Multi-voltage CMOS Circuit Design

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Other Wiley Editorial Offices

John Wiley & Sons Inc., 111 River Street, Hoboken, NJ 07030, USA

Jossey-Bass, 989 Market Street, San Francisco, CA 94103-1741, USA

Wiley-VCH Verlag GmbH, Boschstr. 12, D-69469 Weinheim, Germany

John Wiley & Sons Australia Ltd, 42 McDougall Street, Milton, Queensland 4064, Australia

John Wiley & Sons (Asia) Pte Ltd, 2 Clementi Loop #02-01, Jin Xing Distripark, Singapore 129809

John Wiley & Sons Canada Ltd, 6045 Freemont Blvd, Mississauga, ONT, L5R 4J3

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Library of Congress Cataloging-in-Publication Data

Kursun, Volkan.
Multi-Voltage CMOS Circuit Design / Volkan Kursun, Eby G. Friedman.
p. cm.
Includes bibliographical references and index.
ISBN-13: 978-0-470-01023-5 (cloth : alk. paper)
ISBN-10: 0-470-01023-1 (cloth : alk. paper)
1. Metal oxide semiconductors, Complementary. I. Friedman, Eby G. II. Title.
TK7871.99.M44K87 2006
621.39′732–dc22

2006006472

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN-13 978-0-470-01023-5
ISBN-10 0-470-01023-1

Typeset in 10/12 pt Times by Thomson Digital.
Printed and bound in Great Britain by Antony Rowe Ltd., Chippenham, Wiltshire.
This book is printed on acid-free paper responsibly manufactured from sustainable forestry in which at least two trees are planted for each one used for paper production.

This book is dedicated to the memory of my grandparents
Gülizar and Bahri

To the next generation
Joe, Samuel, Jesse, Jake, Hanan, and Josh

MELIORA

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Preface

The scaling of semiconductor process technologies has been continuing for more than four decades. Advancements in process technologies are the fuel that has been moving the semiconductor industry. In response to growing customer demand for applications that require integrated circuits with enhanced performance and functionality at reduced cost, a new process generation has been introduced by the semiconductor industry every two to three years during the past forty years. The challenge for enhancing the performance and functionality of integrated circuits has traditionally been managing the greater design and manufacturing complexity and higher power consumption. As stressed throughout this book, the generation, distribution, and dissipation of power are at the forefront of current problems faced by integrated circuit designers.

In order to continue the historical trend of reducing the unit cost of a circuit while simultaneously enhancing performance and functionality, radical changes are required in the manner in which integrated circuits are designed. Higher speed at all costs is no longer an option. Energy-efficient semiconductor devices, circuit techniques, and microarchitectures are necessary to maintain the pace of expansion that the semiconductor industry has enjoyed over the past forty years.

Several important opportunities that exist for low power and reliable integrated circuit and system design are highlighted in this book. Design choices that can be made while scaling the supply and threshold voltages, in order to lower power consumption and enhance device reliability without degrading circuit speed, are described. Techniques for simultaneously achieving energy efficiency and high speed are presented.

Systems with multiple power supplies can significantly reduce power consumption without degrading speed by selectively lowering the supply voltage along non-critical delay paths. High-frequency monolithic DC–DC conversion techniques applicable to multiple supply voltage CMOS circuits are presented that provide additional voltage levels with low energy and area overhead. Full integration of a high efficiency buck converter on the same die as a dual supply voltage microprocessor is demonstrated to be feasible. A low swing DC–DC conversion technique is presented that enhances the energy efficiency of a monolithic DC–DC converter. Device reliability issues in monolithic DC–DC converters operating at high input voltages are discussed. Advanced cascode bridge circuits that guarantee the reliable operation of deep submicrometer MOSFETs without exposure to high voltage stress while operating at high input and output voltages are introduced.