

Proceedings of the
IEEE 1987
CUSTOM INTEGRATED CIRCUITS
CONFERENCE



TN 4-53

C987

1987

3964395



Proceedings of the IEEE 1987 CUSTOM INTEGRATED CIRCUITS CONFERENCE



**The Portland Hilton
Portland, Oregon
Educational Sessions
The Westin Benson**

May 4-7, 1987



E8964395

The CICC '87 is sponsored by the IEEE Electron Devices Society, the IEEE Solid-State Circuits Council, and co-sponsored by the IEEE Rochester Section. Its aim is to bring together designers, producers, and users of custom ICs to discuss recent developments and future directions in custom integrated circuits.

87CH2430-7

Papers have been printed without editing as received from the authors.

All opinions expressed in the Digest are those of the authors and are not binding on The Institute of Electrical & Electronics Engineers, Inc.

Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 29 Congress St., Salem, MA 01970. Instructors are permitted to photocopy isolated articles for noncommercial classroom use without fee. For other copying, reprint or republication permission, write to Director, Publishing Services, IEEE, 345 E. 47 St., New York, NY 10017. All rights reserved. Copyright © 1987 by The Institute of Electrical and Electronics Engineers, Inc.

Additional copies may be ordered from
IEEE Order Dept.
445 Hoes Lane
Piscataway, NJ 08854

IEEE Catalog No. 87CH2430-7
Library of Congress Catalog Card No. 85-653738

INTRODUCTION TO CICC '87

We are pleased to welcome you to Portland for the 1987 Custom Integrated Circuits Conference. This is the ninth anniversary of the conference and the second time it is being held in Portland. The conference, in future years, will continue to alternate between East and West Coast sites.

This past year has seen many advances within the Custom Integrated Circuit industry. The newest innovations in design methodologies, circuit simulation, fabrication technology, packaging, testing, reliability, and custom applications are reported in the technical sessions. The conference maintains its strong international character with paper submissions from ten countries. The technical program has been expanded to include 24 sessions in order to adequately cover the variety of topics which are relevant to custom integrated circuits. An additional session has been added, in which newly available commercial offerings of interest to the attendees will be previewed. This session will be held on Monday evening. Author interview sessions will be held from 5:00 until 6:00 each evening and will provide an opportunity to discuss in greater depth those points of interest raised during the presentations.

The keynote speaker this year is Andy Rappaport, President of Technology Research Group. Andy will open the conference with a presentation entitled "The Custom IC Business is Dead, Long Live Custom ICs," in which he will examine the technical and economic factors which are shaping the custom integrated circuit industry.

A continuing strength of the CICC is the closely coupled vendor participation. Exhibits are selected which allow the conference attendees to view the current equipment and tools available for the design and manufacture of custom ICs. This year, the exhibit area has been expanded to accommodate a greater variety of custom IC vendors, workstation manufacturers, CAD tool demonstrations, and other state-of-the-art equipment displays.

Several additional events have been scheduled to augment the technical program. A reception will be held Tuesday evening at the Westin Benson, featuring an international buffet. The Wednesday luncheon speaker is Kyle Fairchild of the Lyndon B. Johnson Space Center, who will speak on the future of space colonization. Three evening panel sessions will be held on Wednesday night dealing with layout tools and methodologies, front-end trade-offs in ASIC chip design, and packaging high performance VLSI functions. The educational sessions which complement the conference proceedings are scheduled to precede the technical program. A number of new speakers and topics have been added to serve the needs of engineers and scientists eager to know more about custom integrated circuits.

We wish to express our thanks to the members of the Technical Program Committee for their hard work and to the authors for the quality of their contributions. Special recognition goes to the conference coordinator Laura Silzars and executive secretary Bobbie Kaspar and the conference staff for their demonstrated excellence in handling all of the organizational details of the conference.

In 1988, CICC will celebrate its tenth anniversary in Rochester, New York.



Tom G. Foxall
General Chairman



Richard W. Bryant
Conference Chairman



Raymond A. Milano
Technical Program Chairman



STEERING COMMITTEE

Richard W. Bryant
Ford Microelectronics, Inc.
Savvas G. Chamberlain
University of Waterloo
Tom G. Foxall
Pacific Microcircuits Ltd.
Lynn F. Fuller
Rochester Institute of Technology

Andras I. Lakatos
Xerox Corporation
David M. Lewis
Eastman Kodak Company
Raymond A. Milano
Vitesse Electronics Corporation
Aris K. Silzars
Tektronix, Inc.

ORGANIZING COMMITTEE

GENERAL CHAIRMAN

Tom G. Foxall
Pacific Microcircuits Ltd.
White Rock, B.C. Canada

CONFERENCE CHAIRMAN

Richard W. Bryant
Ford Microelectronics, Inc.
Colorado Springs, CO

TECHNICAL PROGRAM

Raymond A. Milano
Vitesse Electronics Corp.
Carmarillo, CA

EXHIBITS

Aris K. Silzars
Tektronix, Inc.
Beaverton, OR

EDUCATIONAL SESSIONS

Samuel N. Stevens
Purdue University
West Lafayette, IN

CONFERENCE COORDINATOR

Laura A. H. Silzars
Convention Coordinating
Portland, OR

EXECUTIVE SECRETARY

Roberta Kaspar
Rochester, NY

TREASURER

Constantine Anagnostopoulos
Eastman Kodak Company
Rochester, NY

TECHNICAL PROGRAM COMMITTEE

Abdel-Aty-Zohdy, H.S., Oakland Univ., Rochester, MI
 Allen, J., M.I.T., Cambridge, MA
 Anagnostopoulos, C.N. Eastman Kodak Co., Rochester, NY
 Au, K., Motorola, Austin, TX
 Barber, D., Linear Technology, Inc., Burlington, Ontario, Canada
 Barnes, J., Thomson Components-Mostek Corp., Carrollton, TX
 Black, D., VLSI Microsystems, Inc., Colorado Springs, CO
 Brown, D.E., Mitel Corp., Kanata, Ontario, Canada
 Bryant, R.W., Ford Microelectronics, Inc., Colorado Springs, CO
 Buurma, J., G.E. Semiconductor, Research Triangle Park, NC
 Chamberlain, S.G., Univ. of Waterloo, Waterloo, Ontario, Canada
 Chiao, S.H., San Jose State Univ., San Jose, CA
 Christopher, L., RCA Labs, Hopewell, NJ
 Daly, D.F., Bell Communications Research Inc., Morristown, NJ
 Deyhimi, I., Vitesse Electronics Corp., Camarillo, CA
 Erdelyi, C.K., IBM General Technology Div., Essex Junction, VT
 Foxall, T., Pacific Microcircuits Ltd., White Rock, B.C., Canada
 Fuller, L.F., Rochester Institute of Technology, Rochester, NY
 Goodman, A.L., ATEQ Corp., Beaverton, OR
 Grebene, A.B., ABG Associates, Saratoga, CA
 Hao, S., Rockwell International, Newport Beach, CA
 Hartranft, M.D., Cypress Semiconductor, San Jose, CA
 Hollabaugh, M., AMCC, San Diego, CA
 Horowitz, M., Stanford Univ., Stanford, CA
 Huang, J.S.T., Honeywell Inc., Plymouth, MN
 Jerdonek, R.T., General Electric Co., Schenectady, NY
 Jungo, C., Intern. Microelectronic Products, San Jose, CA
 Kelly, T.M., Eastman Kodak Co., Rochester, NY
 King, M., Northern Telecom Electronics, Ottawa, Ontario, Canada
 Kohyama, S., Toshiba Corp., Kawasaki, Japan
 Lakatos, A., Xerox Corp., Webster, NY

Law, H-F.S., SDA Systems, Santa Clara, CA
 Ledenbach, G.W., Intel Corp., Folsom, CA
 Lewis, D.M., Eastman Kodak Co., Rochester, NY
 Lipman, J., VLSI Technology, Inc., San Jose, CA
 Lloyd, P., AT&T Bell Laboratories, Allentown, PA
 Milano, R.A., Vitesse Electronics Corp., Camarillo, CA
 Moon, M., Intel Corp., Beaverton, OR
 Perkins, D., TriQuint Semiconductor, Hillsboro, OR
 Pope, M., Tektronix, Inc., Beaverton, OR
 Quigley, S.R., IBM, Poughkeepsie, NY
 Rasmussen, R., LSI Logic, Milpitas, CA
 Sangiovanni-Vincentelli, A., Univ. of California, Berkeley, CA
 Scalf, H.L., Gould - AMI Semiconductors, Pocatello, ID
 Sideris, T., Ford Microelectronics, Inc., Colorado Springs, CO
 Silzars, A.K., Tektronix, Inc., Beaverton, OR
 Stevens, S.N., Purdue Univ., West Lafayette, IN
 Tandon, J.C., Xerox Corp., Webster, NY
 Trotter, J.D., Mississippi State, MS
 Venkateswaran, K., VLSI Design Associates, Inc., Campbell, CA
 Vincent, W.A., Delco Electronics, Kokomo, IN
 Wayne, D., Micro-Rel, Tempe, AZ
 Yassa, F.F., General Electric Co., Schenectady, NY
 Zeitzoff, P.M., AT&T Bell Laboratories, Allentown, PA

Overseas advisors

DeClerck, G.J., IMEC, Leuven, Belgium
 Hoefflinger, B., Inst. for Microelectronics, Stuttgart, West Germany
 Milne, A.D., Wolfson Microelectronics Ltd., Edinburgh, Scotland
 Sasaki, H., NEC Corp., Kawasaki, Kanagawa, Japan
 Shenton, G., IMP Europe, Ltd., Swindon, England
 Sugano, T., The Univ. of Tokyo, Tokyo, Japan



Technical Program Committee (Left to Right): ROW 1 (Seated)—D.F. Daly, A. Lakatos, D.M. Lewis, A.K. Silzars, R.A. Milano, R.W. Bryant, L.F. Fuller, C.N. Anagnostopoulos, C.W. Ledenbach, T.M. Kelly. ROW 2: P. Lloyd, F. Yassa, J.C. Tandon, J. Allen, H-F.S. Law, H.L. Scalf, R. Kaspar (executive secretary), L.A.H. Silzars (conference coordinator), R. Rasmussen, M. Hollabaugh, M.D. Hartranft, L. Christopher, K. Venkateswaran. ROW 3: S.R. Quigley, D.E. Brown, S. Kohyama, D. Wayne, A.B. Grebene, M. King, H.S. Abdel-Aty-Zohdy, P.M. Zeitzoff, J.S.T. Huang, J. Lipman, W.A. Vincent. ROW 4: S.H. Chiao, J. Buurma, J. Barnes, D. Perkins, D. Barber, C.K. Erdelyi, M. Moon, R.T. Jerdonek, S.N. Stevens, T. Sideris, K. Au, S. Hao, C. Jungo. (Not Shown: D. Black, S.G. Chamberlain, G.J. DeClerck (overseas advisor), I. Deyhimi, T. Foxall, A.L. Goodman, B. Hoefflinger (overseas advisor), M. Horowitz, A.D. Milne (overseas advisor), M. Pope, A. Sangiovanni-Vincentelli, H. Sasaki (overseas advisor), G. Shenton (overseas advisor), T. Sugano (overseas advisor), J.D. Trotter

EDUCATIONAL SESSIONS

Monday, May 4, 1987

**Westin Benson
Portland, Oregon**

**Samuel N. Stevens
Purdue University
West Lafayette, Indiana**

The Custom Integrated Circuits Conference will continue the educational sessions that have been so successful in the past. The purpose of these sessions is to provide an introduction to a broad range of topics which are fundamental to custom integrated circuits. These sessions are intended to be introductory in nature and will be taught at the senior undergraduate/first year graduate student level.

SESSION 1—IC FABRICATION AND DESIGN

- | | | |
|------|--|---------------|
| E1.1 | VLSI Fabrication Technologies
Marc D. Hartranft, Cypress Semiconductor | 8:00–9:50 am |
| E1.2 | Analog Bipolar IC Design
Gerold W. Neudeck, Purdue University | 10:10–12 noon |
| E1.3 | Analog MOS IC Design
David Wayne, Micor-Rel | 1:00–2:50 pm |
| E1.4 | GaAs Technology and Design Principles
Ira Deyhimy, Vitesse Electronics Corp. | 3:10–5:00 pm |

SESSION 2—DESIGN METHODOLOGIES AND TOOLS

- | | | |
|------|---|---------------|
| E2.1 | Custom ICs—Design Techniques and Tradeoffs
Russ Zinger, TRW LSI Products | 8:00–9:50 am |
| E2.2 | Simulation Tools for Custom IC Design
Mike Lightner, University of Colorado | 10:10–12 noon |
| E2.3 | Custom ICs—A Design Casebook
Andy Rappaport, Technology Research Group | 1:00–2:50 pm |
| E2.4 | Synthesis and Silicon Compilation
Alice Parker, University of Southern California | 3:10–5:00 pm |

CONFERENCE OVERVIEW

The Portland Hilton					Music Box Theatre
Lobby		State Room	Rose Room	Pavillon	
MONDAY, MAY 4					
EDUCATIONAL SESSIONS — The Westin Benson Hotel					
MONDAY, MAY 4					
6-9	Registration	New Custom Products...			
TUESDAY, MAY 5					
7-8	Registration				
8-9					
9-10		Opening/Keynote			
10-11		Module Generators I	Architectural Develop. for CMOS Gate Arrays	GaAs Integrated Circuits	Test. Structures & ATG Approaches
11-12					
12-1					
1-2					
2-3		IC Simulation	Module Generators II	Megahertz Thruput Digital Signal ICs	Performance Oriented Gate Arrays
3-4					
4-5	Author Interviews				
5-6					
6-9	CICC Banquet at the Westin Benson Hotel				
WEDNESDAY, MAY 6					
7-8	Registration				
8-9					
9-10		Standard Cell Libraries	ASICs for Interface Applications	Fabrication Technologies and Tools	Graphics & 2-D Signal Processing
10-11					
11-12		CICC Luncheon			
12-1					
1-2					
2-3		Standard Cell Methodologies	Device & Circuit Modeling	Communications Circuits	High Voltage & SOI
3-4					
4-5	Author Interviews				
5-6					
6-7					
7-8					
8-9	...Layout Tools...		...ASIC Design...	...Packaging...	
9-10					
THURSDAY, MAY 7					
7-8	Registration				
8-9					
9-10		Design Systems	Quick-turn Gate Arrays	Measurement and Reliability	Communication & Data Processing
10-11		Design Database Migration			
11-12					
12-1					
1-2					
2-3		Physical Optimization	Analog Arrays & Circuit Techniques	Converter & Sensor Circuits	Packaging & Interface Appl.
3-4					
4-5	Author Interviews				
5-6					

LIST OF CONTRIBUTORS

- Aadsen, D. R., 66
 Abe, K., 315
 Abe, M., 199
 Acken, J. M., 590
 Aldridge, A. W., 248
 Alijafari, P., 547
 Anderson, F., 35
 Ansari, N., 359
 Arambepola, B., 311
 Armstrong, D. H., 573
 Asada, K., 21
 Aubert, P., 712

 Baker, R., 307
 Baldwin, D., 181
 Banak, M. A., 263
 Bandoh, T., 253
 Barbera, G., 540
 Barouch, B., 5
 Bennett, P. S., 195
 Beunder, M., 44
 Bhandari, N., 345, 698
 Blank, T., 119
 Bohm, D., 488
 Bondoc, J., 698
 Bonneau, M., 245
 Breitenwischer, T. G., 62
 Bridgewater, W. F., 371
 Brown, R. W., 655
 Brunel, J. Y., 153
 Bui, T. H., 227
 Buurma, G., 241
 Byrnett, B. E., 161

 Cameron, K., 421
 Canal, H. G., 547
 Carey, R. E., 263
 Carter, W. S., 515
 Catthoor, F., 157
 Cave, D., 276
 Chan, K., 359
 Chan, P. Y., 96
 Chan, T. 39
 Chang, M. C., 137
 Chang, V., 507
 Chang, Y., 39, 375
 Charles, H. K., Jr., 665
 Chen, C. F., 137
 Chen, M. K., 413
 Cheung, G., 311
 Chia, Y. T., 405
 Chiao, M., 502
 Chiappano, G., 469
 Chin, M. R., 725
 Chow, K., 614
 Choy, B., 439
 Christopher, T. J., 319

 Ciacchella, F. J., 345
 Clatterbaugh, G. V., 665
 Co, R. S., 461
 Colamonico, A., 469
 Coleman, C. R., 498
 Collins, J., 219
 Cordell, R. R., 555
 Coutee, P., 219

 Dawson, R. H., 29
 DeGroat, J. W., 230
 DeMan, H., 157
 Dholakia, S., 149
 Diaz, J., 230
 DiCecca, A., 186
 Dinkledine, T. L., 679
 Director, S. W., 107, 329
 Dixon, R. P., 195
 Donati, M., 469
 Drew, S. W., 559
 Duncan, P., 586
 Dunlop, A. E., 417
 Duong, K., 515

 Eden, R. C., 101, 170
 Edmondson, C., 594
 Embree, M. L., 263
 Emerald, P. R., 280
 Endo, Y., 303
 Enomoto, T., 303
 Evans, S., 614

 Fattaruso, J. W., 647
 Ferrario, J. S., 670
 Fine, B., 644
 Fiore, J., 245
 Fishburn, J. P., 417
 Fletcher, T., 285
 Floyd, K., 165
 Ford, J., 35
 Fowles, D. C., 96
 Frank, D., 295
 Freeman, R. H., 515
 Freeman, S., 72
 Freie, M., 39
 Fujita, K., 315
 Fujita, M., 52, 333
 Fujiwara, H., 315
 Fuller, R. T., 337
 Fuoss, D., 348
 Furnanage, R. A., 263

 Gajski, D. D., 9
 Gal, L., 567
 Gallagher, D. M., 13

 Gammel, J. C., 263
 Ganesan, A., 453
 Gee, D. M., 465
 Geissberger, A. E., 92
 George, P., 409
 Georgiou, C., 257
 Glad, T. J., 449
 Gnansekarin, R., 694
 Goossens, G., 157
 Goto, G., 48, 207
 Gould, E., 245
 Grate, L., 488
 Gross, W., 639
 Grotjohn, T. A., 396
 Grover, L. K., 622
 Guo, B., 694
 Gurney, D. J., 145

 Hall, R. J., 536
 Hallenbeck, K. S., 522
 Hansen, J., 367, 421
 Hanyu, I., 199
 Harasaki, H., 303
 Hartoog, M., 488
 Haruta, R., 333
 Hashimoto, M., 315
 Hatamian, M., 299
 Hayakawa, H., 333
 Hayama, H., 431
 Hayashibara, M., 473
 Helms, W. J., 161
 Heyes, G., 644
 Hijiya, S., 207
 Hill, D. D., 729
 Hirata, K., 431
 Hirata, M., 563
 Hirata, S., 319
 Hobson, L. D., 675
 Hoefflinger, B., 44, 396
 Hoelzl, G., 257
 Hoffman, B., 181, 540
 Honzawa, T., 315
 Horie, A., 379
 Hornung, R., 245
 Horowitz, M., 590
 Hotta, A., 253
 Hotta, T., 253
 Howson, R. D., 547
 Hsieh, H. C., 515
 Hsieh, P. H., 507
 Hsu, C. P., 614, 725
 Hsu, D., 488
 Hsu, K. I., 461
 Hu, C., 409
 Hu, G., 405
 Huang, M. P., 177
 Huber, W. R., 586

 Hui, A., 39
 Hui, K., 409
 Huizer, C. M., 391
 Hung, M., 39
 Hurst, P. J., 449

 Ikushima, I., 651
 Ikuzaki, K., 52
 Illgner, J. J., 449
 Inkol, R. J., 211
 Ishii, A., 379
 Itoh, K., 52
 Itoh, N., 352
 Iwamura, J., 379
 Iwamura, M., 253
 Izumita, T., 443

 Ja, J. Y., 515
 Jain, S. K., 66
 Johannessen, B. O., 92
 Johnson, B., 694
 Johnston, R. E., 341
 Jones, R. C., 679
 Jung, T. W., 413
 Jungo, C., 165, 708

 Kadono, S., 203
 Kajii, K., 199
 Kanasugi, A., 207
 Kanazawa, R., 515
 Kane, M. G., 96
 Kanopoulos, N., 85, 307
 Kao, W., 359
 Kaplan, M. S., 145
 Kapoor, A. K., 345
 Kase, T., 333
 Kato, K., 651
 Kato, T., 473
 Kawashima, M., 52
 Keil, R. F., 248
 Kernhof, J., 44
 Kikuchi, K., 303
 Kirk, R. S., 367, 536
 Kishida, K., 52
 Kissoon-Dunn, E. H., 547
 Kitagawa, N., 315
 Knight, S. P., 319
 Knight, T., 289
 Knorp, K., 39
 Ko, P., 409
 Kobayashi, T., 352
 Kojima, M., 276
 Kojima, N., 319
 Kojima, S., 651
 Kolchmeyer, J. O., 547
 Kolonko, M., 492

Komatsuzaki, K., 315
 Komatsuzaki, T., 315
 Kossey, R. M., 610
 Kosugi, M., 199
 Kotcherlakota, S., 29
 Kowarik, O., 598
 Krambeck, R. H., 483
 Krause, M. A., 655
 Krymm, A., 289
 Kubinec, J., 694
 Kubosawa, H., 48
 Kunc, V., 708
 Kunio, T., 303
 Kurita, K., 253
 Kuroda, T., 241

Labrousse, J. M., 153
 Lam, H. W., 427
 Lamarche, J., 295
 Lamoureux, P., 295
 Landsburg, G. F., 449
 Laroia, R., 559
 Lathrop, R. H., 536
 Lau, P. M., 101, 170
 Laurenson, S. R., 465
 Lee, F. S., 101, 170
 Lee, Y. S., 704
 Leith, J., 17
 Leveille, F., 295
 Liao, K. Y., 725
 Lin, H. C., 400
 Lin, L. T., 190
 Lin, Y. L. S., 9
 Linderman, R. W., 13, 219
 Lindholm, F. A., 413
 Linholm, L. W., 579
 Liu, D. L., 68
 Liu, J., 614
 Long, S., 223
 Lucas, D., 502
 Lucas, R., 119
 Lyngaas, R., 367

Mack, I. A., 400
 Maejima, H., 203, 253
 Makino, T., 323
 Maloberti, F., 469
 Mangieri, B. A., 263
 Marchant, C. E., 88
 Marsh, D. G., 453
 Martin, J., 245
 Martin, K. W., 704
 Martin, R. A., 435
 Masuda, I., 52, 203
 Matsumoto, S., 319
 Matsumura, N., 207
 Mavor, J., 21
 McAllister, L., 245
 McCluskey, E. J., 68
 McGlinchey, G., 689

McGuire, D. J., 453
 McNeill, B. W., 635
 Merki, U., 267
 Meyer, R. G., 647
 Meyr, H., 551
 Meza, P., 639
 Michel, P., 241
 Mikan, D. G., Jr., 670
 Mimura, T., 199
 Mizuno, F., 333
 Molin, S., 722
 Montecchi, F., 469
 Mooney, R., 285
 Moore, L. G., Jr., 717
 Moriarty, J. K., 679
 Mühlemann, K., 267
 Murabayashi, F., 203
 Muramatsu, K., 323

Nagai, H., 563
 Nakagawa, I., 319
 Nakao, T., 52
 Nakata, R., 352
 Nance, S., 526
 Nati, S. F., 88
 Nayebi, M., 698
 Neuvo, Y., 223
 Newton, A. R., 531
 Ng, C., 488
 Ngo, L. T., 515
 Nguyen, H. G., 145
 Nishio, Y., 203
 Nishitani, T., 303
 Nishiyama, A., 352
 Nissan-Cohen, Y., 337
 Nolan, J. G., 684
 Nomura, M., 315
 Nootbaar, K., 177
 Nose, S., 323

Odani, K., 199
 Oettel, R. E., 170
 Oguey, H., 712
 Ohata, Y., 443
 Oishi, K., 319
 Okamura, Y., 133
 Okazaki, S., 333
 Olmstead, J. A., 659
 Or-Bach, Z., 526
 Ormerod, F., 195
 Ortiz-Conde, A., 263
 Owaki, S., 203

Palmisano, G., 469
 Pandel, J., 559
 Panner, J. H., 248
 Park, H., 547
 Patel, V. B., 311
 Perry, R., 614

Peterson, L., 567
 Pierce, K., 526
 Pietruszynski, D. M., 263
 Piro, R., 245
 Pistone, D. R., 522
 Pittman, G. D., 248
 Pleterssek, T., 165
 Pokala, R. P., 371
 Powell, S., 5
 Pyke, R. B., 629

Rabaey, J., 157
 Radack, D. J., 579
 Rapp, V., 257
 Rasmussen, R., 39, 375
 Regenold, D. R., 586
 Reis, R., 385
 Richards, W. R., 337
 Richman, B., 367, 421
 Robinson, M., 165, 708
 Roessler, B., 457
 Roskell, D., 59
 Rosky, D. S., 190
 Rossbach, P. C., 13, 219
 Rowson, J., 149
 Rupp, A., 439

Saari, V. R., 453
 Sadayappan, P., 124
 Sadler, R. A., 92
 Sadler, S., 295
 Sakallah, K. A., 129
 Sakuma, H., 431
 Sakurai, T., 276
 Sandow, P. M., 337
 Sangiovanni-Vincentelli, A. L., 417
 Sasaki, K., 315
 Sase, T., 651
 Sato, H., 651
 Sato, M., 303
 Sato, T., 133
 Saucier, G., 25
 Schalk, R. W., 461
 Schumacher, A., 559
 Serafini, A., 186
 Severloh, H., 492
 Severson, F., 114
 Shamma, N., 345
 Shanblatt, M. A., 618
 Shenton, G., 165, 708
 Shephard, C. G., 219
 Shimizu, I., 272
 Shin, Y. I., 285
 Shiozawa, K., 333
 Shirato, T., 48, 207
 Short, G., 59
 Shugard, D. D., 299
 Shyu, J. M., 417

Siemiatkowski, Z., 684
 Simpkins, S., 114
 Simpson, R., 59
 Singh, H. P., 92
 Soo, D., 276
 Sporer, H., 457
 Srinivasan, S., 502
 Stahl, J., 551
 Stewart, R. G., 319
 Stiglic, M., 708
 Still, D., 181
 Stoelzle, A., 559
 Strojwas, A. J., 329
 Suehiro, Y., 48
 Sundaram, M., 223
 Sunter, S., 237
 Suzuki, M., 199
 Suzuki, S., 323
 Swartz, R. W., 522
 Swartzwelder, J. C., 299

Tachibana, T., 315
 Tago, H., 9
 Takahashi, K., 563
 Takechi, M., 52
 Takeuchi, R., 272
 Tamitani, I., 303
 Tamura, S., 315
 Tanaka, S., 253
 Tang, A. Y. C., 341
 Tang, J., 614
 Tanimoto, H., 473
 Tanimura, N., 319
 Tate, L. R., 215
 Taylor, K., 219
 Tepper, R. S., 177
 Thomas, D. R., 248
 Thonemann, H. G., 492
 Thuau, G., 25
 Tinkey, L. G., 515
 Tohma, Y., 78
 Tom, S., 245
 Torrance, R., 295
 Trontelj, L., 165, 708
 Trontelj, J., 165, 708
 Truong, H. D., 190
 Tsang, J. C., 337
 Tsao, P., 39
 Tsay, C., 439
 Tsoi, H. Y., 439
 Tsumura, M., 272
 Tsutsumi, S., 48
 Turek, J., 59

Upton, M. D., 170
 Usami, K., 379
 Ushiku, Y., 352
 Utsumi, S., 276

Vai, M. K., 618
Vainio, O., 223
Vanhoof, J., 157
Varma, P., 78
Vasanthavada, N., 307
Visvanathan, V., 124
Vithayathil, J., 498
Vo, D., 363
Vora, M. B., 345
Vulih, S., 659

Wakimoto, H., 319
Walker, B., 149

Wang, S., 567
Warren, G., 708
Watanabe, Y., 199
Watkins, D., 375
Watson, G. A., 461
Waymel, B., 245
Weinstein, J., 605
Westberg, C. L., 498
Wick, D., 181
Wilcox, D., 722
Willis, D. M., 319
Windisch, C. H., Jr., 582
Witkosky, B. J., 29

Wolter, E., 457
Wright, J., 594
Wu, B. S., 413

Yajima, A., 133
Yamada, H., 563
Yamashina, M., 303
Yamashita, K., 207
Yamazaki, K., 203
Yao, C. T., 400
Yen, Y. T., 129
Yin, M. T., 137

Yin, P., 39
Yokomizo, G., 133
Yoshida, A., 352
Yu, M. L., 625
Yuen, A., 39
Yuen, R., 177
Yuzuriha, T., 348

Zuber, M. J., 717

CONTENTS

MONDAY EVENING	Pavilion (Hilton)	PAGE
----------------	-------------------	------

NEW CUSTOM PRODUCTS AND SERVICES		1
---	--	----------

Chairman: L. Fuller
Co-Chairman: D. Bryant

TUESDAY MORNING	State Room (Hilton)	PAGE
-----------------	---------------------	------

8:30 WELCOME/OPENING REMARKS		
-------------------------------------	--	--

T. Foxall, General Chairman
D. Bryant, Conference Chairman

8:50 CICC '87 - TECHNICAL PROGRAM		
R. Milano, Technical Program Committee Chairman		

9:00 KEYNOTE ADDRESS		
"The Custom IC Business is Dead, Long Live Custom, ICs"		
A. Rappaport		
Technology Research Group, Boston, MA		

MODULE GENERATORS I		3
Chairman: J.J. Barnes		
Co-Chairman: J. Allen		

9:45 MAP: A Parameterizable Module Generator Development System Oriented to IC Designers		5
S. Powell, B. Barouch, Hughes Aircraft Co., Carlsbad, CA		

10:10 A Flexible-Cell Approach for Module Generation		9
Y—L.S. Lin*, D.D. Gajski*, H. Tago**, Univ. of Illinois, Urbana IL*, Toshiba Corp., Kawasaki, Japan**		

10:35 An Optimizing XROM Silicon Compiler		13
P.C. Rossbach, R.W. Linderman, D.M. Gallagher, Air Force Institute of Technology, Wright-Patterson Air Force Base, OH		

11:00 Crystal Oscillator Compiler		17
J. Leith, Seattle Silicon, Bellevue, WA		

11:25 A MOS Leaf-Cell Generation System from Boolean Expressions		21
K. Asada*, J. Mavor**, Univ. of Tokyo, Tokyo, Japan*, Univ. of Edinburgh, Edinburgh, United Kingdom**		

11:50 Complex MOS Gates Compiler		25
G. Thuau, G. Saucier, INPG, Grenoble, France		

CONTENTS

TUESDAY MORNING	State Room (Hilton)	PAGE
-----------------	---------------------	------

- | | | |
|-------|---|----|
| 12:15 | LATE PAPER
"ASIC Designs using VITAL"
R.H. Dawson, B.J. Witkosky, S. Kotcherlakota, RCA, Somerville, NJ | 29 |
|-------|---|----|
-

TUESDAY MORNING	Rose Room (Hilton)	PAGE
-----------------	--------------------	------

- | | | |
|-------|---|-----|
| | ARCHITECTURAL DEVELOPMENTS FOR LARGE CMOS GATE ARRAYS | 33 |
| | Chairman: H. Scalf
Co-Chairman: M. Hollabaugh | |
| 9:45 | A 0.5 Micron 150K Channelless Gate Array
F. Anderson, J. Ford, Motorola, Inc., Phoenix, AZ | 35 |
| 10:10 | Advanced Structured Arrays Combine High Density Memories with Channel-Free Logic Array
T. Chan, A. Yuen, K. Knorp, M. Hung, P. Tsao, M. Freie, Y. Chang, R. Rasmussen, A. Hui, P. Yin, LSI Logic Corp., Milpitas, CA | 39 |
| 10:35 | Effective Implementation of Complex and Dynamic CMOS Logic in a Gate Forest Environment
M. Beunder, J. Kernhof, B. Hoefflinger, Institut for Mikroelektronik, Stuttgart, West Germany | 44 |
| 11:00 | Layout Approaches to High-Density Channelness Masterslice
H. Kubosawa*, G. Goto*, S. Tsutsumi**, Y. Suehiro**, T. Shirato**, Fujitsu Laboratories Ltd., Atsugi, Japan*, Fujitsu Ltd., Kawasaki, Japan** | 48 |
| 11:25 | Triple-Level Metal Gate Array using Channelless Architecture
K.Y. Liao, C-P Hsu, M-R Chin, Hughes Aircraft Co., Newport Beach, CA | 725 |
| 11:50 | An 18K 1 μm CMOS Gate Array with High Testability Structure
M. Kawashima*, M. Takechi*, K. Ikuzaki*, K. Kishida*, K. Itoh*, M. Fujita*, T. Nakao**, I. Masuda***, Hitachi, Ltd., Tokyo, Japan*, Hitachi Ltd., Kanagawa, Japan**, Hitachi Ltd., Ibaraki, Japan*** | 52 |
-

TUESDAY MORNING	Music Box Theatre	PAGE
-----------------	-------------------	------

- | | | |
|------|---|----|
| | TESTABILITY STRUCTURES AND ATG APPROACHES | 57 |
| | Chairman: M.G. Moon
Co-Chairman: S. Hao | |
| 9:45 | Testability in the TMS34010 Graphics Systems Processor
G. Short, J. Turek, D. Roskell, R. Simpson, Texas Instruments Ltd., Bedford, England | 59 |

CONTENTS

TUESDAY MORNING	Music Box Theatre	PAGE
10:10 Logic Verification and Production Testing of Non-Structured Embedded VLSI Blocks T.G. Breitenwischer, National Semiconductor Corp., Santa Clara, CA		62
10:35 Automation of BIST for Embedded RAM D.R. Aadsen*, S.K. Jain**, AT&T Bell Labs, Allentown, PA*, AT&T Bell Labs, North Andover, MA**		66
11:00 High Fault Coverage Self-Test Structures for CMOS ICs D.L. Liu, E.J. McCluskey, Stanford Univ., Stanford, CA		68
11:25 The F-Path Method of Test Generation for Datapath Logic S. Freeman, RCA Labs, Princeton, NJ		72
11:50 PROTEAN—A Knowledge Based Test Generator P. Varma*, Y. Tohma**, HRC, Middlesex, U.K.*, Tokyo Inst. of Technology, Tokyo, Japan**		78

TUESDAY MORNING	Pavilion (Hilton)	PAGE
GaAs INTEGRATED CIRCUITS Chairman: D.F. Perkins Co-Chairman: S.H. Chiao		83
9:45 A Monolithic GaAs Error Detection and Correction Circuit for Triple Modular Redundancy Applications N. Kanopoulos, Research Triangle Inst., Research Triangle Park, NC		85
10:10 A Gallium Arsenide Encoder/Decoder and Laser Diode Driver for High Speed Optical Communication Links S.F. Nati, C.E. Marchant, General Electric Co., Syracuse, NY		88
10:35 A 2 GHz GaAs Line Code Error Detection Circuit for Fiber Optic Communications B.O. Johannessen*, H.P. Singh**, R.A. Sadler**, A.E. Geissberger**, ITT Corp., Oslo, Norway*, ITT Corp., Roanoke, VA**		92
11:00 A 1.5 GHz Programmable Divide-by-N GaAs Prescaler M.G. Kane, P.Y. Chan, D.C. Fowles, Microwave Semiconductor Corp., Somerset, NJ		96
11:25 GaAs Standard Cell Family Designed with Current Limiting Capacitor Diode FET Logic Approach P.M. Lau, R.C. Eden, F.S. Lee, GigaBit Logic, Newbury Park, CA		101

CONTENTS

TUESDAY AFTERNOON	State Room (Hilton)	PAGE
	IC SIMULATION	105
	Chairman: P. Lloyd Co-Chairman: C. Anagnostopoulos	
1:35	Manufacturing Based Simulation: An Overview S.W. Director, Carnegie Mellon Univ., Pittsburgh, PA	107
2:25	Hadamard Simulation—An Effective, Systematic Tool for Worst Case Circuit Analysis F. Severson, S. Simpkins, Tektronix, Inc., Beaverton, OR	114
2:50	Parallel PISCES R. Lucas, T. Blank, Stanford University, Stanford, CA	119
3:15	Circuit Simulation on a Multiprocessor P. Sadayappan*, V. Visvanathan**, Ohio State Univ., Columbus, OH*, AT&T Bell Labs, Murray Hill, NJ**	124
3:40	SAMO: An Automatic MOS Circuit Partitioner Y-T Yen, K.A. Sakallah, Digital Equipment Corp., Hudson, MA	129
4:05	HICE: Hierarchical Circuit Extraction System for Layout Verification G. Yokomizo, A. Yajima, Y. Okamura, T. Sato, Hitachi, Ltd., Tokyo, Japan	133
4:30	Full Chip RC Routing Extraction and Delay Analysis M-C Chang, C-F Chen, M-T Yin, AT&T Bell Labs, Murray Hill, NJ	137

TUESDAY AFTERNOON	Rose Room (Hilton)	PAGE
	MODULE GENERATORS II	143
	Chairman: J. Lipman Co-Chairman: J. Buurma	
2:00	A CRT Controller Generator M.S. Kaplan, D.J. Gurney, H-G Nguyen, Silicon Design Labs, Inc., Liberty Corner, NJ	145
2:25	A Datapath Compiler for Standard Cells and Gate Arrays J. Rowson, B. Walker, S. Dholakia, VLSI Technology, Inc., San Jose, CA	149
2:50	Basic Operators to Tailor Application Specific Microprocessor System on Silicon J.Y. Brunel, J.M. Labrousse, Laboratoires D'Electronique et de Physique Appliquee, Limeil-Brevannes, France	153
3:15	Cathedral II: Computer Aided Synthesis of Digital Signal Processing Systems J. Rabaey, J. Vanhoof, G. Goossens, F. Catthoor, H. De Man, IMEC Labs., Leuven, Belgium	157

CONTENTS

TUESDAY AFTERNOON	Rose Room (Hilton)	PAGE
3:40	Compiler Generation of A to D Converters W.J. Helms*, B.E. Byrnett**, Univ. of Washington, Seattle, WA*, Seattle Silicon, Bellevue, WA**	161
4:05	Expert System for Automatic Mixed Analog Digital Layout Compilation J. Trontelj*, L. Trontelj*, T. Pleterssek*, G. Shenton**, M. Robinson***, K. Floyd***, C. Jungo***, Univ. Edvard Kardelj, Trzaska, Yugoslavia*, IMP Europe, Swindon, England**, IMP, San Jose, CA***	165
4:30	LATE PAPER "A 4-Bit Gallium Arsenide ALU Designed With a Compiler" R.E. Oettel*, M.D., Upton*, R. Eden**, F. Lee**, P. Lau**; Seattle Silicon Corp., Bellevue, WA*, GigaBit Logic, Newbury Park, CA**	170

TUESDAY AFTERNOON	Music Box Theatre	PAGE
	PERFORMANCE ORIENTED GATE ARRAYS	175
	Chairman: C. Erdelyi Co-Chairman: H. Scalf	
2:00	A 600MHZ 5000 Gate ECL/TTL Gate Array R.S. Tepper, K. Nootbaar, M.P. Huang, R. Yuen, Applied Micro Circuits Corp., San Diego, CA	177
2:25	A Performance-Programmable Bipolar Gate Array Family for Building Mainframe Computer Systems D. Still, D. Baldwin, B. Hoffman, D. Wick, Honeywell, Inc., Colorado Springs, CO	181
2:50	ECL ASICs for Space Application A. DiCecca, A. Serafini, Selenia Spazio, S.p.A., Rome, Italy	186
3:15	A 9100 Gate ECL/TTL Compatible BiCMOS Gate Array L.T. Lin, D.S. Rosky, H.D. Truong, Applied Micro Circuits Corp., San Diego, CA	190
3:40	High Performance BiMOS Gate Arrays with Embedded Configurable Static Memory P.S. Bennett, R.P. Dixon, F. Ormerod, Motorola, Inc., Chandler, AZ	195
4:05	LATE PAPER A 40 ps High Electron Mobility Transistor 4.1K Gate Array K. Kajii, Y. Watanabe, M. Suzuki, I. Hanyu, M. Kosugi, K. Odani, T. Mimura, M. Abe, Fujitsu Labs Ltd., Atsugi, Japan	199
4:15	LATE PAPER A 0.45ns 7K Hi-BiCMOS Gate Array with Configurable 3-Port 4.6K SRAM Y. Nishio*, F. Murabayashi*, I. Masuda*, H. Maejima*, S. Owaki**, K. Yamazaki**, S. Kadono**, Hitachi Res. Lab., Ibaraki-ken, Japan*, Takasaki Works, Gunma-ken, Japan**	203

CONTENTS

TUESDAY AFTERNOON		Pavillion (Hilton)	PAGE
	MEGAHERTZ THROUGHPUT DIGITAL SIGNAL PROCESSING ICs		205
	Chairman: F. Yassa Co-Chairman: T. Foxall		
2:00	A Wafer-Scale 170,000-Gate FFT Processor with Built-In Test Circuits K. Yamashita, A. Kanasugi, S. Hijiya, G. Goto, N. Matsumura, T. Shirato, Fujitsu Labs Ltd., Atsugi, Japan		207
2:25	A Modular Chip Set Implementation of an Associative Comparator R.J. Inkol, Defence Research Establishment, Ottawa, Canada		211
2:50	Sparse Canonical Signed Digit FIR Filter L.R. Tate, RCA, Somerville, NJ		215
3:15	A 70 Mhz 1.2 Micron CMOS 16-Point DFT Processor R.W. Linderman, C.G. Shephard, K. Taylor, P. Coutee, P. Rossbach, J. Collins, Air Force Inst. of Technology, Wright-Patterson Air Force Base, OH		219
3:40	GaAs FIR Median Hybrid Filter O. Vainio*, M. Sundaram**, S. Long**, Y. Neuvo*, Tampere Univ. of Tech., Tampere, Finland*, Univ. of California, Santa Barbara, CA**		223
4:05	A High Speed LMS Adaptive Filter T.H. Bui, RCA, Somerville, NJ		227
4:30	Microcoded RISC Processor for Calculation of the Vector Wave Equation J. Diaz, J.W. DeGroat, Air Force Inst. of Technology, WPABF, OH		230
WEDNESDAY MORNING		State Room (Hilton)	PAGE
	STANDARD CELL LIBRARIES		235
	Chairman: D. Daly Co-Chairman: T. Sideris		
8:20	Designing a CMOS Standard Cell Library S. Sunter, Bell-Northern Research, Ottawa, Canada		237
8:45	A High Performance Scalable Standard Cell Library with True Second Sourcing G. Buurma*, P. Michel**, T. Kuroda***, GE Semiconductor, Research Triangle Park, NC*, Siemens AG, Munich, W. Germany**, Toshiba Corp., Kawasaki, Japan***		241
9:10	A Versatile VLSI Design System for Combining Gate Array and Standard Cell Circuits on the Same Chip R. Hornung*, M. Bonneau*, B. Waymel*, R. Piro**, J. Fiore**, E. Gould**, J. Martin**, L. McAllister**, S. Tom**, IBM, Corbeil-Essonnes, France*, IBM, Essex Junction, VT**		245