

SEMICONDUCTOR MODELING For Simulating Signal, Power, and Electromagnetic Integrity

PREFACE

Why Read This Book?

Semiconductor Modeling is written to give designers and engineers the broadest possible view of using semiconductor models to design high-speed circuit boards. Most issues in the field of designing high-frequency circuits, from the beginning of modeling and simulation using EDA tools to future trends, are discussed and integrated. The authors focus on key ideas in each area.

The main technical focus of *Semiconductor Modeling* is on the use of simulation to help solve practical engineering problems. It draws on over 90 years of diverse technical experience and brings together theory, tools, components, software, and experience to help engineers create successful electronic products.

This book is written to help engineers understand how to go about problem solving while designing high-speed circuits. In particular, it helps engineers in the following areas:

- What to do about non-existent, incomplete, and erroneous semiconductor circuit models.
- How to apply EDA tools to achieve practical designs despite model limitations.
- How a grasp of basic high-speed digital, RF, and EMC design concepts guides design intent.
- How to apply EDA tools to cutting-edge digital technology.
- How to work with suppliers, CAD team members, and others.
- How processes and procedures enable and enhance the design process.

Who Should Read This Book?

This book is written for electronics engineering students and professionals working with models and simulation. This means choosing, obtaining, simulating, analyzing, and verifying models. The authors' goal is to organize and present the material in a way that is helpful to circuit and

product design engineers who have little or no specialized knowledge of high-speed digital design or semiconductors.

To get the most from this book, the reader should have:

- A basic familiarity of analog electronic circuit design, Ohm's Law, and signal analysis in time and frequency domains.
- Exposure to different types of semiconductor devices.
- A Bachelor of Science in Electrical or Electronics Engineering (or its equivalent) or several years of practical experience.

What Models Are Covered?

The following information about models is covered:

- Their inner workings
- Their suitability
- Their limitations
- Their design benefits

Specifically, the book covers IBIS models in detail. They are the most useful models for simulation of high-speed digital designs. For the sake of completeness, other models are also included. They are:

- 2-Port ("black-box") matrix models. They form an underpinning to 2-Port Scattering-Parameter models and find application inside many of the EDA programs used for simulation.
- SPICE models.
- Scattering-Parameter models.
- TCAD device physics models.

Writing Approach Used in This Book

This book draws on a vast body of technical literature. The authors cite references wherever possible for readers who want to pursue derivations, proofs, and in-depth coverage. The analog high-frequency effects of high-speed digital switching are also addressed.

What the authors attempt to present is a technical area so broad, and so deep, that it would take several shelves of college textbooks to cover the subjects in depth. The authors intend to:

- Explain the technical areas in enough technical detail to provide a clear description of the subject.

- Provide derivations and proofs to the extent that they help an understanding of the subject.
- Place all of the material within a framework of:
 - How modeling for high-speed circuitry is done.
 - How different technical specialists work together in this field.
 - How theoretical tools, EDA software, physical observations, and practical experience combine for a successful product design.

The authors' points of view are essentially that of an end user of EDA tools for purposes of designing high-speed electronic circuits. The challenge is to be successful despite limitations in theory, software, work environment, component suppliers, or previous condition of practical experience.

Discrete Semiconductors Are Used as Simple Examples

To promote understanding, this book starts with simple, fundamental concepts and then advances to more complex systems and structures. The discussion starts with the physical-electrical operation of discrete semiconductors. After considering simple gates, the authors switch to IC chips that may contain from tens to hundreds of millions of individual gates.

Individual transistor I/O behavior is similar to the I/O behavior of an IC chip. The IC chip's physical construction at its I/O causes its electrical behavior as a driver or receiver. For most high-speed digital design simulations, the IBIS model is a balanced compromise between speed and complexity. IBIS model characteristics are similar to that of a discrete transistor's input or output. IBIS ignores what happens between the IC input and IC output to the PCB world. Instead, the authors focus on the electrical performance of the interconnections between a driver (generator or output) and a receiver (load or input).

Throughout this book, the authors re-use the same example transistor properties to explain how the properties operate through several levels of use and association.

How Is This Book Organized?

The basic parts of the book are:

1. Where models and simulation fit into product development.
2. Generating 2-Port, Scattering Parameter, SPICE, and IBIS models.
3. Selecting appropriate components for the product and suitable models to simulate the design.
4. Information about the IBIS model file: format, data, and quality control.

5. Managing IBIS models for simulation.
6. Checking and verifying IBIS models.
7. The future of IBIS and related modeling techniques.
8. Glossary, Bibliography, Index, and CD-ROM

About the CD-ROM

The companion CD-ROM includes software selected by the authors to help users learn how to extract models and simulate with them. Sonnet® Lite from Sonnet Software and Visual IBIS Editor® from Mentor Graphics are provided.

The CD-ROM also includes example data sheets, sample model files, IBIS syntax guides, presentations with practical model-building laboratory exercises (including input, intermediate, and output files), and other documentation. The appendixes on the CD include:

- Appendix A, Sample Data Sheets
- Appendix B, Sample IBIS Model Files
- Appendix C, Sample SPICE Models
- Appendix D, Sample S-Parameter Model
- Appendix E, Key Concepts of the IBIS Model
- Appendix F, List of Websites
- Appendix G, List of Software Providers
- Appendix H, Production Realities
- Appendix I, IBIS Quality Checklist
- Appendix J, Device Physics
- Appendix K, Logic Selection Guides
- Appendix L, Training Presentations

Feedback

The authors hope this book helps the reader simulate and design high-speed digital circuits and would greatly appreciate the reader's feedback. Please send suggestions and comments by email to:

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