Advanced CMOS cell design

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Dedication

To Vinay, Bhupesh, Brijesh and Tarun

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Author's Profile (At end of book?)

Etienne SICARD was born in Paris, June 1961. He received the B.S degree in 1984 and the PhD in Electrical Engineering from the University of Toulouse, in 1987, in the laboratory LAAS of Toulouse. He was granted a Monbusho scholarship and stayed 18 months at Osaka University, Japan (1988-1989). Previously a professor of electronics in the Department of Physics, University of Balearic Islands, SPAIN (1990), Etienne SICARD is currently a professor at INSA of Toulouse, Department of Electrical and Computer Engineering. He is a visiting professor at the electronic department of Carleton University, Ottawa, in 2004. His research interest include several aspects of CAD Tools for the design of integrated circuits, including signal integrity in deep sub-micron CMOS ICs and electromagnetic compatibility.

Etienne SICARD is the author of books and several software in the field of micro-Electronics (Microwind), speech therapy (Vocalab) as well as technical papers concerning electromagnetic compatibility of CMOS integrated circuits. He is a member of French SEE and the IEEE EMC society. He was elected in 2006 distinguished IEEE lecturer for EMC of ICs. Email: etienne.sicard@insa-toulouse.fr

SONIA BEN DHIA received the engineering diploma in 1995, and the Ph.D. in Electronic Design from the National Institute of Applied Sciences (INSA), Toulouse, France, in 1998. She is currently at the rank of assistant professor at INSA-Toulouse, Department of Electrical and Computer Engineering where she teaches digital electronics, IC testability and reliability, and analog and RF CMOS design.

She is part of the INSA Studies Directorate board to organize transversal educational courses and take care of internal organization. She is also in charge of the promotion of IT in teaching. Her research interests includes signal integrity in deep sub-micron CMOS ICs and electromagnetic compatibility of ICs. She has authored technical papers on signal integrity and EMC. She contributed to the publication of 3 books (2 for educational purposes based on Microwind software and one dealing with our research topics on EMC of ICs).

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About Microwind and Dsch

The present book makes an extensive use of PC tools Microwind3.1 and Dsch3.1. A lite version of these tools is provided in the companion CD-ROM. All schematic file and layout files examples of the book are included in the CD-ROM.

The web link to the latest version of the software is http://www.microwind.org . The commercial site for the tools is http://www.microwind.net

Contents

MULTIPLIERS

Value	*Name*	*Standard Notation*
10^{18}	***PETA***	P
10^{15}	***EXA***	E
10^{12}	***TERA***	T
10^{9}	***GIGA***	G
10^{6}	***MEGA***	M (MEG in SPICE)
10^{3}	***KILO***	K
10^{0}	**-**	-
10^{-3}	***MILLI***	m
10^{-6}	***MICRO***	u
10^{-9}	***NANO***	n
10^{-12}	***PICO***	p
10^{-15}	***FEMTO***	f
10^{-18}	***ATTO***	a
10^{-21}	***ZEPTO***	z

PHYSICAL CONSTANTS & PARAMETERS

Name	*Value*	*Description*
ε_0	8.85 e $^{-12}$ Farad/m	Vacuum dielectric constant
ε_r SiO_2	3.9 - 4.2	Relative dielectric constant of SiO_2
ε_r Si	11.8	Relative dielectric constant of silicon
ε_r ceramic	12	Relative dielectric constant of ceramic
k	$1.381e^{-23}$ J/°K	Bolztmann's constant
q	$1.6e^{-19}$ Coulomb	Electron charge
μ_n	600 $V.cm^{-2}$	Mobility of electrons in silicon
μ_p	270 $V.cm^{-2}$	Mobility of holes in silicon
γ_{al}	36.5 10^6 S/m	Aluminum conductivity
γ_{si}	$4x10^{-4}$ S/m	Silicon conductivity
n_i	$1.02x10^{10}cm^{-3}$	Intrinsic carrier concentration in silicon at 300°K
ρ_{al}	0.0277 Ω.µm	Aluminum resistivity
γ_{cu}	$58x10^6$ S/m	Copper conductivity
ρ_{cu}	0.0172 Ω.µm	Copper resistivity
$\rho_{tungstène\ (W)}$	0.0530 Ω.µm	Tungsten resistivity
$\rho_{or\ (Ag)}$	0.0220 Ω.µm	Gold resistivity
μ_0	$1.257e^{-6}$ H/m	Vacuum permeability
T	300°K (27°C)	Operating temperature

1 Introduction

A first book called “Basic CMOS cell design” was published in 2005, which proposed a description of the integrate circuit technology scale down, the MOS device from a model, layout and performance point of views and an extensive study of basic gates. The book also included chapters on interconnects and analog cells. This introduction to basic cell design and simulation was based on user-friendly educational tools DSCH and MICROWIND developed by the authors.

The present book “Advanced CMOS cell design” is also fully illustrated by DSCH and MICROWIND tools in their updated version 3.1, provided in the companion CD-ROM. In this new book, chapter 2 introduces novel concepts related to nano-scale technology, with focus on 90nm CMOS generation and chapter 3 proposes an illustration of memories. Chapter 4 gives an introduction to microprocessor architecture at logic level, through a complete project called « Very Simple Microprocessor », written in cooperation with Dr. Mafuz Aziz. Chapter 5 introduces the basic concepts of Field programmable Gate Arrays, from a switch-level point of view. Chapter 6 is dedicated to radio-frequency analog cells, with extensive details on mixers, voltage-controlled oscillators, phase-lock-loops and power amplifiers. Chapter 7 focuses on analog-to-digital and digital to analog converter principles, with an introduction to CMOS sensors. The input/output interfacing principles are illustrated in Chapter 8, with in-depth study of I/O structure and technology refinements. Chapter 9 includes an introduction to silicon-insulator technology, followed by a prospective discussion and a conclusion in chapter 10.
The detailed explanation of the design rules is in appendix A. The details of all commands are given in appendix B for the tool MICROWIND, and in appendix C for the tool Dsch. Finally, appendix D includes a quick reference sheet for the companion tools.

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