

# Preface

Since the start of the twentieth century, modern society has been utilizing electric power for maintaining civil systems such as transportation, communications, factories, houses, and commercial buildings. Power electronics has recently been an active area because of electric vehicles, renewable energies, smart grids, mobile devices, light emitting diodes (LEDs), and wireless power transfer (WPT) technology. Power supplies and switching converters are a requisite for modern devices and most electric systems. More efficient, lower weight, compact, and cheaper power solutions are highly sought by consumers, and power electronics deals with these challenging issues.

It is well known that all switching converters are time varying and equivalent to switched transformers, which I first proved in general about 30 years ago. Although there were the well-known R.D. Middlebrook's state-space averaging techniques and Peter Wood's existence function techniques, they are valid only for DC-DC converter analyses and static analyses of converters, respectively. I wondered at that time why we still did not have a general technique valid for the static and dynamic analyses of any converters.

After studying this problem for several years during my Ph.D. candidate period, I found that power electronics is a unique field among electronic engineering areas in that it always involves time-varying characteristics of converters without any exception. A linear power electronic circuit containing power switches even becomes nonlinear when a power switch operates in the discontinuously conduction mode, which means that the inductor current or capacitor voltage spontaneously becomes zero during a switching period. Therefore, nonlinear time-varying systems are abundant in switching converters, which require a special modeling technique to make the complex nature of the switching converter simple and easy to handle.

There are many books on power electronics that explain how the switching converters operate, and they provide some analytical results and design guidelines. Except for the state averaging and existence function techniques, most books deal with piecewise linear circuit models; hence, mathematical results derived from the models become too complicated to be used in practice. Until now, there is no such

book that generally and systematically deals with the time-varying switching system, transforming it into an equivalent time-invariant circuit. Neither cumbersome equations nor matrix manipulations are needed by the techniques introduced in this book, which are collectively referred to as ‘phasor transformation’.

This book starts with the introduction of the philosophy of power electronics and fundamental knowledge and background of modern power electronics. The switched transformer concept, which is applicable to any switching converter, is introduced and it is shown that DC-DC converter analyses are so straightforward that little equational manipulations are needed. Then the phasor transformation techniques are comprehensively explained in three parts. Single phase and multi-phase AC systems are dealt with through the single phase phasor transformation and circuit DQ transformation, respectively. A general unified phasor transformation is then introduced for the static and dynamic cases. Each part provides readers with corresponding application examples.

As an inventor of the switched transformer model and phasor transformation models in power electronics, I feel that these models are the most fundamental and powerful theories to deal with power electronics with great ease. Throughout my research and developments on practical applications of power electronics during the past three decades, I have also become familiar with the most advanced LED drivers and WPT technologies. I have led a team to develop the WPT systems of the On-Line Electric Vehicles (OLEVs), which were the first of their kind to be commercialized in the world. My students and I have researched the longest distance WPT of 10 W at 10 m and developed several innovative WPT products including the world’s first free space charging mobile device that is plate type with six degrees of freedom. I have included some of these research issues in this book, which vividly shows the practical application of the proposed theories to industries. In this way, this book covers from the ultimately basic concepts to the most advanced state-of-the-art technologies. The usefulness of this book, however, depends on how frequently readers apply it in their engineering problem solving. The intention of writing this book is to provide know-how to beginners, newcomers, and experienced power electronics engineers who want to find an appropriate model and to analyze the switching converter systematically. This book can be used as a textbook for graduate students who major in power electronics or as a reference book of higher level undergraduate students.

I would like to thank Prof. Gyu H. Cho at KAIST for his outstanding leadership in developing a circuit-based unified general method to analyze and design complicated electronic circuits very easily without any equations. My work on modeling power electronics was significantly motivated by Prof. Cho’s ideas on electronic circuits. Furthermore, he persistently encouraged research on this unified general modeling of power electronics, which is a sort of high-risk-high-return research. It is always challenging to study unknown areas, especially the development of a theory in an engineering field. Now I can say the following words:

A circuit is more powerful than equations.

I would also like to thank Mr. Seog Y. Jeong, Ji H. Kim, and Gi C. Jang for their great help in preparing the manuscript of this book. I appreciate very much Springer for its decision to publish this book. Without this help, this book would not have appeared.

As a teacher at a university now, I am very happy to share my experience of struggling throughout my life with worldwide friends to find appropriate switching converter models.

January 2016

Chun T. Rim

Phasor Power Electronics

Rim, C.T.

2016, XIV, 249 p. 193 illus., 54 illus. in color., Hardcover

ISBN: 978-981-10-0535-0