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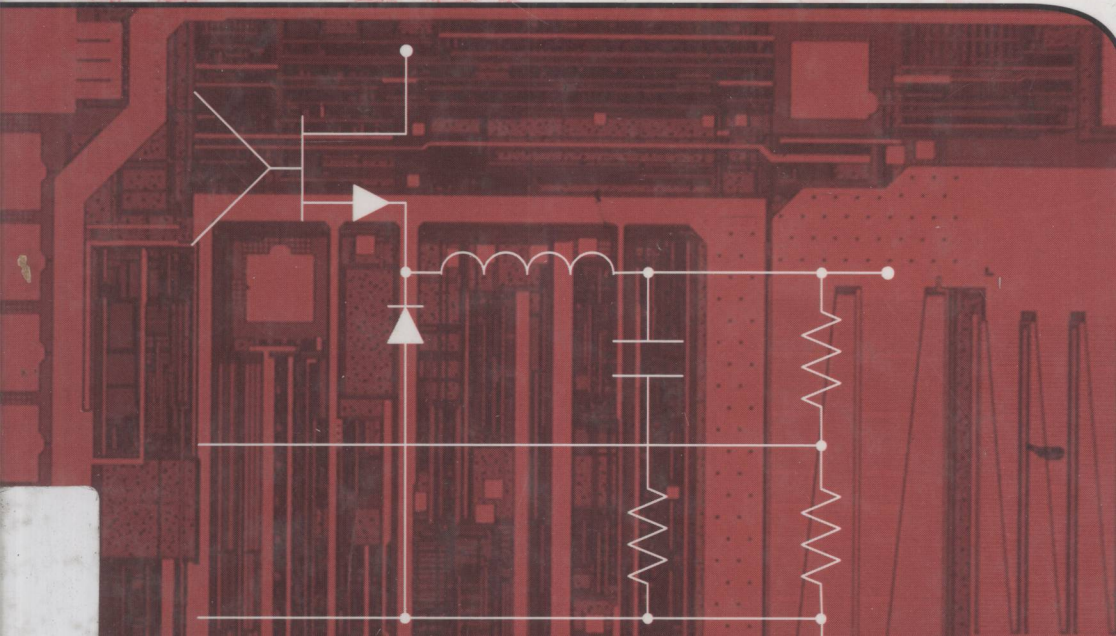
MANAGING POWER ELECTRONICS

VLSI and DSP-Driven Computer Systems

NAZZARENO ROSSETTI



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Dr. Nazzareno Rossetti

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Managing Power Electronics

To Ash and Ty, my two pearls

Foreword

At $13 billion and roughly five percent of the total semiconductor market (2004 data) the power semiconductor market is big and growing fast, typically outgrowing the rest of the semiconductor market.

Modern electronic appliances, while exhibiting increasing functionality, are also expected to consume little power, for reasons of portability, thermal performance, and environmental considerations.

This book is an important contribution to the understanding of the many facets of this market, from technology to circuits, electronic appliances, and market forces at work.

The author's broad industry experience built in almost three decades of design, application, and marketing of analog and power management devices is reflected in the breadth of this book. Topics discussed range from fundamentals of semiconductor physics, to analog and digital circuit design and the complex market dynamics driving the semiconductor business. The author displays in this work a unique ability to reduce complex issues to simple concepts. The book makes good reading for the marketing engineer or business hi-tech professional wanting a quick refresh of integrated circuits and power management design, as well as the technologist wanting to expand his market horizons. The timely market and technical information also serves as excellent reference material for students interested in entering the power management field.

Seth R. Sanders, Professor
Electrical Engineering and Computer
Sciences Department
University of California, Berkeley

Preface

How to Use This Book

This book discusses state-of-the-art power management techniques of modern electronic appliances relying on such Very Large Scale Integration (VLSI) chips as CPUs and DSPs.

It also covers specific circuit design issues and their implications, including original derivation of important expressions.

This book is geared toward systems and applications, although it also gets into the specific technical aspects of discrete and integrated solutions, like the analysis of circuits within the power chips which power PCs and other modern electronics.

The first half of this book is a good complement to classic semiconductor text books because it deals with the same complex issues in a more conversational way. It avoids completely the use of complex expressions and minimizing the use of formulas to useful ones, that allow us to plug values in and get an actual result.

The second half of the book is a broad review of the modern technology landscape seen through the eyes of the power management engineer, continually challenged by the rising complexity of modern electronic appliances.

Scope

In this book, power management is covered in its many facets, including semiconductor manufacturing processes, packages, circuits, functions, and systems. The first chapter is a general overview of the semiconductor industry and gives a glimpse of its many accomplishments in a relatively short time. Semiconductor processes and packages are discussed in the second chapter. Great effort has been put here in explaining complex concepts in conversational and intuitive fashion. Chapter 3 is a guided "tour de force" in analog design building from the transistor up to higher level functions and leading to the implementation of a

complete voltage regulator. In chapter 4 we discuss a number of popular DC-DC voltage regulation architectures, each responding to specific requirements demanded by the application at hand. Similarly in chapter 5 we move on to discuss AC-DC architectures for power conversion. After the technical foundation is laid with these first 5 chapters, we move to analyze some of the most popular electronic appliances. In chapter 6 we cover ultra portable appliances such as cellular telephones, Personal Digital Assistants (PDAs) and Digital Still Cameras (DSCs) and discuss the amazing success of these devices and the trend toward convergence leading to smart phones that incorporate PDAs, DSCs, Global Positioning Systems (GPS), Internet appliances and more into one small handheld device. Then in chapter 7 we cover specifically the desktop PC, a resilient device which continues to reinvent itself and defeat the many attempts by competing platforms to make it obsolete. Then we go into portable computing with the notebook PC aspiring to claim the center stage for the coming age of "computing anywhere, anytime." Finally some special power management topics are covered in chapter 8. In closure the appendix section provides more in dept information about parts discussed in the chapters.

Acknowledgments

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About the Author

Reno Rossetti is a published author of technical articles for the major electronics trade magazines, power management developer, mentor, architect, and speaker. He holds a doctorate in electrical engineering from Politecnico of Torino, Italy and a Degree in Business Administration from Bocconi University of Milan, Italy. He has more than 25 years experience in the semiconductors industry, covering integrated circuit design, semiconductor applications and marketing roles. He is currently the director of Strategy for the Integrated Circuits Group at Fairchild Semiconductor, a leading Semiconductor manufacturer providing innovative solutions for power management and power conversion.

Over the years he has designed several innovative power conversion and management solutions for Desktop and Portable System Electronics and CPUs. His patented "Valley Control" architecture (patent issued in

2000) became a leading control architecture powering many generations of voltage regulators controllers for personal computer central processing units (CPUs), He defined and released to production the first "Integrated Power Supply," LM2825, a full power supply, complete with magnetics and capacitors, confined in a standard dip 24 package and produced with standard IC manufacturing packaging technology. This resulted in a reliable and superior power supply with a mean time before failure of 20 million hours and density of 35W/cubic inch. It received several awards, including 1996 product of the year for EETimes and EDN. More recently he has been concerned with and created intellectual property (IP) for advanced power management aspects including application of micro-electro-mechanical (MEM) technologies to power supplies and untethered power distribution systems. Rossetti holds several patents in the field of voltage regulation and power management. His articles and commentaries have appeared in the main electronics magazines in the United States, Europe and Asia (EETimes, Planet Analog, PCIM, etc.).

Contents

Chapter 1

Introduction

1.1 Technology Landscape

Power management is, literally and metaphorically, the hottest area in computing and computing appliances.

In 1965, while working at Fairchild Semiconductor, Gordon Moore predicted that the number of transistors in an integrated circuit would double approximately every two years. Moore's law, as his observation has been dubbed, has so far been the foundation of the business of personal computing and its derivative applications. With its publication in Electronics magazine on April 19th, 1965, Moore's law was introduced to the world, along with its profound technological, business, and financial implications.

As long as new computers continue to deliver more performance—and Moore's law says they will—people will continue to buy them. Whether people get bored with old technology or simply outgrow it, outdated computers seem to have little value. Hence, people are only willing to pay for the *additional* value of a new product, compared to the old one, not the value of a product in its entirety. This means consumers want to pay roughly the same price or even less for the new product as for the old. In essence they want the old technology for free and are willing to pay only for the new one.

Financially, building the facilities to produce smaller and smaller transistors requires billions of dollars of investment. For every new generation of chips, the old facility is either scrapped or used to produce some electronics down the food chain. A new facility has to be built