Volume VI

Power Electronics Components and Circuit Modeling and Analysis

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About the Book

VPEC researchers have devoted substantial effort in modeling and analysis in the past. The second volume in VPEC's book series, *Modeling and Analysis and Design of PWM Converters*, presented a collection of earlier efforts in modeling of converter components and circuits. The present volume is a continuation of our efforts in the modeling area and includes work on device modeling as well as on the modeling of various converter technologies.

The book begins with an article covering recent developments of power semiconductor devices by Prof. Alex Huang, who joined the faculty at VPEC in fall of 1994. This review article is followed by two papers (1.2, 1.3) about IGBT modeling and nondestructive characterization of MCT and IGBT devices.

The second part of the book presents a collection of VPEC papers on the modeling and analysis of high-frequency magnetic devices. This technology area is one where research efforts and general models are scarce and where "trial and error" design still dominate. In recent years, VPEC has assembled a small research group to explore this fertile ground for improvements in the analysis and modeling of transformers and inductors with a particular focus on modeling device parasitics and high-frequency characteristics. This work has been divided roughly into the areas of analytical modeling and winding loss, numerical simulation of winding performance, measurement and simulation of core losses.

Articles 2.1 through 2.4 focus on the development of analytical tools and approximate equations for the modeling of winding characteristics in transformers and inductors. The first four articles examine the uses of 1-D and 2-D approximations to the magnetic fields in the transformer winding areas. These methods permit the modeling of high-frequency winding effects without the need for time-consuming finite-element solutions.

While the use of the analytical models mentioned above can result in significant time savings for certain winding and core geometries, the use of numerical methods such as finite element analysis (FEA) is crucial for the accurate modeling of arbitrary geometry devices. VPEC has used both 2-D and 3-D FEA tools to examine a variety of magnetic device performance issues; some of the results of this work are presented in articles 2.7-2.14. The use of FEA for simulating core losses and flux distribution in complex ferrite structures is examined along with planar winding arrangements and transformer termination issues.

The third part of the book begins with reports on our recent work on modeling of current-mode control using average current-mode control, charge control, and quasi-average current mode control. The remaining part of the book presents a modified describing function technique for a more accurate modeling of converter circuits, specifically, resonant converters. By incorporating higher order harmonics, the small-signal models for resonant converter and multi-resonant converters can be derived for the first time. An equivalent circuit model can be realized to facilitate small-signal and analysis using the popular circuit simulation tools such as *spice* or *saber*. The basic modeling concept was first proposed by Sander G. Vergesen of M.I.T. and Jim Groves of Virginia Tech. The technique was perfected by E. Yang of Virginia Tech and a computer software was developed to implement the model. This modeling technique can also be used for PWM converters to provide a more accurate small signal model.

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