

**Proceedings**

**18th International  
Conference on VLSI Design**

*held jointly with*

**4th International Conference on Embedded Systems Design**

## About the Cover

A banyan tree (*Ficus benghalensis*) grows wide-spreading branches that send down aerial roots like clumps of rope, until they enter the ground and become trunks. The **Great Banyan tree** is a landmark of Kolkata. It stands in the Indian Botanic Gardens which is about 8 kms. from the heart of the city, across the River Hooghly. This tree is more than 250 years old and finds mention in the Guinness Book of World Records for its canopy. It existed on a Phoenix (date palm) tree before the establishment of the garden in 1787. In 1925, the main trunk of this tree measuring 16m in girth had to be removed after it was infected by wood rotting fungi. There are more than 2800 prop roots and it covers an area of 1.50 hectares. The circumference of its canopy is about 450 m and gives the appearance of a small forest which has developed purely from a single tree during the course of time. The front cover gives us a glimpse of this famous tree.

The theme of this conference *Power-Aware design of VLSI systems* encompasses a wide spectrum of challenges which have to be met by the support of several disciplines in science and engineering, intertwined like a banyan tree.

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# Proceedings

## 18th International Conference on VLSI Design

*held jointly with*  
4th International Conference on Embedded Systems Design

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**Kolkata, India**

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# VLSI Design 2005

## Table of Contents

Message from the General Chairs .....	xviii
Message from the Program Chairs .....	xxi
Conference Committee .....	xxiii
Conference Steering Committee .....	xxv
Technical Program Committee .....	xxvi
VLSI Design 2004 Conference Awards .....	xxviii
Reviewers .....	xxvix
VLSI Design Conference History .....	xxxii
Embedded Systems Design Conference History .....	xxxiii

### Tutorials

#### Invited Tutorial

Power-Aware, Reliable Microprocessor Design .....	3
<i>P. Bose</i>	
High-Speed Interconnect Technology: On-Chip and Off-Chip .....	7
<i>S. Sapatnekar, J. Roychowdhury, and R. Harjani</i>	
Testing Nanometer Digital Integration Circuits: Myths, Reality and the Road Ahead .....	8
<i>S. Blanton and S. Mitra</i>	
SoC Design Methodology: A Practical Approach .....	10
<i>A. Jain, A. Saha, and J. Rao</i>	
Test Methodologies in the Deep Submicron Era — Analog, Mixed-Signal, and RF .....	12
<i>A. Chatterjee, A. Keshavarzi, A. Patra, and S. Mukhopadhyay</i>	
Recent Advances in Verification, Equivalence Checking and SAT-Solvers .....	14
<i>D. Pradhan, M. Abadir, and M. Varea</i>	
Compact MOSFET Models for Low Power Analog CMOS Design .....	15
<i>A. Bhattacharyya</i>	
Physics and Technology: Towards Low-Power DSM Design .....	16
<i>D. Mukhopadhyay, P. Basu, and V. Rao</i>	
Architectural, System Level and Protocol Level Techniques for Power Optimization for Networked Embedded Systems .....	18
<i>L. Benini, S. Shukla, and R. Gupta</i>	

### Inaugural Keynote Address

The High Walls have Crumpled .....	21
<i>C. Liu</i>	

### Keynotes

65nm Omnibudsman .....	25
<i>T. Vucurevich</i>	

ESL — The Next Leadership Opportunity for India?.....	26
<i>A. Naumann</i>	
VLSI Design Challenges for Gigascale Integration.....	27
<i>S. Borkar</i>	

**Banquet Speech**

Moore’s Law is Unconstitutional .....	31
<i>W. Rhines</i>	

**Plenary Sessions**

Configurable Processor the Building Block for SOC (System-On-a-Chip).....	35
<i>B. Fu</i>	
Modeling Usable and Reusable Transactors in System Verilog .....	36
<i>J. Bergeron</i>	
Optimizing SoC Manufacturability.....	37
<i>Y. Zorian</i>	

**Session 1A: Test I**

*Chairs: K. Saluja and A. Jas*

**Papers**

Tuple Detection for Path Delay Faults: A Method for Improving Test Set Quality .....	41
<i>I. Pomeranz and S. Reddy</i>	
A Delay Test to Differentiate Resistive Interconnect Faults from Weak Transistor Defects .....	47
<i>H. Yan and A. Singh</i>	
Efficient Space/Time Compression to Reduce Test Data Volume and Testing Time for IP Cores .....	53
<i>L. Li, K. Chakrabarty, S. Kajihara, and S. Swaminathan</i>	
On Efficient X-Handling Using a Selective Compaction Scheme to Achieve High Test Response Compaction Ratios .....	59
<i>H. Tang, C. Wang, J. Rajski, S. Reddy, J. Tyszer, and I. Pomeranz</i>	
Heterogeneous and Multi-Level Compression Techniques for Test Volume Reduction in Systems-on-Chip .....	65
<i>L. Lingappan, S. Ravi, A. Raghunathan, N. Jha, and S. Chakradhar</i>	
Cellular Automata Based Test Structures with Logic Folding .....	71
<i>B. Sikdar, S. Das, S. Roy, N. Ganguly, and D. Das</i>	

**Session 1B: Physical Design**

*Chairs: S. Gupta and J. Ghosh*

**Embedded Tutorial**

Electromigration-Aware Physical Design of Integrated Circuits.....	77
<i>J. Lienig and G. Jerke</i>	

## Papers

Variance Reduction in Monte Carlo Capacitance Extraction .....	85
<i>S. Batterywala and M. Desai</i>	
A Fast Buffered Routing Tree Construction Algorithm under Accurate Delay Model .....	91
<i>Y. Wang, Y. Cai, and X. Hong</i>	
Improved Layout-Driven Area-Constrained Timing Optimization by Net Buffering .....	97
<i>R. Murgai</i>	

## Session 1C: Embedded Systems

*Chairs: A. Basu and L. Benini*

## Papers

Battery Model for Embedded Systems .....	105
<i>V. Rao, G. Singhal, A. Kumar, and N. Navet</i>	
Rapid Embedded Hardware/Software System Generation.....	111
<i>J. Peddersen, S. Shee, A. Janapsatya, and S. Parameswaran</i>	
A Unified Architecture for Adaptive Compression of Data and Code on Embedded Systems.....	117
<i>H. Lekatsas, J. Henkel, V. Jakkula, and S. Chakradhar</i>	
A Heuristic for Peak Power Constrained Design of Network-on-Chip (NoC) Based Multimode Systems .....	124
<i>P. Bhojwani, R. Mahapatra, E. Kim, and T. Chen</i>	
A Low-Power Current-Mode Clock Distribution Scheme for Multi-GHz NoC-Based SoCs.....	130
<i>A. Narasimhan, S. Divekar, P. Elakkumanan, and R. Sridhar</i>	
Implementing LDPC Decoding on Network-on-Chip.....	134
<i>T. Theocharides, G. Link, N. Vijaykrishnan, and M. Irwin</i>	
A RISC Hardware Platform for Low Power Java .....	138
<i>P. Capewell and I. Watson</i>	

## Session 1D: Low Power

*Chairs: A. Devgan and J. Roychowdhury*

## Papers

A Low Power Reprogrammable Parallel Processing VLSI Architecture for Computation of B-Spline Based Medical Image Processing System for Fast Characterization of Tiny Objects Suspended in Cellular Fluid.....	147
<i>S. Mondal, A. De, and P. Biswas</i>	
Design of a Low Power Image Watermarking Encoder Using Dual Voltage and Frequency .....	153
<i>S. Mohanty, N. Ranganathan, and K. Balakrishnan</i>	
Level-Shifter Free Design of Low Power Dual Supply Voltage CMOS Circuits Using Dual Threshold Voltages .....	159
<i>A. Diril, Y. Dhillon, A. Chatterjee, and A. Singh</i>	
Accurate Stacking Effect Macro-Modeling of Leakage Power in Sub-100nm Circuits.....	165
<i>S. Yang, W. Wolf, N. Vijaykrishnan, Y. Xie, and W. Wang</i>	

Charge-Recovery Power Clock Generators for Adiabatic Logic Circuits .....	171
<i>M. Arsalan and M. Shams</i>	
Power Optimization in Current Mode Circuits .....	175
<i>M. Bhat and H. Jamadagni</i>	

### **Session 2A: Formal Verification**

*Chairs: S. Chakraborty and S. Shukla*

#### **Papers**

Lazy Constraints and SAT Heuristics for Proof-Based Abstraction .....	183
<i>A. Gupta, M. Ganai, and P. Ashar</i>	
Q-PREZ: QBF Evaluation Using Partition, Resolution and Elimination with ZBDDs .....	189
<i>K. Chandrasekar and M. Hsiao</i>	
A Verification System for Transient Response of Analog Circuits Using Model Checking .....	195
<i>T. Dastidar and P. Chakrabarti</i>	
Formal Methods for Analyzing the Completeness of an Assertion Suite against a High-Level Fault Model .....	201
<i>S. Das, A. Banerjee, P. Basu, P. Dasgupta, P. Chakrabarti, C. Mohan, and L. Fix</i>	
A Universal Random Test Generator for Functional Verification of Microprocessors and System-on-Chip .....	207
<i>K. Bhaskar, M. Prasanth, G. Chandramouli, and V. Kamakoti</i>	
Syntactic Transformation of Assume-Guarantee Assertions: From Sub-Modules to Modules .....	213
<i>P. Basu, P. Dasgupta, and P. Chakrabarti</i>	

### **Session 2B: Nanotechnology and Biochips**

*Chairs: P. Chakrabarti and S. Ramesh*

#### **Embedded Tutorial**

Design, Testing, and Applications of Digital Microfluidics-Based Biochips .....	221
<i>K. Chakrabarty</i>	

#### **Papers**

Synthesis of Majority and Minority Networks and Its Applications to QCA, TPL and SET Based Nanotechnologies.....	229
<i>R. Zhang, P. Gupta, and N. Jha</i>	
Design, Fabrication, Testing and Simulation of Porous Silicon Based Smart MEMS Pressure Sensor .....	235
<i>C. Pramanik, T. Islam, H. Saha, J. Bhattarcharya, S. Banerjee, and S. Dey</i>	
A Nanosensor Array-Based VLSI Gas Discriminator .....	241
<i>K. Irick, W. Xu, N. Vijaykrishnan, and M. Irwin</i>	



## **Session 2C: Synthesis I**

*Chairs: C. Ravikumar and B. Al-Hashimi*

### **Papers**

Synthesis of Reversible Circuits for Testing with Universal Test Set and C-Testability of Reversible Iterative Logic Arrays .....	249
<i>A. Chakraborty</i>	
Design of a Reversible Binary Coded Decimal Adder by Using Reversible 4-Bit Parallel Adder .....	255
<i>H. Babu and A. Chowdhury</i>	
Optimization of Mixed Logic Circuits with Application to a 64-Bit Static Adder .....	261
<i>Y. Wan and M. Shams</i>	
Behavioral Synthesis of Data-Dominated Circuits for Minimal Energy Implementation.....	267
<i>X. Tang, T. Jiang, A. Jones, and P. Banerjee</i>	
Integrated On-Chip Storage Evaluation in ASIP Synthesis .....	274
<i>M. Jain, M. Balakrishnan, and A. Kumar</i>	
Extracting Exact Finite State Machines from Behavioral SystemC Descriptions .....	280
<i>V. Saun and P. Panda</i>	

## **Session 2D: RF and Mixed Signal**

*Chairs: A. Patra and R. Joshi*

### **Papers**

A System-Level Alternate Test Approach for Specification Test of RF Transceivers in Loopback Mode .....	289
<i>A. Halder, S. Bhattacharya, G. Srinivasan, and A. Chatterjee</i>	
Effects of Technology and Dimensional Scaling on Input Loss Prediction of RF MOSFETs .....	295
<i>T. Das, C. Washburn, P. Mukund, S. Howard, K. Paradis, J.-G. Jang, J. Kolnik, and J. Burlison</i>	
Design of Multi-GHz Asynchronous Pipelined Circuits in MOS Current-Mode Logic.....	301
<i>T. Kwan and M. Shams</i>	
Design of Second-Order Sub-Bandgap Mixed-Mode Voltage Reference Circuit for Low Voltage Applications.....	307
<i>R. Paul, A. Patra, S. Baranwal, and K. Dash</i>	
A 160MSPS 8-Bit Pipeline Based ADC .....	313
<i>S. Halder, A. Ghosh, R. Prasad, A. Chatterjee, and S. Banerjee</i>	
A 10-Bit 80-MSPS 2.5-V 27.65-mW 0.185-mm <sup>2</sup> Segmented Current Steering CMOS DAC .....	319
<i>S. Halder, S. Banerjee, A. Ghosh, R. Prasad, A. Chatterjee, and S. Dey</i>	

### **Session 3A: Signal Integrity and Crosstalk**

*Chairs: S. Sapatnekar and S. Batterywala*

#### **Papers**

Active Noise Cancellation Using Aggressor-Aware Clamping Circuit for Robust On-Chip Communication.....	325
<i>A. Katoch, M. Meijer, and S. Jain</i>	
An Efficient Methodology for Noise Characterization.....	330
<i>G. Varshney and S. Chandrasekar</i>	
Application of DC Transfer Characteristics in the Elimination of Redundant Vectors for Transient Noise Characterization of Static CMOS Circuits.....	336
<i>S. Chandrasekar, V. Visvanathan, and G. Varshney</i>	
Crosstalk Noise Analysis at Multiple Frequencies .....	342
<i>S. Shrivastava and S. Chandrasekar</i>	
Worst-Case Crosstalk Noise Analysis Based on Dual-Exponential Noise Metrics .....	348
<i>J. Sun, Y. Zheng, Q. Ye, and T. Ye</i>	
ABCD Modeling of Crosstalk Coupling Noise to Analyze the Signal Integrity Losses on the Victim Interconnect in DSM Chips .....	354
<i>A. Palit, V. Meyer, W. Anheier, and J. Schloeffel</i>	

### **Session 3B: Process Variation**

*Chairs: D. Sharma and H. Saha*

#### **Papers**

Impact of Process Variations on Multi-Level Signaling for On-Chip Interconnects.....	362
<i>V. Venkatraman and W. Burlison</i>	
A Quasi-Delay-Insensitive Method to Overcome Transistor Variation .....	368
<i>C. Brej and J. Garside</i>	
Influence of Leakage Reduction Techniques on Delay/Leakage Uncertainty.....	374
<i>Y.-F. Tsai, N. Vijaykrishnan, Y. Xie, and M. Irwin</i>	
Multivariate Normal Distribution Based Statistical Timing Analysis Using Global Projection and Local Expansion .....	380
<i>B. Wang and P. Mazumder</i>	
Evaluation of Device Parameters of HfO <sub>2</sub> /SiO <sub>2</sub> /Si Gate Dielectric Stack for MOSFETs.....	386
<i>A. Madan, S. Bose, P. George, and C. Shekhar</i>	
Impact of Channel Engineering on Unity Gain Frequency and Noise-Figure in 90nm NMOS Transistor for RF Applications .....	392
<i>R. Srinivasan and N. Bhat</i>	

### **Session 3C: Design Methodology**

*Chairs: S. Chakradhar and C. Shekhar*

#### **Papers**

A Methodology and Tooling Enabling Application Specific Processor Design.....	399
<i>A. Hoffmann, F. Fiedler, A. Nohl, and S. Parupalli</i>	
An Efficient End to End Design of Rijndael Cryptosystem in 0.18 $\mu$ CMOS .....	405
<i>D. Mukhopadhyay and D. Roy Chowdhury</i>	
ADOPT: An Approach to Activity Based Delay Optimization .....	411
<i>G. Arora, A. Sharma, D. Nagchoudhury, and M. Balakrishnan</i>	
Coding for Reliable On-Chip Buses: Fundamental Limits and Practical Codes.....	417
<i>S. Sridhara and N. Shanbhag</i>	
False Path and Clock Scheduling Based Yield-Aware Gate Sizing .....	423
<i>J.-L. Tsai, D. Baik, C. Chen, and K. Saluja</i>	
Variable Resizing for Area Improvement in Behavioral Synthesis .....	427
<i>R. Gopalakrishnan and R. Moona</i>	

### **Session 3D: Placement and Routing**

*Chairs: B. Bhattacharya and S. Mehta*

#### **Papers**

Orthogonal Circuit Visualization Improved by Merging the Placement and Routing Phases.....	433
<i>T. Eschbach, W. Günther, and B. Becker</i>	
Lithography Driven Layout Design .....	439
<i>M. Garg, L. Le Cam, and M. Gonzalez</i>	
Non-Manhattan Routing Using a Manhattan Router .....	445
<i>E. Hursey, N. Jayakumar, and S. Khatri</i>	
Placement and Routing for 3D-FPGAs Using Reinforcement Learning and Support Vector Machines.....	451
<i>R. Manimegalai, E. Soumya, V. Muralidharan, B. Ravindran, V. Kamakoti, and D. Bhatia</i>	
Automatic Device Layout Generation for Analog Layout Retargeting .....	457
<i>R. Hartono, N. Jangkrajarn, S. Bhattacharya, and C.-J. Shi</i>	
Floorplan-Based Crosstalk Estimation for Macrocell-Based Designs .....	463
<i>S. Gupta, S. Katkooi, and H. Sankaran</i>	

### **Session 4A: Test II**

*Chairs: S. Reddy and G. Vidyasagar*

#### **Papers**

Distance Restricted Scan Chain Reordering to Enhance Delay Fault Coverage .....	471
<i>W. Li, S. Wang, S. Chakradhar, and S. Reddy</i>	

Novel Algorithm for Testing Crosstalk Induced Delay Faults in VLSI Circuits .....	479
<i>Aniket and R. Arunachalam</i>	
An Ultra-Fast, On-Chip BiST for RF Low Noise Amplifiers .....	485
<i>A. Gopalan, T. Das, C. Washburn, and P. Mukund</i>	
On Finding Consecutive Test Vectors in a Random Sequence for Energy-Aware BIST Design .....	491
<i>S. Zhang, S. Seth, and B. Bhattacharya</i>	
A Framework for Distributed and Hierarchical Design-for-Test .....	497
<i>C. Ravikumar, R. Dandamudi, V. Devanathan, N. Halder, K. Kiran, and P. Kumar</i>	
A Novel Specification Based Test Pattern Generation Using Genetic Algorithm and Wavelets .....	504
<i>P. Kalpana and K. Gunavathi</i>	

### **Session 4B: Analog**

*Chairs: A. Chatterjee and G. Visweswaran*

#### **Papers**

Programmable High Frequency RC Oscillator .....	511
<i>F. Bala and T. Nandy</i>	
Exact Analytical Equations for Predicting Nonlinear Phase Errors and Jitter in Ring Oscillators .....	516
<i>J. Roychowdhury</i>	
On-Chip Voltage Regulator with Improved Transient Response .....	522
<i>A. Maity, R. Raghavendra, and P. Mandal</i>	
An Active Learning Scheme Using Support Vector Machines for Analog Circuit Feasibility Classification .....	528
<i>M. Ding and R. Vemuri</i>	
A Hierarchical Cost Tree Mutation Approach to Optimization of Analog Circuits.....	535
<i>A. Somani, P. Chakrabarti, and A. Patra</i>	
A Wide-Swing $V_T$ -Referenced Circuit with Insensitivity to Device Mismatch .....	539
<i>C.-J. Yen, W.-Y. Chung, and M. Chi</i>	

### **Session 4C: Architecture**

*Chairs: B. Sinha and T. Mitra*

#### **Papers**

Dictionary Based Code Compression for Variable Length Instruction Encodings .....	545
<i>D. Das, R. Kumar, and P. Chakrabarti</i>	
Synthesis of Application-Specific Heterogeneous Multiprocessor Architectures Using Extensible Processors .....	551
<i>F. Sun, S. Ravi, A. Raghunathan, and N. Jha</i>	
Evaluation of Speed and Area of Clustered VLIW Processors .....	557
<i>A. Terechko, M. Garg, and H. Corporaal</i>	
A Technique for Throughput and Register Optimization during Resource Constrained Pipelined Scheduling.....	564
<i>N. Rangan and K. Chatha</i>	

Dynamically Exploiting Frequent Operand Values for Energy Efficiency in Integer Functional Units .....	570
<i>K. Gandhi and N. Mahapatra</i>	

#### **Session 4D: Power Estimation and Low Power Design**

*Chairs: P. Thadikaran and A. Tyagi*

##### **Papers**

Power Monitors: A Framework for System-Level Power Estimation Using Heterogeneous Power Models .....	579
<i>N. Bansal, K. Lahiri, A. Raghunathan, and S. Chakradhar</i>	
Estimation of Switching Activity in Sequential Circuits Using Dynamic Bayesian Networks.....	586
<i>S. Bhanja, K. Lingasubramanian, and N. Ranganathan</i>	
Energy-Efficient Compressed Address Transmission.....	592
<i>J. Liu, S. Sundaresan, and N. Mahapatra</i>	
Variable Input Delay CMOS Logic for Low Power Design .....	598
<i>T. Raja, V. Agrawal, and M. Bushnell</i>	
Gate Leakage and Its Reduction in Deep Submicron SRAM .....	606
<i>A. Goel and B. Mazhari</i>	

#### **Session 5A: Interconnect**

*Chairs: S. Zachariah and M. Desai*

##### **Embedded Tutorial**

Revisiting VLSI Interconnects in Deep Sub-Micron: Some Open Questions .....	615
<i>P. Dasgupta</i>	

##### **Papers**

ISIS: A Genetic Algorithm Based Technique for Custom On-Chip Interconnection Network Synthesis.....	623
<i>K. Srinivasan and K. Chatha</i>	
Projection Based Fast Passive Compact Macromodeling of High-Speed VLSI Circuits and Interconnects.....	629
<i>D. Saraswat, R. Achar, and M. Nakhla</i>	
A Low-Swing Differential Signaling Scheme for On-Chip Global Interconnects .....	634
<i>A. Narasimhan, M. Kasotiya, and R. Sridhar</i>	
Performances of Coupled Interconnect Lines: The Impact of Inductance and Routing Orientation .....	640
<i>D. Deschacht and A. Lopez</i>	

## **Session 5B: Synthesis II**

*Chairs: N. Dutt and P. Panda*

### **Papers**

On Physical-Aware Synthesis of Vertically Integrated 3D Systems.....	647
<i>M. Mukherjee and R. Vemuri</i>	
Energy Efficient Hardware Synthesis of Polynomial Expressions .....	653
<i>A. Hosangadi, F. Fallah, and R. Kastner</i>	
Algorithmic Implementation of Low-Power High Performance FIR Filtering IP Cores .....	659
<i>C. Wang, A. Erdogan, and T. Arslan</i>	
On-Line Synthesis for Partially Reconfigurable FPGAs.....	663
<i>R. Huang and R. Vemuri</i>	
A Combinational Logic Mapper for Actel's SX/AX Family .....	669
<i>S. Chattopadhyay and M. Dewangan</i>	
A Novel Approach to Minimizing Reconfiguration Cost for LUT-Based FPGAs.....	673
<i>K. Raghuraman, H. Wang, and S. Tragoudas</i>	

## **Session 5C: Power-Aware Design and Thermal Issues**

*Chairs: N. Jha and A. Pal*

### **Embedded Tutorial**

Power Variability and Its Impact on Design .....	679
<i>A. Devgan and S. Nassif</i>	

### **Papers**

An Accurate Energy and Thermal Model for Global Signal Buses .....	685
<i>K. Sundaresan and N. Mahapatra</i>	
Hot Spots and Zones in a Chip: A Geometrician's View .....	691
<i>S. Majumder, S. Sur-Kolay, S. Nandy, B. Bhattacharya, and B. Chakraborty</i>	
Direct Temperature Measurement for VLSI Circuits and 3-D Modeling of Self-Heating in Sub-0.13 $\mu\text{m}$ SOI Technologies .....	697
<i>R. Joshi, S. Kang, N. Zamdmir, A. Mocuta, C. Chuang, and J. Pascual-Gutiérrez</i>	

## **Session 5D: Technology**

*Chairs: S. Kathtik and S. Banerjee*

### **Embedded Tutorials**

DFM: Linking Design and Manufacturing .....	705
<i>S. Raghvendra and P. Hurat</i>	
The Impact of Inductance on Transients Affecting Gate Oxide Reliability .....	709
<i>Nagaraj NS, W. Hunter, P. Balsara, and C. Cantrell</i>	

### **Session 6A: Test III**

*Chairs: T. Chakraborty and R. Parekhji*

#### **Papers**

An Accurate Probabilistic Model for Error Detection.....	717
<i>T. Rejimon and S. Bhanja</i>	
Using Contrapositive Law in an Implication Graph to Identify Logic Redundancies .....	723
<i>K. Dave, V. Agrawal, and M. Bushnell</i>	
Off-Line Testing of Asynchronous Circuits.....	730
<i>D. Koppad, A. Bystrov, and A. Yakovlev</i>	
Detecting SEU-Caused Routing Errors in SRAM-Based FPGAs .....	736
<i>E. Reddy, V. Chandrasekhar, M. Sashikanth, V. Kamakoti, and N. Vijaykrishnan</i>	
Multiple Fault Testing of Logic Resources of SRAM-Based FPGAs.....	742
<i>S. Goyal, M. Choudhury, S. Rao, and K. Kumar</i>	

### **Session 6B: Algorithms and Applications**

*Chairs: P. Sengupta and M. Balakrishnan*

#### **Papers**

A Novel Bus Encoding Scheme from Energy and Crosstalk Efficiency Perspective for AMBA Based Generic SoC Systems .....	751
<i>Z. Khan, T. Arslan, and A. Erdogan</i>	
Application of Douglas-Peucker Algorithm to Generate Compact but Accurate IBIS Models .....	757
<i>G. Nandakumar, N. Patel, R. Reddy, and M. Kothandaraman</i>	
An Effective VHDL-AMS Simulation Algorithm with Event Partitioning.....	762
<i>H. Ghasemi and Z. Navabi</i>	
Application of Alpha Power Law Models to PLL Design Methodology.....	768
<i>B. Suresh, V. Visvanathan, R. Krishnan, and H. Jamadagni</i>	
Exploiting Radio Hierarchies for Power-Efficient Wireless Device Discovery and Connection Setup .....	774
<i>T. Pering, V. Raghunathan, and R. Want</i>	
Fully Integrated CMOS Frequency Synthesizer for ZigBee Applications.....	780
<i>S. Singh, T. Bhattacharyya, and A. Dutta</i>	

### **Session 6C: Poster Presentations**

*Chair: P. Nandy and P. Saha*

#### **Papers**

Computer Aided Test (CAT) Tool for Mixed Signal SOCs.....	787
<i>S. Banerjee, D. Mukhopadhyay, and D. Roy Chowdhury</i>	
A Novel Low Power 16X16 Content Addressable Memory Using PAL.....	791
<i>G. Bala and J. Perinbam</i>	

A Principal Component Neural Network-Based Face Recognition System and Its ASIC Implementation .....	795
<i>C. Prasanna, N. Sudha, and V. Kamakoti</i>	
Synthesis of Asynchronous Circuits Using Early Data Validity .....	799
<i>N. Gupta and D. Edwards</i>	
A Low Overhead High Speed Histogram Based Test Methodology for Analog Circuits and IP Cores.....	804
<i>S. Bahukudumbi and K. Bharath</i>	
A Methodology for Fast Vector Based Power Supply and Substrate Noise Analyses .....	808
<i>S. Debnath, J. Sukumar, and H. Udaykumar</i>	
An Operational Amplifier Model for Test Planning at Behavioral Level .....	812
<i>E. Romero, G. Peretti, and C. Marqués</i>	
Memory-Centric Motion Estimator .....	816
<i>A. Berić, R. Sethuraman, J. van Meerbergen, and G. de Haan</i>	
SCINDY: Logic Crosstalk Delay Fault Simulation in Sequential Circuits .....	820
<i>M. Phadoongsidhi and K. Saluja</i>	
A New Asymmetric Skewed Buffer Design for Runtime Leakage Power Reduction .....	824
<i>Y.-S. Lin and D. Sylvester</i>	
A Relative Comparative Based Datapath for Increasing Resolution in a Capacitive Fingerprint Sensor Chip .....	828
<i>M. Ojha, A. Anand, G. Visweswaran, and D. Nagchoudhuri</i>	
Applicability of General Purpose Processors to Network Applications .....	832
<i>M. Durbhakula</i>	
Power Switch Network Design for MTCMOS.....	836
<i>R. Vilangudipitchai and P. Balsara</i>	

### **Session 6D: Poster Presentations and Research Scholar Forum**

*Chair: N. Bhat and P. Mukherjee*

#### **Papers**

Structural Fault Diagnosis in Charge-Pump Based Phase-Locked Loops.....	842
<i>A. Medury, I. Carlson, A. Alvandpour, and J. Stensby</i>	
Dual-Edge Triggered Static Pulsed Flip-Flops.....	846
<i>A. Ghadiri and H. Mahmoodi</i>	
A New CMOS Current Conveyors based Translinear Loop for Log-Domain Circuit Design.....	850
<i>D. Dutta, W. Serdijn, S. Banerjee, and S. Gupta</i>	
A High Accuracy Bandgap Reference with Chopped Modulator to Compensate MOSFET Mismatch .....	854
<i>L.-X. Liu, Y.-T. Yang, and Z.-M. Zhu</i>	
A High-Efficiency, Dual-Mode, Dynamic, Buck-Boost Power Supply IC for Portable Applications .....	858
<i>B. Sahu and G. Rincón-Mora</i>	
Design Issues in Switched Capacitor Ladder Filters.....	862
<i>A. Basu and A. Dhar</i>	



ASIC Design of the Linearisation Circuit of a PTC Thermistor .....	866
<i>S. Roy Chowdhury, C. Pramanik, and H. Saha</i>	
A Reconfigurable Oscillator Topology for Dual-Band Operation.....	870
<i>T.-L. Hsieh and R. Gharpurey</i>	
Reducing Leakage with Mixed- $V_{th}$ (MVT).....	874
<i>F. Sill, F. Grassert, and D. Timmermann</i>	
System in a Package Design of a RF Front End System Using Application Specific Reduced Order Models .....	878
<i>G. Nayak, C. Washburn, and P. Mukund</i>	
<b>Author Index</b> .....	<b>883</b>

## Message from the General Chairs



**Sandip Kundu**



**Partha Pratim Das**

It is a great privilege to welcome you to Kolkata for the joint 18<sup>th</sup> International Conference on VLSI Design and 4<sup>th</sup> International Conference on Embedded Systems. As a premier event, the conference packs a three-day technical program with plenary sessions, technical presentations, panel discussions, embedded tutorials followed by two days of tutorials.

The joint conference is a multidisciplinary event with the objective of fostering interaction between system architecture, logic and circuit design and device fabric domains. Design automation has been a traditional theme at this conference. Embedded systems design, rapid prototyping and embedded software design run as a parallel theme at this event. Conference tracks have been organized around these themes.

This year's major theme of the conference is *Power-aware Design of VLSI Systems*. Demand for power-aware designs is driven by the need for lower power mobile devices as well as high power systems where performance has to be traded with the cost of cooling. Given the exploding market demand in both of these segments, *power-aware design of VLSI systems* is a highly relevant topic today.

VLSI design conference has a proud tradition of bringing together top researchers from the academic institutions, research laboratories and high-technology companies from all over the world. This year is no exception. For 2005, the conference received 352 paper submissions from 25 countries. Of the 352 papers originally submitted to the conference, the program committee selected 97 regular papers (28%), 16 short papers (4.5%) and 24 poster papers (6.8%). Tutorials are a popular feature of this conference. This year 21 tutorial proposals were received, of which 6 were chosen for full day presentations and 4 for half day presentations.

In recognition of growing reputation of this conference, IEE proceedings on Computer and Digital techniques is planning a special issue on this edition of the conference. Beginning this year, the Design Automation Conference executive committee has designated sister conference status to this conference.

This year, the conference features several luminaries from industry and academia as keynote speakers. On Monday, Prof. C. L. Liu will deliver the opening keynote, "The High Walls have Crumpled". Dr. Alan Naumann, CEO of CoWare Incorporated and Dr. Ted Vucurevich,

CTO of Cadence Design Systems are Tuesday morning keynote speakers. Dr. Walden Rhines, CEO of Mentor Graphics Corporation will deliver a banquet speech on Tuesday evening. Shekhar Borkar, an Intel Fellow, is the featured speaker on Wednesday morning.

The conference is co-sponsored by VLSI Society of India, IEEE Circuits and Systems Society, IEEE Solid State Circuits Society, IEEE Electron Devices Society, ACM SIGDA.

The conference is an excellent venue for networking. Coffee breaks throughout the day provide opportunity for informal networking. A separate track is dedicated to Industry Forum. What better way to exchange ideas and forge friendship with peers across the industry?

We would be remiss without a few words about the host city. Kolkata is well known for its rich cultural and literary traditions and continues to attract writers and artists from all over the world. For those of you, who have traveled great distances to come to this conference, we will certainly recommend you to venture out to experience the color and vitality of this city first hand!

The conference is a product of hard work by many volunteers who have freely given their time, planning for this event to come together. First and foremost, we thank Prof. Vishwani Agrawal, the steering committee chair, for providing the vision and being the inspiration behind the conference from year to year. Our sincere gratitude goes to the technical program co-chairs, Prof. Susmita Sur-Kolay and Prof. Kaushik Roy who worked diligently throughout the year starting with call for papers, assembling a world class technical program committee, managing an on-time review process and working through the details of the final program. We thank Prof. Rana Dattagupta, chair of the organizing committee for local arrangements and Prof. Sivaji Chakravorti, the vice chair, for his able assistance. The tutorial chairs Prof. Parthasarathi Dasgupta and Prof. Krishnendu Chakrabarty, special session and panels chairs Prof. Debesh K. Das and Prof. Pallab Dasgupta, industry forum chairs Dr. Sudipta Bhawmik and Dr. Pradip Dutta, publication chair Dr. Srimat Chakradhar, fellowship chair Prof. Susanta Sen, design contest chairs Dr. Raj Sekhar Mitra and Prof. Biplab Sikdar, publicity chairs Prof. Susanta Chakraborty, Prof. Kewal Saluja, Prof. Atsushi Takahashi and Prof. Paul Molitor deserve special recognition for their efforts. We also thank our ACM/SIGDA liaison Prof. Sharad Seth, IEEE liaison Prof. N. Ranganathan and VSI liaison Dr. Biswadeep Mitra for obtaining society sponsorships. We cannot thank enough our exhibit and sponsorship chairs Dr. C. P. Ravikumar and Dr. Partha Ray for their diligent handling of exhibitors and sponsors. Special recognition is also due to our finance chair Nand G. Chattopadhyay, who was instrumental in every operational aspect of the conference including legal contracts with conference hotel and other suppliers. The organization of the conference hinged critically on the professional services of the event managers, the New Wave Display Services (P) Ltd. The support provided by their representatives Rex Anthony and Soumen Bose have been pivotal for us. Ashis Auddy did not hold any office but made himself available for anything that needed attention to details – especially contributing to every aspect of esthetic designs. Gautam Das and Subhra Lahiri helped manage the Conference website. We thank them all. We also thank the student volunteers, technical program committee and local organizing committee members for making this event a success. The conference is critically dependent on services of volunteers. If you are interested in volunteering in coming years, conference organizers are eager to hear from you. The conference needs constant infusion of people and ideas to sustain its growth and stay in tune with times.

A conference of this magnitude cannot be held without generous support from our industrial partners. We gratefully acknowledge Cadence Design Systems, Intel Corporation, Mentor Graphics, Synopsys, Texas Instruments, Centillium Communications, CoWare, Infineon,

National Semiconductor, Tensilica, Virage Logic, CG-CoreEI, IBM, Interra Systems, LogicVision, Mechantronics Test Equipment, nSys, eInfoChips, Open-Silicon and Trident TechLabs for their financial support. Many others have also expressed their intention to support the Conference. We thank them in advance. We thank all our authors, reviewers, speakers and session chairs for making VLSI Design Conference and Embedded Systems Conference, premier events in their respective fields. Lastly, a special word of thanks to all of you, our conference attendees! We have worked hard to bring you a substantive technical program as well as providing a forum for informal exchanges. We wish you a productive, informative and enjoyable conference experience.

October 11, 2004

**Sandip Kundu**, General Co-Chair  
**Partha Pratim Das**, General Co-Chair

## Message from the Program Chairs



**Susmita Sur-Kolay**



**Kaushik Roy**

Welcome to the 18<sup>th</sup> International Conference on VLSI Design and the 4<sup>th</sup> International Conference on Embedded Systems!

The degree of scaling in VLSI technology and ever increasing integration density have led to unprecedented levels of power dissipation in current day VLSI circuits, and possibly creating a barrier to further scaling and integration unless effective design techniques are developed to reduce power. Aply, the theme of the conference this year is power-aware design and several papers address this problem at various levels of design abstraction – from devices to circuits and architecture.

VLSI Design '05 will provide an excellent forum for students, researchers and other professionals to present and discuss various state-of-the-art of VLSI Design and Embedded Systems issues including synthesis, testing, EDA tools, mixed signal design and architecture with emphasis low power design. With technical co-sponsorship from IEEE CASS, SSCS and EDS and ACM SIGDA, we received a record number of 352 submissions from researchers located in 25 countries. Of these, there were 52 proposals for embedded tutorials. The increasing popularity and importance of this conference around the globe has led to its recognition as a Sister Conference by the Design Automation Conference (DAC) Committee.

For the first time in the history of the VLSI Design Conference, the notion of tracks was introduced to enable better processing of the wide range of topics. The three tracks, with two track chairs per track, were on Design Methods, Design Tools and Embedded Systems. We wish to express our sincere thanks to the track chairs: Prof. Navakant Bhat, Dr. Rajiv Joshi, Prof. Sachin Sapatnekar, Dr. Alok Kumar, Prof. Nikil Dutt and Prof. S. Ramesh. Once again web-based submission and review process employed DOCMAN, a document management system which was developed for this conference in 2001 by Dr. Srimat Chakradhar. The papers and embedded tutorial proposals were reviewed by an international pool of reviewers, which primarily included a 75-member strong program committee (PC), consisting of top VLSI experts from all over the world.

In keeping with tradition, paper selection for the final program was done in two phases of program committee meetings: the first one was held in USA and the second one in India. Teleconferencing and emails were used to exchange opinion and decisions between the two committees in order to ensure uniformity of the paper selection process. Based on the views of the referees and the PC members, the decision on selection of the papers was finalized

unanimously from both ends. We were able to accept 97 regular papers, 16 short papers and 23 posters, along with 5 embedded tutorials. Unfortunately, due to conference size limitations, many good papers had to be rejected. Eight of the selected papers were nominated for the Best Paper award. Four of these eight papers were also nominated for the Best Student Paper award. A blue-ribbon international panel reviewed the candidate papers, and ranked them against each other. The panel members were chosen on the basis of their outstanding contributions to the area of VLSI Design and CAD, with the requirement that none of them had submitted papers to VLSI Design '05.

The program also includes four keynote addresses, four invited plenary talks, one banquet speech, and a panel discussion by eminent experts in the industry. An excellent industry forum program with vendor presentations and panel discussions has been put together by Dr. Pradip Dutta and Dr. Sudipto Bhawmik. Owing to the outstanding work of the tutorial chairs, Prof. Partha Sarathi Dasgupta and Prof. Krishnenedu Chakrabarti, we have an excellent program of seven full-day tutorials and two half-day tutorials to be presented in four parallel tracks over two days following the conference. The tutorials were selected from 21 submissions after careful review.

On behalf of the 2005 Program Committee, we thank all the reviewers, the volunteers of the program committee, the awards panel of judges, the conference steering committee, and the authors. In particular, we wish to thank Vishwani Agrawal, whose guidance and involvement continue to be invaluable resources behind the success of this conference. We wish to thank publication chair, Srimat Chakradhar of NEC, for this arduous task of managing all the camera-ready manuscripts, and Jeniferdawn Cantarella of IEEE Computer Society Press for her assistance in printing the proceedings. Our special thanks go to Dr. C. P. Ravikumar of Texas Instruments, Bangalore, Dr. Rob Roy of Zenasis Technologies USA for their support, and to Professor M. Bushnell of Rutgers University for hosting program committee meetings with teleconferencing between two committees. We are highly indebted to the general chairs, Partha Pratim Das and Sandip Kundu, and organizing chair, Prof. Rana Dattagupta, for providing the infrastructure and financial support necessary for running the conference. Special thanks are due to Prof. P. P. Chakrabarti, Prof. Pallab Dasgupta of IIT Kharagpur, Prof. Debesh Das of Jadavpur University, Dr. S. C. Nandy of ISI Kolkata. Grateful acknowledgement is also due to of Pritha Banerjee, Debasis Mitra, Sambhu Pradhan, Suchandra Roy Bagchi, Pramita Chakraborty of ISI, Swarup Bhunia of Purdue University and Soumen Bose of New Wave for their help with the many facets of the program committee. Finally, we would like to express our gratitude for the invaluable support provided by Interra Systems Kolkata; the Indian Statistical Institute, Calcutta; Rutgers University, NEC USA; and Purdue University.

We are certain that you will have an extremely fruitful experience while attending this joint Conference. We hope that you continue to participate in the International Conference on VLSI Design and Embedded Systems. Your comments and suggestions for further improvement in this will be greatly appreciated.

May you enjoy the cultural panorama of India during your stay in and around this historic city of Kolkata which has been a haven for world-famous scientists, philosophers and artists!

***Kaushik Roy***  
***Susmita Sur-Kolay***

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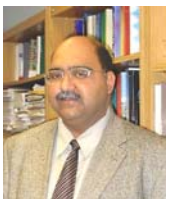
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# VLSI Design 2004 Conference Awards

## Technical Paper Awards

### **Arun Kumar Choudhury Best Paper Award (Tie)**

“Gate Sizing and Buffer Insertion Using Economic Models for Power Optimization”

Ashok K. Murugavel and N. Ranganathan  
*University of South Florida*

“Design of RF Tuner for Cable Modem Applications”

V. Veeresh Babu, Sumantra Seth, and A. N. Chandorkar  
*IIT Bombay*

### **Nripendra Nath Biswas Best Student Paper**

“Static Timing Analysis of Irreversible Crosstalk Noise Pulse Faults”

Marong Phadoongsidhi and Kewal K. Saluja  
*University of Wisconsin, Madison*

## Design Contest Awards

“Katha Mala: A Voice Output Communication Aid for Children  
with Severe Speech and Multiple Disorders”

Arijit Mukhopadhyay, Pratik Worah, Susmit Biswas, Saptarshi Biswas,  
Ramasish Das, and Anupam Basu

“High Speed Optoelectronic Receivers in Si-Ge”

Amit Gupta, Steven P. Levitan, Leo Selavao, and Donald M. Chirarulli

## Reviewers

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Emrah Acar  
Thorsten Adler  
Amit Agarwal  
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Ashish Ghosh  
Dipnarayan Guha  
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Pallav Gupta  
Rajesh Gupta  
Sumit Gupta  
Andreas Hoffmann  
Xianlong Hong  
Ralf Huuck

Paolo lenne  
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Vikram Iyengar  
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Srinivas Katkooori  
Atul Katoch  
Sunil P. Khatri  
Keunwoo Kim  
Inge Koch  
Peter Kollig  
Deepali B. Koppad  
Srinath Krishnan  
Alok Kumar  
Mamidala Jagadesh Kumar  
Shashi Kumar  
Sandip Kundu  
Tadahiro Kuroda  
Kanishka Lahiri  
Haris Lekatsas  
Peng Li  
Rung-Bin Lin  
Yuan Lu  
Patrick H. Madden  
Nihar R. Mahapatra  
Hamid Mahmoudi  
Subhamoy Maitra  
Subhashis Majumder  
Chittaranjan A. Mandal  
Ion Mandoiu  
Erik Jan Marinissen  
Leo Mathew  
Peter Mattson  
Dan Mazor  
Mahesh M. Mehendale  
Shashank Kantilal Mehta  
Vinod Menezes  
Marius Minea  
Prabhat Mishra  
Durga Misra  
Debasis Mitra  
Mandar Mitra

S. Mitra  
Raj S. Mitra  
Subhasish Mitra  
Tulika Mitra  
Chunduri Rama Mohan  
Saraju P. Mohanty  
Paul Louis Molitor  
Rajat Moona  
Anandshankar S. Mudlapur  
A. Mukherjee  
Nilanjan Mukherjee  
Prosit Mukherjee  
Tamal Mukherjee  
Debdeep Mukhopadhyay  
S. Mukhopadhyay  
Saibal Mukhopadhaya  
P. R. Mukund  
Sudha N.  
Krishnendu Mukhopadhyay  
Nagi Naganathan  
Dipankar Nagchoudhuri  
Deleep R. Nair  
Prasanta Kumar Nandi  
Sukumar Nandi  
Soumitra Kumar Nandy  
Takashi Nanya  
Sreedhar Natarajan  
Venkatesh Natarajan  
Zainalabedin Navabi  
Nicolas Navet  
Dan Nicolaescu  
Pavel V. Nikitin  
Saeid Nooshabadi  
Adrian Nunez  
Albert Nymeyer  
Hidetoshi Onodera  
Arjun K. Pai  
Ajit Pal  
N. R. Pal  
Ajoy K. Palit  
Preeti Ranjan Panda  
Partha Pratim Pande  
Rohit Pandey  
Davide Pandini  
Sri Parameswaran  
Rubin A. Parekhji  
Pankaj Pathak  
Amit Patra  
Kolin Paul  
Bipul C. Paul  
Shanthy Pavan

Jim F. Plusquellic  
Irith Pomeranz  
Suresh P. R.  
Nachiketa Prachanda  
Vani Prasad  
Anand Raghunathan  
Hafizur Rahaman  
Rajesh Raina  
Sanjay Rajopadhye  
Krithivasan Ramamritham  
N. Ranganathan  
S.S.S. P. Rao  
Ramgopal Rao  
Paruj Ratanaworabhan  
C. P. Ravikumar  
Partha Ray  
Arijit Raychowdhury  
Sudhakar M. Reddy  
Marly Roncken  
Subir Kumar Roy  
Rob (Rabindra) K. Roy  
Margaret Marek Sadowska  
Anidya Saha  
Hiranmay Saha  
Kaushik Saha  
Prakash Ranjan Sahay  
Kewal K. Saluja  
Gagandeep Sandha  
Sachin S. Sapatnekar  
Dharmendra Saraswat  
Subir Kumar Sarkar  
Majid Sarrafzadeh  
Prashant Saxena  
Susanta Sen  
Indranil Sengupta  
Sharad C. Seth  
Ramesh Sethu  
Rajamani Sethuram  
Alena Shamsheeva  
Li Shang  
Dinesh Sharma  
Seng Lin Shee  
Sandeep K. Shukla

Adit D. Singh  
Arani Sinha  
Mani Soma  
Abhishek Somani  
Peilin Song  
Arcot Sowmya  
Ramalingam Sridhar  
Rajagopalan Srinivasan  
S. Srinivasan  
Ashok Srivastava  
Kenneth S. Stevens  
Dirk Stroobandt  
Charles E. Stroud  
Savithri Sundareswaran  
Susmita Sur-Kolay  
Andrei Sergeevich Terechko  
Hiroyuki Tomiyama  
Raghuram S. Tupuri  
Akhilesh Tyagi  
Noppanunt Utamaphethai  
Keith Vallerio  
Dirk Van Compernelle  
Fabian Vargas  
Kuruvilla Varghese  
Kamakoti Veezhinathan  
Miroslav N. Velez  
Hari Vijay Venkatanarayanan  
Raguraman Venkatesan  
G. S. Visweswaran  
Wayne Wolf  
Martin D.F. Wong  
Jiang Xu  
Kiat Seng Yeo  
Tomohiro Yoneda  
Hoi-Jun Yoo  
Baozhen Yu  
Sujit T. Zachariah  
Yong Zhan  
Junwu Zhang  
Tong Zhang  
Rui Zhang

## VLSI Design Conference History

Meeting Sequence	Place	Dates	Number of Papers	Number of Posters	Number of Tutorials	Proceedings Pages
<b>First</b>	Madras, India	Dec. 26-28, 1985	29	0	1	193
<b>Second</b>	Bangalore, India	Dec. 15-18, 1988	26	21	4	496
<b>Third</b>	Bangalore, India	Jan. 6-9, 1990	30	22	4	390
<b>Fourth</b>	New Delhi, India	Jan. 4-8, 1991	45	16	9	315
<b>Fifth</b>	Bangalore, India	Jan. 4-7, 1992	57	24	4	378
<b>Sixth</b>	Bombay, India	Jan. 3-6, 1993	70	9	6	371
<b>Seventh</b>	Calcutta, India	Jan. 5-8, 1994	87	0	6	448
<b>Eighth</b>	New Delhi, India	Jan. 4-7, 1995	77	6	6	456
<b>Ninth</b>	Bangalore, India	Jan. 3-6, 1996	75	16	6	480
<b>Tenth</b>	Hyderabad, India	Jan. 4-7, 1997	84	18	6	608
<b>Eleventh</b>	Chennai, India	Jan. 4-7, 1998	98	0	6	624
<b>Twelfth</b>	Goa, India	Jan. 7-10, 1999	103	0	6	682
<b>Thirteenth</b>	Calcutta, India	Jan. 3-7, 2000	93	0	6	590
<b>Fourteenth</b>	Bangalore, India	Jan. 3-7, 2001	77	0	9	592
<b>Fifteenth</b>	Bangalore, India	Jan. 7-11, 2002	109	0	8	834
<b>Sixteenth</b>	New Delhi, India	Jan. 4-8, 2003	84	0	6	622
<b>Seventeenth</b>	Mumbai, India	Jan. 5-9, 2004	120	44	8	1132
<b>Eighteenth</b>	Kolkata, India	Jan. 3-7, 2005				922



## Workshop on Embedded Systems Design: History

Meeting Sequence	Place	Dates	Number of Papers	Number of Speakers	Proceedings Pages
First	New Delhi, India	Jan. 2-4, 2002	8	8	70
Second	New Delhi, India	Jan. 4-8, 2003	84	84	622
Third	Mumbai, India	Jan. 5-9, 2004	120	120	1132
Fourth	Kolkata, India	Jan. 3-7, 2005			922