

Lecture Notes in Computer Science 2799
Edited by G. Goos, J. Hartmanis, and J. van Leeuwen

Springer

Berlin

Heidelberg

New York

Hong Kong

London

Milan

Paris

Tokyo

Jorge Juan Chico Enrico Macii (Eds.)

Integrated Circuit and System Design

Power and Timing Modeling, Optimization and Simulation

13th International Workshop, PATMOS 2003
Turin, Italy, September 10-12, 2003
Proceedings



Springer

Series Editors

Gerhard Goos, Karlsruhe University, Germany
Juris Hartmanis, Cornell University, NY, USA
Jan van Leeuwen, Utrecht University, The Netherlands

Volume Editors

Jorge Juan Chico
Universidad de Sevilla
Departamento de Tecnologia Electronica
Avenida Reina Mercedes, s/n., 41012 Sevilla, Spain
E-mail: jjchico@dte.us.es

Enrico Macii
Politecnico di Torino
Dipartimento di Automatica e Informatica
Corso Duca degli Abruzzi, 24, 10129 Torino, Italy
E-mail: enrico.macii@polito.it

Cataloguing-in-Publication Data applied for

A catalog record for this book is available from the Library of Congress

Bibliographic information published by Die Deutsche Bibliothek
Die Deutsche Bibliothek lists this publication in the Deutsche Nationalbibliografie;
detailed bibliographic data is available in the Internet at <<http://dnb.ddb.de>>.

CR Subject Classification (1998): B.7, B.8, C.1, C.4, B.2, B.6, J.6

ISSN 0302-9743

ISBN 3-540-20074-6 Springer-Verlag Berlin Heidelberg New York

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer-Verlag. Violations are liable for prosecution under the German Copyright Law.

Springer-Verlag Berlin Heidelberg New York
a member of BertelsmannSpringer Science+Business Media GmbH

<http://www.springer.de>

© Springer-Verlag Berlin Heidelberg 2003
Printed in Germany

Typesetting: Camera-ready by author, data conversion PTP-Berlin GmbH
Printed on acid-free paper SPIN 10931929 06/3142 5 4 3 2 1 0

Preface

Welcome to the proceedings of PATMOS 2003. This was the 13th in a series of international workshops held in several locations in Europe. Over the years, PATMOS has gained recognition as one of the major European events devoted to power and timing aspects of integrated circuit and system design. Despite its significant growth and development, PATMOS can still be considered as a very informal forum, featuring high-level scientific presentations together with open discussions and panel sessions in a free and relaxed environment.

This year, PATMOS took place in Turin, Italy, organized by the Politecnico di Torino, with technical co-sponsorship from the IEEE Circuits and Systems Society and the generous support of the European Commission, as well as that of several industrial sponsors, including BullDAST, Cadence, Mentor Graphics, STMicroelectronics, and Synopsys.

The objective of the PATMOS workshop is to provide a forum to discuss and investigate the emerging problems in methodologies and tools for the design of new generations of integrated circuits and systems. A major emphasis of the technical program is on speed and low-power aspects, with particular regard to modeling, characterization, design, and architectures.

A total of 85 contributed papers were received. Many thanks to all the authors that submitted their contributions. In spite of a very dense technical program, we were able to accept only 43 regular papers and 18 posters. Posters differ from regular papers in that they are presented to the audience during three sessions in which authors stand by cardboard displays and answer questions. Authors of regular papers, instead, deliver traditional oral presentations of their contributions during the sessions of the technical program.

Three keynote talks, offered by leading experts from industry and academia, served as starters for the three days of the workshop: Dr. Andrea Cuomo, Corporate VP of STMicroelectronics, Dr. Antun Domic, Senior VP of Synopsys Inc., and Dr. Ricardo Reis, Professor at the Universidad Federal Rio Grande do Sul addressed hot issues regarding architectures for next generation integrated platforms, EDA tools for energy-efficient design, and physical synthesis for high-speed and low-power circuits, respectively.

An industrial session, in which scientists from EDA and IC manufacturing companies illustrated their most recent advances in R&D activities and leading-edge technology development complemented the technical program.

Finally, a one-hour panel session took advantage of the presence of Officers from the European Commission and Coordinators of large EU-funded collaborative projects to provide insights into the new instruments and mechanisms now available in Europe for supporting research and innovation activities.

Last, but not least, a rich social program, paired with an industrial exhibition, guaranteed additional opportunities for establishing new relationships among the workshop participants.

Many thanks to the technical program committee for all their hard work in paper review, paper selection, and session organization. Additional experts also collaborated in the review process, and we acknowledge their contribution. Lists of technical program committee members and of additional reviewers can be found the following pages. Thanks also to the invited speakers for graciously donating their time and to the panelists for an enlightening and entertaining session. We hope you found the workshop both stimulating and helpful and that you will enjoyed your stay in Turin for the whole duration of the event.

September 2003

Jorge Juan Chico
Enrico Macii

Organization

Organizing Committee

General Chair:

Program Chair:

Industrial Chair:

Conference Manager:

Prof. Enrico Macii, Politecnico di Torino, Italy

Prof. Jorge Juan Chico, Universidad de Sevilla, Spain

Dr. Roberto Zafalon, STMicroelectronics, Italy

Ms. Agnieszka Furman, Politecnico di Torino, Italy

Program Committee

D. Auvergne, U. Montpellier, France

J. Bormans, IMEC, Belgium

J. Figueras, U. Catalunya, Spain

J. A. Carballo, IBM, USA

C. E. Goutis, U. Patras, Greece

A. Guyot, INPG Grenoble, France

R. Hartenstein, U. Kaiserslautern, Germany

S. Jones, U. Loughborough, UK

P. Larsson-Edefors, Chalmers T.U. Sweden

V. Moshnyaga, U. Fukuoka, Japan

W. Nebel, U. Oldenburg, Germany

J.A. Nossek, T.U. Munich, Germany

A. Nunez, Las Palmas, Spain

M. Papaefthymiou, U. Michigan, USA

F. Pessolano, Philips, The Netherlands

H. Pfleiderer, U. Ulm, Germany

C. Piguet, CSEM, Switzerland

R. Reis, U. Porto Alegre, Brazil

M. Robert, U. Montpellier, France

A. Rubio, U. Catalunya, Spain

D. Sciuto, Politecnico di Milano, Italy

D. Soudris, U. Trace, Greece

J. Sparsø, DTU, Denmark

A. Stauffer, EPFL, Switzerland

A. Stempkowsky, Acad. of Sciences, Russia

T. Stouraitis, U. Patras, Greece

A.M. Trullemans-Anckaert, U. Louvain-la-Neuve, Belgium

R. Zafalon, STMicroelectronics, Italy

PATMOS Steering Committee

D. Auvergne, U. Montpellier, France
R. Hartenstein, U. Kaiserslautern, Germany
W. Nebel, U. Oldenburg, Germany
C. Piguet, CSEM, Switzerland
A. Rubio, U. Catalunya, Spain
J. Figueras, U. Catalunya, Spain
B. Ricco, U. Bologna, Italy
D. Soudris, U. Trace, Greece
J. Sparsø, T.U. Denmark
A.M. Trullemans-Anckaert, U. Louvain, Belgium
P. Pirsch, U. Hannover, Germany
B. Hochet, EIVd, Switzerland
A.J. Acosta, U. Sevilla/IMSE-CNM, Spain
J. Juan, U. Sevilla/IMSE-CNM, Spain
E. Macii, Politecnico di Torino, Italy
R. Zafalon, STMicroelectronics, Italy
V. Palioras, U. Patras, Greece
J. Vounckx , IMEC, Belgium

Executive Sub-committee

President: Joan Figueras, U. Catalunya, Spain
Vice-president: Reiner Hartenstein, U. Kaiserslautern, Germany
Secretary: Wolfgang Nebel, U. Oldenburg, Germany

Reviewers

A. Acosta	J. Luis Güntzel	J. Van Lunteren
D. Auvergne	A. Guyot	A. Macii
N. Azemard	E. Hall	S. Manich
P. Babighian	K. Inoue	K. Masselos
M.J. Bellido	A. Ivaldi	P. Maurine
L. Bisdounis	J. Jachalsky	M. Meijer
A. Bona	R. Jiménez	S. Moch
J.A. Carballo	J. Juan	V. Moshnyaga
J.M. Daga	K. Karagianni	W. Nebel
A. Dehnhardt	C. Kashyap	S. Nikolaidis
M. Donno	H. Klussman	N. Nolte
J. Figueras	O. Koufopavlou	A. Nuñez
L. Friebel	S. Lagudu	M. Papaefthymiou
F. Fummi	C. Lefurgy	F. Pessolano
C. Goutis	J.D. Legat	H.-J. Pfleiderer

C. Piguet	C. Silvano	M. Valencia
P. Pirsch	C. Simon-Klar	S.-M. Yoo
C. Psychalinos	D. Soudris	V. Zaccaria
R. Reis	J. Sparsø	R. Zafalon
J. Rius	A. Stempkowsky	M. Wahle
F. Salice	G. Theodoridis	M. Winter
A. Schallenberg	A. Tisserand	
D. Sciuto	L. Torres	
H. Shafi	A.M. Trullemans	

Sponsors and Industrial Supporters

IEEE Circuits and Systems Society (Technical Co-sponsor)

Politecnico di Torino

European Commission

BullDAST s.r.l.

Cadence Design Systems, Inc.

Mentor Graphics, Italian Site

STMicroelectronics, s.r.l.

Synopsys, Inc.

Table of Contents

Keynote Speech

- Architectural Challenges for the Next Decade Integrated Platforms 1
A. Cuomo (*STMicroelectronics, Agrate Brianza, Italy*)

Gate-Level Modeling and Design

- Analysis of High-Speed Logic Families 2
G. Privitera, F. Pessolano (*Philips Research, Eindhoven, The Netherlands*)
- Low-Voltage, Double-Edge-Triggered Flip Flop 11
P. Varma, A. Chakraborty (*Indian Institute of Technology, New Delhi, India*)

- A Genetic Bus Encoding Technique for Power Optimization of Embedded Systems 21
G. Ascia, V. Catania, M. Palesi (*Università di Catania, Italy*)

- State Encoding for Low-Power FSMs in FPGA 31
L. Mengibar, L. Entrena, M.G. Lorenz, R. Sánchez-Reillo (*Universidad Carlos III, Madrid, Spain*)

Low Level Modeling and Characterization

- Reduced Leverage of Dual Supply Voltages in Ultra Deep Submicron Technologies 41
T. Schoenauer, J. Berthold, C. Heer (*Infineon Technologies, München, Germany*)

- A Compact Charge-Based Crosstalk Induced Delay Model for Submicronic CMOS Gates 51
J.L. Rosselló, J. Segura (*University of Balearic Islands, Spain*)

- CMOS Gate Sizing under Delay Constraint 60
A. Verle, X. Michel, P. Maurine, N. Azémard, D. Auvergne (*LIRMM, Université de Montpellier II, Montpellier, France*)

- Process Characterization for Low VTH and Low Power Design 70
E. Seebacher, G. Rappitsch, H. Höller (*Austriamicrosystems, Austria*)

Power and Energy Consumption of CMOS Circuits: Measurement Methods and Experimental Results	80
---	----

J. Rius, A. Peidro, S. Manich, R. Rodriguez (Departament d'Enginyeria Electronica, UPC, Barcelona, Spain)

Interconnect Modeling and Optimization

Effects of Temperature in Deep-Submicron Global Interconnect Optimization	90
---	----

M.R. Casu, M. Graziano, G. Piccinini, G. Masera, M. Zamboni (Politecnico di Torino, Italy)

Interconnect Parasitic Extraction Tool for Radio-Frequency Integrated Circuits	101
--	-----

J. Lescot, F.J.R. Clément (Cadence Design Systems, Voiron, France)

Estimation of Crosstalk Noise for On-Chip Buses	111
---	-----

S. Tuuna, J. Isoaho (University of Turku, Finland)

A Block-Based Approach for SoC Global Interconnect Electrical Parameters Characterization	121
---	-----

M. Addino, M.R. Casu, G. Masera, G. Piccinini, M. Zamboni (Politecnico di Torino, Italy)

Interconnect Driven Low Power High-Level Synthesis	131
--	-----

A. Stammermann, D. Helms, M. Schulte, A. Schulz, W. Nebel (OFFIS Research Institute, Oldenburg, Germany)

Asynchronous Techniques

Bridging Clock Domains by Synchronizing the Mice in the Mousetrap ...	141
---	-----

J. Kessel, A. Peeters, S.-J. Kim (Philips Research Laboratories, Eindhoven, Germany)

Power-Consumption Reduction in Asynchronous Circuits Using Delay Path Unequalization	151
--	-----

S. López, O. Garnica, J.I. Hidalgo, J. Lanchares, R. Hermida (Universidad Complutense de Madrid, Spain)

New GALS Technique for Datapath Architectures	161
---	-----

M. Krstić, E. Grass (IHP Microelectronics, Frankfurt, Germany)

Power/Area Tradeoffs in 1-of-M Parallel-Prefix Asynchronous Adders ...	171
--	-----

J.L. Fragoso, G. Sicard, M. Renaudin (TIMA Laboratory, Grenoble, France)

Statistic Implementation of QDI Asynchronous Primitives	181
---	-----

P. Maurine, J.B. Rigaud, F. Bouesse, G. Sicard, M. Renaudin (LIRMM, Montpellier, France)

Keynote Speech

- The Emergency of Design for Energy Efficiency: An EDA Perspective ... 192
A. Domic (Synopsys, Inc., Mountain View, USA)

Industrial Session

- The Most Complete Mixed-Signal Simulation Solution with
 ADVance MS 193
J. Oudinot (Mentor Graphics, Meudon La Foret, France)

- Signal Integrity and Power Supply Network Analysis of Deep
 SubMicron Chips 194
L.K. Scheffer (Cadence Design Systems, USA)

- Power Management in Synopsys Galaxy Design Platform 195
Synopsys, Inc., Mountain View, USA

- Open Multimedia Platform for Next-Generation Mobile Devices 196
STMicroelectronics, Agrate Brianza, Italy

RTL Power Modeling and Memory Optimisation

- Statistical Power Estimation of Behavioral Descriptions 197
*B. Arts, N. van der Eng, M. Heijligers, H. Munk, F. Theeuwen (Philips
 Research Laboratories, Eindhoven, The Netherlands),
 L. Benini (Università di Bologna, Italy), E. Macii, A. Milia, R. Maro,
 A. Bellu (Politecnico di Torino, Italy)*

- A Statistic Power Model for Non-synthetic RTL Operators 208
*M. Bruno (BullDast s.r.l), A. Macii (Politecnico di Torino, Italy),
 M. Poncino (Università di Verona, Italy)*

- Energy Efficient Register Renaming 219
*G. Kucuk, O. Ergin, D. Ponomarev, K. Ghose (SUNY Binghamton,
 USA)*

- Stand-by Power Reduction for Storage Circuits 229
S. Cservany, J.-M. Masgonty, C. Piguet (CSEM, Switzerland)

- A Unified Framework for Power-Aware Design of Embedded Systems 239
J.L. Ayala, M. Lopez-Vallejo (Universidad Politecnica de Madrid, Spain)

High-Level Modeling

- A Flexible Framework for Fast Multi-objective Design Space Exploration
 of Embedded Systems 249
G. Palermo, C. Silvano, V. Zaccaria (Politecnico di Milano, Italy)

High Level Area and Current Estimation	259
<i>Fei Li, Lei He (UCLA, USA), Joe Basile, Rakesh J. Patel, Hema Ramamurthy (Intel Corporation, USA)</i>	
Switching Activity Estimation in Non-linear Architectures	269
<i>A. García-Ortiz, L. Kabulepa, M. Glesner (Institute of Microelectronic Systems, Mstad, Germany)</i>	
Instruction Level Energy Modeling for Pipelined Processors	279
<i>S. Nikolaidis, N. Kavvadias, T. Laopoulos, L. Bisdounis, S. Blionas (Aristotele University of Thessaloniki, Greece)</i>	
Power Estimation Approach of Dynamic Data Storage on a Hardware Software Boundary Level	289
<i>M. Leeman, D. Atienza, F. Catthoor, V. De Florio, G. Deconinck, J.M. Mendias, R. Lauwereins (ESAT, Belgium)</i>	
Power Efficient Technologies and Designs	
An Adiabatic Charge Pump Based Charge Recycling Design Style	299
<i>V. Manne, A. Tyagi (Iowa State University, USA)</i>	
Reduction of the Energy Consumption in Adiabatic Gates by Optimal Transistor Sizing	309
<i>J. Fischer, E. Amirante, F. Randazzo, G. Iannaccone, D. Schmitt-Landsiedel (Institute for Technical Electronics, Technical University Munich, Germany)</i>	
Low Power Response Time Accelerator with Full Resolution for LCD Panel	319
<i>Tae-Chan Kim, Meejoung Kim, Chulwoo Kim, Bong-Young Chung, Soo-Won Kim (Samsung Electronics Co.Ltd, Korea)</i>	
Memory Compaction and Power Optimization for Wavelet-Based Coders	328
<i>V. Ferentinos, M. Milia, G. Lafruit, J. Bormans, F. Catthoor (IMEC-DESICS, Belgium)</i>	
Design Space Exploration and Trade-Offs in Analog Amplifier Design	338
<i>E. Hjalmarson, R. Hägglund, L. Wanhammar (Linkoping University, Sweden)</i>	
Keynote Speech	
Power and Timing Driven Physical Design Automation	348
<i>R. Reis (Universidad Federal Rio Grande do Sul, Porto Alegre, Brazil)</i>	

Communication Modeling and Design

- Analysis of Energy Consumed by Secure Session Negotiation Protocols in Wireless Networks 358
R. Karri, P. Mishra (Polytechnic University, New York, USA)

- Remote Power Control of Wireless Network Interfaces 369
A. Acquaviva, T. Simunic, V. Deolalikar, S. Roy (Università di Urbino, Italy)

- Architecture-Driven Voltage Scaling for High-Throughput Turbo-Decoders 379
F. Gilbert, N. When (University of Kaiserslautern, Germany)

- A Fully Digital Numerical-Controlled-Oscillator 389
Seyed Reza Abdollahi (Mazandaran, Iran), B. Bakkaloglu (Texas Instrument, USA), S.K. Hosseini (Iran Marine Industry, Iran)

Low Power Issues in Processors and Multimedia

- Energy Optimization of High-Performance Circuits 399
Hoang Q. Dao, Bart R. Zeydel, Vojin G. Oklobdzija (University of California, USA)

- Instruction Buffering Exploration for Low Energy Embedded Processors . 409
T. Vander Aa, M. Jayapala, F. Barat, G. Deconinck, R. Lauwereins, H. Corporaal, F. Catthoor, (ESAT/ELECTA, Belgium)

- Power-Aware Branch Predictor Update for High-Performance Processors . 420
A. Baniasadi (University of Victoria, Canada)

- Power Optimization Methodology for Multimedia Applications
 Implementation on Reconfigurable Platforms 430
K. Tatas, K. Siozios, D.J. Soudris, A. Thanailakis (Democritus University of Thrace, Greece), K. Masselos, K. Potamianos, S. Blionas (Intracom SA, Greece)

- High-Level Algorithmic Complexity Analysis for the Implementation of a Motion-JPEG2000 Encoder 440
M. Ravasi, M. Mattavelli (Swiss Federal Institute of Technology, Switzerland, Greece), P. Schumacher, R. Turney (Xilinx Research Labs, USA)

Poster Session 1

- Metric Definition for Circuit Speed Optimization..... 451
X. Michel, A. Verle, N. Azémard, P. Maurine, D. Auvergne (LIRMM, France)

Optical versus Electrical Interconnections for Clock Distribution Networks in New VLSI Technologies	461
<i>G. Tosik, F. Gaffiot, Z. Lisik, I. O'Connor, F. Tissafi-Drissi (Ecole Centrale de Lyon, France)</i>	
An Asynchronous Viterbi Decoder for Low-Power Applications	471
<i>B. Javadi, M. Naderi, H. Pedram, A. Afzali-Kusha, M.K. Akbari (Amirkabir University of Technology, Iran)</i>	
Analysis of the Contribution of Interconnect Effects in the Energy Dissipation of VLSI Circuits	481
<i>E. Isern, M. Roca, F. Moll (Universitat Illes Balears, Spain)</i>	
A New Hybrid CBL-CMOS Cell for Optimum Noise/Power Application	491
<i>R. Jiménez, P. Parra, P. Sanmartín, A.J. Acosta (IMSE-CNM/Universidad de Sevilla/Universidad de Huelva, Spain)</i>	
Computational Delay Models to Estimate the Delay of Floating Cubes in CMOS Circuits	501
<i>D. Guerrero, G. Wilke, J.L. Güntzel, M.J. Bellido, J.J. Chico, P. Ruiz-de-Clavijo, A. Millan (IMSE-CNM/Universidad de Sevilla, Spain)</i>	
Poster Session 2	
A Practical ASIC Methodology for Flexible Clock Tree Synthesis with Routing Blockages	511
<i>Dongsheng Wang, P. Suaris, Nan-chi Chou (Mentor Graphics Corporation, Oregon, USA)</i>	
Frequent Value Cache for Low-Power Asynchronous Dual-Rail Bus	520
<i>Byung-Soo Choi, Dong-Ik Lee (Kwangju Institute of Science and Technology, South Korea)</i>	
Reducing Static Energy of Cache Memories via Prediction-Table-Less Way Prediction	530
<i>Akihito Sakanaka, Toshinori Sato (U. Fukuoka, Japan)</i>	
A Bottom-Up Approach to On-Chip Signal Integrity	540
<i>A. Acquaviva, A. Bogliolo (Università di Urbino, Italy)</i>	
Advanced Cell Modeling Techniques Based on Polynomial Expressions ...	550
<i>Wen-Tsong Shiue, Weetit Wanalertlak (Oregon State University, USA)</i>	
RTL-Based Signal Statistics Calculation Facilitates Low Power Design Approaches	559
<i>P. Fugger, (Infineon, Austria)</i>	

Poster Session 3

Data Dependences Critical Path Evaluation at C/C++ System Level Description	569
<i>A. Prihozhy, M. Mattavelli, D. Mlynek (Ecole Polytechnique Federal de Lausanne, Switzerland)</i>	
A Hardware/Sofware Partitioning and Scheduling Approach for Embedded Systems with Low-Power and High Performance Requirements	580
<i>J. Resano, D. Mozos, E. Pérez, H. Mecha, J. Septién (Universidad Complutense de Madrid, Spain)</i>	
Consideration of Control System and Memory Contributions in Pratical Resource-Constrained Scheduling for Low Power	590
<i>Chee Lee, Wen-Tsong Shiue (Oregon State University, USA)</i>	
Low Power Cache with Successive Tag Comparison Algorithm	599
<i>Tae-Chan Kim, Chulwoo Kim, Bong-Young Chung, Soo-Won Kim (Samsung, Kyunggi-Do, Korea)</i>	
FPGA Architecture Design and Toolset for Logic Implementation	607
<i>K. Tatas, K. Siozios, N. Vasiliadis, D.J. Soudris, S. Nikolaidis, S. Siskos, A. Thanailakis (Democritus University of Trace, Greece)</i>	
Bit-Level Allocation for Low Power in Behavioural High-Level Synthesis .	617
<i>M.C. Molina, R. Ruiz-Sautua, J.M. Mendias, R. Hermida (Universidad Complutense de Madrid, Spain)</i>	
Author Index	629