan. Since then, many scientists and engineers have made significant contributions to its modifications in three-phase, four-wire circuits, its expansions to more than three-phase circuits, and its applications to power electronics equipment. However, neither a monograph nor book on this subject has been available in the market. Filling this gap was the main motivation for writing this book. The instantaneous power theory, or simply "the *p-q* theory," makes clear the physical meaning of what the instantaneous active and reactive power is in a three-phase circuit. Moreover, it provides a clear insight into how energy flows from a source to a load, or circulates between phases, in a three-phase circuit.

At the beginning of writing this book, we decided to try to present the basic concepts of the theory as didactically as possible. Hence, the book was structured to present in Chapter 1 the problems related to nonlinear loads and harmonics. Chapter 2 describes the background of electrical power definitions based on conventional theories. Then, Chapter 3 deals with the instantaneous power theory. In this chapter, special attention is paid to the effort to offer abundant materials intended to make the reader understand the theory, particularly for designing controllers for active filters for power conditioning. Part of Chapter 3 is dedicated to presenting alternative sets of instantaneous power definitions. One of the alternatives, called the "modified *p-q* theory," expands the original imaginary power definition to an instantaneous imaginary power vector with three components. Another approach, called in this book the "*abc* theory," uses the *abc*-phase voltages and currents directly to define the active and nonactive current components. Comparisons in difference and physical meaning between these theories conclude Chapter 3.

Chapter 4 is exclusively dedicated to shunt active filters with different filter structures, showing clearly whether energy storage elements such as capacitors and inductors are necessary or not, and how much they are theoretically dispensable to the active filters. This consideration of the energy storage elements is one of the strongest points in the instantaneous power theory. Chapter 5 addresses series active filters, including hybrid configurations of active and passive filters. The hybrid configurations may provide an economical solution to harmonic filtering, particularly in medium-voltage, adjustable-speed motor drives.

Chapter 6 presents combined series and shunt power conditioners, including the unified power quality conditioner (UPQC), and the unified power flow controller (UPFC) that is a FACTS (flexible ac transmission system) device. Finally, it leads to the universal active power line conditioner (UPLC) that integrates the UPQC with the UPFC in terms of functionality.

Pioneering applications of the *p-q* theory to power conditioning are illustrated throughout the book, which helps the reader to understand the substantial nature of the instantaneous power theory, along with distinct differences from conventional theories.

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