

***Advanced CMOS cell design***

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**Dedication**

To Vinay, Bhupesh, Brijesh and Tarun

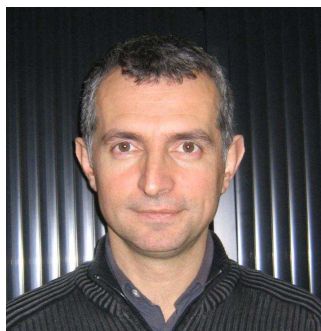
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**Author's Profile (At end of book?)**

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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>

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Design Rule File

Simulation parameters for DSCH3

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### MULTIPLIERS

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

### PHYSICAL CONSTANTS & PARAMETERS

| <i>Name</i>                   | <i>Value</i>                           | <i>Description</i>                                  |
|-------------------------------|--|---|
| $\epsilon_0$                  | $8.85 \times 10^{-12}$ Farad/m         | Vacuum dielectric constant                          |
| $\epsilon_r$ SiO <sub>2</sub> | 3.9 - 4.2                              | Relative dielectric constant of SiO <sub>2</sub>    |
| $\epsilon_r$ Si               | 11.8                                   | Relative dielectric constant of silicon             |
| $\epsilon_r$ ceramic          | 12                                     | Relative dielectric constant of ceramic             |
| k                             | $1.381 \times 10^{-23}$ J/°K           | Boltzmann's constant                                |
| q                             | $1.6 \times 10^{-19}$ Coulomb          | Electron charge                                     |
| $\mu_n$                       | 600 V.cm <sup>-2</sup>                 | Mobility of electrons in silicon                    |
| $\mu_p$                       | 270 V.cm <sup>-2</sup>                 | Mobility of holes in silicon                        |
| $\gamma_{al}$                 | $36.5 \times 10^6$ S/m                 | Aluminum conductivity                               |
| $\gamma_{si}$                 | $4 \times 10^{-4}$ S/m                 | Silicon conductivity                                |
| $n_i$                         | $1.02 \times 10^{10}$ cm <sup>-3</sup> | Intrinsic carrier concentration in silicon at 300°K |
| $\rho_{al}$                   | 0.0277 $\Omega$ . $\mu$ m              | Aluminum resistivity                                |
| $\gamma_{cu}$                 | $58 \times 10^6$ S/m                   | Copper conductivity                                 |
| $\rho_{cu}$                   | 0.0172 $\Omega$ . $\mu$ m              | Copper resistivity                                  |
| $\rho_{tungstène (W)}$        | 0.0530 $\Omega$ . $\mu$ m              | Tungsten resistivity                                |
| $\rho_{or (Ag)}$              | 0.0220 $\Omega$ . $\mu$ m              | Gold resistivity                                    |
| $\mu_0$                       | $1.257 \times 10^{-6}$ 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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